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SPEECH

The Federal Reserve's Recent Actions to Support the Flow of Credit to Households and Businesses

April 14, 2020

Lorie K. Logan, Executive Vice President

Remarks before the Foreign Exchange Committee, Federal Reserve Bank of New York, New York City
As prepared for delivery

Good afternoon. As members of the Foreign Exchange Committee, you are all well aware of the importance of well-functioning financial markets. I would like to thank you for the commitment you have shown to supporting the smooth functioning of the foreign exchange market. Your continued leadership is especially important in these challenging times. And we are all grateful to those who are putting themselves in harm's way on the front lines to take care of others during this unprecedented public health emergency.

In early to mid-March, amid extreme volatility across financial markets triggered by the coronavirus pandemic, several markets at the center of the U.S. financial system were severely disrupted. In short-term funding markets, it was difficult to borrow for longer than overnight. In the usually very liquid markets for Treasury securities and agency mortgage-backed securities (MBS), trading became impaired. In investment-grade credit markets, even healthy borrowers found that credit was unavailable or very expensive.

These markets matter not only for those who participate in them, but also—because of their central role in the financial system—for workers and families throughout the United States. Continued disruptions could quickly make it more difficult for families to obtain mortgages at reasonable interest rates, for businesses to fund their operations and pay their workers, and for local, state, and federal governments to pay for essential services. Such a credit crunch would exacerbate the hardships many are experiencing in this period of economic constraint necessary to fight the spread of the coronavirus, and reduce the odds of a strong recovery afterward.

Therefore, it was important for the Federal Reserve to act quickly and decisively to support market functioning and the flow of credit. Over a period of a few weeks, the Federal Open Market Committee (FOMC) lowered the target range for the federal funds rate to near zero. The Federal Reserve also announced a sequence of strong actions to support the flow of funding in short-term markets, the functioning of Treasury and MBS markets, and the availability of credit to households, businesses, and state and local governments.

Today, I will provide an overview of these actions to date from my perspective as manager of the System Open Market Account and head of the New York Fed's Open Market Trading Desk. The Fed's recent actions have involved an unprecedented array of tools—from standard open market operations conducted by the Desk and deployed on a larger scale than ever before, to new facilities that use the Federal Reserve's emergency powers with the consent of the Treasury Secretary and financial backing from the Treasury and Congress. Some actions targeted problems in a single market, while others worked to support functioning across many markets. In addition, because they were deployed in close succession, the actions reinforced each other, with improvements in each market supporting the functioning of other markets and the financial system overall. I will speak about recent actions to support liquidity and the flow of credit in four areas: domestic short-term funding markets, international dollar funding markets, markets for Treasuries and MBS, and credit markets.

Before I proceed, let me note that the views I express are my own and do not necessarily reflect those of the Federal Reserve Bank of New York or the Federal Reserve System.[1]

Domestic Short-Term Funding Markets

Funding markets transfer funds from households and businesses that seek safe, easily accessible short-term investments to firms that have short-term borrowing needs. For example, a manufacturing company with a temporary surplus of cash might invest in a money market mutual fund, planning to take the money back out in a few weeks to invest in new equipment. In turn, the money market fund might buy commercial paper issued by another company that needs to cover its payroll, or it might use a repurchase agreement (or "repo") to lend to a broker-dealer that needs to finance an inventory of Treasury securities. The smooth flow of funds in these markets allows businesses to readily finance their operations and investors to engage in vibrant trading that keeps a wide range of other markets working well.

In mid-March, short-term funding markets became severely impaired. In repo and commercial paper markets, there was little term funding available. Even for overnight borrowing, some market participants paid much higher rates than usual. Figure 1 shows the Secured Overnight Financing Rate (SOFR), which is the median rate on certain overnight repos against Treasury collateral, as well as the 75th and 95th percentiles of the distribution of these Treasury repo rates. Ordinarily, this distribution of rates is very tight. However, in the second and third weeks of March, it widened notably, with some borrowers paying dozens of basis points above the median, and well above the FOMC's target range for the federal funds rate.

The initial pressures in funding markets led to further strains. Investors became reluctant to buy the commercial paper of healthy issuers, for fear that when the paper came due, the issuers would have difficulty rolling it over into new paper. Prime money market funds—which invest in commercial paper—saw outflows of about $150 billion over the month of March as some investors worried that difficulty selling holdings would eventually prevent the funds from satisfying withdrawals.

Starting March 9, the Federal Reserve launched a series of actions to stabilize funding markets. The first two actions involved expanding the use of standard tools: repo operations by the Desk and discount window lending by all 12 Reserve Banks.

- The Desk increased daily offerings of overnight repos from $100 billion to $150 billion, then to $175 billion, and ultimately to even larger amounts.[2] The Desk also began offerings of one-month and three-month term repos, each for $500 billion.[3] These offerings allow dealers to access ample funding for Treasury and MBS collateral.
- The Federal Reserve Board lowered the primary credit rate by 150 basis points, to 0.25 percent, and announced that banks could borrow from the discount window for up to 90 days.[4] These steps provide banks with ready access to funding that they can use to provide credit to households and businesses.

Shortly thereafter, several additional actions used emergency tools, based on the Board's authority to act in unusual and exigent circumstances with consent of the Treasury Secretary and, in some cases, funding as well:

- The Primary Dealer Credit Facility (PDCF) allows the New York Fed's primary dealers to obtain funding against a wide range of collateral at the same rate as the discount rate. By increasing dealers' access to funding, this facility helps them to provide credit across numerous markets.[5]
- The Money Market Mutual Fund Liquidity Facility (MMLF) lends against assets that banks acquire from money market funds. By helping to ensure that money market funds will be able to meet demands for redemptions, this facility encourages investors to leave cash in these funds, which then provide credit that flows to the broader economy.[6]
- The Commercial Paper Funding Facility (CPFF) purchases commercial paper directly from highly rated companies and municipal governments. The availability of this facility reduces the risk that eligible commercial paper issuers will be unable to roll over their debts at maturity. In turn, the reduction in risk encourages investors to buy commercial paper from businesses that use the funds to pay employees and invest in operations, and from municipalities that use credit to provide public services. Furthermore, because this facility purchases newly issued commercial paper, it not only enhances liquidity but also directly supports the flow of credit to eligible issuers.[7]

International Dollar Funding Markets

As the world's preeminent reserve currency, the dollar plays a leading role in trade and investment far beyond our country's borders. Banks around the world borrow dollars in international markets to finance these activities. In addition, global banks borrow dollars to finance investments in the United States—lending, that is, to American families, companies, and the U.S. government. As members of the FX Committee, you are well versed in the importance of international dollar funding markets.

These markets, too, came under severe strain in March. Shown in Figure 2, the yen-dollar swap basis spread—a measure of the premium paid to borrow dollars using yen in the foreign exchange market—soared by roughly 200 basis points. Other foreign exchange swap basis spreads also rose sharply, and foreign exchange swap trading volumes declined. These pressures had the potential to spill over to domestic funding markets, as international banks can compete to borrow dollars in the U.S., as well as the potential to disrupt the flow of credit from international financial institutions to domestic borrowers.

To ease strains in global U.S. dollar funding markets, the Federal Reserve and other central banks took coordinated actions in March to enhance the provision of U.S. dollar liquidity through central bank swap lines around the world. These swap lines are designed to improve liquidity conditions in the United States and abroad by providing foreign central banks with the capacity to deliver dollar funding to institutions in their jurisdictions during times of global funding market stress. This supports activities that rely on access to U.S. dollar funding, including supplying credit to U.S. borrowers. The Federal Reserve and the central banks of Canada, the United Kingdom, Japan, Switzerland, and the euro area agreed to lower the pricing on the standing swap lines, to

supply dollars at longer tenors in addition to regular one-week operations, and to increase the frequency of one-week operations. The Federal Reserve also established temporary swap lines, limited in size, with nine other central banks around the world.

In addition to the swap lines, the Federal Reserve established a temporary repo facility to allow foreign and international monetary authorities to temporarily exchange U.S. Treasury securities held in their accounts with the New York Fed for U.S. dollars. This facility provides those central banks with an alternative source of dollar funding that they can then lend to institutions in their jurisdictions. The facility also helps to support the smooth functioning of the market for U.S. Treasury securities by reducing foreign central banks' need to sell these securities outright when private cash and repo markets become stressed.

Markets for Treasury and Mortgage-Backed Securities

The market for U.S. Treasury securities is commonly described as the deepest and most liquid in the world. Ordinarily, it is easy for investors to sell Treasuries quickly and at low cost. This liquidity adds significantly to the value of Treasury securities, helping the U.S. government to borrow at low interest rates. As many other interest rates are priced relative to the safe interest rate on Treasuries, the liquidity of the Treasury market ultimately reduces financing costs for families and firms throughout the economy.

Although not as liquid as the Treasury market, the market for agency MBS—pools of residential mortgages backed by Ginnie Mae, Fannie Mae, and Freddie Mac—is also ordinarily very liquid. This liquidity makes MBS a more attractive investment, supporting low mortgage rates and the flow of mortgage financing to American households.

However, in mid-March, liquidity in Treasuries and MBS dried up. The Desk's market monitoring and data analysis suggest that two key factors were at work. First, amid large moves in asset prices and uncertainty about access to liquidity, many investors sought to sell bond holdings. Some of these investors, such as asset managers that might need to meet redemptions, were seeking to raise cash. Others were rebalancing their portfolios after the sharp fall in equity prices, or exiting positions that were no longer viable in the highly volatile market conditions. These large sales of bonds drove up dealers' inventories of Treasuries and MBS; facing balance sheet constraints and internal risk limits amid the elevated volatility, dealers had to cut back on intermediation. Second, volatile market conditions led some trading firms to step back from the market, further reducing liquidity. Figure 3 shows the consequences: The average bid-ask spread for Treasury securities, a measure of transactions costs, rose by a factor of about 13 over the first few weeks of March. Many other measures of functioning in the Treasury and MBS markets also deteriorated.

In response, the Desk, at the direction of the FOMC, is undertaking extensive purchases of Treasuries and MBS to support the functioning of these critical markets. Although asset purchases are a standard Desk tool, the scale of these purchases has been unparalleled, totaling about $1.6 trillion in the past four weeks. Also, we are now buying agency commercial mortgage-backed securities (CMBS), which are pools of mortgages on apartment buildings and other commercial properties that are backed by Fannie Mae, Freddie Mac, and Ginnie Mae. As important as the volume of purchases is the FOMC's commitment, announced March 23, to purchase whatever amounts are needed to support smooth market functioning and effective transmission of monetary policy.[8] Extending a strong commitment to support market functioning has calmed trading conditions and allayed the potentially self-fulfilling fear that conditions might deteriorate further.

I should note that supporting smooth market functioning does not mean restoring every aspect of market functioning to its level before the coronavirus crisis. Some aspects of liquidity—especially aspects related to transactions costs and market depth—are importantly affected by fundamental factors such as how the current extraordinary uncertainty about the economic outlook influences trading behavior. These aspects of market functioning may not return all the way to pre-crisis levels for some time, even as our purchases slow.

Nor does supporting smooth market functioning mean eliminating all volatility. In well-functioning markets, prices will respond rapidly and efficiently to new information. During the unprecedented disruption caused by the coronavirus pandemic, a great deal of new information arrives every day about the outlook for specific markets, such as housing, and for the economy as a whole. These changes in the outlook should move the Treasury and agency MBS markets irrespective of the Federal Reserve's purchases.

Credit Markets

In normal times, credit markets allow households and businesses to finance a vast array of activities: buying a car or a house, attending college, covering a short-term gap between revenue and expenses, or making a long-term investment in new products or factories. In this time of economic stress, credit markets are all the more critical, helping families to borrow rather than forgo necessities, and helping businesses to keep going, cover their payrolls, and, eventually, make the investments needed for a strong recovery.

Yet credit markets have come under substantial pressure in recent weeks. For example, the spread of interest rates on investment-grade corporate bonds relative to Treasury securities widened by about 250 basis points from late February to mid-March, as illustrated in Figure 4.

Much of that pressure results from significant changes in the economic outlook: With many businesses temporarily closed and millions of people losing their jobs, lenders see a greater likelihood that some borrowers will be unable to repay. But impaired

market functioning has also contributed to the pressures. For example, borrowers often repay their debts by borrowing anew, but rolling over debt is difficult in a stressed market, so lenders may conclude that market dysfunction will lead to defaults even by financially sound borrowers and respond by reducing lending or seeking higher interest rates. We saw several signs that poor market conditions were contributing to credit stress in March, including a drop-off in corporate and municipal bond issuance and large outflows from bond mutual funds.

Many of the Federal Reserve actions in funding and asset markets that I described earlier are also helping to support credit markets. For example, the PDCF, CPFF, and MMLF can all provide funding for loans to creditworthy borrowers such as households, businesses, or local governments, while MBS purchases support a key market for credit to households.

In addition, the Federal Reserve Board, with the consent of the Treasury Secretary and backing provided by the Treasury and Congress under the CARES Act, has used its emergency authority to announce numerous steps targeted at other major credit markets. The Primary Market Corporate Credit Facility (PMCCF) will buy newly issued corporate bonds and syndicated loans, while the Secondary Market Corporate Credit Facility (SMCCF) will give investors an outlet to sell corporate bonds—in both cases supporting a key market for credit to large employers.[9] The Board has also announced a Main Street Lending Program that will purchase up to $600 billion in loans to small and midsize businesses, as well as a facility that will support the Small Business Administration's Paycheck Protection Program (PPP) by supplying liquidity to financial institutions that make PPP loans to small businesses.[10] In addition, the Term Asset-Backed Securities Loan Facility (TALF) will support the issuance of securities backed by student loans, auto loans, credit card loans, small business loans, and other debt, while the Municipal Liquidity Facility (MLF) will lend up to $500 billion to state and local governments.[11] All of these steps will help keep credit markets working and credit flowing to qualified borrowers in response to the coronavirus pandemic.

Conclusion

Modern financial markets are closely connected to one another. Stresses in one market can easily lead to stresses in others, raising the risk that the financial system as a whole becomes significantly impaired. For example, if short-term funding markets are disrupted, otherwise creditworthy borrowers may have difficulty rolling over their debts—which can make the borrowers more risky and create pressures in credit markets. The Global Financial Crisis of 2007-'08 showed how rapidly problems can spread across financial markets and ultimately damage the economy.

Today's crisis is different, having originated outside the financial system, in an enormous challenge to public health. Yet the lesson of the previous crisis still applies, and the Federal Reserve has taken it to heart in responding to the recent stresses in funding markets, Treasury and MBS markets, and credit markets. By acting quickly and forcefully to support all of these markets at once, we have been able to stabilize market conditions. Many challenges surely lie ahead for the economy and financial markets. But the past month demonstrates that the Federal Reserve will use its tools aggressively to keep markets working so that credit can flow to households, businesses, and state and local governments throughout our economy.

Thank you.

Figures PDF

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[1] I would like to thank Sam Schulhofer-Wohl for his assistance in preparing these remarks, Ashley Rhodes for her assistance with data, and colleagues in the Federal Reserve System for valuable comments and suggestions.

[2] See Statement Regarding Repurchase Operations (March 9, 2020), Statement Regarding Repurchase Operations (March 11, 2020), and Statement Regarding Repurchase Operations (March 17, 2020).

[3] See Statement Regarding Treasury Reserve Management Purchases and Repurchase Operations (March 12, 2020).

[4] See Federal Reserve Actions to Support the Flow of Credit to Households and Businesses, Board of Governors of the Federal Reserve System (March 15, 2020).

[5] See Primary Dealer Credit Facility, Board of Governors of the Federal Reserve System.

[6] See Money Market Mutual Fund Liquidity Facility, Board of Governors of the Federal Reserve System.

[7] See Commercial Paper Funding Facility, Board of Governors of the Federal Reserve System.

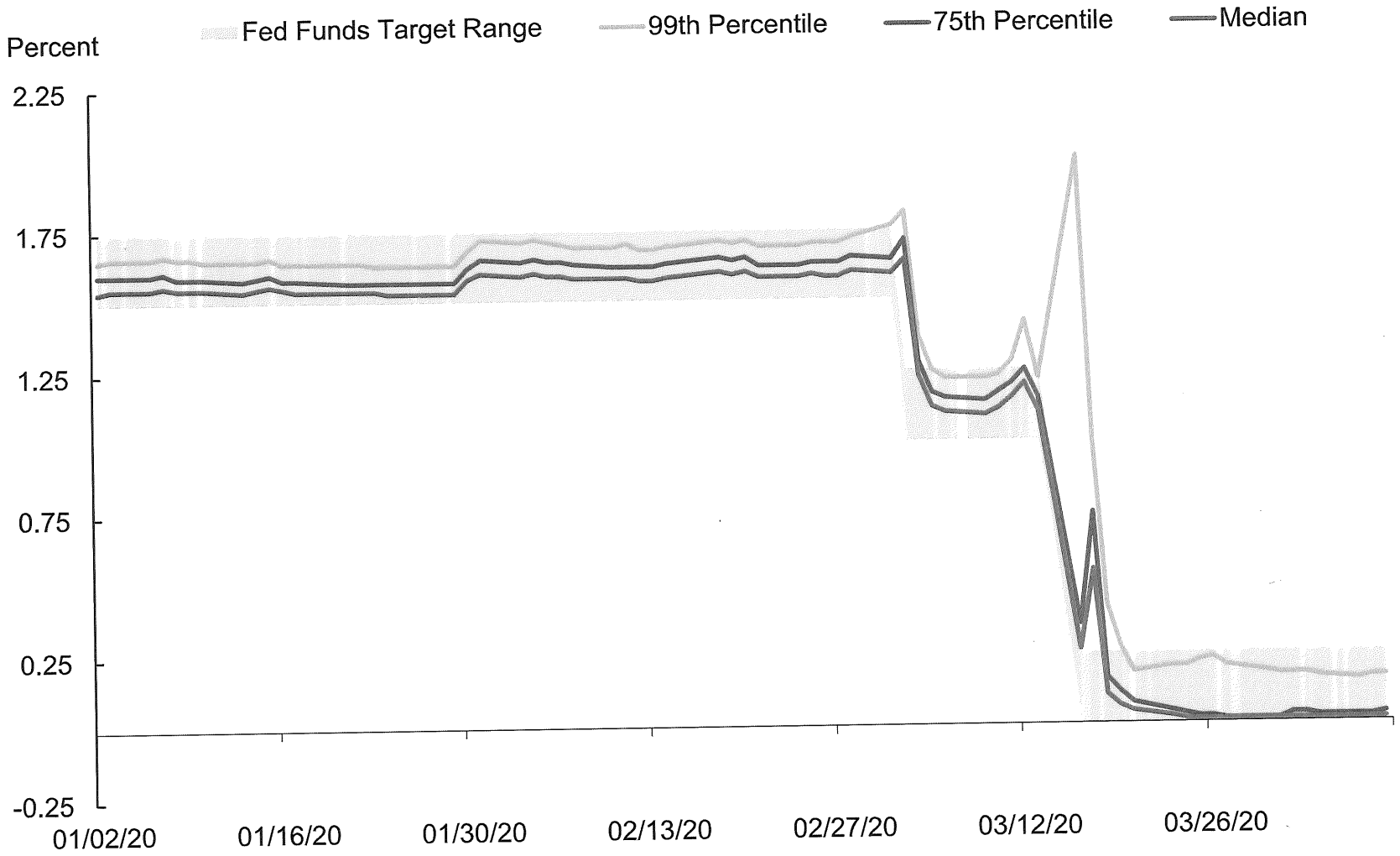
[8] See Federal Reserve issues FOMC statement (March 23, 2020).

[9] See Primary Market Corporate Credit Facility and Secondary Market Corporate Credit Facility, Board of Governors of the Federal Reserve System.

[10] See Main Street Lending Program and Paycheck Protection Program Liquidity Facility, Board of Governors of the Federal Reserve System.

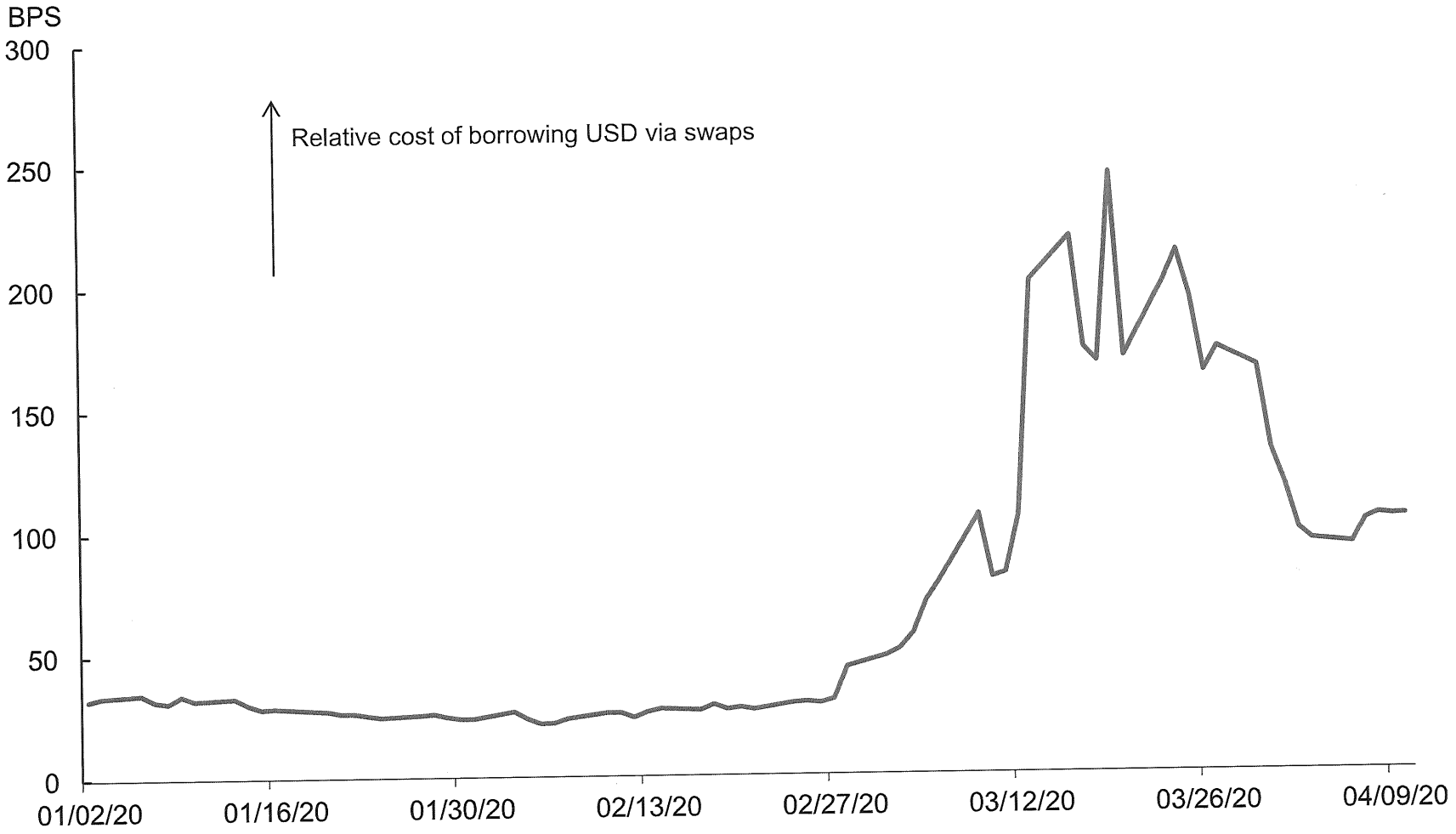
[11] See Term Asset-Backed Securities Loan Facility and Municipal Liquidity Facility, Board of Governors of the Federal Reserve System.

Figure 1: Secured Overnight Financing Rate



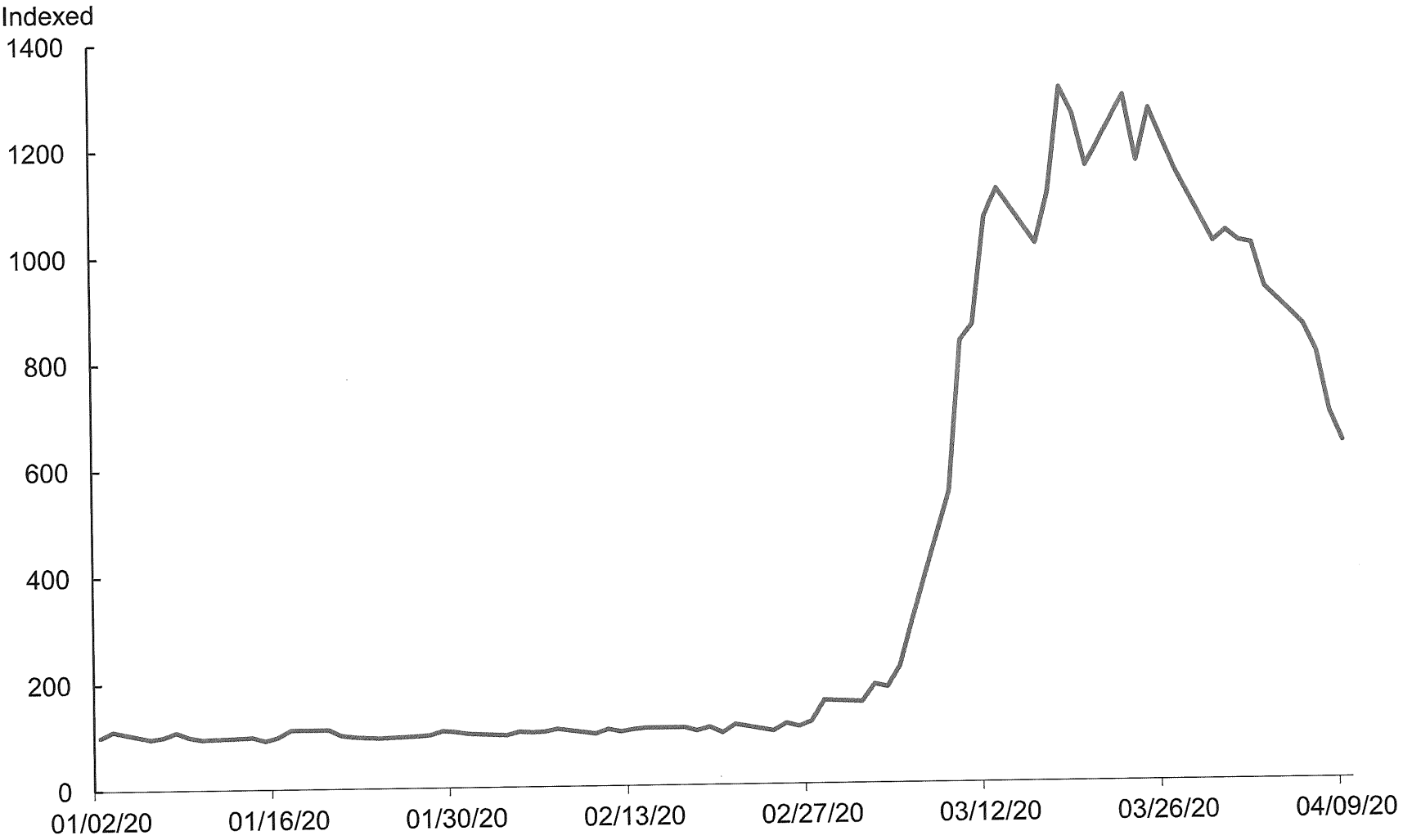
Source: Federal Reserve Bank of New York

Figure 2: Three-Month Japanese Yen-U.S. Dollar FX-Swap Implied Basis



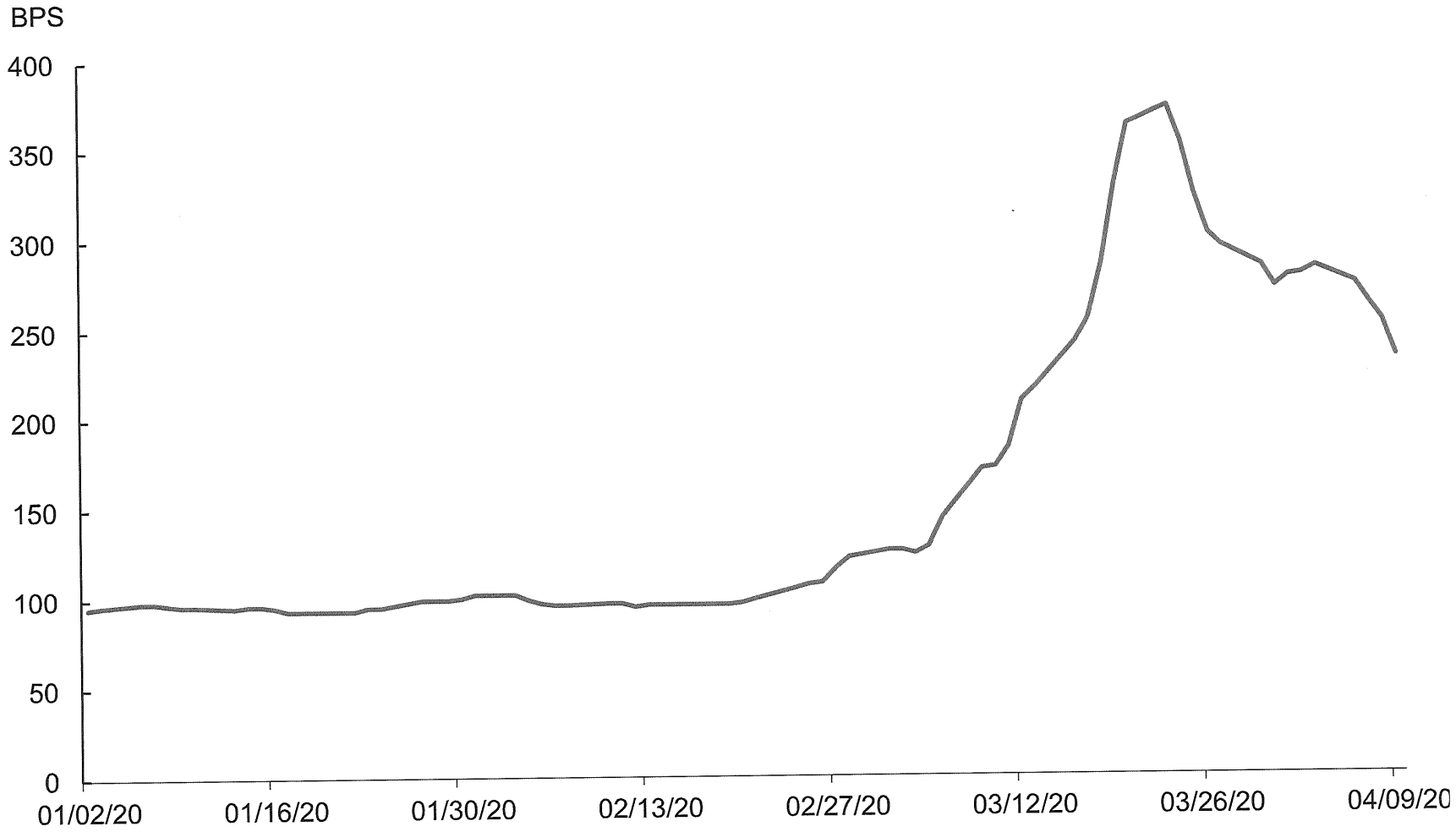
Note: Based off of OIS.
Source: Bloomberg Finance L.P.

Figure 3: Treasury Bid-Ask Spreads



Note: Average Bid-Ask Spreads indexed to 100 as of 01/02/2020.
Source: Bloomberg Finance L.P.

Figure 4: Investment-Grade Credit Spreads



Source: Bloomberg Finance L.P.

FEDERAL RESERVE BANK *of* NEW YORK *Serving the Second District and the Nation*

SPEECH

Implementing the Fed's Facilities: Moving at Maximum Speed with Maximum Care

April 17, 2020

Daleep Singh, Executive Vice President

Remarks before the Money Marketeers of New York University (delivered via audio webinar)
As prepared for delivery

Good morning everyone. Thanks for being here, and let me begin by offering best wishes for everyone's health under these difficult circumstances. I should also make clear at the outset that the views I express are my own and do not necessarily reflect those of the Federal Reserve Bank of New York or the Federal Reserve System.

In my remarks today I'd like to review the context in which the Federal Reserve launched an unprecedented set of policy actions, and I will then describe our approach to standing up emergency facilities at maximum speed with maximum care as we execute our mission.

Context in Mid-March

As you will no doubt recall, financial markets in mid-March were seized by the uncertainty caused by virus outbreak, both in terms of the speed and scale of impact on the economic outlook, and for society as a whole. Extreme uncertainty triggered unprecedented market volatility across asset classes, escalating into a system-wide deleveraging event that appeared to overwhelm the capacity of financial intermediaries to absorb and transfer risk in an orderly manner. Liquidity dried up across markets, including in U.S. Treasuries, the benchmark upon which virtually every other asset is priced or hedged, the foundation for the dollar's primacy as a reserve currency, and the source of funding for our federal government.

As uncertainty rose and liquidity deteriorated, demand for cash and safe assets rose and demand for assets with any form of credit or liquidity risk plummeted. For a few weeks in March, even Treasury yields began to rise, especially in longer maturities, and so did the cost for almost all forms of household and corporate borrowing. Access to financing beyond overnight tenors became severely impaired, causing acute dislocation across short-term funding markets and triggering outflows across prime money market funds.

In the race to safety, dollars became increasingly scarce, intensifying the stress across global markets. Emerging market economies experienced an unprecedented outflow of capital from non-residents. Sovereign yields surged in the most indebted European countries. The ominous reality was that a synchronized global selloff had taken on a life of its own, with little prospect for self-correction.

Moving with Maximum Speed

Against this backdrop, policymakers at the Federal Reserve acted swiftly and unreservedly in an effort to break the damaging psychology that was taking hold. The series of policy actions announced over the past month – both conventional and unconventional – reflected a full recognition that the current shock is qualitatively different from the financial crisis of 2008, without a culprit other than the virus itself. Unconstrained by a diagnosis of who was to blame – and considering the mounting downside risks – the speed and scale of the policy response was free to match the dimensions of the unfolding shock.

I won't review all of the actions that the Fed has taken over the past month – they are well documented elsewhere - but I would like to note of the breadth of activity to stabilize the financial system and to support the flow of credit, both within and outside banking system.

To that end, I'll describe a few of the lending and credit facilities that the New York Fed is charged with standing up to supply credit for households, businesses, and state and local governments:

Commercial Paper Funding Facility

By the middle of March, unusually high funding needs and pullbacks by key lenders of short-term funds led to surging rates in the market for commercial paper, or short-term IOUs issued by businesses and municipalities. Interest rates on longer-term commercial paper, in particular, rose to levels not seen since the financial crisis of 2008. Many issuers were reportedly unable to place commercial paper with a term of longer than a week, leading to increased risk that companies would not be able to fund basic operational needs, such as meeting payrolls or financing inventories.

With backing from the U.S. Treasury, the Federal Reserve established the commercial paper funding facility as a funding vehicle that can purchase new issuance of commercial paper from highly rated businesses and municipalities, and certain issuers that were downgraded after the virus shock. By providing assurances to issuers and investors that retiring commercial paper can be replaced with new issuance, the facility will promote confidence in the market and support the flow of credit to businesses and municipalities.

Corporate Credit Facilities (CCFs)

At the same time that short-term commercial paper markets were nearly frozen, so too were markets for longer-term corporate borrowing – at precisely the moment when companies most needed a financing buffer. Borrowing rates for investment-grade corporate issuers relative to Treasury securities increased by about 2.5 percentage points in the first half of March, while issuance for companies rated below investment grade came to a halt.

In this context, the primary market corporate credit facility (PMCCF) was designed to provide funding for highly rated companies that need access to financing in order to maintain business operations during this period of dislocation. Again with backing from the U.S. Treasury, the Federal Reserve will create a funding vehicle to backstop eligible corporate borrowers for up to four years, at an interest rate that is better aligned with corporates' underlying credit risk than was available through market-based financing during March. This funding can be provided by the PMCCF either through purchases of eligible corporate bonds as the sole investor at issuance, or from purchases of portions of syndications at issuance.

The secondary market corporate credit facility (SMCCF), also backed by the U.S. Treasury with funding from the Federal Reserve, will play an important complementary role to the PMCCF. Here again, there will be two mechanisms at work: the SMCCF may either purchase eligible corporate bonds with a remaining maturity of 5 years or less, or it can purchase U.S.-listed ETFs. For ETFs, the preponderance of holdings will be of ETFs whose primary investment objective is exposure to U.S. investment-grade corporate bonds, and the remainder will be in ETFs whose primary investment objective is exposure to U.S. high-yield corporate bonds.

Taken together, the corporate credit facilities will have three main objectives when we go live in the coming weeks: first, to provide broad support for market functioning in secondary markets to allow for orderly and timely risk transfer in corporate credit; second, to support primary issuance for businesses at funding costs that better reflect normal liquidity conditions; and third, to reduce the incidence and severity of fire sales and/or indiscriminate liquidation.

Municipal Liquidity Facility

The last facility I'll mention today is the municipal liquidity facility, which was designed to help provide states, cities and counties with the funding needed to provide essential public services to their citizens. Due to the virus outbreak, the municipal securities market has recently been under considerable strain as investors have become reluctant to purchase municipal securities. As a result, interest rates on municipal securities have increased significantly. At the same time, states, cities, and counties are facing severe liquidity constraints resulting from the increase in state and local government expenditures related to the COVID-19 pandemic and the decrease and delay of certain tax revenue. By ensuring the smooth functioning of this market, particularly in times of strain, the Federal Reserve is providing credit that will support families, businesses, and jobs in communities, large and small, across the economy.

The immediate purpose of the Municipal Liquidity Facility is to enhance the liquidity of the municipal securities market by increasing the availability of funding to eligible States, Cities and Counties through Tax Anticipation Notes ("TANs"), Tax and Revenue Anticipation Notes ("TRANs"), Bond Anticipation Notes ("BANs"), and other similar short-term notes from eligible issuers (collectively, "Notes"). The eligible issuer's proceeds from its notes sales can in turn be used to support its political subdivisions and instrumentalities, among other uses. This facility will provide a form of bridge financing to eligible issuers, and by addressing the cash management needs of eligible issuers, the facility will also encourage investors to once again engage in the municipal securities market.

Of course what I've just covered is not an exhaustive list. The Federal Reserve Board has also announced a number of other programs designed to supply credit directly to households, businesses, and municipalities. These include:

- The Paycheck Protection Program Liquidity Facility will bolster the effectiveness of the Small Business Administration's Paycheck Protection Program by supplying liquidity to participating financial institutions through two-year loans backed by PPP loans as collateral.
- The Main Street Lending Program will enhance support for small and mid-sized businesses that were in good financial standing before the crisis by purchasing up to $600 billion in four-year loans to small and mid-size businesses.
- The Term Asset-Backed Securities Loan Facility (TALF) will support issuance of securities backed by student loans, auto loans, credit card loans, small business loans, and other debt.

Moving with Maximum Care

Considering the speed and scale of damage caused by the virus outbreak, we are making all efforts to implement these facilities at maximum speed. At the same time, though, we are moving with maximum care, drawing upon all of the lessons learned since 2008.

First and foremost, we know that transparency will be key to sustaining public confidence in our efforts. What does this mean in practice? It means that when we work with outside vendors, we explain why we're doing so, who we're working with, and how much we're paying for their services. It requires if we accelerate the vendor selection process to minimize time to market, we operate under a short-term contract and then open up the process to a competitive range of bidders, looking beyond the largest and most established players and providing broad access to a diverse range of smaller players. It means putting on our website the eligibility of borrowers and laying out the terms and conditions of the facilities as clearly as possible, along with posting FAQs and providing opportunities to ask questions. And it means that we actively explore ways to go beyond what's required by legislation and proactively report on the usage of the facilities as much as possible, subject to meeting our policy objectives.

In terms of governance, we will embed the facilities into our existing infrastructure for controls, management, and oversight. We will proactively identify and address conflicts of interest – real or perceived - for anyone working on the facilities. Personal investment guidelines will be refined as needed, and rules will be clear on the gathering of market intelligence and handling sensitive information related to the facilities. Good governance will also require balancing loss protection with financial stability goals, which requires integration of our risk management team into the full life-cycle of the facilities, from policy design to the eventual wind-down.

As a concluding thought, we know the ultimate definition of success is accomplishing what we set out to do in support of the American economy. In pursuing this goal, we've been entrusted with a great responsibility to deploy large sums of public resources, and we have an obligation to the public to be accountable for all our actions. We look forward to engaging with our oversight bodies and those appointed under the CARES Act to ensure that the American people understand the steps we are taking on their behalf as faithful stewards of the public trust.

FEDERAL RESERVE BANK of ST. LOUIS

Interest Rate Risk, Bank Runs and Silicon Valley Bank

By Christopher J. Neely, Michelle Clark Neely

May 11, 2023

KEY TAKEAWAYS

- When commercial banks borrow—from depositors and other sources—over the short term and lend for long periods, it creates the risk that rising interest rates will reduce the value of their long-term assets.
- Bad news or a large drop in asset values may worry depositors and trigger a bank run, which could put a bank out of business if it cannot quickly liquidate assets to meet demands for withdrawals.
- Bank runs can hurt the broader economy by disrupting business relationships.
- Two types of policies have greatly reduced the incidence of bank runs: emergency lending facilities—i.e., lenders of last resort, like central banks—and deposit insurance.

At any given time, some people are saving money, perhaps for emergencies or for college or retirement, while others want to borrow money to buy a house or a car or invest in a business. The largest borrowers—such as governments or large corporations—can sell bonds to raise capital, while smaller borrowers—e.g., smaller companies or individuals—tend to borrow from banks because it would be expensive and risky for savers to evaluate the creditworthiness of smaller borrowers. Banks specialize in evaluating the creditworthiness of borrowers, intermediating between borrowers and lenders.

To obtain funds to make loans, banks borrow from individuals and firms over the short term in the form of deposits. Savers like quick access to their money in case of emergency—such as a job loss—so banks commonly offer demand or savings deposits, which allow depositors to get their money back immediately, or certificates of deposit (CDs), which typically mature in a few months to a few years. In contrast, many firms and individuals want to borrow over the long term for projects, such as building a factory, or major purchases, such as buying a house.

Banks perform a *maturity transformation* when they borrow over the short term and lend for long periods. This transformation creates a potential problem, though: Depositors might demand their money from banks before borrowers repay their loans. Banks keep funds in reserve for the depositors who want to get their money out, with some extra for insurance, but can't pay off all their depositors at once.[1]

Interest Rate Risk in Maturity Transformation

Borrowing over short periods and lending for long periods generally allows banks to make money, because long-term interest rates are usually higher than short-term interest rates. But this strategy carries the risk that interest rates will rise, reducing the value of a bank's long-term fixed-rate assets—usually loans or bonds—because higher interest rates reduce

the present value of the payoffs to those loans or bonds.[2] Potential decline in asset values because of an increase in interest rates is known as *interest rate risk* or *duration risk*, and it can reduce a bank's net worth (assets minus liabilities).

Banks can mitigate interest rate risk in several ways, but most are costly and involve reducing the bank's net amount of maturity transformation. For example, a bank wishing to hedge (reduce) interest rate risk might lock in longer-term deposits in the form of CDs or time deposits, or make more short-term loans instead of long-term loans. Properly managing interest rate risk is a critically important task for banks.[3]

Characteristics of Bank Runs

If depositors learn of such a decline in their bank's net worth, they might fear for the bank's solvency and the safety of their deposits and transfer their money to a safer bank. An attempt by many depositors to simultaneously withdraw their money is called a *bank run*, and such an episode can put a bank out of business. Even if the value of the bank's assets (loans and securities) exceeds that of its liabilities (deposits and borrowings), a bank cannot quickly liquidate its assets to immediately pay off all its liabilities.

A curious thing about bank runs is that they can be self-fulfilling prophecies. If many depositors seek to simultaneously withdraw their money, the attempt puts the bank at risk, and so it makes sense for other depositors to withdraw their money, too, whether or not the bank run is actually justified by fundamentals. Economists Douglas W. Diamond and Philip H. Dybvig formalized this possibility in a well-known paper (PDF), for which they shared the 2022 Nobel Prize in economics with Ben Bernanke.

Bank runs can damage the economy because they disrupt relationships between borrowers and lenders, and uninsured depositors can lose their money. Removing banks from their role of mediating between savers and borrowers is called *disintermediation*. During the early part of the Great Depression, thousands of banks failed. Many economists consider this to be one of the Great Depression's principal causes (PDF).

Policies to Mitigate Bank Runs

Two types of policies have greatly reduced the incidence of bank runs: emergency lending facilities, i.e., a lender of last resort, and deposit insurance.

A fundamentally sound bank whose assets are greater than its liabilities might still fail if it is unable to satisfy its depositors' demands for funds during a bank run. One solution to this problem is to borrow against the bank's illiquid assets, such as business or commercial real estate loans. But bank runs often occur during a financial crisis, when it is difficult or impossible to borrow, even against good collateral. A solution to this problem is to create an emergency lender —a lender of last resort—with very deep pockets that can provide loans during the worst times. Central banks have long had the duty to lend to illiquid but solvent financial institutions in such times of crisis. Indeed, a major purpose for which the Federal Reserve was created was to be a lender of last resort.

Deposit insurance also helps reduce the frequency of bank runs by reducing the incentives for depositors to withdraw their money at the first sign of trouble. The Federal Deposit Insurance Corp. (FDIC) guarantees bank deposits up to $250,000 per depositor, per bank, meaning that no depositor with deposits less than or equal to this figure will lose money.[4] Banks may still be subject to runs, however, if uninsured depositors fear that they will lose their money in the event of a bank failure.

Deposit Insurance Alters Incentives

While deposit insurance helps guard against bank runs, it has a disadvantage in that it removes a source of *market discipline* on banks: Insured depositors no longer have an incentive to track and evaluate banks' financial health.[5] Federal

deposit insurance hasn't automatically covered all deposits partly because larger depositors are thought to be sophisticated enough to evaluate banks' financial health, thereby providing banks an incentive to behave prudently. Extending deposit insurance to larger depositors would remove this incentive and increase the fees banks must pay the FDIC for insurance coverage. Because deposit insurance greatly reduces depositors' incentives to withdraw their funds at the first sign of trouble, insured deposits tend to be much more stable than uninsured deposits.

The Run on Silicon Valley Bank

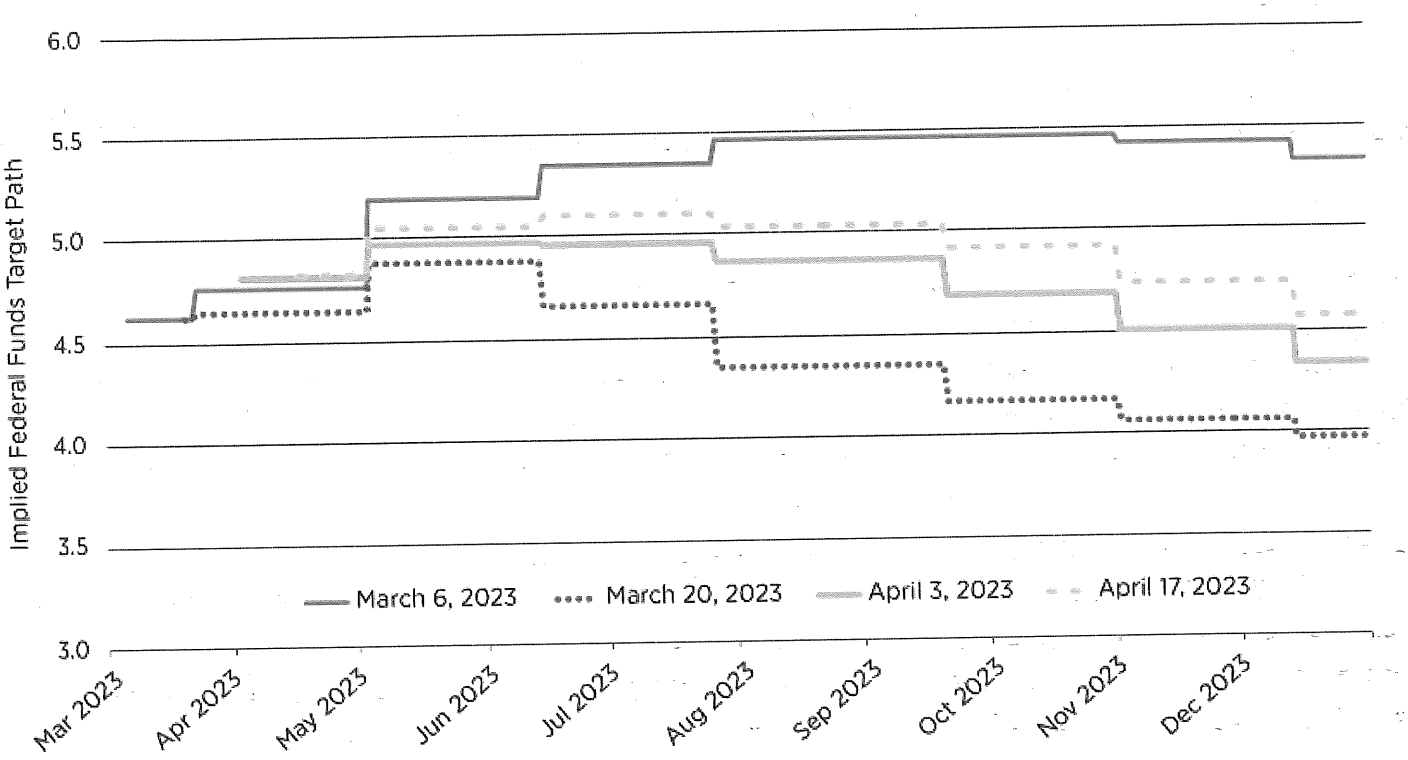
Silicon Valley Bank had several risk factors for a run. This $200 billion bank catered to, and was thus dependent on, the tech sector. When tech was booming, the bank grew very quickly, thanks to a large influx of uninsured deposits from venture capital and tech firms, which were used to meet payroll and operating expenses. Silicon Valley Bank largely invested these deposits in long-term bonds, especially mortgage-backed securities, in an effort to increase yield and bank earnings at a time when interest rates were very low. But the values of these bonds were highly sensitive to interest rate increases.

The 2021-22 surge in inflation prompted the Federal Open Market Committee (FOMC) to raise the federal funds rate target range from 0%-0.25% on March 16, 2022, to 4.75%-5% by March 23, 2023. On March 8, 2023, Silicon Valley Bank posted a $1.8 billion loss on the sale of $21 billion of these securities and announced a plan to raise capital. Uninsured depositors saw these moves as signs of bank distress, word started circulating on social media, and the next day customers withdrew more than $40 billion from the bank. It was a modern twist on a classic bank run in that the deposits could be quickly withdrawn electronically. Silicon Valley Bank could not sell or borrow enough against its assets to meet the demands for deposits. The California Department of Financial Protection and Innovation seized the bank on March 10, 2023.[6]

The run on Silicon Valley Bank kicked off fears that there would be runs against banks in similar situations. Signature Bank in New York, a $100 billion institution, ran into similar problems with uninsured depositors pulling their funds, leading the New York State Department of Financial Services to close the institution on March 12, 2023.

In response to the failures of Silicon Valley Bank and Signature Bank, market expectations of near-term interest rate increases declined in mid-to-late March, and banks further tightened terms on loans, making credit harder to get.[7] The following figure shows that market expectations of the middle of the federal funds target range declined substantially between March 6 and March 20, before partially recovering by the middle of April.

Futures-Implied Expected Paths for the Middle of the Federal Funds Target Range



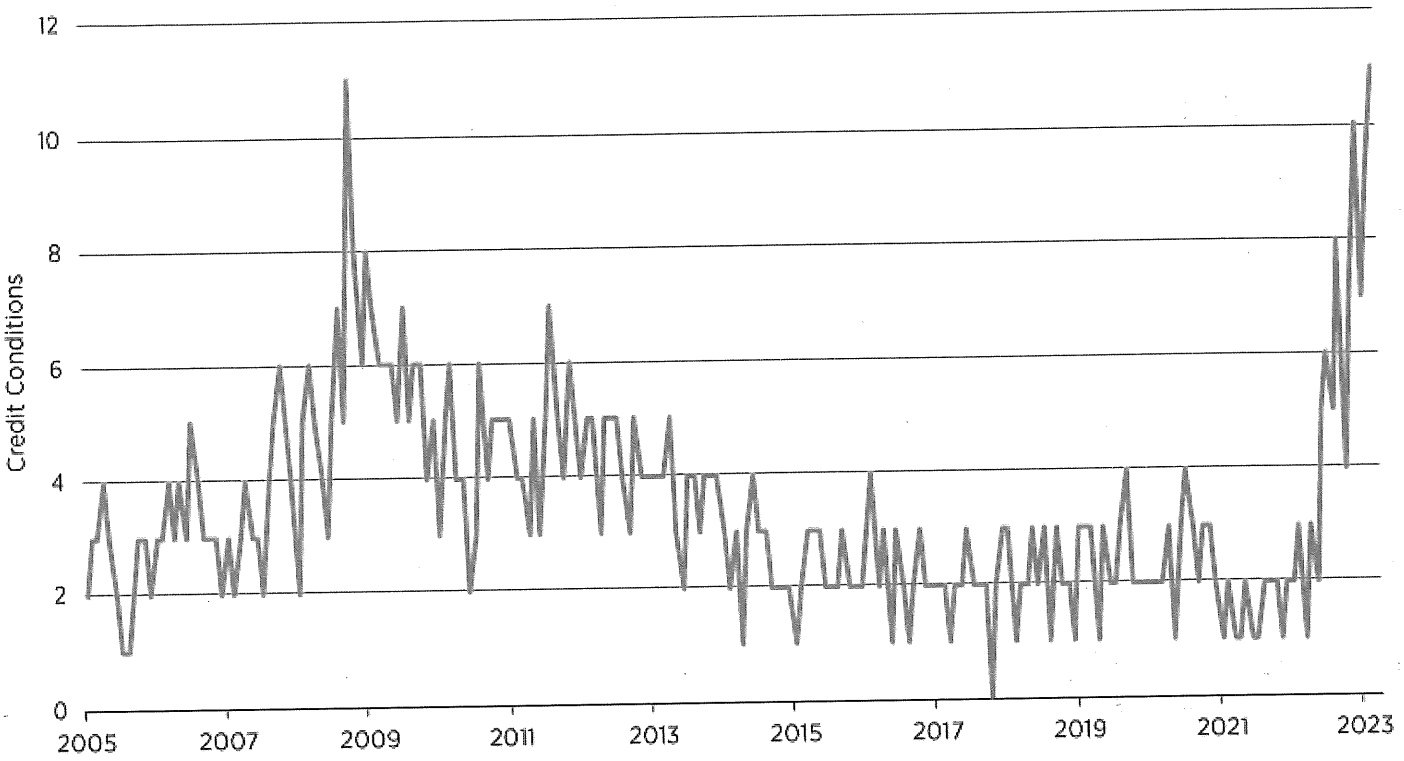
■ FEDERAL RESERVE BANK OF ST. LOUIS

SOURCE: Chicago Board of Trade via Haver.

NOTES: The figure displays the expected paths of the middle of the federal funds target range implied by federal funds futures prices as of March 6, 2023, March 20, 2023, April 3, 2023, and April 17, 2023, assuming target changes occur only at scheduled FOMC meetings and that the average federal funds rate is in the middle of the target range.

The figure below shows that credit conditions for households in March 2023 were tighter than at any time since October 2008. In addition, capital markets temporarily froze up, with corporations issuing very few bonds in the weeks following Silicon Valley Bank's failure.

Credit Conditions for Buying Large Household Goods



■ FEDERAL RESERVE BANK OF ST. LOUIS

SOURCE: University of Michigan Surveys of Consumers via Haver.

NOTE: Higher numbers indicate tighter credit conditions for purchasing large household goods.

The financial stress associated with the failures of Silicon Valley Bank, Signature Bank and, more recently, First Republic Bank remind us that modern economies still depend on traditional financial institutions. And even with mitigating policies such as central bank emergency lending programs and deposit insurance, bank survival depends on bank executives properly managing assets and liabilities.

Notes

1. Banks use a number of liabilities other than deposits to fund loans, including federal funds purchased, brokered deposits and borrowings from Federal Home Loan Banks. These all tend to be more expensive than deposits.
2. Another channel of interest rate risk occurs when a general rise in interest rates forces banks to pay higher interest on deposits but produces only slow increases in bank revenue as new long-term loans are made at higher interest rates. In practice, however, deposit rates typically rise much more slowly than other short-term interest rates.
3. For more on this issue, see the Feb. 9, 2023, blog post "Rising Interest Rates Complicate Banks' Investment Portfolios" by St. Louis Fed Senior Vice President Carl White.
4. Similarly, the National Credit Union Share Insurance Fund insures credit union accounts.
5. Commercial banks must submit quarterly balance sheet and income statements, known as Call Reports. To review a bank's Call Report, one can access the Federal Financial Institutions Examination Council's Central Data Repository.
6. In late April, the Federal Reserve released a review of its supervision of Silicon Valley Bank. The report analyzed the actions of bank management and Fed supervisors that preceded the failure. See the full report (PDF).
7. The Fed's January 2023 Senior Loan Officer Opinion Survey on Bank Lending Practices noted tightening credit conditions before the March bank failures.

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IN FOCUS

April 11, 2023

Bank Failures: The FDIC's Systemic Risk Exception

When Silicon Valley Bank (SVB) and Signature Bank failed, the Treasury Secretary, the Federal Deposit Insurance Corporation (FDIC), and the Federal Reserve (Fed) announced on March 12, 2023, that the FDIC would guarantee uninsured deposits at those banks under the statutory systemic risk exception to least-cost resolution (LCR; 12 U.S.C. §1823(c)(4)(G)). (See CRS Insight IN12125, *Silicon Valley Bank and Signature Bank Failures*.) The FDIC insures deposits up to a statutory limit of $250,000. (See CRS In Focus IF12361, *Deposit Insurance and the Failures of Silicon Valley Bank and Signature Bank*.) Currently, the FDIC projects that the two resolutions will cost the FDIC $22.5 billion. The two banks' combined estimated uninsured deposits were $231.1 billion in 2022. Under LCR, at least some of these losses would have been borne by uninsured depositors.

FDIC Least-Cost Resolution

When a bank fails, it does not enter the bankruptcy process like other businesses to resolve creditors' claims. Instead, it is taken into receivership by the FDIC, which takes control of the bank and resolves it through an administrative process. Costs to the FDIC associated with a resolution are funded by drawing on the FDIC's Deposit Insurance Fund, which is funded through assessments on banks and backed by the U.S. Treasury. (See CRS In Focus IF10055, *Bank Failures and the FDIC*.)

A banking crisis in the 1980s was more costly to the FDIC, and ultimately the taxpayer, because of the frequent use of regulatory forbearance—allowing troubled banks to stay open—which in many cases increased the losses that they suffered before they were ultimately shut down. In some cases, the FDIC used open bank assistance to provide funds or guarantees to troubled banks to keep them going rather than taking them into receivership.

Following the crisis, Congress reformed how the FDIC resolves banks in 1991 (P.L. 102-242). This act introduced prompt corrective action and LCR requirements as cornerstones of resolution. These two principles are intended to minimize resolution costs by ensuring that banks are resolved as quickly and inexpensively as possible. As such, uninsured depositors and other creditors can be repaid in a resolution only insofar as it is consistent with LCR, unless the systemic risk exception is invoked.

What Is the Systemic Risk Exception?

Systemic risk is financial market risk that poses a threat to financial stability. (See CRS In Focus IF10700, *Introduction to Financial Services: Systemic Risk*.) In the case of SVB and Signature, the FDIC, Fed, and Treasury Secretary were concerned that a run by uninsured depositors would spread to other banks, causing a broader crisis that could be detrimental to the real economy.

Under the 1991 law, LCR can be waived under the systemic risk exception when five statutory requirements have been met: (1) The Treasury Secretary, in consultation with the President and upon a written recommendation of at least two-thirds of the boards of the FDIC and Fed, determines LCR "would have serious adverse effects on economic conditions or financial stability" and the FDIC's actions would avoid or mitigate those effects. (2) Any loss to the FDIC must be repaid through a special assessment on banks by the FDIC. In levying this assessment, the FDIC need not follow normal deposit insurance assessment rates and may consider who benefited from the action and the effects on the banking industry (as amended by P.L. 111-22). In testimony, FDIC Chair Martin Gruenberg confirmed that the FDIC will be levying a special assessment in this case. (3) The Treasury Secretary must document the decision. (4) The Government Accountability Office (GAO) must review the incident. (5) The Treasury Secretary must notify the congressional committees of jurisdiction within three days.

Before 1991, the FDIC considered several goals, including cost, in determining how to deal with a troubled bank. As such, LCR, even with the exception, represents a constraint on its pre-1991 authority. The FDIC can take a number of actions under the exception, but it can be used only in an FDIC receivership.

Previous Uses of the Exception

Before 2023, GAO reported five planned uses of the systemic risk exception since 1991, all occurring between September 2008 (in the depths of the financial crisis) and March 2009.

1. **Wachovia.** The FDIC sought a buyer to prevent the imminent failure of Wachovia, the fourth-largest U.S. bank. Citigroup made an offer to acquire Wachovia under which the FDIC would partially guarantee $312 billion of Wachovia's assets using the systemic risk exception. The FDIC initially accepted this offer but subsequently rejected it in favor of a competing offer from Wells Fargo that required no FDIC assistance.
2. **Citigroup.** Concerned that Citigroup, the third-largest U.S. bank, would fail and exacerbate the financial crisis, policymakers decided to provide an assistance package involving the Fed, the FDIC, and the Troubled Asset Relief Program (TARP). As part of this package, the FDIC used its systemic risk exception to provide open bank assistance in the form of a partial asset guarantee for $306 billion of Citigroup's assets. This guarantee (joint with the Fed and TARP) never paid

regulation or deposit insurance could also change the likelihood of the systemic risk exception being used again.

Marc Labonte, Specialist in Macroeconomic Policy

IF12378

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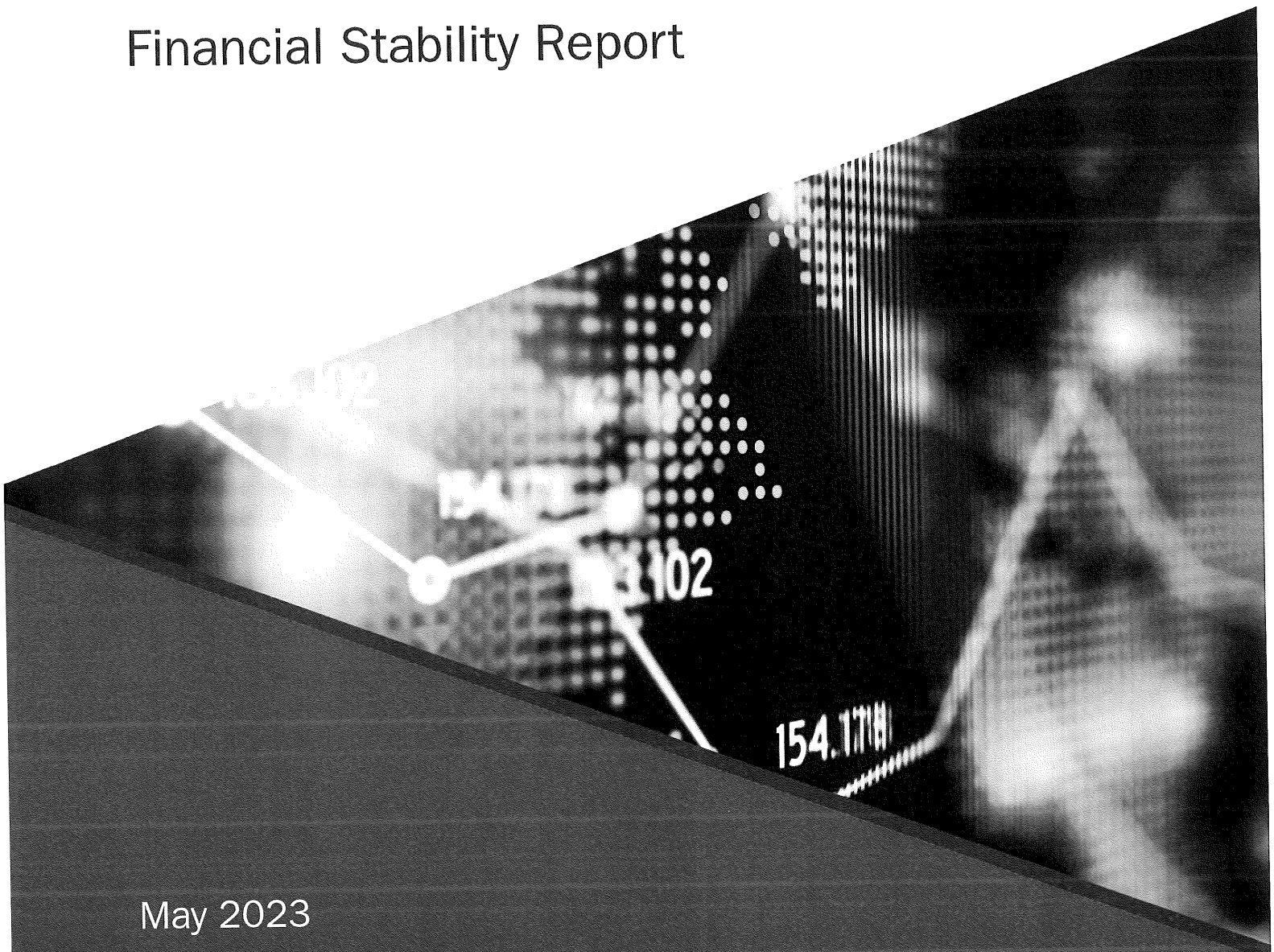
Financial Stability Report



May 2023

BOARD OF GOVERNORS OF THE FEDERAL RESERVE SYSTEM

Box 3.1. The Bank Stresses since March 2023

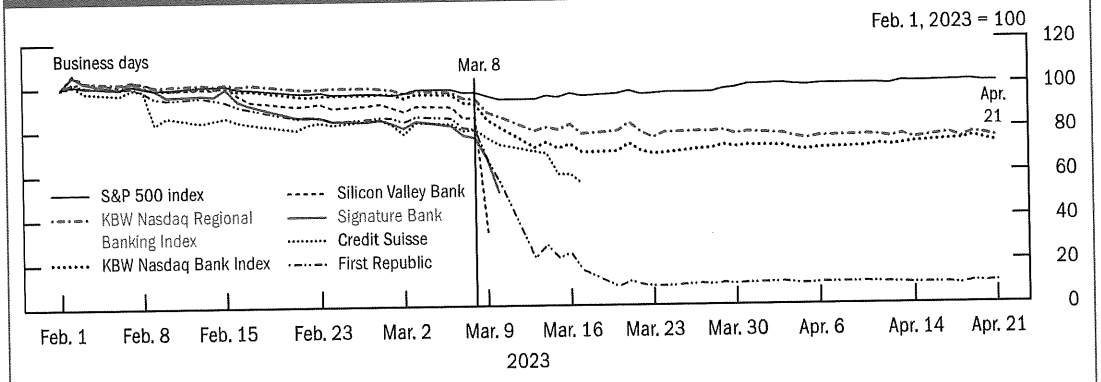
The banking system came under severe stress late in the week of March 6, 2023. On Wednesday, March 8, Silvergate Bank, an institution supervised by the Federal Reserve with $11 billion in assets at the end of 2022, announced its intention to voluntarily wind down its operations and to fully repay all deposits.[1]

On that Wednesday afternoon, SVB, an institution supervised by the Federal Reserve with $209 billion in assets at the end of 2022, announced it had sold $21 billion from its AFS securities portfolio at an after-tax loss of $1.8 billion, was planning to increase nondeposit borrowing from $15 billion to $30 billion, and was commencing a public offering to raise capital by $2.25 billion.[2] The bank also noted that it had been in dialogue with a rating agency that was considering a negative rating action, with the possibility that another agency would follow suit. Later that day, the bank received a one-notch rating downgrade, and its rating outlook was changed from stable to negative. These announcements led to a loss of confidence in the bank, as reflected in the sharp decline in SVB's stock market price, illustrated in figure A, and unprecedented deposit withdrawals from customers, totaling $42 billion in a single business day on Thursday, March 9. As additional deposit withdrawal requests accumulated, the bank informed regulators on the morning of Friday, March 10, that $100 billion in deposit withdrawals were scheduled or expected for that day.[3] The bank was unable to pay those obligations, and, on the morning of Friday, March 10, the Department of Financial Protection and Innovation of the State of California declared SVB insolvent, took possession of the bank, and appointed the FDIC as receiver.

It appeared that contagion from SVB's failure could be far-reaching and cause damage to the broader banking system. The prospect of uninsured depositors not being able to access their funds appeared to raise concerns about the possibility of destabilizing runs at other U.S. commercial banks. This

(continued)

Figure A. Bank stock prices and stock indexes



Source: Center for Research in Security Prices, CRSP/Compustat Merged Database, Wharton Research Data Services; Federal Reserve Bank of St. Louis, Federal Reserve Economic Data.

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1 See Silvergate Bank (2023), "Silvergate Capital Corporation Announces Intent to Wind Down Operations and Voluntarily Liquidate Silvergate Bank," press release, March 8, https://ir.silvergate.com/news/news-details/2023/Silvergate-Capital-Corporation-Announces-Intent-to-Wind-Down-Operations-and-Voluntarily-Liquidate-Silvergate-Bank/default.aspx. The announcement followed deposit outflows in the fourth quarter of 2022 that reduced deposit balances by more than 50 percent.

2 See Silicon Valley Bank (2023), "Strategic Actions/Q1'23 Mid-Quarter Update" (Santa Clara, Calif.: SVB, March 8), available at https://ir.svb.com/events-and-presentations/default.aspx.

3 The $42 billion in deposit withdrawals on March 9 comes from the order taking possession of property and business from the Department of Financial Protection and Innovation of the State of California available on the department's website at https://dfpi.ca.gov/wp-content/uploads/sites/337/2023/03/DFPI-Orders-Silicon-Valley-Bank-03102023.pdf?emrc=bedc09. The $100 billion in scheduled or expected deposit withdrawals for March 10 comes from *Review of the Federal Reserve's Supervision and Regulation of Silicon Valley Bank* available on the Federal Reserve's website at https://www.federalreserve.gov/publications/files/svb-review-20230428.pdf.

Box 3.1—*continued*

concern over broader contagion led to sizable declines in bank stocks, as reflected by the declines in the KBW bank indexes (as shown in figure A). On March 10, Signature Bank, an institution supervised by the FDIC with $110 billion in assets at the end of 2022, continued experiencing stock price declines and suffered a run, with depositors withdrawing 20 percent of deposit balances.[4] Signature Bank was closed on Sunday, March 12, by the New York State Department of Financial Services, and the FDIC was named receiver.[5] The speed and magnitude of the runs on uninsured deposits at SVB and Signature Bank generated broader concerns about the resilience of banks with a large concentration of uninsured deposits and significant declines in the fair value of fixed-rate assets in a rising rate environment. The bank runs at SVB and Signature Bank contributed to a further deterioration of confidence in banks, amplifying the initial bank stresses. Other banks also saw notable deposit outflows, threatening households' and businesses' ability to access accounts they routinely use to make payments. In contrast, the largest banks saw significant deposit inflows. On Sunday, March 12, the Federal Reserve, together with the FDIC and the U.S. Department of the Treasury, announced decisive actions to protect households and businesses (see the box "The Federal Reserve's Actions to Protect Bank Depositors and Support the Flow of Credit to Households and Businesses").

The runs on SVB and Signature Bank were of unprecedented speed compared with previous runs. During the run on Washington Mutual in 2008—to date, the run that caused the largest failure of an insured depository institution by inflation-adjusted total assets—depositors withdrew about $17 billion over the course of eight business days, with the largest deposit withdrawal in one day reaching just over 2 percent of pre-run deposits.[6] By comparison, the highest one-day withdrawal rate was more than 20 percent in the case of SVB and Signature Bank, at the time the second- and third-largest depository institutions by inflation-adjusted total assets, respectively, that failed due to a bank run (figure B).[7] At SVB, withdrawals would have been even larger had regulators not closed the bank on the morning of March 10. Figure B also compares the speed of the runs on Washington Mutual, SVB, and Signature Bank with the run on Continental Illinois, the fifth-largest depository institution by inflation-adjusted total assets to fail due to a bank run. Continental Illinois sustained sizable withdrawals of uninsured deposits for six consecutive days in May 1984, with a peak one-day withdrawal rate of 7.8 percent of deposits, before a public assistance package was put in place.[8] The unprecedented speed of the run on SVB was likely facilitated by widespread adoption among SVB's tightly networked depositor base of technologies enabling depositors to submit withdrawal requests electronically and to share messages about the bank's perceived problems via messaging apps and on social media. But the faster speed of the run in the Continental Illinois case relative to Washington Mutual also points to the role of the concentration of uninsured deposits.

In international markets, Credit Suisse came under renewed pressure. In recent years, Credit Suisse had experienced a succession of risk-management, corporate-governance, and compliance failures. And in 2022, it reported the largest after-tax loss since the 2007–09 financial crisis and experienced significant deposit outflows in the last quarter of the year. During the week of March 13, the firm published its annual report, which was originally scheduled for publication the previous week, and its

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4 See Federal Deposit Insurance Corporation (2023), *FDIC's Supervision of Signature Bank* (Washington: FDIC, April), https://www.fdic.gov/news/press-releases/2023/pr23033a.pdf.

5 See New York State Department of Financial Services (2023), "Superintendent Adrienne A. Harris Announces New York Department of Financial Services Takes Possession of Signature Bank," press release, March 12, https://www.dfs.ny.gov/reports_and_publications/press_releases/pr20230312.

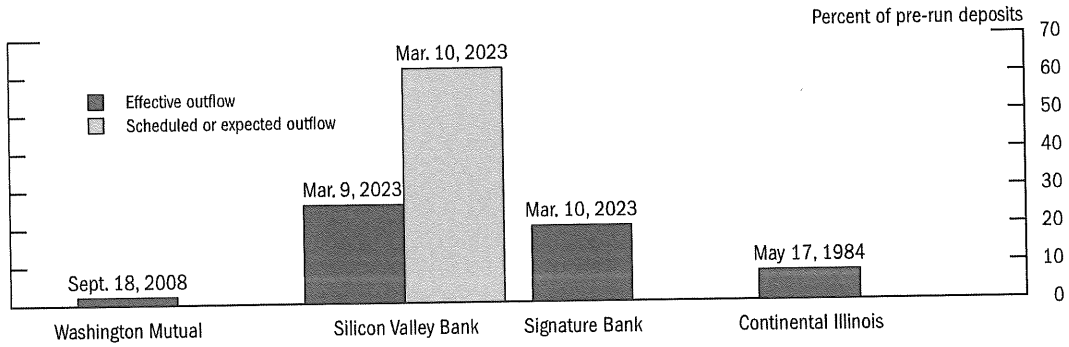
6 See Office of Thrift Supervision (2008), "OTS Fact Sheet on Washington Mutual Bank," September 25, www.fcic.gov/documents/view/905. The one-day deposit withdrawal rate is estimated using only consumer and small business deposits; see Declaration of Thomas M. Blake to the U.S. Bankruptcy Court, District of Delaware, Chapter 11 Case No. 08-12229 (MFW) and Adversary Proceeding No. 09-50934 (MFW) (2009).

7 After the data close on April 21, 2023, First Republic Bank failed, making it the second-largest depository institution to fail due to a bank run.

8 See Mark Carlson and Jonathan Rose (2019), "The incentives of Large Sophisticated Creditors to Run on a Too Big to Fail Financial Institution," *Journal of Financial Stability*, vol. 41 (April), pp. 91–104.

Box 3.1—*continued*

Figure B. Peak 1-day withdrawal rates for runs on the largest banks, by inflation-adjusted total assets



Sources: For Washington Mutual, Jonathan D Rose (2015), "Old-Fashioned Deposit Runs," Finance and Economics Discussion Series 2015-111 (Washington: Board of Governors of the Federal Reserve System, December). For Silicon Valley Bank, Financial Institutions Examination Council, Consolidated Reports of Condition and Income; California Department of Financial Protection and Innovation (2023), "Order Taking Possession of Property and Business" (San Francisco: DFPI, March 10); and Board of Governors of the Federal Reserve System (2023), *Review of the Federal Reserve's Supervision and Regulation of Silicon Valley Bank* (Washington: Board of Governors, April). For Signature Bank, Federal Deposit Insurance Corporation (2023), *FDIC's Supervision of Signature Bank*, (Washington: FDIC, April). For Continental Illinois, Mark Carlson and Jonathan Rose (2019), "The Incentives of Large Sophisticated Creditors to Run on a Too Big to Fail Financial Institution," *Journal of Financial Stability*, vol. 41 (April), pp. 91–104.

largest shareholder announced it would not buy additional shares in the bank. The bank stock price declined further, and on March 16, Credit Suisse announced its intention to access emergency liquidity support provided by the Swiss National Bank for up to CHF 50 billion. Despite the announcement of this liquidity support, investors' confidence continued to deteriorate, as reflected by the continued price decline of Credit Suisse shares (as shown in figure A). On Sunday, March 19, UBS agreed to merge with Credit Suisse in a deal that involved triggering the write-off of a certain type of Credit Suisse's contingent convertible capital instruments, as well as liquidity support and loss sharing from the Swiss government. In addition, on Sunday, March 19, the Federal Reserve, together with other central banks, announced measures to enhance the provision of liquidity in global funding markets (see the box "The Federal Reserve's Actions to Protect Bank Depositors and Support the Flow of Credit to Households and Businesses"). The spillovers of the stresses related to Credit Suisse to the U.S. have so far been muted.

Following the runs on SVB and Signature Bank, First Republic Bank, an institution supervised by the FDIC with $213 billion in assets at the end of 2022, experienced notable deposit outflows between March 10 and March 16. The bank's equity price declined significantly through the end of March and declined even further following the publication of its first quarter earnings on April 24. The California Department of Financial Protection and Innovation took possession of First Republic Bank before markets opened on Monday, May 1, appointing the FDIC as receiver.[9] At the same time, the FDIC entered into a purchase and assumption agreement with JPMorgan Chase Bank to assume all of the deposits and most of the assets of the failed bank, with the bank and the FDIC entering into a loss-sharing agreement.[10]

[9] See the order taking possession of property and business from the Department of Financial Protection and Innovation of the State of California available on the department's website at https://dfpi.ca.gov/2023/05/01/california-financial-regulator-takes-possession-of-first-republic-bank/.

[10] See Federal Deposit Insurance Corporation (2023), "JPMorgan Chase Bank, National Association, Columbus, Ohio Assumes All the Deposits of First Republic Bank, San Francisco, California," press release, May 1, https://www.fdic.gov/news/press-releases/2023/pr23034.html.

Box 4.1. The Federal Reserve's Actions to Protect Bank Depositors and Support the Flow of Credit to Households and Businesses

In March 2023, the domestic and global banking sector experienced acute stress, following a loss of confidence in SVB and Signature Bank. After experiencing bank runs of unprecedented speed, SVB and Signature Bank failed, and there were broader spillovers to the banking sector. Credit Suisse came under renewed pressure, leading to its acquisition by UBS in a deal that involved liquidity support and loss sharing from the Swiss government as well as the write-off of a certain type of contingent capital instruments (see the box "The Bank Stresses since March 2023"). The fast propagation of these stresses was compounded by novel factors. Social media and messaging apps facilitated the communication of perceived bank concerns among the network of uninsured depositors, and the availability of information technology facilitated the movement of deposits. In response, the Federal Reserve, together with the FDIC and the U.S. Department of the Treasury, took decisive actions to protect bank depositors and support the continued flow of credit to households and businesses. These actions reduced stress across the financial system, supporting financial stability and minimizing the effect on businesses, households, taxpayers, and the broader economy.

On Sunday, March 12, the Federal Reserve, together with the FDIC and the U.S. Department of the Treasury, announced two actions designed to support all bank depositors and the continued flow of credit to households and businesses. After receiving a recommendation from the boards of the FDIC and the Federal Reserve, and consulting with the President, the Treasury Secretary approved a systemic risk exception, enabling the FDIC to complete its resolution of SVB and Signature Bank in a manner that fully protects all depositors. Depositors were given full access to their accounts on the Monday following the announcement. In contrast to depositors, shareholders and certain unsecured debt holders were not protected, and senior management at these banks was removed. The losses associated with these actions, later estimated by the FDIC to be $22.5 billion, will not be borne by taxpayers and instead will be borne by the Deposit Insurance Fund, which will be replenished by special assessments on banks, as required by law.[1]

At the same time, on Sunday, March 12, with approval by the Treasury Secretary, the Federal Reserve Board announced the establishment of the BTFP, making available additional funding to eligible depository institutions. The BTFP offers loans of up to one year in length to federally insured banks, savings associations, and credit unions, and to U.S. branches and agencies of foreign banks. New loans can be requested under the BTFP until at least March 11, 2024. To borrow from the BTFP, eligible institutions can pledge any collateral eligible for purchase by the Federal Reserve in open market operations, such as U.S. Treasury securities, U.S. agency securities, and U.S. agency mortgage-backed securities. The BTFP extends loans against the par value of eligible collateral—that is, the face amount of the securities without giving effect to any declines in fair value. With approval of the Treasury Secretary, the U.S. Department of the Treasury has committed to make available up to $25 billion from the Exchange Stabilization Fund as a backstop for the BTFP. The Federal Reserve does not anticipate that it will be necessary to draw on these backstop funds.

The BTFP will be an additional source of borrowing for depository institutions against high-quality securities, which eliminates an institution's need to quickly sell those securities should a significant fraction

(continued)

[1] The exact cost of the resolution of SVB and Signature Bank will be determined when the FDIC terminates the receiverships. Current estimates from the FDIC about the cost to its Deposit Insurance Fund from the failure of SVB and Signature Bank are approximately $20 billion and $2.5 billion, respectively. See Federal Deposit Insurance Corporation (2023), "Subsidiary of New York Community Bancorp, Inc., to Assume Deposits of Signature Bridge Bank, N.A., from the FDIC," press release, March 19, https://www.fdic.gov/news/press-releases/2023/pr23021.html; and Federal Deposit Insurance Corporation (2023), "First–Citizens Bank & Trust Company, Raleigh, NC, to Assume All Deposits and Loans of Silicon Valley Bridge Bank, N.A., from the FDIC," press release, March 26, https://www.fdic.gov/news/press-releases/2023/pr23023.html.

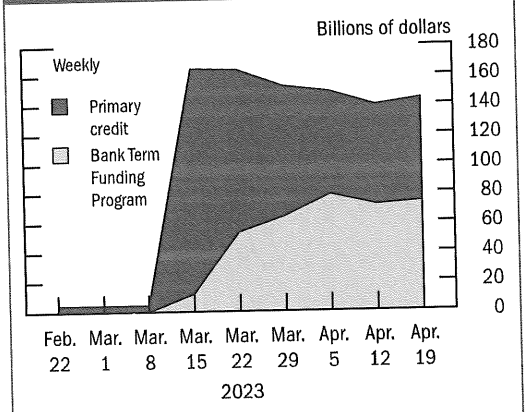
Box 4.1.—*continued*

of depositors withdraw their funding suddenly or the financial system curtail bank funding, helping assure depositors that banks have the ability to meet the needs of all their customers.

In addition, depository institutions may continue to obtain liquidity against a wide range of collateral through the discount window, which remains open and available. Moreover, at the same time as the BTFP was established, it was announced that the discount window will apply the same margins used for the securities eligible for the BTFP.

Following the acute banking stresses in early March and the announcements on March 12, primary credit extended through the discount window increased from less than $5 billion to more than $150 billion during the first week and quickly fell back to about $70 billion, whereas credit extended through the BTFP increased steadily by smaller increments and stabilized in a range between $70 billion and $80 billion (figure A).

Figure A. Outstanding balances of primary credit and Bank Term Funding Program



Source: Federal Reserve Board, Statistical Release H.4.1, "Factors Affecting Reserve Balances."

The Federal Reserve is prepared to address any liquidity pressures that may arise and is committed to ensuring that the U.S. banking system continues to perform its vital roles of ensuring that depositors' savings remain safe and providing access to credit to households and businesses in a manner that promotes strong and sustainable economic growth. These additional funding sources bolster the capacity of the banking system to safeguard deposits and ensure the ongoing provision of money and credit to the economy. The additional funding to eligible depository institutions will continue to serve as an important backstop against further bank stresses and support the flow of credit.

In international markets, Credit Suisse came under renewed pressure, and UBS agreed to merge with the firm on Sunday, March 19, in a deal that involved the write-off of a certain type of contingent convertible capital instruments as well as liquidity support and loss sharing from the Swiss government. On Sunday, March 19, the Federal Reserve, together with the Bank of Canada, the Bank of England, the Bank of Japan, the European Central Bank, and the Swiss National Bank, announced measures to mitigate the effects of strains on global funding markets via the standing U.S. dollar liquidity swap line arrangements. The network of swap lines among these central banks is a set of available standing facilities and serves as an important liquidity backstop to ease strains in global funding markets, thereby helping mitigate the effects of such strains on the supply of credit to U.S. households and businesses (see the box "Transmission of Stress Abroad to the U.S. Financial System"). To improve the swap lines' effectiveness in providing U.S. dollar funding, these central banks agreed to increase the frequency of seven-day maturity operations from weekly to daily and to continue at this frequency. These daily operations commenced on Monday, March 20. Following the announcement on March 19, demand for these swap lines ticked up by slightly over $100 million and then fell back to levels below $500 million observed before the announcement. These central banks announced on April 25 that the frequency of swap line operations will revert from daily back to once a week beginning on May 1.

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Understanding Monetary Policy Implementation

Huberto M. Ennis and Todd Keister

Over the last two decades, central banks around the world have adopted a common approach to monetary policy that involves targeting the value of a short-term interest rate. In the United States, for example, the Federal Open Market Committee (FOMC) announces a rate that it wishes to prevail in the federal funds market, where commercial banks lend balances held at the Federal Reserve to each other overnight. Changes in this short-term interest rate eventually translate into changes in other interest rates in the economy and thereby influence the overall level of prices and of real economic activity.

Once a target interest rate is announced, the problem of implementation arises: How can a central bank ensure that the relevant market interest rate stays at or near the chosen target? The Federal Reserve has a variety of tools available to influence the behavior of the interest rate in the federal funds market (called the *fed funds rate*). In general, the Fed aims to adjust the total supply of reserve balances so that it equals demand at exactly the target rate of interest. This process necessarily involves some estimation, since the Fed does not know the exact demand for reserve balances, nor does it completely control the supply in the market.

A critical issue in the implementation process, therefore, is the sensitivity of the market interest rate to unanticipated changes in supply and/or demand.

Some of the material in this article resulted from our participation in the Federal Reserve System task force created to study paying interest on reserves. We are very grateful to the other members of this group, who patiently taught us many of the things that we discuss here. We also would like to thank Kevin Bryan, Yash Mehra, Rafael Repullo, John Walter, John Weinberg, and the participants at the 2008 Columbia Business School/New York Fed conference on "The Role of Money Markets" for useful comments on a previous draft. All remaining errors are, of course, our own. The views expressed here do not necessarily represent those of the Federal Reserve Bank of New York, the Federal Reserve Bank of Richmond, or the Federal Reserve System. Ennis is on leave from the Richmond Fed at University Carlos III of Madrid and Keister is at the Federal Reserve Bank of New York. E-mails: hennis@eco.uc3m.es, Todd.Keister@ny.frb.org.

If small estimation errors lead to large swings in the interest rate, a central bank will find it difficult to effectively implement monetary policy, that is, to consistently hit the target rate. The degree of sensitivity depends on a variety of factors related to the design of the implementation process, such as the time period over which banks are required to hold reserves and the interest rate, if any, that a central bank pays on reserve balances.

The ability to hit a target interest rate consistently plays a critical role in a central bank's communication policy. The overall effectiveness of monetary policy depends, in part, on individuals' perceptions of the central bank's actions and objectives. If the market interest rate were to deviate consistently from the central bank's announced target, individuals might question whether these deviations simply represent glitches in the implementation process or whether they instead represent an unannounced change in the stance of monetary policy. Sustained deviations of the average fed funds rate from the FOMC's target in August 2007, for example, led some media commentators to claim that the Fed had engaged in a "stealth easing," taking actions that lowered the market interest rate without announcing a change in the official target.[1] In such times, the ability to hit a target interest rate consistently allows the central bank to clearly (and credibly) communicate its policy to market participants.

Under most circumstances, the Fed changes the total supply of reserve balances available to commercial banks by exchanging government bonds or other securities for reserves in an open market operation. Occasionally, the Fed also provides reserves directly to certain banks through its discount window. In some situations, the Fed has developed other, ad hoc methods of influencing the supply and distribution of reserves in the market. For example, during the recent period of financial turmoil, the market's ability to smoothly distribute reserves across banks became partially impaired, which led to significant fluctuations in the average fed funds rate both during the day and across days. In December 2007, partly to address these problems, the Fed introduced the Term Auction Facility (TAF), a bimonthly auction of a fixed quantity of reserve balances to all banks eligible to borrow at the discount window. In principle, the TAF has increased these banks' ability to access reserves directly and, in this way, has helped ease the pressure on the market to redistribute reserves and avoid abnormal fluctuations in the market rate. Such operations, of course, need to be managed so as to achieve the ultimate goal of implementing the chosen target interest rate. Balancing the demand and supply of reserves is at the very core of this problem.

This article presents a simple analytical framework for understanding the process of monetary policy implementation and the factors that influence a

[1] See, for example, "A 'Stealth Easing' by the Fed?" (Coy 2007).

central bank's ability to keep the market interest rate close to a target level. We present this framework graphically, focusing on how various features of the implementation process affect the sensitivity of the market interest rate to unanticipated changes in supply or demand. We discuss the current approach used by the Fed, including the use of reserve maintenance periods to decrease this sensitivity. We also show how this framework can be used to study a wide range of issues related to monetary policy implementation.

In 2006, the U.S. Congress enacted legislation that will give the Fed the authority to pay interest on reserve balances beginning in October 2011.[2] We use our simple framework to illustrate how the ability to pay interest on reserves can be a useful policy tool for a central bank. In particular, we show how paying interest on reserves can decrease the sensitivity of the market interest rate to estimation errors and, thus, enable a central bank to better achieve its desired interest rate.

The model we present uses the basic approach to reserve management introduced by Poole (1968) and subsequently advanced by many others (see, for example, Dotsey 1991; Guthrie and Wright 2000; Bartolini, Bertola, and Prati 2002; and Clouse and Dow 2002). The specific details of our formalization closely follow those in Ennis and Weinberg (2007), after some additional simplifications that allow us to conduct all of our analysis graphically. Ennis and Weinberg (2007) focused on the interplay between daylight credit and the Fed's overnight treatment of bank reserves. In this article, we take a more comprehensive view of the process of monetary policy implementation and we investigate several important topics, such as the role of reserve maintenance periods, which were left unexplored by Ennis and Weinberg (2007).

1. U.S. MONETARY POLICY IMPLEMENTATION

Banks hold reserve balances in accounts at the Federal Reserve in order to satisfy reserve requirements and to be able to make interbank payments. During the day, banks can also access funds by obtaining an overdraft from their reserve accounts at the Fed. The terms by which the Fed provides daylight credit are one of the factors determining the demand for reserves by banks.

To adjust their reserve holdings, banks can borrow and lend balances in the fed funds market, which operates weekdays from 9:30 a.m. to 6:30 p.m. A bank wanting to decrease its reserve holdings, for example, can do so in this market by making unsecured, overnight loans to other banks.

The fed funds market plays a crucial role in monetary policy implementation because this is where the Federal Reserve intervenes to pursue its policy objectives. The stance of monetary policy is decided by the FOMC, which

[2] After this article was written, the effective date for the authority to pay interest on reserves was moved to October 1, 2008, by the Emergency Economic Stabilization Act of 2008.

selects a target for the overnight interest rate prevailing in this market. The Committee then instructs the Open Market Desk to adjust, via open market operations, the supply of reserve balances so as to steer the market interest rate toward the selected target.[3]

The Desk conducts open market operations largely by arranging repurchase agreements (repos) with primary securities dealers in a sealed-bid, discriminatory price auction. Repos involve using reserve balances to purchase securities with the explicit agreement that the transaction will be reversed at maturity. Repos usually have overnight maturity, but the Desk also employs other maturities (for example, two-day and two-week repos are commonly used). Open market operations are typically conducted early in the morning when the market for repos is most active.

The new reserves created in an open market operation are deposited in the participating securities dealers' bank accounts and, hence, increase the total supply of reserves in the banking system. In this way, each day the Desk tries to move the supply of reserve balances as close as possible to the level that would leave the market-clearing interest rate equal to the target rate. An essential step in this process is accurately forecasting both aggregate reserve demand and those changes in the existing supply of reserve balances that are due to *autonomous factors* beyond the Fed's control, such as payments into and out of the Treasury's account and changes in the quantity of currency in circulation. Forecasting errors will lead the actual supply of reserve balances to deviate from the intended level and, hence, will cause the market rate to diverge from the target rate, even if reserve demand is perfectly anticipated.

Reserve requirements in the United States are calculated as a proportion of the quantity of transaction deposits on a bank's balance sheet during a two-week computation period prior to the start of the maintenance period. These requirements can be met through a combination of vault cash and reserve balances held at the Fed. During the two-week reserve maintenance period, a bank's end-of-day reserve balances must, on average, equal the reserve requirement minus the quantity of vault cash held during the computation period. Reserve requirements make a large portion of the demand for reserve balances fairly predictable, which simplifies monetary policy implementation.

Reserve maintenance periods allow banks to spread out their reserve holdings over time without having to scramble for funds to meet a requirement at the end of each day. However, near the end of the maintenance period, this averaging effect tends to lose force. On the last day of the period, a bank has some level of remaining requirement that must be met on that day. This generates a fairly inelastic demand for reserve balances and makes implementing a target interest rate more challenging. For this reason, the Fed allows banks

[3] See Hilton and Hrung (2007) for a more detailed overview of the Fed's monetary policy implementation procedures.

holding excess or deficient balances at the end of a maintenance period to carry over those balances and use them to satisfy up to 4 percent of their requirement in the following period.

If a bank finds itself short of reserves at the end of the maintenance period, even after taking into account the carryover possibilities, it has several options. It can try to find a counterparty late in the day offering an acceptable interest rate. However, this may not be feasible because of an aggregate shortage of reserve balances or because of the existence of trading frictions in this market. A second alternative is to borrow at the discount window of its corresponding Federal Reserve Bank.[4] The discount window offers collateralized overnight loans of reserves to banks that have previously pledged appropriate collateral. Discount window loans are typically charged an interest rate that is 100 basis points above the target fed funds rate, although changing the size of this gap is possible and has been used, at times, as a policy instrument. Finally, if the bank does not have the appropriate collateral or chooses not to borrow at the discount window for other reasons, it will be charged a penalty fee proportional to the amount of the shortage.

Currently, banks earn no interest on the reserve balances they hold in their accounts at the Federal Reserve.[5] This situation may soon change: The Financial Services Regulatory Relief Act of 2006 allows the Fed to begin paying interest on reserve balances in October 2011. The Act also includes provisions that give the Fed more flexibility in determining reserve requirements, including the ability to eliminate the requirements altogether. Thus, this legislation opens the door to potentially substantial changes in the way the Fed implements monetary policy. To evaluate the best approach within the new, broader set of alternatives, it seems useful to develop a simple analytical framework that is able to address many of the relevant aspects of the problem. We introduce and discuss such a framework in the sections that follow.

2. THE DEMAND FOR RESERVES

In this section, we present a simple framework that is useful for understanding banks' demand for reserves. In this framework, a bank holds reserves primarily to satisfy reserve requirements, although other factors, such as the desire to make interbank payments, may also play a role. Since banks cannot fully predict the timing of payments, they face uncertainty about the net outflows from their reserve accounts and, therefore, are typically unable to exactly satisfy their reserve requirements. Instead, they must balance the possibility

[4] There are 12 regions and corresponding Reserve Banks in the Federal Reserve System. For each commercial bank, the corresponding Reserve Bank is determined by the region where the commercial bank is headquartered.

[5] See footnote 2.

of holding excess reserve balances—and the associated opportunity cost—against the possibility of being penalized for a reserve deficiency. A bank's demand for reserves results from optimally balancing these two concerns.

The Basic Framework

We assume banks are risk-neutral and maximize expected profits. At the beginning of the day, banks can borrow and lend reserves in a competitive interbank market. Let R be the quantity of reserves chosen by a bank in the interbank market. The central bank affects the supply of reserves in this market by conducting open market operations. Total reserve supply is equal to the quantity set by the central bank through its operations, adjusted by a potentially random amount to reflect unpredictable changes in autonomous factors.

During the day, each bank makes payments to and receives payments from other banks. To keep things as simple as possible, suppose that each bank will make exactly one payment and receive exactly one payment during the "middle" part of the day. Furthermore, suppose that these two payment flows are of exactly the same size, $P_D > 0$, and that this size is nonstochastic. However, the order in which these payments occur during the day is random; some banks will receive the incoming payment before making the outgoing one, while others will make the outgoing payment before receiving the incoming one.

At the end of the day, after the interbank market has closed, each bank experiences another payment shock, P, that affects its end-of-day reserve balance. The value of P can be either positive, indicating a net outflow of funds, or negative, indicating a net inflow of funds. We assume that the payment shock, P, is uniformly distributed on the interval $[-\overline{P}, \overline{P}]$. The value of this shock is not yet known when the interbank market is open; hence, a bank's demand for reserves in this market is affected by the distribution of the payment shock and not the realization.

We assume, as a starting point, that a bank must meet a given reserve requirement, K, at the end of each day.[6] If the bank finds itself holding fewer than K reserves at the end of the day, after the payment shock P has been realized, it must borrow funds at a "penalty" rate of interest, r_P, to satisfy the requirement. This rate can be thought of as the rate charged by the central bank on discount window loans, adjusted to take into account any "stigma" associated with using this facility. In reality, a bank may pay a deficiency fee instead of borrowing from the discount window or it may borrow funds

[6] We discuss more complicated systems of reserve requirements later, including multiple-day maintenance periods. For the logic in the derivations that follow, the particular value of K does not matter. The case of $K = 0$ corresponds to a system without reserve requirements.

in the interbank market very late in the day when this market is illiquid. In the model, the rate r_P simply represents the cost associated with a late-day reserve deficiency, whatever the source of that cost may be.

The specific assumptions we make about the number and size of payments that a bank sends are not important; they only serve to keep the analysis free of unnecessary complications. Two basic features of the model are important. First, the bank cannot perfectly anticipate its end-of-day reserve position. This uncertainty creates a "precautionary" demand for reserves that smoothly responds to changes in the interest rate. Second, a bank makes payments during the day as a part of its normal operations and the pattern of these payments can potentially lead to an overdraft in the bank's reserve account. We initially assume that the central bank offers daylight credit to banks to cover such overdrafts at no charge. We study the case where daylight overdrafts are costly later in this section.

The Benchmark Case

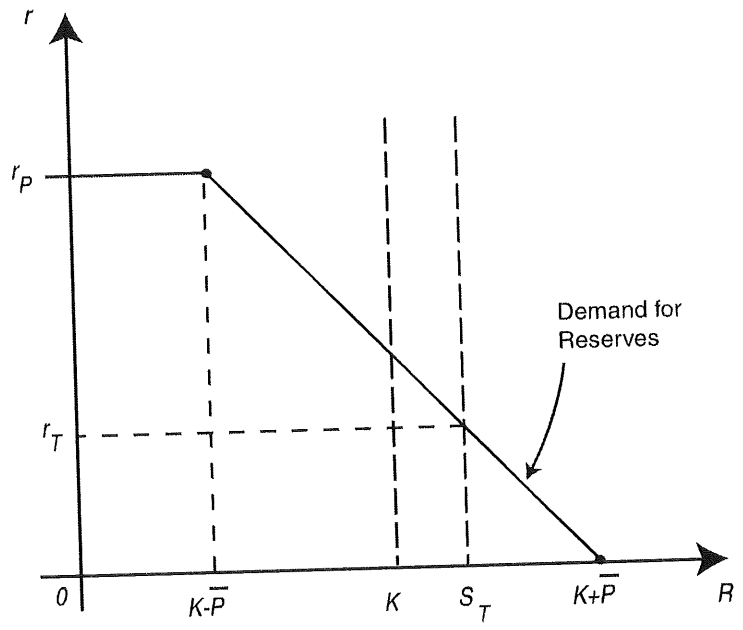
We begin by analyzing a simple benchmark case; we show later in this section how the framework can be extended to include a variety of features that are important in reality. In the benchmark case, banks must meet their reserve requirement at the end of each day, and the central bank pays no interest on reserves held by banks overnight. Furthermore, the central bank offers daylight credit free of charge.

Figure 1 depicts an individual bank's demand for reserves in the interbank market under this benchmark scenario. On the horizontal axis we measure the bank's choice of reserve holdings *before the late-day payment is realized.* On the vertical axis we measure the market interest rate for overnight loans. To draw the demand curve, we ask: Given a particular value for the interest rate, what quantity of reserves would the bank demand to hold if that rate prevailed in the market?

A bank would be unwilling to hold any reserves if the market interest rate were higher than r_P. If the market rate were higher than the penalty rate, the bank would choose to meet its requirement entirely by borrowing from the discount window. It would actually like to borrow even more than its requirement and lend the rest out at the higher market rate, but this fact is not important for the analysis. The important point is simply that there will be no demand for (nonborrowed) reserves for any interest rate larger than r_P.

When the market interest rate exactly equals the penalty rate, r_P, a bank would be indifferent between holding any amount of reserves between zero and $K - \overline{P}$ and, hence, the demand curve is horizontal at r_P. As long as the bank's reserve holdings, R, are smaller than $K - \overline{P}$, the bank will need to borrow at the discount window to satisfy its reserve requirement, K, even if the late-day inflow of funds into the bank's reserve account is the largest

Figure 1 Benchmark Demand for Reserves



possible value, $\overline{P}$.[7] The alternative would be to borrow more reserves in the market to reduce this potential need for discount window lending. Since the market rate is equal to the penalty rate, both strategies deliver the same level of profit and the bank is indifferent between them.

For market interest rates below the penalty rate, however, a bank will choose to hold at least $K - \overline{P}$ reserves. As discussed above, if the bank held fewer than $K - \overline{P}$ reserves it would be certain to need to borrow from the discount window, which would not be an optimal choice when the market rate is lower than the discount rate. The bank's demand for reserves in this situation can be described as "precautionary" in the sense that the bank chooses its reserve holdings to balance the possibility of falling short of the requirement against the possibility of ending up with extra reserves in its account at the end of the day.

[7] To see this, note that even in the best case scenario the bank will find itself holding $R+\overline{P}$ reserves after the arrival of the late-day payment flow. When $R < K - \overline{P}$, the bank's end-of-day holdings of reserves is insufficient to satisfy its reserve requirement, K, unless it takes a loan at the discount window.

If the market interest rate were very low—close to zero—the opportunity cost of holding reserves would be very small. In this case, the bank would hold enough precautionary reserves so that it is virtually certain that unforeseen movements on its balance sheet will not decrease its reserves below the required level. In other words, the bank will hold $K + \overline{P}$ reserves in this case. If the market interest rate were exactly zero, there would be no opportunity cost of holding reserves. The demand curve is, therefore, flat along the horizontal axis after $K + \overline{P}$.

In between the two extremes, $K - \overline{P}$ and $K + \overline{P}$, the demand for reserves will vary inversely with the market interest rate measured on the vertical axis; this portion of the demand curve is represented by the downward-sloping line in Figure 1. The curve is downward-sloping for two reasons. First, the market interest rate represents the opportunity cost of holding reserves overnight. When this rate is lower, finding itself with excess balances is less costly for the bank and, hence, the bank is more willing to hold precautionary balances. Second, when the market rate is lower, the relative cost of having to access the discount window is larger, which also tends to increase the bank's precautionary demand for reserves.

The linearity of the downward-sloping part of the demand curve results from the assumption that the late-day payment shock is uniformly distributed. With other probability distributions, the demand curve will be nonlinear, but its basic shape will remain unchanged. In particular, the points where the demand curve intersects the penalty rate, r_P, and the horizontal axis will be the same for any distribution with support $[-\overline{P}, \overline{P}]$.[8]

The Equilibrium Interest Rate

Suppose, for the moment, that there is a single bank in the economy. Then the demand curve in Figure 1 also represents the total demand for reserves. Let S denote the total supply of reserves in the interbank market, as jointly determined by the central bank's open market operations and autonomous factors. Then the equilibrium interest rate is determined by the height of the demand curve at point S. As shown in the diagram, there is a unique level of reserve supply, S_T, that will generate a given target interest rate, r_T.

Now suppose there are many banks in the economy, but they are all identical in that they have the same level of required reserves, face the same payment shock, etc. When there are many banks, the total demand for reserves can be found by simply "adding up" the individual demand curves. For any interest

[8] The *support* of the probability distribution is the set of values of the payment shock that is assigned positive probability. An explicit formula for the demand curve in the uniform case is derived in Ennis and Weinberg (2007). If the shock instead had an unbounded distribution, such as the normal distribution used by Whitesell (2006) and others, the demand curve would asymptote to the penalty rate and the horizontal axis but never intersect them.

rate r, total demand is simply the sum of the quantity of reserves demanded by each individual bank.

For presentation purposes, it is useful to look at the average demand for reserves, that is, the total demand divided by the number of banks. When all banks are identical, the average demand is exactly equal to the demand of each individual bank. In other words, in the benchmark case where banks are identical, the demand curve in Figure 1 also represents the *aggregate* demand for reserves, expressed in per-bank terms. The determination of the equilibrium interest rate then proceeds exactly as in the single-bank case. In particular, the market-clearing interest rate will be equal to the target rate, r_T, if and only if reserve supply (expressed in per-bank terms) is equal to S_T.

Note that the central bank has two distinct ways in which it can potentially affect the market interest rate: changing the supply of reserves available in the market and changing (either directly or indirectly) the penalty rate. Suppose, for example, that the central bank wishes to decrease the market interest rate. It could either increase the supply of reserves through open market operations, leading to a movement down the demand curve, or it could decrease the penalty rate, which would rotate the demand curve downward while leaving the supply of reserves unchanged. Both policies would cause the market interest rate to fall.

Heterogeneity

While the assumption that all banks are identical was useful for simplifying the presentation above, it is clearly a poor representation of reality in most economies. The United States, for example, has thousands of banks and other depository institutions that differ dramatically in size, range of activities, etc. We now show how the analysis above changes when there is heterogeneity among banks and, in particular, how the size distribution of banks might affect the aggregate demand for reserves.

Each bank still has a demand curve of the form depicted in Figure 1, but now these curves can be different from each other because banks may have different levels of required reserves, face different distributions of the payment shock, and/or face different penalty rates. These individual demand curves can be aggregated exactly as before: For any interest rate r, the total demand for reserves is simply the sum of the quantity of reserves demanded by each individual bank. The aggregate demand curve, expressed in per-bank terms, will again be similar to that presented in Figure 1, with the exact shape being determined by the properties of the various individual demands. If different banks have different levels of required reserves, for example, the requirement K in the aggregate demand curve will be equal to the average of the individual banks' requirements.

As the figure shows, when daylight credit is costly, the level of reserves required to implement a given target rate is higher (S_2 rather than S_1 in the diagram). In other words, costly daylight credit tends to increase banks' reserve holdings. The demand curve is also flatter, meaning that reserve holdings are more sensitive to changes in the interest rate.

3. INTEREST RATE VOLATILITY

One of the key determinants of a central bank's ability to consistently achieve its target interest rate is the slope of the aggregate demand curve for reserves. In this section, we describe the relationship between this slope and the volatility of the market interest rate in the basic framework. The next two sections then discuss policy tools that can be used to limit this volatility.

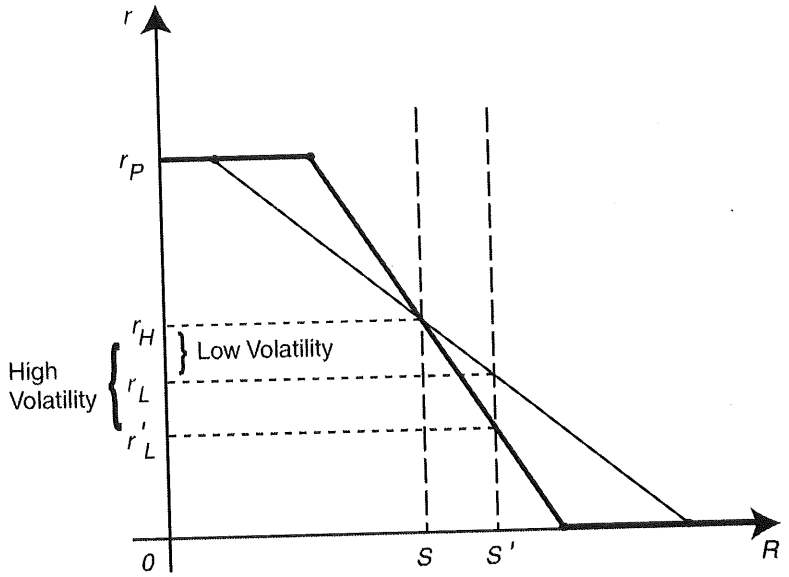
While the central bank can use open market operations to affect the supply of reserves available in the market, it typically cannot completely control this supply. Payments into and out of the Treasury account, as well as changes in the amount of cash in circulation, also affect the total supply of reserves. The central bank can anticipate much of the change in such autonomous factors, but there will often be significant unanticipated changes that cause the total supply of reserves to be different from what the central bank intended. As is clear from Figure 1, if the supply of reserves ends up being different from the intended amount, S_T, the market interest rate will deviate from the target rate, r_T.

Figure 4 illustrates the fact that a flatter demand curve for reserves is associated with less volatility in the market interest rate, given a particular level of uncertainty associated with autonomous factors. Suppose this uncertainty implies that, after a given open market operation, the total supply of reserves will be equal to either S or S' in the figure. With the steeper (thick) demand curve, this uncertainty about the supply of reserves leads to a relatively wide range of uncertainty about the market rate. With the flatter (thin) demand curve, in contrast, the variation in the market rate is smaller. For this reason, the slope of the demand curve, and those policies that affect the slope, are important determinants of the observed degree of volatility of the market interest rate around the target.

As discussed in the previous section, a variety of factors affect the slope of the aggregate demand for reserves. Figure 4 can be viewed, for example, as comparing a situation where all banks face relatively little late-day uncertainty with one where all banks face more uncertainty; the latter case corresponds

unaffected. The analysis also takes the size and timing of payments as given. Several papers have studied the interesting question of how banks respond to incentives in choosing the timing of their outgoing payments and, hence, their daylight credit usage. See, for example, McAndrews and Rajan (2000) and Bech and Garratt (2003).

Figure 4 Interest Rate Volatility



to the thin line in the figure. However, it should be clear that the reasoning presented above does not depend on this particular interpretation. The exact same results about interest rate volatility would obtain if the demand curves had different slopes because banks face different penalty rates in the two scenarios or because of some other factor(s). What the figure shows is that there is a direct relationship between the slope of the demand curve and the amount of interest rate volatility caused by forecast errors or other unanticipated changes in the supply of reserves.

Central banks generally aim to limit the volatility of the interest rate around their target level to the extent possible. For this reason, a variety of policy arrangements have been designed in an attempt to decrease the slope of the demand curve, at least in the region that is considered "relevant." In the remainder of the article, we show how some of these tools can be analyzed in the context of our simple framework. In Section 4 we discuss reserve maintenance periods, while in Section 5 we discuss approaches that become feasible when the central bank pays interest on reserves.

4. RESERVE MAINTENANCE PERIODS

Perhaps the most significant arrangement designed to flatten the demand curve for reserves is the introduction of reserve maintenance periods. In a system

5. PAYING INTEREST ON RESERVES

We now introduce the possibility that the central bank pays interest on the reserve balances held overnight by banks in their accounts at the central bank. As discussed in Section 1, most central banks currently pay interest on reserves in some form, and Congress has authorized the Federal Reserve to begin doing so in October 2011. The ability to pay interest on reserves gives a central bank an additional policy tool that can be used to help minimize the volatility of the market interest rate and steer this rate to the target level. This tool can be especially useful during periods of financial distress. For example, during the recent financial turmoil, the fed funds rate has experienced increased volatility during the day and has, in many cases, collapsed to values near zero late in the day. As we will see below, the ability to pay interest on reserves allows the central bank to effectively put a floor on the values of the interest rate that can be observed in the market. Such a floor reduces volatility and potentially increases the ability of the central bank to achieve its target rate.

In this section, we describe two approaches to monetary policy implementation that rely on paying interest on reserves: an interest rate corridor and a system with clearing bands. We explain the basic components of each approach and how each tends to flatten the demand curve for reserves.

Interest Rate Corridors

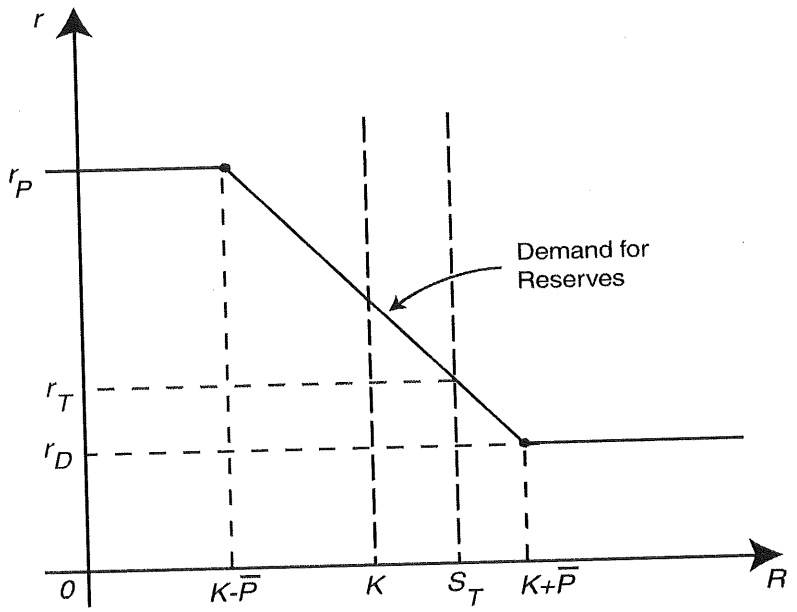
One simple policy a central bank could follow would be to pay a fixed interest rate, r_D, on all reserve balances that a bank holds in its account at the central bank.[15] This policy places a floor on the market interest rate: No bank would be willing to lend reserves at an interest rate lower than r_D, since they could instead earn r_D by simply holding the reserves on deposit at the central bank. Together, the penalty rate, r_P, and the deposit rate, r_D, form a "corridor" in which the market interest rate will remain.[16]

Figure 6 depicts the demand for reserves under a corridor system. As in the earlier figures, there is no demand for reserves if the market interest rate is higher than the penalty rate, r_P. For values of the market interest rate below r_P, a bank will choose to hold at least $K - \overline{P}$ reserves for exactly the same

[15] In practice, reserve balances held to meet requirements are often compensated at a different rate than those that are held in excess of a bank's requirement. For the daily process of targeting the overnight market interest rate, the rate paid on *excess* reserves is what matters; this is the rate we denote r_D in our analysis.

[16] A central bank may prefer to use a *lending facility* that is distinct from its discount window to form the upper bound of the corridor. Banks may be reluctant to borrow from the discount window, which serves as a lender of last resort, because they fear that others would interpret this borrowing as a sign of poor financial health. The terms associated with the lending facility could be designed to minimize this type of stigma effect and, thus, create a more reliable upper bound on the market interest rate.

Figure 6 A Conventional Corridor



reason as in Figure 1: if it held a lower level of reserves, it would be certain to need to borrow at the penalty rate, r_P. Also as before, the demand for reserves is downward-sloping in this region. The big change from Figure 1 is that the demand curve now becomes flat at the deposit rate. If the market rate were lower than the deposit rate, a bank's demand for reserves would be essentially infinite, as it would try to borrow at the market rate and earn a profit by simply holding the reserves overnight.

The figure shows that, regardless of the level of reserve supply, S, the market interest rate will always stay in the corridor formed by the rates r_P and r_D. The width of the corridor, $r_P - r_D$, is then a policy choice. Choosing a relatively narrow corridor will clearly limit the range and volatility of the market interest rate. Note that narrowing the corridor also implies that the downward-sloping part of the demand curve becomes flatter (to see this, notice that the boundary points $K - \overline{P}$ and $K + \overline{P}$ do not depend on r_P or r_D). Hence, the size of the interest rate movement associated with a given shock to an autonomous factor is smaller, even when the shock is small enough to keep the rate within the corridor.

An interesting case to consider is one in which the lending and deposit rates are set the same distance on either side of the target rate (x basis points above and below the target, respectively). This system is called *a symmetric*

corridor. A change in policy stance that involves increasing the target rate, then, effectively amounts to changing the levels of the lending and deposit rates, which shifts the demand curve along with them. The supply of reserves needed to maintain a higher target rate, for example, may not be lower. In fact— perhaps surprisingly—in the simple model studied here, the target level of the supply of reserves would not change at all when the policy rate changes.

If the demand curve in Figure 6 is too steep to allow the central bank to effectively achieve its goal of keeping the market rate close to the target, a corridor system could be combined with a reserve maintenance period of the type described in Section 4. The presence of a reserve maintenance period would generate a flat region in the demand curve as in Figure 5. The features of the corridor would make the two downward-sloping parts of the demand curve in Figure 5 less steep, which would limit the interest rate volatility associated with events where reserve supply exits the flat region of the demand curve, as well as on the last day of the maintenance period when the flat region is not present.

Another way to limit interest rate volatility is for the central bank to set the deposit rate equal to the target rate and then provide enough reserves to make the supply, S_T, intersect the demand curve well into the flat portion of the demand curve at rate r_D. This "floor system" has been recently advocated as a way to simplify monetary policy implementation (see, for example, Woodford 2000, Goodfriend 2002, and Lacker 2006). Note that such a system does not rely on a reserve maintenance period to generate the flat region of the demand curve, nor does it rely on reserve requirements to induce banks to hold reserves. To the extent that reserve requirements, and the associated reporting procedures, place significant administrative burdens on both banks and the central bank, setting the floor of the corridor at the target rate and simplifying, or even eliminating, reserve requirements could potentially be an attractive system for monetary policy implementation.

It should be noted, however, that the market interest rate will always remain some distance above the floor in such a system, since lenders in the market must be compensated for transactions costs and for assuming some counterparty credit risk. In other words, in a floor system the central bank is able to fully control the risk-free interest rate, but not necessarily the market rate. In normal times, the gap between the market rate and the rate paid on reserves would likely be stable and small. In periods of financial distress, however, elevated credit risk premia may drive the average market interest rate significantly above the interest rate paid on reserves. Our simple model abstracts from these important considerations.[17]

[17] The central bank could also set an upper limit for the quantity of reserves on which it would pay the target rate of interest to a bank; reserves above this limit would earn a lower rate (possibly zero). Whitesell (2006) proposed that banks be allowed to choose their own upper

the market interest rate is low, for example, simply to earn the higher interest rate paid by the central bank.

The intertemporal aspect of reserve maintenance periods has two clear drawbacks. First, if—for whatever reason—the expected future rate differs from the target rate, r_T, it becomes difficult for the central bank to achieve the target rate in the current period. Second, large shocks to the supply of reserves on one day can have spillover effects on subsequent days in the maintenance period. If, for example, the supply of reserves is unusually high one day, banks will satisfy an unusually large portion of their reserve requirements and, as a result, the flat portion of the demand curve will be smaller on all subsequent days, increasing the potential for rate volatility on those days.

The clearing band approach, in contrast, generates a flat portion in the demand curve that always lies at the current target interest rate, even if market participants expect the target rate to change in the near future. Moreover, the width of the flat portion is "reset" every day; it does not depend on past events. These features are important potential advantages of the clearing band approach. We should again point out, however, that our simple model has abstracted from transaction costs and credit risk. As with the floor system discussed above, these considerations could result in the average market interest rate being higher than the rate r_T, as the latter represents a risk-free rate.

6. CONCLUSION

A recent change in legislation that allows the Federal Reserve to pay interest on reserves has renewed interest in the debate over the most effective way to implement monetary policy. In this article, we have provided a basic framework that can be useful for analyzing the main properties of the various alternatives. While we have conducted all our analysis graphically, our simplifying assumptions permit a fairly precise description of the alternatives and their effectiveness at implementing a target interest rate.

Many extensions of our basic framework are possible and we have analyzed several of them in this article. However, some important issues remain unexplored. For example, we only briefly mentioned the difficulties that fluctuations in aggregate credit risk can introduce in the implementation process. Also, as the debate continues, new questions will arise. We believe that the framework introduced in this article can be a useful first step in the search for much-needed answers.

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https://www.stlouisfed.org/publications/regional-economist/april-2016/interest-rate-control-is-more-complicated-than-you-thought

Interest Rate Control Is More Complicated Than You Thought

Stephen D. Williamson

Most people are aware that decisions by the Federal Reserve (Fed) affect market interest rates. These decisions have consequences for the interest rates that consumers pay on mortgage loans, credit cards and auto loans, and for the interest rates faced by businesses on bank loans, corporate bonds and commercial paper.

But there is more than one interest rate that the Fed sets, either as a target or by administrative fiat. Many people are aware of the target for the federal funds rate, or fed funds rate, that the Federal Open Market Committee (FOMC) of the Fed sets at its eight regular meetings a year. The fed funds rate is an interest rate on overnight credit arrangements among financial institutions—that is, a very short-term interest rate. The Fed also sets the discount rate, or the interest rate on primary credit, which is an interest rate at which the Fed lends to commercial banks in its role as a lender of last resort. Still another rate is that on interest paid by the Fed on reserves. Banks hold reserve accounts with the Fed; these accounts essentially play the role of checking accounts for financial institutions. (A reserve account is useful when a bank needs to make large payments to other financial institutions.) Thus, a reserve account is a loan to the Fed from a bank. Before late 2008, reserve accounts paid zero interest, as dictated by Congress in the Federal Reserve Act.

Prior to the financial crisis (late 2007 through 2008), the Fed conducted monetary policy within what economists call a *channel system*. The Fed targeted the overnight fed funds rate within a "channel," with the discount rate as the upper bound on the channel and the interest rate on reserves as the lower bound on the channel. For example, in January 2007, the discount rate was set at 6.25 percent, the fed funds rate was targeted at 5.25 percent and the interest rate on reserves was 0 percent. The fed funds rate could not, in principle, go above the discount rate because no bank would choose to borrow from another bank at an interest rate higher than the rate at which it could borrow from the Fed (the discount rate). Similarly, no bank would lend to another bank at an interest rate lower than the interest rate it could receive from the Fed (the interest rate on reserves). In 2007, the New York Fed would intervene every day in financial markets—through open market operations, which are the purchase and sale of assets by the Fed—to try to bring the fed funds rate as close as possible to the target set by the FOMC.

But between 2007 and now, the details of how the Fed conducts monetary policy have changed in important ways. First, since late 2008, the reserves held at the Fed by financial institutions have

earned interest; such interest payments are allowed under an amendment to the Federal Reserve Act passed by Congress. Further, and more importantly, the interest rate on excess reserves, or IOER, is set by the Fed and can be changed over time.

Second, during the Great Recession (late 2007 to mid-2009) and its aftermath, the Fed engaged in some unconventional monetary policy actions. For our purposes, the most important of these was a program of large-scale asset purchases, sometimes known as quantitative easing. This program led to a large increase in the stock of reserves at the Fed—effectively, the Fed purchased a large quantity of assets (U.S. Treasury securities and agency mortgage-backed securities) by issuing more reserves.

For the Fed, the large stock of reserves outstanding implies that monetary policy works differently now—within a *floor system* rather than a channel system. In a floor system, the IOER plays a key role. In principle, what should happen in a floor system is that, with plenty of reserves in the system, the Fed can achieve its target for the fed funds rate by simply setting the IOER. Why? If the fed funds rate were lower than the IOER, then banks would be able to make a profit from borrowing on the fed funds market and lending to the Fed at the IOER, thus forcing up the fed funds rate. If the fed funds rate were higher than the IOER, then a bank wanting to lend would earn more interest on the fed funds market than by lending to the Fed at the IOER. The large demand for fed funds would then force the fed funds rate down.

According to this logic, controlling the fed funds rate should be easy for the Fed under a floor system. But theory and reality sometimes do not agree. From late 2008 to December 2015, the IOER was set at 0.25 percent. However, contrary to what many people might think, since early 2009 the fed funds rate has generally been 5 to 20 basis points (one basis point is equal to 0.01 percentage points) lower than the IOER. This difference between the IOER and the fed funds rate is typically ascribed to costs for commercial banks associated with borrowing on the fed funds market.1

The persistent difference between the IOER and the fed funds rate was a concern for the Fed as it anticipated the time when "liftoff" would occur, where liftoff refers to the date at which the Fed would depart from its long period (since late 2008) of zero interest rate policy, or ZIRP. Could the Fed expect that the fed funds rate would increase along with the IOER if the Fed attempted to control the fed funds rate only through increases in the IOER?

The solution adopted by the Fed is unique in central banking—a floor system with a subfloor. The New York Fed, in intervening in overnight financial markets, is now making use of an overnight reverse repurchase agreement (ON-RRP) facility. ON-RRPs are essentially reserves by another name. In ON-RRP transactions, financial institutions lend to the Fed, just as they do when they hold reserve accounts with the Fed. The difference between reserves and ON-RRPs is that, in an ON-RRP arrangement, the Fed posts securities in its portfolio as collateral, just as in any private repurchase agreement transaction. A repurchase agreement is simply a special kind of financial market loan that is secured by collateral just as, for example, your mortgage is secured by your house, which can be seized if you default on the mortgage.

Without getting into all the details,2 the idea behind the floor-with-subfloor system is that the Fed sets, along with the discount rate and IOER, an ON-RRP rate, which is the rate at which financial

institutions can lend to the Fed in the market for repurchase agreements. The ON-RRP rate is set below the IOER, and then policy is announced as a target range for the fed funds rate, with the top of the range given by the IOER and the bottom of the range determined by the ON-RRP rate. Thus, the IOER sets the floor, and the ON-RRP rate sets the subfloor.

But could this system work? On Dec. 16, 2015, the FOMC decided to increase the target range for the federal funds rate from 0-0.25 percent to 0.25-0.50 percent,3 with the discount rate at 1.0 percent, the IOER at 0.50 percent and the ON-RRP rate set at 0.25 percent.

As shown in Figure 1, the value of ON-RRPs outstanding increased from $105 billion on Dec. 17, 2015, to $475 billion on Dec. 31, following which the quantity dropped back to the neighborhood of $100 billion. In the fed funds market, as shown in Figure 2, the average daily fed funds rate has typically been within a tight range of 0.35-0.37 percent, except on Dec. 31, 2015, when the average rate was 0.20 percent. Thus, in terms of results, the Fed has been successful in controlling the fed funds rate within the 0.25-0.50 percent range.

But why was the average fed funds rate so low and the ON-RRP quantity so high on Dec. 31, 2015? This date was both the quarter-end and year-end, which is important because at this time financial reporting takes place and financial institutions want to have their balance sheets appear as favorable as possible to their shareholders and regulators. Lending on the fed funds market can be a risky activity, as lending is unsecured, while lending to the Fed in the form of ON-RRPs is essentially riskless. Therefore, we might expect that, on Dec. 31, lenders in the overnight market would shift their activity from the fed funds market to the ON-RRP market, as this would reduce risk on their balance sheets. Sure enough, we saw a large increase in ON-RRP activity on Dec. 31.

Still, why were fed funds market lenders accepting an average interest rate of 0.20 percent on Dec. 31, 2015, which is lower than the ON-RRP rate on that date, and why were some participants accepting interest rates as low as 0.08 percent? A potential explanation for this is that fed funds market trades and ON-RRP trades are very different in terms of the time of the day lending occurs and when the loan is paid back the next day. In particular, ON-RRP borrowing by the Fed occurs between 12:45 and 1:15 p.m. ET, and loans are paid back the next day between 3:30 and 5:15 p.m. ET. However, a fed funds transaction can occur as late as 6:30 p.m., with funds potentially returned early the next day.4 So, while a fed funds market transaction may be riskier because lending is unsecured, it is also more liquid, as lending can occur later in the day and funds can be returned more quickly the next day. Thus, lenders may be willing to pay for liquidity with a lower overnight interest rate, and this would have a larger effect at the quarter-end, when trading on the fed funds market is thin.

Research assistance was provided by Jonas Crews, a research analyst at the Bank.

Figure 1

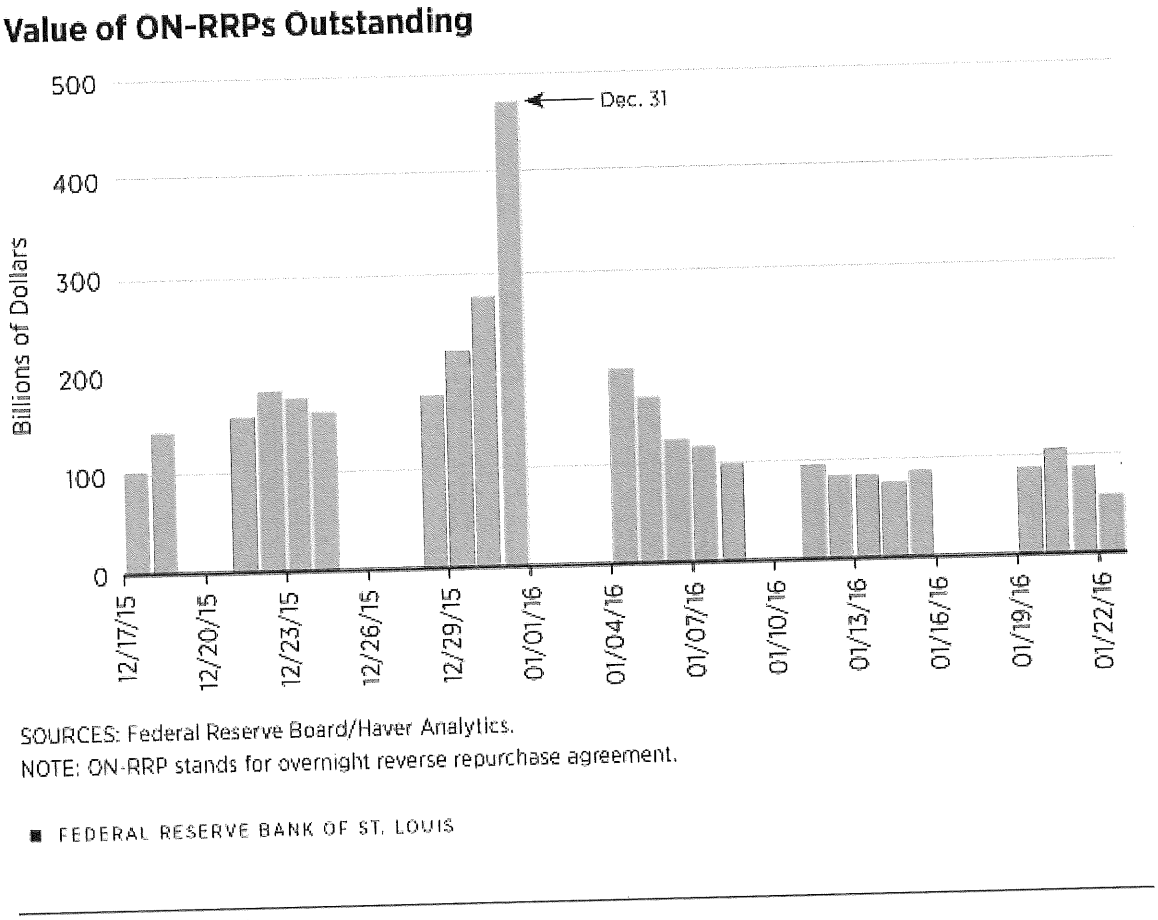
Value of ON-RRPs Outstanding
Billions of Dollars
500
400
300
200
100
0
Dec. 31
12/17/15
12/20/15
12/23/15
12/26/15
12/29/15
01/01/16
01/04/16
01/07/16
01/10/16
01/13/16
01/16/16
01/19/16
01/22/16
SOURCES: Federal Reserve Board/Haver Analytics.
NOTE: ON-RRP stands for overnight reverse repurchase agreement.
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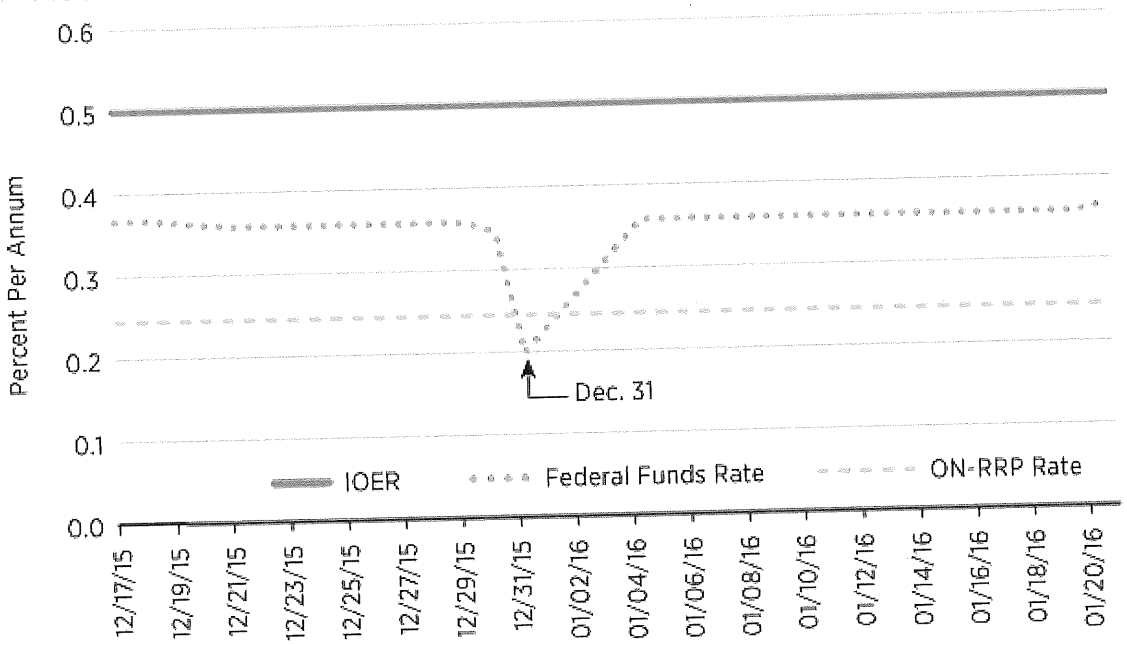
Figure 2

A Floor and a Subfloor for the Federal Funds Rate



SOURCES: Federal Reserve Board/Haver Analytics.

NOTE: In principle, the large stock of reserves outstanding should result in the fed funds rate equaling the interest on excess reserves (IOER), but economic factors have resulted in the former rate running below the latter. The rate for overnight reverse repurchase agreements (ON-RRP) should serve as a secondary floor for the fed funds rate, and it largely has. The only time the fed funds rate has fallen below the ON-RRP rate since liftoff was Dec. 31, 2015, and this is likely explained, in part, by the fact that financial reporting took place on that day and the fact that there are differences in the time frames of fed funds and ON-RRP transactions.

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Endnotes

1. See Williamson. [back to text]
2. See Williamson for more information. [back to text]
3. See Board of Governors. [back to text]
4. See Bartolini, Hilton and McAndrews for more information on the timing of transactions. [back to text]

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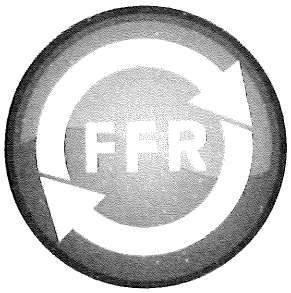


A New Frontier: Monetary Policy with Ample Reserves

Scott A. Wolla, Ph.D., Economic Education Coordinator

GLOSSARY

Arbitrage: The simultaneous purchase and sale of a good in order to profit from a difference in price.

Balance sheet: A statement of the assets and liabilities of a firm or individual at some given time.

Federal funds rate (FFR): The interest rate at which a depository institution lends funds that are immediately available to another depository institution overnight.

Federal Open Market Committee (FOMC): A committee created by law that consists of the seven members of the Board of Governors; the president of the Federal Reserve Bank of New York; and, on a rotating basis, the presidents of four other Reserve Banks. Nonvoting Reserve Bank presidents also participate in FOMC deliberations and discussion.

Liquidity: The quality that makes an asset easily convertible into cash with relatively little loss of value in the conversion process.

Monetary policy: Central bank actions involving the use of interest rate or money supply tools to achieve such goals as maximum employment and stable prices.

Open market operations: The buying and selling of government securities through primary dealers by the Federal Reserve in order to influence the money supply.

Stimulus: Actions taken by a government or a central bank that are intended to encourage economic activity and growth.

> "Consistent with its statutory mandate, the Committee seeks to foster maximum employment and price stability. In support of these goals, the Committee decided to maintain the target range for the federal funds rate at 2-1/4 to 2-1/2 percent."
> —FOMC Statement, March 20, 2019[1]

Introduction

The Federal Reserve is the central bank of the United States. Its dual mandate from Congress is to promote maximum employment and price stability. To achieve this mandate, the Federal Reserve conducts monetary policy by influencing market interest rates. However, the means by which the Federal Reserve influences interest rates have changed over time.

Influencing the Economy through the Federal Funds Rate

For decades prior to 2008, the Federal Reserve's **Federal Open Market Committee (FOMC)** would adjust monetary policy to match economic conditions by raising or lowering its target for the **federal funds rate (FFR)**, the rate that banks charge each other for overnight loans.[2] The Fed can influence the general cost of borrowing through this one rate because, although short-term interest rates differ from each other, they are closely linked.[3] If one short-term rate gets much below others, financial institutions will tend to borrow in that market and lend where rates are higher. This tendency puts upward pressure on the lower rate and downward pressure on the higher rate—keeping rates linked. This is known as **arbitrage**, an important aspect of the way financial markets, and monetary policy, work. So, by influencing one rate—the FFR—the Federal Reserve can influence other short-term rates, which affect longer-term interest rates, consumer and producer decisions, and ultimately the level of employment and inflation in the U.S. economy (Figure 1).

Monetary Policy with Scarce Reserves

Prior to September 2008, the Federal Reserve primarily bought and sold relatively small quantities of Treasury securities in the open market, termed **open market operations**, to adjust the level of bank reserves and thereby influence the FFR. Bank reserves are the sum of cash that banks hold in

Figure 1
Transmission of Monetary Policy

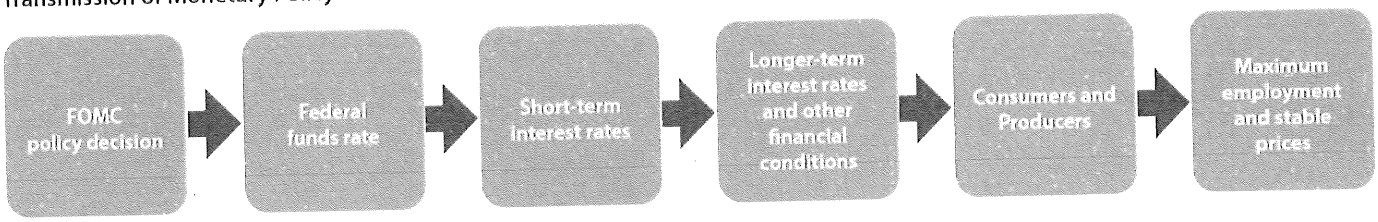
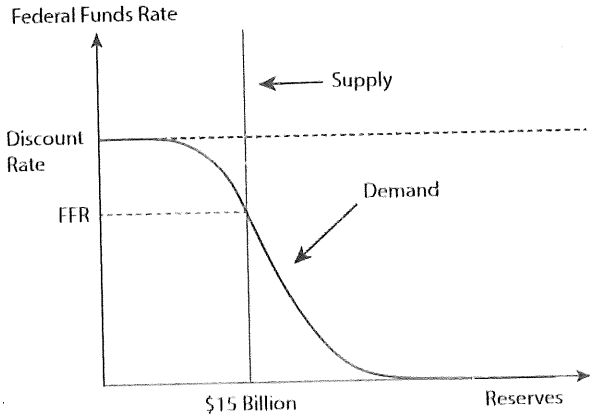


Figure 2
Monetary Policy with Scarce Reserves



The supply of bank reserves is vertical because the supply of reserves collectively held by the banking system is determined by the Federal Reserve.* When reserves are scarce, the Federal Reserve can shift the supply curve to the right or left by adding or subtracting reserves from the banking system using open market operations. The intersection of supply and demand determines the FFR.

When the supply curve was in the downward-sloping region of the demand curve, relatively small shifts in supply had a significant effect on the FFR. The Trading Desk at the Federal Reserve Bank of New York used open market operations to fine-tune the supply of reserves to achieve the target FFR set by the FOMC. This fine-tuning was done by selling or purchasing securities to shift the reserve supply curve left or right.

*More precisely, a central bank, such as the Federal Reserve, determines a country's "monetary base," which is the sum of currency held by the public plus total bank reserves. The monetary base equals the value of the central bank's assets. But, conditional on the public's choice of how much currency to hold, the choice of the monetary base pins down total bank reserves.

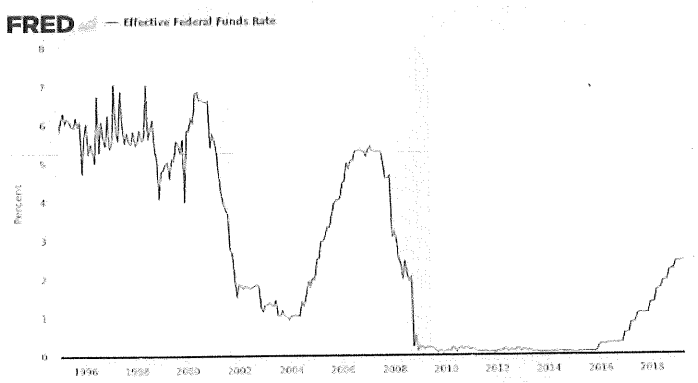
their vaults and the deposits they maintain at Federal Reserve Banks. Reserves fall into two categories. First, banks hold *required reserves*, funds that must be held as vault cash or deposits at a Federal Reserve Bank.[4] And banks can also hold *excess reserves*, funds held as vault cash or deposits at a Federal Reserve Bank in excess of required reserves. Banks had long argued that because they had to hold required reserves, these reserves were a tax because the Fed did not pay interest on these holdings. Absent the requirement, banks could lend or invest those reserves to earn interest. As a result, banks maintained required reserves, but minimized excess reserves, preferring to earn interest by lending or investing the funds. And, because reserves were scarce, Banks frequently had to borrow in the federal funds market (paying the FFR) to ensure they were meeting their overnight reserve requirements.

In that framework, the Federal Reserve could raise or lower the FFR by making relatively small changes to the supply of reserves (Figure 2). For example, the Fed could increase reserves by buying Treasury securities on the open market and crediting the accounts of the seller with reserves as payment. A greater quantity of reserves shifted the reserves supply curve to the right and put downward pressure on the FFR. And a lower FFR tended to put downward pressure on other interest rates in the economy.

Likewise, the Fed could decrease reserves by selling Treasury securities on the open market and debiting the accounts of buyers. As the supply of reserves decreased, it shifted the reserves supply curve to the left and put upward pressure on the FFR. And as the FFR increased, so did other interest rates.

The Federal Reserve used these policies to achieve its dual mandate. For example, the Fed could increase reserves to decrease the FFR and other interest rates, thereby encouraging economic activity when the economy was in recession (to achieve its maximum employment objective). Or, it could reduce reserves to increase the FFR and other interest rates in an attempt to restrain spending when inflation exceeded its 2 percent inflation objective (to achieve its price stability objective). The Trading Desk of the Federal Reserve Bank of New York conducted open market operations, as needed, to maintain the FFR very near the FOMC's target rate (Figure 3).

Figure 3
Monetary Policy Prior to 2008: The FFR Target

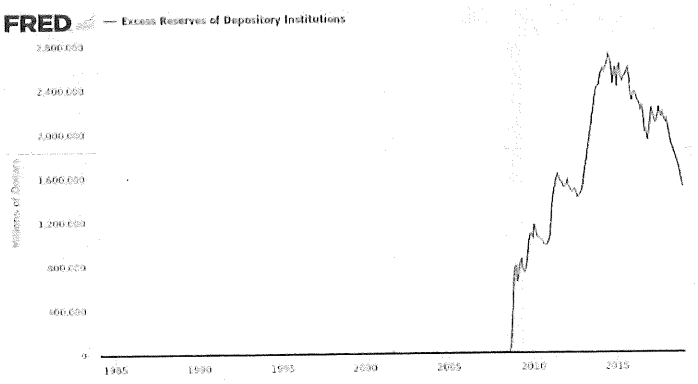


The FOMC's FFR target has varied widely in response to economic conditions. Prior to 2008, the FOMC set a single target for the FFR and used open market operations to move the rate toward its target.

NOTE: Gray bars indicate recessions as determined by the National Bureau of Economic Research (NBER).

SOURCE: FRED®, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/graph/?g=n3lM, accessed February 22, 2019.

Figure 4
Excess Reserves



NOTE: Gray bars indicate recessions as determined by the NBER.

SOURCE: FRED®, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/graph/?g=mc6A , accessed February 22, 2019.

The Financial Crisis

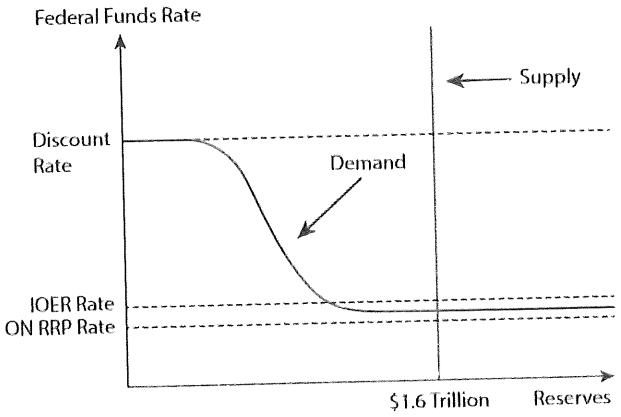
The Financial Crisis and resulting recession, known as the Great Recession, hit the U.S. economy hard. By December 2008, the Federal Reserve had lowered the FFR to a target rate range of 0 to 25 basis points.[5] Then, to provide further **stimulus** and **liquidity**, the Federal Reserve made a series of large-scale asset purchases between late 2008 and 2014.[6] The primary purpose of these purchases was to lower long-term interest rates to encourage consumption and investment. The purchases, which were also open market operations, increased the size of the Fed's **balance sheet** and also dramatically increased the amount of reserves in the banking system. In addition, over the course of the crisis, the Fed introduced two new tools to U.S. monetary policy: interest on reserves (IOR) and the overnight reverse repurchase agreement (ON RRP) facility. (See the table for a list of monetary policy acronyms.)

Congress had enacted IOR in 2006, with an originally scheduled start in 2011. To enable the Fed to use this tool during the Financial Crisis, the start was pushed up to October 2008, and it applied to both required reserves (paying interest on required reserves, or IORR) *and* excess reserves (paying interest on excess reserves, or IOER).[7] IORR eliminates the implicit tax on reserves requirements. And, because the IOER rate influences banks' decision to hold more or fewer reserves, it gives the Fed an additional tool for conducting monetary policy.[8] Prior to the summer of 2008, excess reserves had not exceeded $2 billion; by December 2008 they reached $767 billion, eventually peaking near $2.7 trillion in August 2014 (Figure 4) because of the large-scale asset purchases by the Fed over this period.

Monetary Policy Acronyms	
Federal funds rate	FFR
Federal open market committee	FOMC
Interest on reserves	IOR
Interest on required reserves	IORR
Interest on excess reserves	IOER
Overnight reverse repurchase agreement	ON RRP

The second new tool of monetary policy is the ON RRP facility: When an institution uses the ON RRP facility it essentially deposits reserves at the Fed overnight (with a U.S. government security from the Federal Reserve's portfolio acting as collateral) and earns interest (the ON RRP rate) on the deposit.[9] This is similar to a consumer buying a certificate of deposit, holding it for a specified time, and being paid interest when it is redeemed. The purpose of the ON RRP facility is to set a floor on interest rates.

Figure 5
Monetary Policy with Ample Reserves



In a world with ample reserves, the Federal Reserve operates where the following are true:

(i) The demand curve is flat and near the IOER rate.

(ii) The supply of reserves is ample and far to the right of the origin, intersecting demand on the flat portion of the curve. As such, making slight adjustments to the supply of reserves no longer puts upward or downward pressure on the FFR and instead the FFR is guided by the IOER rate as well as the ON RRP rate.

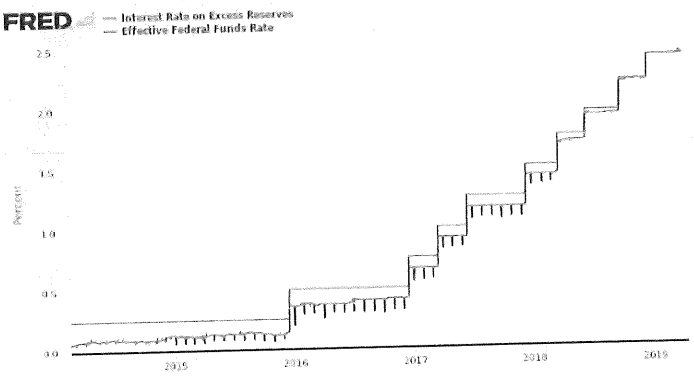
The Current Framework: Monetary Policy with Ample Reserves

Although the quantity of excess reserves has been declining since its peak in 2014, reserve balances are currently far in excess of banks' reserve requirements and the FOMC has indicated that it will in the longer-run conduct policy with ample reserves. With such a large quantity of reserves in the banking system, the Federal Reserve can no longer effectively influence the FFR by small changes in the supply of reserves. For example, a relatively small increase in reserves will not lower interest rates, nor will a relatively small reduction in reserves raise short-term interest rates (Figure 5). Instead, the Fed uses its newer tools—IOER and the ON RRP facility—to influence the FRR and short-term interest rates more generally.

IOER

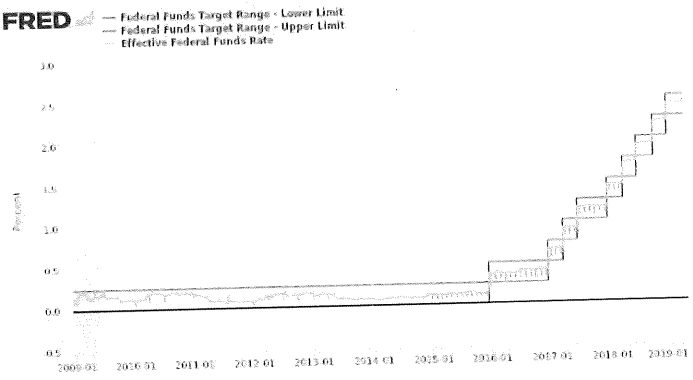
The IOER rate offers a safe, risk-free investment option to banks holding reserves at the Fed. Given this rate, banks will not lend reserves in the market for less than the IOER rate. Arbitrage plays a key role in steering the federal funds toward the target. For example, if the FFR falls very far below the IOER rate, banks have an incentive to borrow in the federal funds market and to deposit those reserves at the Fed, earning a profit on the difference.

Figure 6
Interest on Excess Reserves



SOURCE: FRED®, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/graph/?g=mXVq, accessed February 22, 2019.

Figure 7
Monetary Policy with Ample Reserves



The FFR target is now communicated as a range 25 basis points wide rather than a single rate.

NOTE: Gray bar indicates recession as determined by the NBER.

SOURCE: FRED®, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/graph/?g=n3lV, accessed February 22, 2019.

This tends to pull the FFR in the direction of the IOER rate (Figure 6). As such, to conduct monetary policy, the Federal Reserve moves the FFR into the target range set by the FOMC primarily by adjusting the IOER rate.[10] But not every financial institution can hold reserves with the Fed.

ON RRP Facility

More types of financial institutions can participate in the ON RRP program than can earn interest on reserves. These institutions use the facility's rate to arbitrage other short-

term rates. In particular, because these institutions will never be willing to lend funds for lower than the ON RRP rate, the FFR will not fall below the ON RRP rate. As such, the rate paid on ON RRP transactions acts as a floor for the FFR.

FFR Range

Rather than setting a single target for the FFR, the target is now communicated as a range 25 basis points wide. As stated above, the IOER rate and ON RRP rate are used to guide the FFR within the target range (Figure 7).

Despite the recent changes, the FFR will continue to be the primary means of adjusting the stance of monetary policy.[11] And the transmission channels are the same—the FFR influences other interest rates in the economy, which influence the decisions of consumers and producers (see Figure 1). To conduct monetary policy, the FOMC increases or decreases the target range in a manner consistent with its policy goals of price stability and maximum employment.[12]

Conclusion

When reserves were scarce, the Federal Reserve could influence the FFR with small changes in the supply of reserves by conducting open market operations that would shift the supply curve to the right (increasing reserves) or left (decreasing reserves). In the past few years, the Federal Reserve has adopted a new strategy for implementing monetary policy. With ample reserves in the banking system, the Fed now sets a target range for the FFR and uses the rates on IOER and the ON RRP facility to keep the FFR rate in the FOMC's target range. ■

Notes

[1] Board of Governors of the Federal Reserve System. "FOMC Statement." March 20, 2019; https://www.federalreserve.gov/newsevents/pressreleases/monetary20190320a.htm.

[2] In 2008, as the FFR neared zero, the FOMC began to implement monetary policy primarily through purchases of long-term bonds to reduce long-term interest rates, a strategy commonly (but inaccurately) known as "quantitative easing." Such purchases are one type of "unconventional" monetary policy. The FOMC supplemented this strategy with "forward guidance" to financial markets. The FFR remained near zero until December 2015.

[3] Short rates can differ because of several factors: the duration of the loan, the credit worthiness of the borrower, and whether collateral is required/available.

[4] Although legal reserve requirements still exist, in practice, financial innovation in the 1990s had enabled banks to avoid nearly any obligation to hold reserves.

[5] A basis point is 1/100th of 1 percent. It is used chiefly to express differences in interest rates. For example, an increase in a particular interest rate of 0.25 percent can be described as an increase of 25 basis points.

[6] Board of Governors of the Federal Reserve System. "What Were the Federal Reserve's Large-Scale Asset Purchases?" https://www.federalreserve.gov/faqs/what-were-the-federal-reserves-large-scale-asset-purchases.htm.

[7] Board of Governors of the Federal Reserve System. "Interest on Required Reserve Balances and Excess Balances." https://www.federalreserve.gov/monetarypolicy/reqresbalances.htm.

[8] Board of Governors of the Federal Reserve System. See footnote 7.

[9] Federal Reserve Bank of New York. "Reverse Repo Counterparties." https://www.newyorkfed.org/markets/rrp_counterparties

[10] Board of Governors of the Federal Reserve System. See footnote 7.

[11] Board of Governors of the Federal Reserve System. "FOMC Communications Related to Policy Normalization." https://www.federalreserve.gov/monetarypolicy/policy-normalization.htm.

[12] Board of Governors of the Federal Reserve System. See footnote 11.

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The Fed's "Ample-Reserves" Approach to Implementing Monetary Policy

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February 19, 2020

Abstract

We describe the Federal Reserve's (the Fed's) approach to implementing monetary policy in an ample-reserves regime. We use a stylized model to explain the factors the Fed considers and the tools it uses to ensure interest rate control when the quantity of reserves is ample. Then, we take a close look at the Fed's experience operating in this regime in the post-crisis period, both as it has raised and lowered its policy rate. Looking ahead, we highlight some considerations relevant for maintaining a level of reserves consistent with the efficient and effective implementation of monetary policy, and conclude with an overview of the benefits of an ample-reserves regime. This primer is intended to enhance discussions and understanding of the Fed's actions and communications regarding monetary policy implementation, as many resources on this topic may be out of date given the recent evolution of the policy environment.

Keywords: Monetary policy implementation, reserve balances, ample-reserves regime, administered rates, interest on reserves, open market operations
JEL: E58, E52, E43

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1. Introduction

The Federal Open Market Committee's (FOMC) primary means of achieving its dual mandate of maximum employment and stable prices is to set the target range for its policy rate—the federal funds rate—and communicate any expected changes in the near-term path of that rate.[1] Adjustments to the target range, when combined with careful policy communications and transparent policy strategy, transmit to other short-term interest rates and set off a chain of broader influences on financial conditions, making them more or less accommodative of economic growth. But how does the Federal Reserve (the Fed) ensure that adjustments in the target range for its policy rate affect the market-determined federal funds rate and other short-term rates? It does so through careful attention to monetary policy *implementation*.

In January 2019, the FOMC communicated its intention to continue implementing monetary policy in a regime with an ample supply of reserves.[2] This decision was reached following more than a decade of successful policy implementation in an environment with plentiful reserves in the banking system. In this regime, when the FOMC wants to adjust the stance of policy, it moves the target range for the federal funds rate up or down and communicates information about the range to the public. To implement a corresponding change in market rates, the Fed adjusts its administered interest rates. Together these steps affect the market-determined federal funds rate and other overnight market interest rates. In contrast to the Fed's previous implementation regime, in which the quantity of reserves was substantially less plentiful (and thus termed "limited," or sometimes "scarce"), the Fed is not required to

[1] The Federal Reserve Act directs the Board of Governors and the FOMC to conduct monetary policy "so as to promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates." Because long-term interest rates remain moderate in a stable economy with low expected inflation, this set of goals is often referred to as the "dual mandate" of maximum employment and price stability.

[2] The FOMC's announcement may be found on the Federal Reserve Board's web site at the following link: https://www.federalreserve.gov/newsevents/pressreleases/monetary20190130c.htm.

actively manage, or frequently adjust, the supply of reserves to maintain interest rate control. The ample-reserves regime provides good control of the federal funds rate in a simple and efficient manner and enables effective transmission of the stance of policy to broader financial markets. Moreover, this regime has proven resilient to significant changes in the monetary and regulatory environments since the Global Financial Crisis of 2007-09.[3]

In this paper, we describe the Fed's "ample reserves" approach to implementing monetary policy, review its experience operating in this regime, and highlight some operational issues it may face on the path forward. This information is intended to enhance discussions and understanding of the Fed's actions and communications related to monetary policy implementation. In particular, the material may be used to supplement textbooks and other existing learning materials that may be out of date in their descriptions of how the Fed implements monetary policy when reserve supply is considered ample.

The rest of the paper proceeds as follows. Using a stylized demand and supply framework, we begin in section 2 by describing the roles of banks and the Fed in influencing reserves. We then describe how an "ample" quantity of reserves is determined and how the Fed controls the federal funds rate when the quantity of reserves is ample, including the basic mechanics of the tools the Fed uses in this operating regime. In section 3, we take a close look at the Fed's experience using this regime, and discuss the technical adjustments the Fed has implemented to ensure interest rate control. Turning to section 4, we describe some operational considerations the Fed may encounter as it seeks to maintain an ample quantity of reserves over time. Finally, section 5 concludes by highlighting the benefits of the FOMC's chosen

[3] For an overview of these changes and an analysis of their effects on money markets, see Klee, Senyuz, and Yoldas (2019).

implementation regime and reminds the reader of some key takeaways about its use going forward.

2. Policy implementation with ample reserves

The Fed implements monetary policy with the aim of keeping the federal funds rate in the FOMC's target range.[4] The federal funds rate (FFR) is the interest rate at which depository institutions, or what we term "banks," borrow reserves from and lend reserves to one another on an overnight basis to meet short-term funding needs.[5] To understand how the Fed implements policy, it is easiest to consider a stylized model of the demand for and supply of reserves.

2.1 Banks' demand for reserves

Banks may hold a portion of their cash in an account at the Fed; these funds are referred to as reserve balances, or reserves. One can think of banks' reserve accounts in much the same way as households' checking accounts. Just as individuals use the cash in their checking and other transactional accounts to facilitate their deposit and payment activities, banks use reserves in managing their liquidity needs. Unlike other liquid assets, reserve balances are immediately available throughout the day to make payments for lending, securities settlement, meeting deposit outflows, and for other intermediation activities.

There are many reasons for banks to demand reserves. Before the crisis, banks' demand was largely driven by the Fed's reserve requirements and banks' intraday payment needs. Today, a host of additional factors come into play. First, the Fed now pays interest on reserves,

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[4] The Fed actually seeks to keep the daily "effective" FFR in the target range. The effective FFR is the volume-weighted median rate of all overnight federal funds transactions that occurred on a given day. These data, published daily, may be found on the Federal Reserve Bank of New York's web site here: https://apps.newyorkfed.org/markets/autorates/fed%20funds.

[5] We use the term "banks" throughout to refer to depository institutions, which include commercial banks, savings banks, credit unions, thrift institutions, and most U.S. branches and agencies of foreign banks.

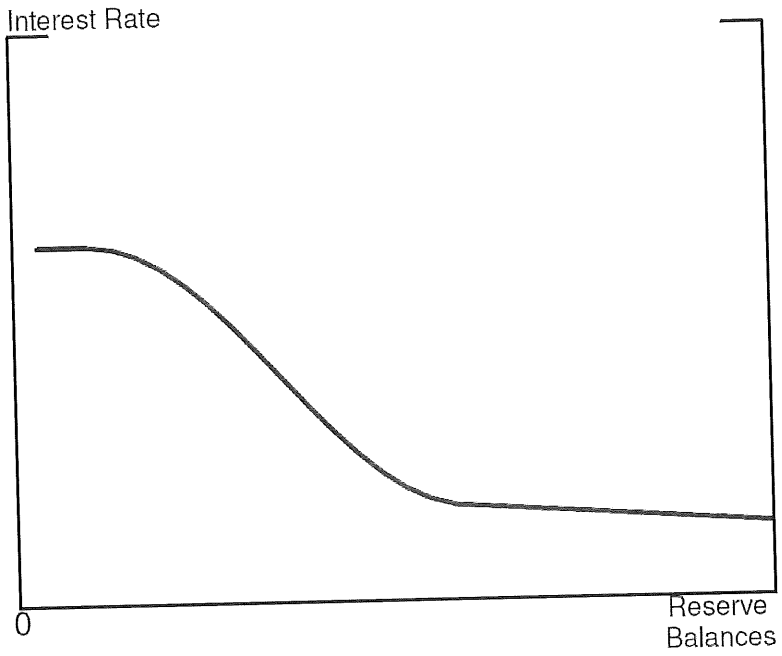
and so holding these balances has become more attractive. Second, in response to the financial crisis, banks have enhanced their internal liquidity risk management practices, taking into account their individual business models and liquidity preferences, and reserves are useful for this purpose. Third, banks may hold reserves to help meet several post-crisis regulatory liquidity standards created in part to enhance banks' self-sufficiency in times of financial stress, such as resolution planning and the liquidity coverage ratio. Finally, some changes in the federal funds market since the financial crisis have also boosted banks' demand for reserves. In particular, late-day trading conditions are less liquid and banks are more hesitant to tap intraday or other credit from the Fed. Taken together, the mix of factors influencing banks' demand for reserves today is complex and also likely to continue to evolve over time.[6]

Figure 1 provides a stylized illustration of a demand curve for reserves. This downward-sloping curve has two portions. The steep portion of the curve captures the idea that the higher the opportunity cost of holding reserve balances, the lower is banks' demand. Conversely, as the cost of overnight borrowing in the federal funds market falls, banks are generally inclined to hold more reserves to provide themselves with an extra liquidity cushion. On this steep portion of the curve, banks' demand is quite sensitive to changes in reserve supply; the rate at which these funds are traded, the federal funds rate, adjusts with even modest changes in reserve supply. The demand curve also has a nearly flat, or flat, portion, located where the quantity of reserves in the banking system is significantly larger. The transition from the steep portion of the curve to the nearly flat portion illustrates that as the quantity of reserves in the banking system increases, at

[6] Beginning in September 2018, the Federal Reserve has periodically conducted a *Senior Financial Officer Survey* to ask individual banks about their reserve balance management practices, including the importance of various factors in driving their reserve demand. In August 2019, banks responded that meeting routine intraday payment flows and satisfying internal liquidity stress metrics were very important factors in determining their demand for reserves. A summary of the results of each survey is published on the Federal Reserve Board's web site, available at the following link: https://www.federalreserve.gov/data/sfos/sfos.htm. In addition, Logan (2019a) discusses banks' demand for reserves.

some point, banks do not find much benefit from holding additional reserves other than earning the interest the Fed pays on these balances. As a result, and as we'll see below, the demand curve flattens out at a level that is close to the interest rate earned on reserve balances. On the flat portion of the curve, banks' demand is not sensitive to changes in reserve supply; the federal funds rate does not materially move when supply is adjusted either up or down.

Figure 1
Banks' Demand for Reserves



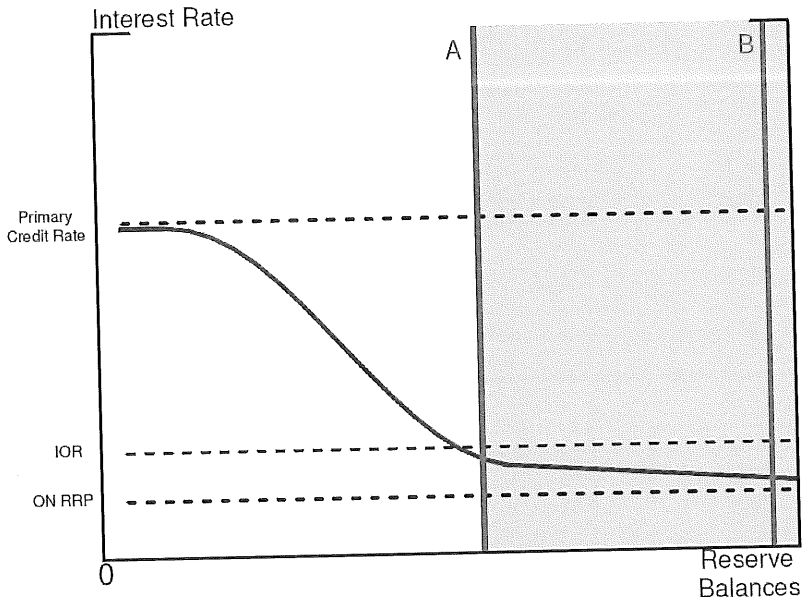
2.2 The Fed's supply of reserves

Many factors that affect the supply of reserves. Some influences are independent of the Fed's control, termed autonomous factors, and others are directly related to the Fed's actions, termed open market operations. Because the Fed understands how autonomous factors affect the supply of reserves, it can choose what operations to take, if any, in response. As a result, one should think of the Fed as controlling the supply of reserves in the banking system.

So what quantity of reserves must the Fed supply to be in an ample-reserves regime? The term "ample" is fundamentally tied to the location of the Fed's supply curve relative to banks' demand curve. In particular, to be ample, the Fed's reserve supply must be positioned so that the equilibrium FFR does not materially change with movements in the quantity of reserves in the banking system. This condition is met when the Fed's supply curve intersects banks' demand curve on the portion of the demand curve that is nearly flat.

Figure 2 illustrates the Fed's ample-reserves regime. The red supply curves are vertical because the Fed controls the level of reserves. To be in an ample reserves-regime, the quantity

Figure 2
The Fed's Ample-Reserves Regime



of reserves must be at least as large as the (stylized) quantity labeled "A"—reserve supply must fall in the gray shaded region. In this region, any supply curve will intersect the demand curve at its relatively flat portion, meeting the condition for being in an ample regime. While the quantity labeled "A" represents the minimum level of reserves needed to be in an ample-reserves regime,

the quantity "B" represents a super plentiful amount of reserves, and one that is also consistent with being in an ample regime.

An important takeaway from figure 2 is that the stylized gray region is very wide. An ample-reserves regime functions well with a wide range of reserve levels in the banking system, such as a quantity near, or even greater than, vertical line "B," as well as a quantity that is significantly smaller, such as closer to vertical line "A," or with any reserve quantity in between.

Over the past several years, the quantity of reserves supplied by the Fed has moved widely within this gray range. During the period from late 2008 to late 2014, the Fed conducted a series of large-scale purchases of longer-term securities to put downward pressure on longer-term interest rates in response to the Great Recession that severely weaken the U.S economy. When the Fed completed these purchases, reserves stood at a peak of $2.8 trillion, or 15 percent of U.S. nominal GDP.[7] At this time, the vertical supply curve was essentially near "B," a quantity sometimes referred to as "abundant" or "super abundant."[8] Then, as the economy recovered, the Fed took steps to reduce the supply of reserves. Between late 2014 and August 2019, reserves slowly declined, on balance, and at the end of this period, they stood near $1.5 trillion, a quantity much closer to "A." So at what approximate quantity of reserves might the Fed prefer to operate in the long run?

In January 2019, the FOMC announced its plans for implementing monetary policy over the longer run. The Committee described its choice of implementation regime this way:[9]

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[7] A summary of the Fed's purchase programs may be found on the Federal Reserve Board's web site at this link: https://www.federalreserve.gov/monetarypolicy/bst_openmarketops.htm. In addition, see Bernanke (2012) for a broader discussion of the Fed's response to the crisis.

[8] See Yellen (2017) for a discussion of the role of reserves in the policy implementation framework, both when reserves were relatively limited and when they were characterized as abundant.

[9] The FOMC's announcement may be found on the Federal Reserve Board's web site at the following link: https://www.federalreserve.gov/newsevents/pressreleases/monetary20190130c.htm.

> The Committee intends to continue to implement monetary policy in a regime in which an ample supply of reserves ensures that control over the level of the federal funds rate and other short-term interest rates is exercised primarily through the setting of the Federal Reserve's administered rates, and in which active management of the supply of reserves is not required.

With this announcement, the Committee communicated that it will not return to its pre-crisis implementation regime. In that limited-reserves regime, the Fed supplied an amount of reserves well to the left of vertical line "A" in figure 2; it operated on the steep portion of banks' demand curve where even modest changes in the supply of reserves affect the equilibrium level of the FFR. In addition, characterizing the desired supply of reserves as "ample" signaled that the Committee does not want to operate in the long run with a super plentiful amount of reserves, such as one depicted as being closer to vertical line "B." This indication is also tied to the Committee's previously stated intention that the Fed will, in the longer run, hold no more securities than necessary to implement monetary policy efficiently and effectively.[10] Thus, taking the pieces together, the Committee's announcement indicated that, going forward, the Fed will keep supplying a quantity of reserves in the gray region, and that the quantity will be closer to the vertical line labeled "A" than "B." With this framing, we now turn to how the Fed controls the FFR when the quantity of reserves in the banking system is in the gray region.

2.3 Rate control tools

When implementing monetary policy in an ample-reserves regime, the Fed primarily relies on its administered interest rates to keep the FFR within its target range. But it also

[10] Holding other parts of the Fed's balance sheet constant, an increase (decrease) in securities will increase (decrease) reserves. So a statement about "holding no more securities than necessary" is also saying the Fed plans to hold no more reserves than necessary to implement policy efficiently and effectively. Information about the Federal Reserve's Policy Normalization Principles and Plans is summarized on the Federal Reserve Board's web site at the following link: https://www.federalreserve.gov/monetarypolicy/policy-normalization-discussions-communications-history.htm.

periodically needs to adjust the quantity of reserves in the banking system, using open market operations, to maintain an ample supply. We describe each of these rate control tactics in turn.

Administered rates

Administered rates are standing interest rates the Fed sets, or administers. Currently, the Fed predominantly relies on two such interest rates. Each rate is available to a specific set of counterparties on particular cash deposits held at the Fed. The counterparties can decide if they want to deposit their cash at the Fed and earn the relevant standing rate or lend it instead to another market participant at a negotiated rate in one of the various money markets for cash. One can think of the Fed's administered rates as reservation rates—they set a lower bar on the return a counterparty is willing to accept from others in money markets. Hence, movements in the Fed's administered rates directly help steer money market interest rates.

The Fed's key administered rate is the interest on reserves (IOR) rate, the rate that banks earn from the Fed on the funds they deposit in their reserve accounts.[11] When choosing whether to hold some cash in their accounts at the Fed and earn the IOR rate or invest the cash in another money market instrument, such as Treasury bills, banks mainly consider their liquidity needs and the relative returns available on alternative investments. With the payment of IOR, banks have little or no incentive to lend reserves at rates lower than IOR, which is reflected in the flattening out of banks' reserve demand curve near the IOR rate (see figure 2). In this sense, the IOR rate acts as a reservation rate in banks' intermediation activities, helping to establish a minimum, or a

[11] Technically, the Fed pays interest on two different components of reserves—required reserves, tied to the Fed's reserve requirements as specified in Regulation D, and excess reserves, balances that are above the level of reserves banks are required by the Fed to hold. Under authority from Congress granted in the Financial Services Regulatory Relief Act of 2006 and the Emergency Economic Stabilization Act of 2008, the Board of Governors directed the Federal Reserve Banks to pay interest on required reserve balances and on excess balances, and these two rates are currently set equal. For simplicity, we use "IOR rate" to refer to the single rate at which the Federal Reserve Banks pay interest on all reserve balances.

floor, under the various overnight market returns that banks consider. In addition, as long as the supply of reserves remains ample, banks should compete with each other so that lending in the federal funds market occurs at rates that are never too far above the IOR rate. As a result, in an ample reserves regime, the FFR is expected to trade near the IOR rate. While it can be modestly above or below the IOR rate depending on seasonal factors and market conditions, the incentives described above combine to prevent the FFR from drifting away from the IOR rate. Because of the close linkage between the IOR rate and the FFR, the IOR rate is the Fed's primary tool of policy implementation—for keeping the FFR in its target range.

In addition to banks, various nonbank institutions actively participate in U.S. money markets, and these institutions are not eligible to earn IOR. For example, government-sponsored enterprises account for the majority of lending in the federal funds market since the financial crisis, and they often lend excess cash at rates below IOR. As a result, IOR by itself is unable to set a firm floor under the constellation of overnight money market rates. To enhance its rate control, the Fed introduced a supplementary tool, the standing overnight reverse repurchase (ON RRP) facility, to influence the interest rates at which nonbanks lend cash in money markets. The Fed began testing this form of open market operation in September 2013 and employed the facility when the FOMC first raised interest rates following the crisis in December 2015.[12]

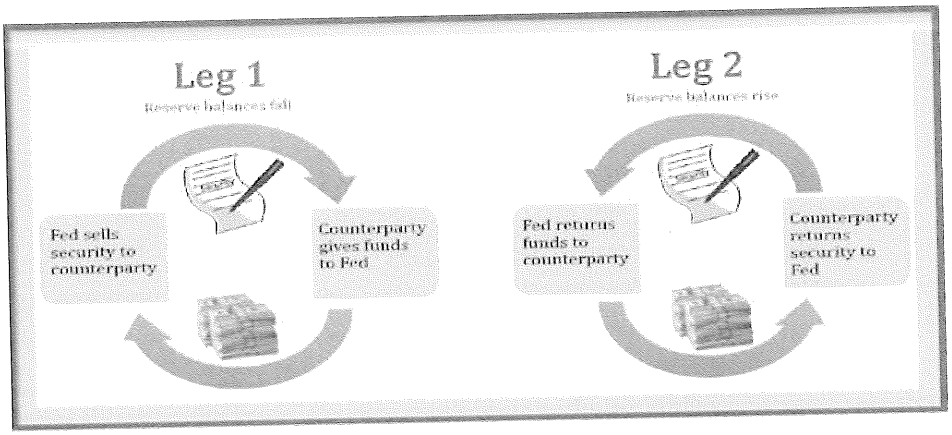
The FOMC sets the facility's offering rate (ON RRP rate), the maximum interest rate the Fed is willing to pay in an ON RRP transaction.[13] Figure 3 illustrates a reverse repurchase

[12] The Fed introduced the ON RRP facility in September 2013 and conducted test operations through late 2015. In September 2014, the FOMC indicated that it intended to use the facility as needed to help control the federal funds rate. For more information, see the Federal Reserve Board's and the Federal Reserve Bank of New York's web sites at these links, respectively: https://www.federalreserve.gov/monetarypolicy/overnight-reverse-repurchase-agreements.htm; https://www.newyorkfed.org/markets/rrp_faq.html.

[13] The interest rate a counterparty receives is the facility's offering rate except in the highly unlikely event that the amount of propositions the Fed receives exceeds the amount of securities available for the operation. In that case, the interest rate would be determined by an auction process conducted by the Federal Reserve Bank of New York, as described in the FAQs available at the following link: https://www.newyorkfed.org/markets/rrp_faq.html.

agreement (or reverse repo, or RRP) transaction between the Fed and one of its counterparties, and notes its effect on reserves. In the first leg of the transaction, the counterparty deposits its cash in the Fed's ON RRP facility and the Fed recognizes that some of its Treasury securities are temporarily sold to the counterparty. With this step, reserve supply declines by the amount of cash deposited in the Fed's facility. On the second day, or leg 2, the transaction is unwound, with the Fed returning to the counterparty their cash deposit plus interest earned, and with the interest tied to the ON RRP transaction rate. In addition, the temporary sale of the Treasury securities is unwound, and reserve supply increases. Given the nature of this transaction, take-up of the Fed's ON RRPs constitutes a type of open market operation.

Figure 3
Illustration of a Reverse Repo (RRP) Transaction



The ON RRP facility is available to about 130 counterparties. Many of these counterparties, including money market funds, government-sponsored enterprises, in addition to banks, are very active in money markets.[14] Because of the possibility of doing reverse repo with the Fed at its standing offering rate, these market participants have little incentive to lend cash to

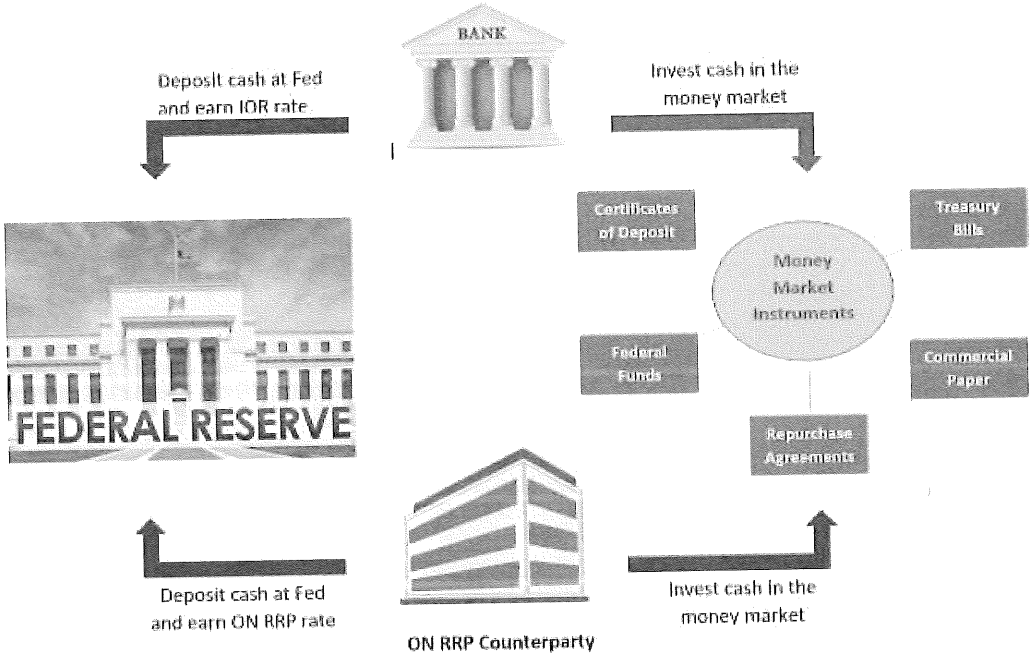
[14] For more on how the ON RRP facility complements the use of IOR and helps control short-term interest rates, including some issues the Fed considered in its design, see Frost et al. (2015).

others at a lower rate. Thus, for these counterparties, the ON RRP facility's offering rate plays a role similar to that of the IOR rate for banks—the ON RRP rate acts as a reservation rate in money market investment and cash management decisions, helping to put a floor under the various overnight market rates that these institutions consider, regardless of whether these counterparties actually use the Fed's facility on any given day or not. So while it's true that when take-up at the ON RRP facility rises, reserves decline (all else equal), the primary purpose of the facility is not to adjust reserve supply but to directly influence short-term interest rates faced by nonbanks.

Figure 4 illustrates how the Fed's IOR and ON RRP rates act as reservation rates for the Fed's counterparties—providing standing options for a range of money market participants when they consider investing their cash in various money market instruments or with the Fed.

Figure 4

The Fed's Administered Rates act as Reservation Rates



The Fed adjusts these administered rates in concert with changes in the target range for its policy rate, and its counterparties use the new levels of these reservation rates in their evaluation of where to invest cash. This dynamic allows the Fed to achieve the FOMC's desired stance of policy.[15] And, importantly, this approach to interest rate control does not require the Fed to frequently adjust the quantity of reserves in the banking system. But how does the Fed ensure the quantity of reserves remains ample over time?

Open market operations (OMOs)

Open market operations, or OMOs—purchasing or selling securities in the open market—are a long-standing tool of policy implementation. This tool is currently used in two different ways. As we noted above, for the past several years the Fed has been using an ON RRP facility designed to directly influence short-term *interest rates*. In addition, for decades, the Fed has used OMOs to alter the *quantity* of reserves it supplies—to purposefully expand or contract the amount of reserves in the banking system.[16] The latter type of OMOs, designed to adjust reserve quantities, is specifically used by the Fed to maintain an ample level of reserves in the banking system. As discussed above, to be in an ample-reserves regime, the Fed needs to maintain a quantity of reserves that is in the gray shaded region in figure 2, one that is at least as large as the (stylized) quantity "A." And, in so doing, the Fed must account for the effects of autonomous factors on the supply of reserves.

As noted in section 2.2, the Fed monitors several autonomous factors. Highlighted in Table 1, these factors are liabilities of the Fed other than reserves and include currency in

[15] Some erroneously refer to the Fed's ample-reserves implementation regime as a "corridor" regime. The Fed's ample-reserves regime is a "floor" regime with two floor, or deposit rates: one for banks (the IOR rate) and one primarily for nonbanks (the ON RRP rate). The fact that the Fed may set the IOR rate a bit above the ON RRP rate does not reflect an intention to create a rate corridor.

[16] For more information on how various OMOs affect reserves, see Ihrig, Mize, and Weinbach (2017).

circulation, the Treasury's cash account, or General Account, at the Fed (the TGA), and outstanding reverse repo agreements (the latter includes the Fed's foreign repurchase pool and balances at the ON RRP facility). Box 1 describes each of these non-reserve liabilities and their purpose. Here we describe how these factors intersect policy implementation.

Table 1
The Fed's Liabilities: Autonomous Factors Highlighted

Fed Liability Item	Amount* ($ billions)
Currency in circulation	1,748
Reserve Balances	1,695
U.S. Treasury, General Account (TGA)	404
Reverse repurchase agreements	224
Other liabilities	73

* As of February 12, 2020.
Source: Federal Reserve Board, H.4.1 statistical release.

The levels of the Fed's non-reserve liabilities move over time, exhibiting both long-run trend growth as well as short-run fluctuations. For example, currency in circulation has grown on average about 6 percent a year, and the public's demand often temporarily expands around holidays. Each of these influences causes reserves to decline, all else equal. In addition, Treasury's account at the Fed fluctuates, sometimes substantially, including around corporate and personal tax payment dates; the movements cause aggregate reserves to fluctuate in response, in the opposite direction. In general, reserves decline dollar-for-dollar when the Fed's non-reserve liabilities increase, and vice versa. The effects on reserves from changes in the

autonomous factors reflect the fact that the activities associated with each of the Fed's non-reserve liabilities clear through reserve accounts at the Fed.[17]

Does the Fed need to respond to the effects of changes in autonomous factors on reserves? The answer is, sometimes. When currency or another non-reserve liability grows, the Fed has to decide if it wants to offset the decline in reserves by purchasing securities in the open market. The Fed will conduct a permanent OMO (buy securities and hold them to maturity) if it thinks the drain in reserves is permanent; it will conduct a temporary OMO (a repurchase agreement or repo) if it thinks the drain is temporary.[18] Either of these actions will immediately expand the supply of reserves in the banking system, shifting any supply curve in figure 2 rightward within the gray region. Whether the Fed judges it needs to undertake one of these actions or not depends on the location of the original supply curve and the size of the effect on reserve supply relative to the quantity associated with the vertical line "A" in figure 2.

The discount window and other tools

The Fed also continues to administer several interest rates that it charges to banks for loans extended through its long-standing lending programs known collectively as the discount window. The Fed typically adjusts these rates in sync with its other administered rates. The main lending program is for primary credit—overnight loans extended to banks in generally sound financial condition. The primary credit rate is typically set above the general level of

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[17] For example, when a bank requests currency for its customers, an armored truck comes to a regional Federal Reserve Bank, picks up the cash that was ordered, and delivers it to the requesting bank. The Fed decreases the ordering bank's reserve account to take payment for the cash. (These steps are similar to those that occur when you go to your bank or an ATM for cash: When you withdraw cash, your bank takes payment by debiting your bank account.)

[18] A repo (or RP) operation is the opposite of the RRP transaction shown in figure 3. When the Fed conducts a repo, it lends cash to the market, temporarily purchases a security from an eligible counterparty, and agrees to sell the security back when the term of the contract ends, receiving the lent cash back plus interest when the transaction unwinds. Each year, the Federal Reserve Bank of New York publishes an annual report of open market operations conducted during the previous year, available at the following link: https://www.newyorkfed.org/markets/annual_reports.

short-term interest rates. This rate is depicted in figure 2 as the intercept of the demand curve on the y-axis because banks should be unwilling to buy reserves at market rates that are much, if any, above the rate they can pay to borrow from the Fed. In that sense, the discount window provides a backup source of funding for banks, with pricing that is intended to discourage frequent borrowing while still providing a ceiling on short-term market rates. However, for many years, banks have demonstrated reluctance to use the discount window out of concern that borrowing from the central bank sends negative signals about their financial condition, a dynamic typically referred to as the stigma associated with the use of the discount window. The Fed also maintains other policy implementation tools, ones that are less frequently relied upon.[19]

3. How has policy implementation worked with ample reserves?

The Fed has accumulated a lot of experience implementing policy with a sizable level of reserves. Here we take a look at the Fed's experience using an ample-reserves regime, including how the Fed has adjusted its tools to maintain the FFR in the FOMC's target range.

3.1 Transmission of the policy rate to other interest rates

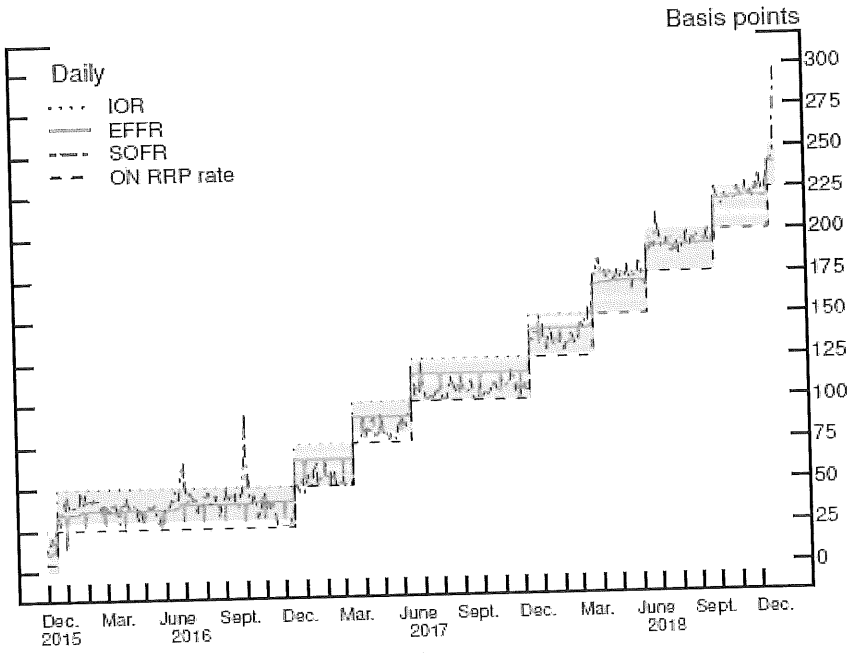
Figure 5 illustrates the movements in the Fed's administered rates and selected overnight money market rates over the most recent period of ups (panel A) and downs (panel B) in the target range, shown by the gray shaded regions. The IOR and ON RRP rates are shown by the dotted and dashed black lines, respectively. The blue solid line shows the (effective) federal funds rate, and the red dash-dotted line shows the secured overnight financing rate, or SOFR, which is a broad measure of the cost of borrowing cash overnight when collateralized by Treasury securities. Panel A begins with the first step in the Fed's process of normalizing the stance of monetary policy after the Great Recession. Specifically, in December 2015, after seven

[19] A summary of all of the Fed's policy tools can be found on the Federal Reserve Board's website. https://www.federalreserve.gov/monetarypolicy/policytools.htm.

Figure 5

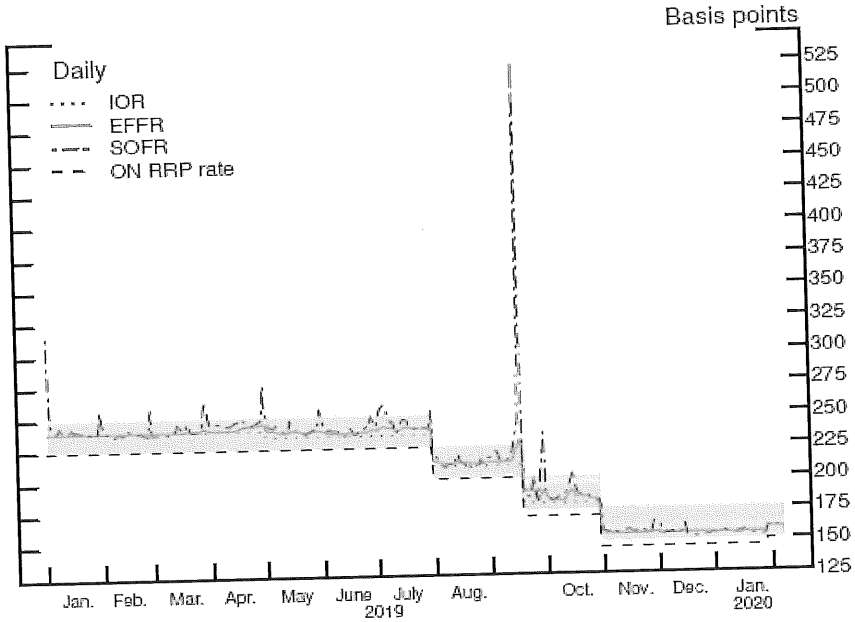
Policy Rate Pass-through to Selected Overnight Money Market Rates

Panel A: Pass through of policy rate hikes



Source: Federal Reserve Bank of New York.

Panel B: Pass through of policy rate cuts



Source: Federal Reserve Bank of New York.

years of keeping the fed funds rate near zero (in a range of 0 to ¼ percent), the FOMC increased its target range for the federal funds rate by ¼ percent (25 basis points), to a range of ¼ to ½ percent. At that time, the Fed's key administered rates, the IOR and ON RRP rates, were set at the top (0.50 percent) and bottom (0.25 percent) of the target range, respectively.[20] Immediately after the Fed increased both administered rates, a constellation of short-term market interest rates moved up simultaneously. Since then, the FOMC increased the target range for the federal funds rate eight more times through the end of 2018. Then, as shown in panel B, the FOMC reduced the target range three times in 2019 to cushion the economy from possible headwinds to economic growth. With each of the FOMC's decisions to move the target range up or down, the Fed adjusted its administered rates accordingly, and the federal funds rate and other short-term market rates followed suit.[21]

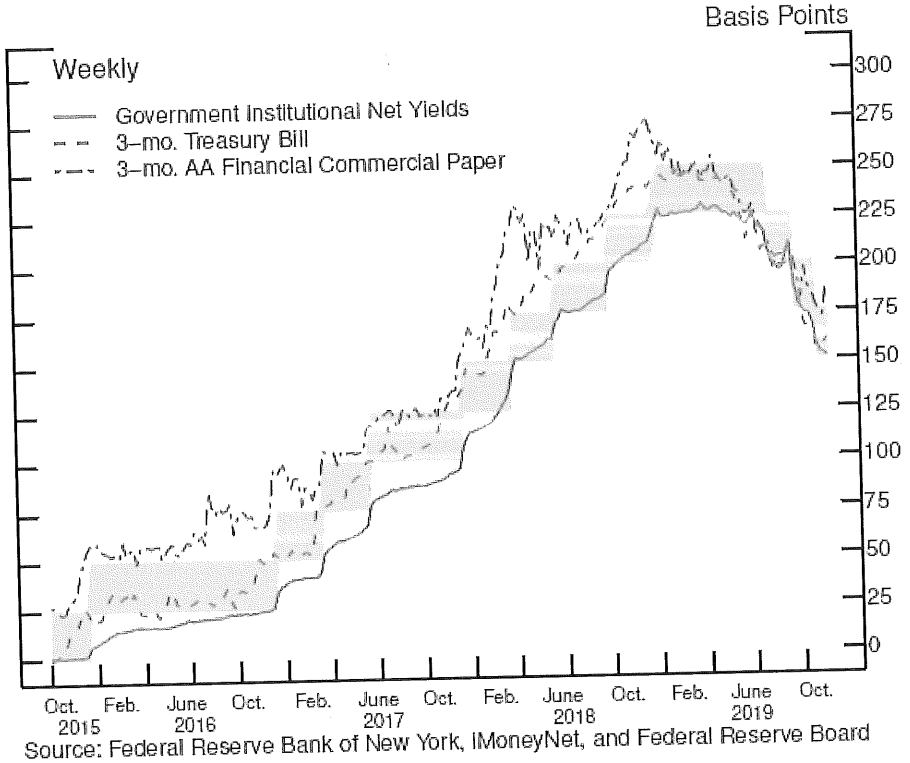
One can see that the changes in the FFR and other short-term interest rates also passed through to longer-term interest rates. For example, figure 6 plots three such rates. The rate shown in solid green is the net yield on government money funds held by institutional investors, which reflects the weighted-average return on the underlying assets held, less fees charged, by the fund. Also shown are rates on 3-month Treasury bills (the purple dashed line) and AA-rated commercial paper of financial companies (the red dash-dotted line). Each of these rates also moved with the changes in the FOMC's target range. In fact, these rates moved up and down a bit in anticipation of the Fed's policy rate changes as term interest rates reflect not only prevailing overnight interest rates but also market participants' expectations for the level of

[20] For a full discussion of how the Fed designed its tools to work at liftoff, see Ihrig, Meade, and Weinbach (2015).
[21] During the period shown, there were two days only when the daily effective FFR printed outside of the target range. On December 31, 2015, the effective FFR printed five basis points below the bottom of the target range and on September 17, 2019, it printed five basis point above the top of the target range.

overnight rates in the future.[22] When market participants expect the Fed to tighten or ease the stance of policy, term rates can rise or fall to some extent ahead of the FOMC's actual decision.

Figure 6

Policy Rate Pass-through to Selected Longer-term Interest Rates



Source: Federal Reserve Bank of New York, IMoneyNet, and Federal Reserve Board H.15 release.

Overall, the FOMC's adjustments to the stance of policy have transmitted to a relatively broad set of market interest rates and influenced financial conditions, as well as consumers' and businesses' economic decisions. These adjustments ultimately created conditions that have helped prolong the post-crisis economic expansion by fostering the achievement of both legs of the FOMC's dual mandate.

[22] For a more detailed account of how the first three post-crisis rate hikes were transmitted to other interest rates, see Anderson, Ihrig, Styczynski, and Weinbach (2017).

3.2 Technical adjustments within the implementation regime

As we just discussed, the FOMC has been successful in steering the federal funds rate up and down to reflect the desired stance of monetary policy, and those changes have transmitted to broader financial conditions. Part of the Fed's success in maintaining the FFR within the target range has been due to its flexibility in adjusting the parameters of its implementation tools as needed to support interest rate control. These actions are purely technical measures to support the effective implementation of monetary policy; such actions do not represent a change in the stance of monetary policy. In this subsection, we discuss two broad categories of technical adjustments that the Fed has made in response to evolving financial market conditions and as it has gained more experience with the current operating regime.

Technical adjustments to the Fed's administered rates

A close look at either panel in figure 5 reveals that the position of the IOR rate (the dotted black line) relative to the top of the FOMC's target range (the top of the shaded region) has not remained fixed. At times, such as when pressures in short-term funding markets have emerged, the Fed has made technical adjustments to the setting of the IOR rate to help keep the FFR trading within the target range. For example, in the spring of 2018, upward pressure on money market rates, including the effective FFR, materialized. The pressure seemed to stem from a large increase in the net supply of Treasury bills, which pushed the yields on those securities higher and, with increased repo financing activity on the part of the bill holders, put some upward pressure on repo rates. As a result, a constellation of short-term money market interest rates moved higher, the effective FFR increased within the target range, and money funds allocated their cash investments into higher-yielding Treasury bills and private repo instead of into the Fed's ON RRP facility. To ensure that the effective FFR remained well within the target

range, the Fed made a small downward technical adjustment to the IOR rate, reducing it by 5 basis points, to a level that was 5 basis points below the top of the target range. This change was accomplished by implementing a 20-basis-point increase in the IOR rate at a time when the FOMC raised the target range by 25 basis points.

The Fed made a few more technical adjustments to the IOR rate between 2018 and 2020. In 2018 and 2019, the Fed again lowered the IOR rate relative to the top of the target range. And in September 2019, the Fed also simultaneously lowered the ON RRP rate, setting it 5 basis points below the bottom of the target range, keeping a spread between the IOR and the ON RRP rates of 10 basis points. These small technical adjustments exerted downward pressure on the federal funds rate and other money market rates and fostered trading in the federal funds market at rates well within the target range. The Fed has also made adjustments in the other direction. In January 2020, the Fed unwound its previous step, adjusting the IOR and ON RRP rates each higher by 5 basis points, to keep the FFR trading well within the target range. These technical adjustments, all made within the ample-reserves regime, are used for policy implementation purposes only.[23]

Technical adjustments to the supply of reserves

Although active management of the supply of reserves is not, by design, a feature of an ample-reserves regime, there are times when the Desk may take steps, in accordance with the direction it receives from the FOMC, to adjust the supply of reserves in order to support interest rate control. This step was taken in mid-September 2019 when strains in funding markets

[23] The Fed publishes an Implementation Note after every FOMC meeting and any time implementation adjustments are made, available on the Federal Reserve Board's web site (with other FOMC meeting documents) at the following link: https://www.federalreserve.gov/monetarypolicy/fomccalendars.htm.

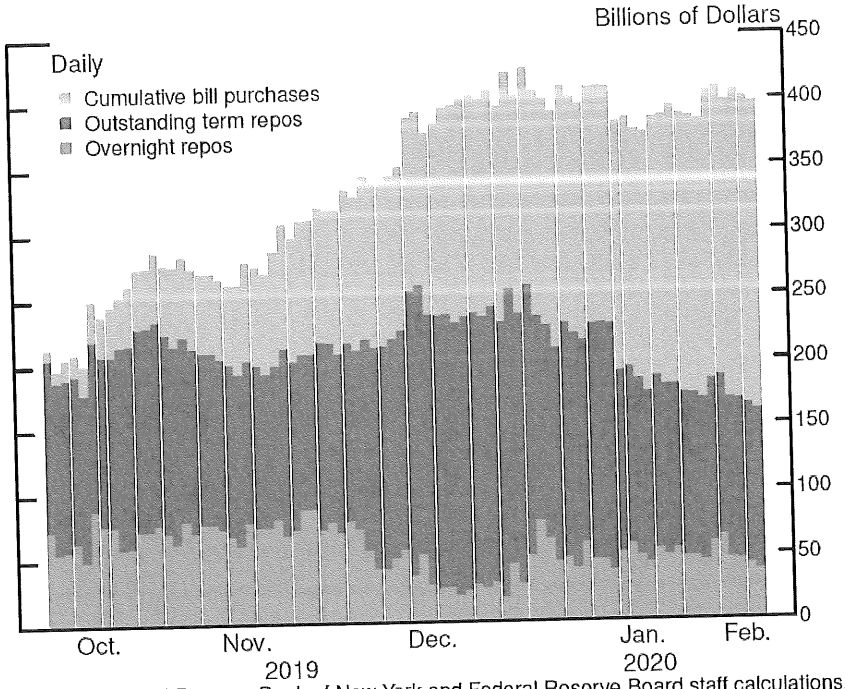
emerged as quarterly corporate tax payments and the settlement of Treasury securities coincided and resulted in a large amount of cash being drained from money markets.[24] In fact, reserve balances fell by more than $100 billion over just two days. Although the drain in reserves associated with seasonal tax payments was expected to put some upward pressure on money market rates, the increases in rates that materialized were exceptionally large by historical standards. As shown in panel B of figure 5, the SOFR (red dash-dotted line) spiked and the effective FFR (blue solid line) moved 5 basis points above the target range. The moves in each rate were much larger than those observed over the past few years. (Box 2 presents an analysis of the relationship between changes in the quantity of reserves and the FFR and provides estimates of rate sensitivity at various reserve levels.) In response to these market developments, and consistent with the directive from the FOMC to maintain the FFR in the FOMC's target range, the Desk undertook OMOs to temporarily purchase securities to add reserves. Specifically, the Desk conducted repos to provide immediate liquidity to the market and help alleviate the funding strains, ensuring the FFR resumed trading within the target range.

In addition, the FOMC judged that the prevailing level of reserve supply at that time may have been a bit too low to be consistent with operating in an ample-reserves regime. Accordingly, in early October 2019, the FOMC directed the Desk to maintain over time reserve balances at least as large as the level that had prevailed in "early September," a time when there were no evident pressures in money markets, and instructed the Desk how to go about increasing reserve supply. Consistent with those instructions, the Desk announced further overnight and term repos (temporary OMOs) as well as reserve management purchases in the form of outright

[24] See Anbil, Anderson, and Senyuz (forthcoming 2020) for an overview of money market events in September 2019, including a more detailed discussion of the factors that contributed to the strains that emerged in the repo market.

purchases (permanent OMOs) of Treasury bills at a pace of about $60 billion per month at least into the second quarter of 2020. The Committee explicitly noted that these bill purchases were purely a technical measure to increase reserve levels and support the effectiveness of monetary policy implementation.[25] Figure 7 shows the composition of these reserve management OMOs, which totaled several hundred billion dollars as of February 2020.

Figure 7
The Fed's Reserve Management OMOs in 2019-2020



Source: Federal Reserve Bank of New York and Federal Reserve Board staff calculations.

Looking ahead, once reserve balances are judged to be sufficiently high, the need for sizable Treasury bill purchases will diminish, and the Fed will likely scale back or phase out its repo operations.[26] At that time, the Fed will be in position to conduct OMOs over time solely to

[25] See the FOMC's October 2019 "Statement Regarding Monetary Policy Implementation," available at this link: https://www.federalreserve.gov/monetarypolicy/files/monetary20191011a1.pdf. Logan (2019b) reviews money market developments over the year and also discusses these particular open market operations.
[26] For a discussion of FOMC participants' views on this issue, see the minutes to the January 2020 FOMC minutes, available at the following link: https://www.federalreserve.gov/newsevents/pressreleases/monetary20200219a.htm.

accommodate trend growth in autonomous factors to maintain an ample level of reserves, a discussion we take up in the next section.

4. Maintaining ample reserves

Looking ahead, the Fed will seek to stay in an ample-reserves regime by supplying a quantity of reserves that is consistently ample, avoiding the need to actively manage the supply of reserves. To do so, the Fed will continue to be vigilant in monitoring various factors that could potentially affect the level or variability of reserves, continue to gain more information about banks' evolving demand for reserves, and remain ready to respond if the need arises. Here we discuss some considerations that might arise in maintaining an ample reserves-regime. Note that our discussion of these issues is intended to be illustrative, not exhaustive.

4.1 Evolution of autonomous factors

As we discussed in section 2.3, autonomous factors include currency, the Treasury's General Account (TGA), reverse repos, and other Fed liabilities that are directly linked, operationally, with the supply of reserves. As the level of these factors increase or decrease, they drain or add reserves, shifting the Fed's supply curve left or right, respectively.

Equation 1 shows how the Fed's supply of reserves, R, evolves over time:

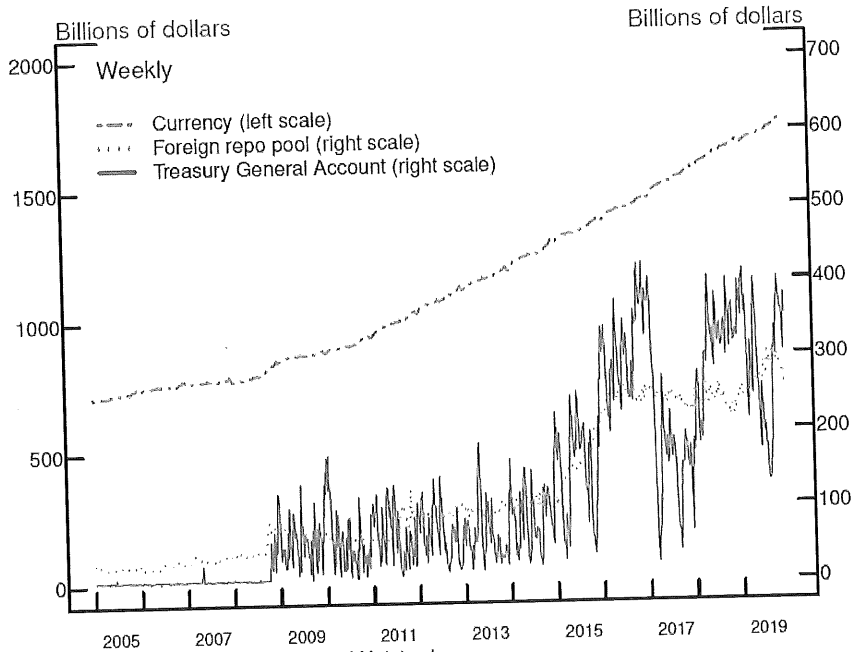
$$R_t = R_{t-1} - \Delta AF_t + OMOs_t \qquad (1)$$

The equation captures the fact that today's level of reserves will be equal to yesterday's quantity in the absence of any changes in autonomous factors (AF) or OMOs.[27] But, as shown in Figure

[27] In this equation, "*OMOs*" are defined as the aggregate net addition to reserves from these operations (any reverse repos would be accounted for with a negative sign).

8, autonomous factors exhibit substantial fluctuations in the short run and also grow over time. Moreover, the degree of variation in these factors can change over time; each of the factors exhibits more variability now than prior to the crisis. This pattern is particularly true for the TGA, the most volatile factor (the solid red line). Taken together, over the past few years, the weekly swings in the factors suggest that, at the extreme, they can jointly change by about $200 billion from one week to the next.

Figure 8
Selected Fed Non-Reserve Liabilities



Source: Federal Reserve Board H.4.1 release.

The Fed needs to consider these short-run movements in autonomous factors in ensuring its supply of reserves remains ample. In particular, the variability of the autonomous factors influences the Fed's judgment about the practical location of the vertical line "A" in figure 2—the minimum quantity of reserves that constitutes being in an ample-reserves regime. So what is

the Fed's desired minimum level of reserves? When asked about this topic, Chair Powell replied with a detailed response that is linked to our discussion.[28]

> *"... in terms of the actually desired reserve level, we know that reserves will continue to move up and down over the course of the calendar year in a wide range depending on volatility in non-reserve liabilities, particularly the Treasury General Account, or TGA. In particular, reserve levels will need to be at a level high enough to remain ample even when the TGA peaks during the April tax season. Effectively, what that means is that we need reserves at all times to be no lower than they were in early September [2019]—and, I would say, around $1½ trillion, subject to learning more. ... So, most of the time, reserves will be moving in a range substantially higher than that but not going below $1½ trillion."*

In other words, in setting the quantity "A," the Fed explicitly accounts for the short-run variability in autonomous factors. The Fed sets "A" large enough to stay consistently in an ample reserves-regime, even when autonomous factors occasionally cause a very large drain in reserves. And, given that the behavior of the autonomous factors could evolve over time, the Fed's view of the location of "A" could change going forward.

In addition to daily fluctuations in autonomous factors, the Fed also needs to consider their long-run growth in ensuring its supply of reserves remains ample, that is, at least as large as a given quantity "A." As shown in figure 8, currency (the purple dash-dotted line), trends up over time. As noted above, currency has expanded an average of about 6 percent per year, and with more than $1.5 trillion of currency in circulation, such growth amounts to a large nominal increase each year.[29] The TGA has also grown over the past decade, and the size of this account

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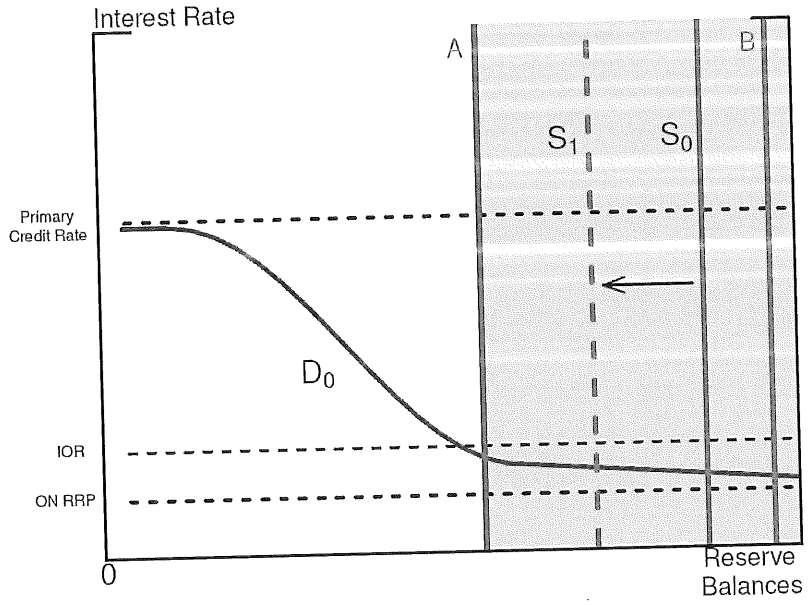
[28] See the transcript of Chair Powell's January 2020 press conference, available on the Federal Reserve Board's web site at the following link: https://www.federalreserve.gov/mediacenter/files/FOMCpresconf20200129.pdf.

[29] For example, currency in circulation has nearly doubled over the past decade, expanding from about $985 billion at the end of 2010 to about $1.7 trillion in February 2020. This means that the Fed's balance sheet would have expanded by more than $700 billion over that period regardless of any other factors. Data on currency in circulation are available on the Federal Reserve Board's web site at the following link: https://www.federalreserve.gov/releases/h6/.

could continue to expand as the nominal value of payment flows managed by the Treasury increases over time. Overall, the long-term growth of these autonomous factors will slowly, but permanently, drain reserves. This reserve-draining effect is illustrated in figure 9, with the leftward shift in the supply curve, from S_0 to S_1.

Figure 9

Reserve Supply is Drained by an Expansion of Autonomous Factors



To offset the reserve-draining effect of trend growth in its non-reserve liabilities, the Fed will, over time, need to regularly conduct permanent OMOs (reserve management purchases) to inject reserves into the banking system and shift the supply curve back to the right. For example, if the Fed estimates that its non-reserve liabilities will grow by $10 billion a month, it would need to purchase $10 billion of Treasury securities each month to offset the reserve-draining effects of this growth. These OMOs will be necessary over time to keep the quantity of reserves ample.

4.2 Other factors

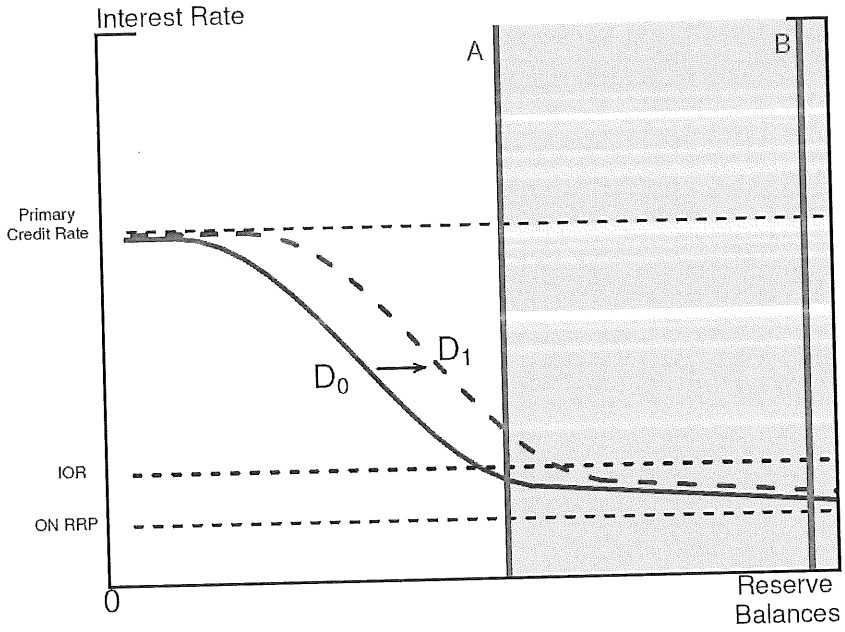
Unlike the autonomous factors that are known to affect the supply of reserves each day, other, less certain, factors may change the supply of or demand for reserves over time. And, of course, still other factors may one day need to be taken into consideration that are not yet conceived today. Here we provide a couple of examples of such potential factors for illustrative purposes. Given the uncertainty with which various factors may materialize, as well as their ultimate influence on the federal funds and other money markets, the Fed will need to stay vigilant in monitoring conditions in money markets going forward.

We start by thinking about factors that could affect the demand for reserves. First, consider a development that significantly reduces banks' demand for reserves. For example, a technological change could enable banks to speed the processing of payments and economize on cash, or the Fed could introduce a change to its existing policies or tools that lead banks to have a greater preference for investing in non-reserve liquid assets. In this situation, the Fed's existing supply of reserves would still be ample. Next, consider the opposite case, a development that results in a marked increase in banks' demand for reserves. For example, banks' preference for holding reserves could shift higher as a result of new or persistently heightened perceptions of liquidity risks. In this situation, the Fed could need to take action to ensure the quantity of reserves it supplies remains ample.

Figure 10 illustrates a rightward shift in the demand curve, from D_0 to D_1. In this scenario, the vertical line "A" would move to the right along with the outward shift of the demand curve. Would the Fed need to adjust its supply curve? The answer is that it depends. If supply was sufficiently to the right of "A" when that point shifts, the Fed's current implementation regime would still work fine. If instead reserve supply was close to "A" when

that point shifts, the Fed would likely need to add some reserves to the banking system, by conducting OMOs in the form of permanent purchases of securities, to remain in an ample-reserves regime relative to the new position of "A."

Figure 10
Increase in Demand for Reserves in an Ample-Reserves Regime



One can also conceive of considerations that could affect the Fed's long-run supply of reserves. One such consideration is the long-run implications of the current, low interest rate environment on reserve supply. For some time now in the United States and in other advanced economies around the world, macroeconomic variables such as average inflation, output growth, and short- and longer-term interest rates have been persistently low relative to their longer-term historical norms.[30] As a result, the Fed and many other central banks have been operating in

[30] Many factors are contributing to the current macroeconomic environment—well-anchored inflation expectations in the context of improved monetary policy, aging demographics, increased globalization, slower productivity

economic environments in which the policy rate is set relatively low. If growth of the U.S. economy were to significantly slow, the FOMC would likely lower the policy rate, as usual, to provide stimulus to economy activity. However, there is less room for the FOMC to provide stimulus to the economy by lowering the policy rate if the federal funds rate is already relatively low. To provide additional policy accommodation in such circumstances, the FOMC would most likely need to employ large-scale asset purchases, as it did during the financial crisis and subsequent severe recession. Regardless of its starting point, purchases of this size would shift the supply curve well to the right, closer to vertical line "B" in figure 2. On balance in this situation, the current regime would seamlessly continue to work, providing the Fed a means of stable interest rate control as the FOMC provided needed economic stimulus to the economy.

5. Concluding remarks

The Fed is one of many central banks around the world that is implementing monetary policy with plentiful reserves. In this primer, we provided a stylized framework to describe how a central bank implements policy in such a regime, including the specific tools the Fed uses to ensure interest rate control with ample reserves. We reviewed the effectiveness of the regime over the past decade and discussed some operational considerations relevant for maintaining an ample supply of reserves going forward.

Our discussion highlighted some of the Fed's key motivations for choosing to operate in an ample-reserves regime in the long run. First, as described in section 2, an ample-reserves regime is simple and efficient to operate. While the Fed needs to manage reserve supply in any implementation regime, the ample-reserves regime eliminates the need for the Fed to intervene in

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growth, greater demand for safe assets, and weaker links between unemployment and inflation. And these factors seem likely to persist. For more discussion of this issue, see Chair Powell's speech on "Challenges for Monetary Policy," available at the following link: https://www.federalreserve.gov/newsevents/speech/powell20190823a.htm.

markets on a daily basis, which is an operationally attractive feature. Second, as shown in section 3, the regime is effective. The Fed's administered rates have enabled successful control of the federal funds rate and its transmission to other short-term interest rates as well as to broader financial conditions, all of which support the FOMC's achievement of its dual mandate. Third, as highlighted in section 3 and discussed in section 4, the regime has proven resilient to a variety of changes in the economic, financial, and regulatory environments, and is expected to stay so going forward.

Finally, we emphasized that operating in an ample-reserves regime going forward, the Fed will periodically need to add reserves to the banking system to accommodate ongoing growth in its non-reserve liabilities, and also highlighted the importance of monitoring for developments that could necessitate a shift in the Fed's assessment of the minimal quantity of reserves needed to stay in an ample-reserves regime. Overall, the Fed will need to be vigilant in monitoring conditions that influence banks' evolving reserve demand, the autonomous factors that affect reserve supply, and other dynamics that might shift reserve demand or supply as the economy and financial markets continue to evolve.

Box 1
The Fed's Non-reserve Liabilities

Many of the Fed's liabilities arise from its statutory responsibilities, such as supplying currency to the public and serving as the U.S. Treasury's fiscal agent. Each liability has social benefits and plays an important role as a safe and liquid asset for the public, the banking system, the U.S. government, or other institutions. Here we briefly describe each of the Fed's primary non-reserve liabilities.[31] A key point is that, taken together, the Fed's non-reserve liabilities tend to increase over time. This is because the Fed's largest liability, currency, and to which we first turn, exhibits trend growth.

Federal Reserve notes. Federal Reserve notes outstanding—also known as (paper) currency in circulation, or simply currency, shown as the green region in the chart—have traditionally been the largest liability item on the Fed's balance sheet. The public's demand for currency tends to increase with the nominal size of the economy because households and businesses have sought, collectively, to hold more cash as the volume of economic transactions grows. In addition, with heavy usage of U.S. currency overseas, changes in global economic growth, as well as in financial and geopolitical stability, can also materially affect the rate of U.S. currency growth. Over the past decade, the amount of notes in circulation has almost doubled, from about $900 billion in late 2009 to almost $1.8 trillion by early 2020.

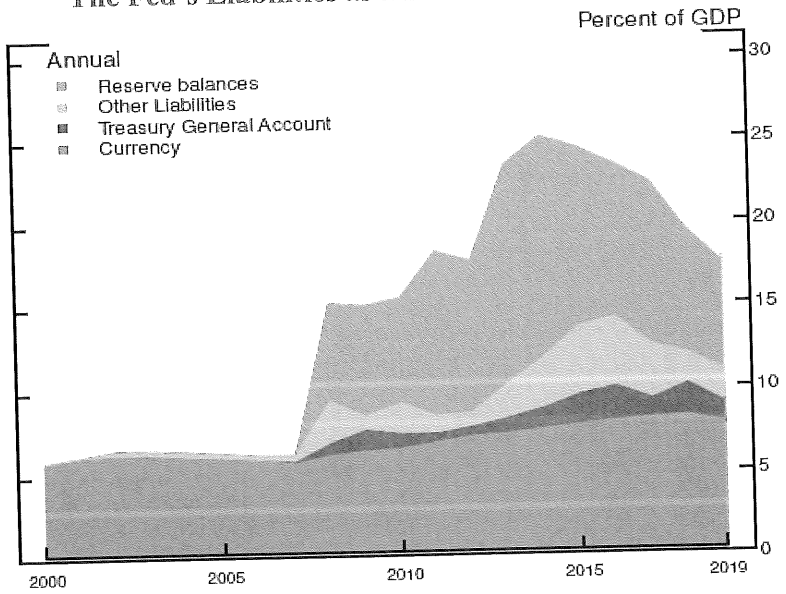
Treasury General Account (TGA). The U.S. Treasury holds cash balances at the Fed in the TGA, shown by the blue region in the chart. Treasury's payments activity flows through this account—the account is used to collect tax payments and to receive the proceeds of Treasury's securities sales, and it is used to pay the federal government's bills, including interest and principal on maturing Treasury securities. Prior to 2008, the Treasury targeted a steady, low balance of $5 billion in the TGA on most days, and it used separate, private accounts at commercial banks to manage the bulk of its cash flows outside of the TGA. Since 2008, the Treasury has used the TGA as its primary account for managing its cash flows. In May 2015, the Treasury announced its intention to hold in the TGA a level of cash generally sufficient to cover

[31] Data on the Fed's assets and liabilities are published weekly on the Board's H.4.1 statistical release, available at the following link: https://www.federalreserve.gov/releases/h41/.

one week of outflows, subject to a minimum balance of roughly $150 billion.[32] The rationale for this decision was to protect the resilience of government payments and to avoid potential concerns about the safety of U.S. government debt that could be damaging for the global financial system. As of the end of 2019, the TGA stood above $300 billion.

Foreign Repo Pool. The Fed conducts overnight reverse repo with foreign official accounts, also known as the foreign repo pool and included in the yellow region of the chart, in order to provide an investment option for foreign official institutions. The daily amount invested in the foreign repo pool has also increased in recent years. The Fed has long offered this custodial service to foreign central banks, foreign governments, and international official institutions to facilitate immediate access to dollar liquidity to support their operational needs, to clear and settle securities in their accounts, or to address any unexpected dollar shortages. The foreign repo pool has grown from an average level of around $30 billion before the crisis to a current average of about $250 billion, equivalent to a little more than 1 percent of GDP, reflecting in part foreign central banks' preference to maintain more substantial dollar liquidity buffers since the crisis.

Figure 1.1
The Fed's Liabilities as a Share of Nominal GDP



Source: Federal Reserve Board.

[32] Treasury's press release containing this announcement may be found on its web site at the following link: https://www.treasury.gov/press-center/press-releases/Pages/jl0249.aspx.

Other deposits. Other deposits, also included in the yellow region of the chart, consist of balances held at the Fed by international and multilateral organizations as well as government-sponsored enterprises. This liability item also includes the accounts of Designated Financial Market Utilities (DFMUs) which provide the infrastructure for transferring, clearing, and settling payments, securities, and other transactions among financial institutions. Other deposits have risen from less than $1 billion before the crisis to about [$80 billion] at the end of 2019, owing mainly to the establishment of accounts for DFMUs that have been designated as systemically important by the Financial Stability Oversight Council (FSOC).

Overnight reverse repo (ON RRP) facility. When the Fed's eligible counterparties choose to take up ON RRPs at the Fed's facility, the cash they deposit is logged as an increase in the Fed's reverse repo liabilities; this item is also included in the yellow region of the chart. Over the past half-decade, the outstanding amount of ON RRPs has ranged from $0 to more than $350 billion, largely depending on the relative positions of comparable money market interest rates and other conditions in money markets.

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Federal Reserve Board of Governors

Statement on Longer-Run Goals and Monetary Policy Strategy

As adopted effective January 24, 2012

Following careful deliberations at its recent meetings, the Federal Open Market Committee (FOMC) has reached broad agreement on the following principles regarding its longer-run goals and monetary policy strategy. The Committee intends to reaffirm these principles and to make adjustments as appropriate at its annual organizational meeting each January.

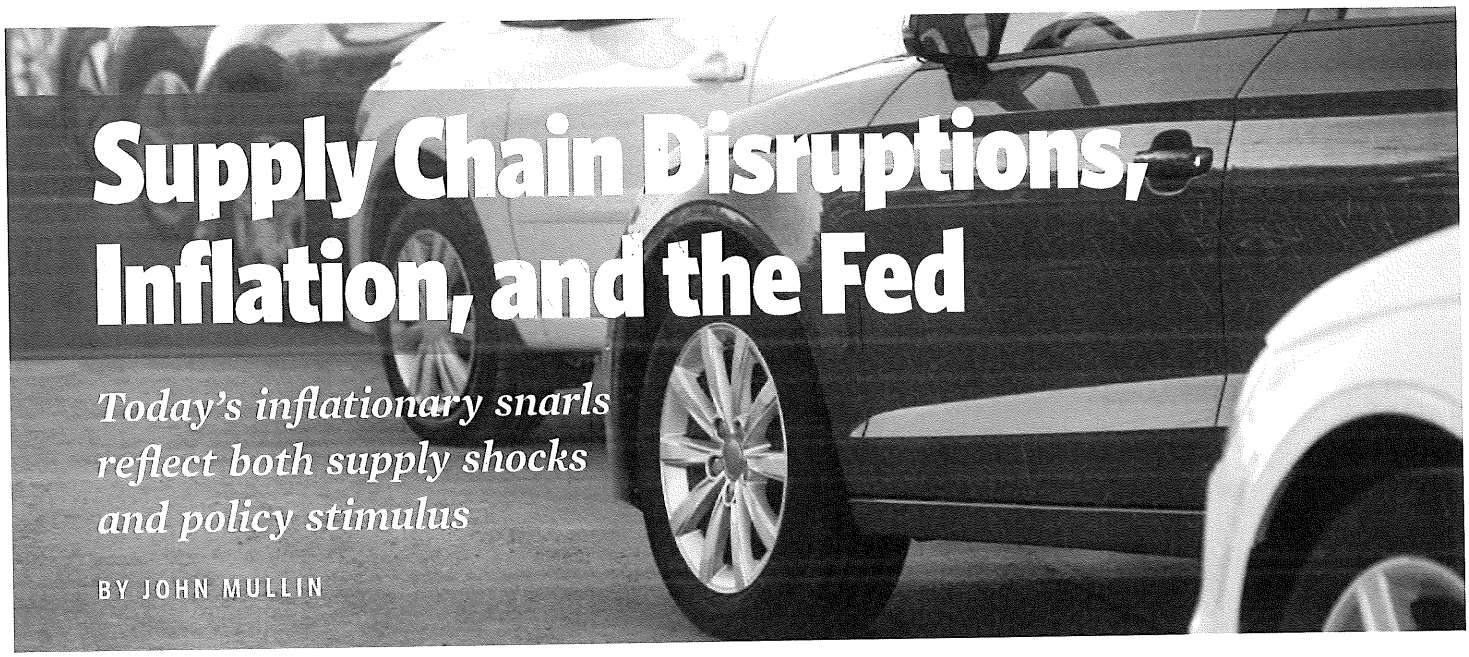
The FOMC is firmly committed to fulfilling its statutory mandate from the Congress of promoting maximum employment, stable prices, and moderate long-term interest rates. The Committee seeks to explain its monetary policy decisions to the public as clearly as possible. Such clarity facilitates well-informed decisionmaking by households and businesses, reduces economic and financial uncertainty, increases the effectiveness of monetary policy, and enhances transparency and accountability, which are essential in a democratic society.

Inflation, employment, and long-term interest rates fluctuate over time in response to economic and financial disturbances. Moreover, monetary policy actions tend to influence economic activity and prices with a lag. Therefore, the Committee's policy decisions reflect its longer-run goals, its medium-term outlook, and its assessments of the balance of risks, including risks to the financial system that could impede the attainment of the Committee's goals.

The inflation rate over the longer run is primarily determined by monetary policy, and hence the Committee has the ability to specify a longer-run goal for inflation. The Committee judges that inflation at the rate of 2 percent, as measured by the annual change in the price index for personal consumption expenditures, is most consistent over the longer run with the Federal Reserve's statutory mandate. Communicating this inflation goal clearly to the public helps keep longer-term inflation expectations firmly anchored, thereby fostering price stability and moderate long-term interest rates and enhancing the Committee's ability to promote maximum employment in the face of significant economic disturbances.

The maximum level of employment is largely determined by nonmonetary factors that affect the structure and dynamics of the labor market. These factors may change over time and may not be directly measurable. Consequently, it would not be appropriate to specify a fixed goal for employment; rather, the Committee's policy decisions must be informed by assessments of the maximum level of employment, recognizing that such assessments are necessarily uncertain and subject to revision. The Committee considers a wide range of indicators in making these assessments. Information about Committee participants' estimates of the longer-run normal rates of output growth and unemployment is published four times per year in the FOMC's Summary of Economic Projections. For example, in the most recent projections, FOMC participants' estimates of the longer-run normal rate of unemployment had a central tendency of 5.2 percent to 6.0 percent, roughly unchanged from last January but substantially higher than the corresponding interval several years earlier.

In setting monetary policy, the Committee seeks to mitigate deviations of inflation from its longer-run goal and deviations of employment from the Committee's assessments of its maximum level. These objectives are generally complementary. However, under circumstances in which the Committee judges that the objectives are not complementary, it follows a balanced approach in promoting them, taking into account the magnitude of the deviations and the potentially different time horizons over which employment and inflation are projected to return to levels judged consistent with its mandate.



Supply Chain Disruptions, Inflation, and the Fed

Today's inflationary snarls reflect both supply shocks and policy stimulus

BY JOHN MULLIN

Used cars became a hot commodity during the pandemic, with their prices increasing by roughly 50 percent between January 2020 and December 2021. The spike in used car prices was a prominent example of how global supply chain disruptions have contributed to U.S. inflation. It also highlighted the complexity of global supply and demand relationships.

In the early stages of the COVID-19 pandemic, many U.S. and European auto manufacturers shut down production to help stop the disease's spread. Semiconductor producers, concentrated in Asia, responded by shifting production toward chips for electronic devices such as computers and games. As the pandemic progressed, demand increased in these other markets as homebound consumers shifted their spending away from services such as restaurant meals and travel and toward consumer durables.

Later in 2020, when U.S. auto manufacturers resumed production, they faced chip supply shortages. The shortages not only reflected pandemic-related production shutdowns in Asia, they also reflected a reluctance on the part of chip manufacturers to shift production back to chips used in auto production and away from the relatively lucrative market for chips used in electronic devices.

The diminished supply of new cars in the U.S. market provided support for higher used car prices. (See chart.) Since used cars comprise roughly 4 percent of the basket that makes up the consumer price index (CPI), the 50 percent cumulative price increase for the category increased the overall CPI by a cumulative 2 percentage points. According to an analysis by Richmond Fed economist Alex Wolman, the increase in motor vehicle prices ranked as one of the "main culprits" of the U.S. inflationary increase through November 2021.

The used car example illustrates the limited ability of monetary policy to control inflation's short-run trajectory. "It's true that inflation is a monetary phenomenon, in the sense that monetary policy has the ability to control inflation over the medium to long run," says Wolman. "However, even when monetary policy is being successful at controlling inflation, unusual shocks to supply and demand for particular goods and services move inflation around from month to month."

The U.S. economy has indeed faced a string of unusual supply and demand shocks since the pandemic's onset — most of which have tended to boost inflation. But this fact does not necessarily let the Fed off the hook.

A MIX OF SUPPLY AND DEMAND SHOCKS

Since the onset of the pandemic, the U.S. economy has been hit by a series of supply and demand shocks. The first of these, of course, was the pandemic itself. Several early analyses of the pandemic characterized it as a combined supply-demand shock. For example, an NBER working paper in February by Martin Eichenbaum of Northwestern University, Sergio Rebelo of Northwestern University's Kellogg School of Management, and Mathias Trabandt of Goethe University Frankfurt presented a model of epidemics in which COVID-19 "acts like a negative shock to the demand for consumption and the supply of labor."

The view of the pandemic as a combination of negative supply and demand shocks found support in the data. For instance, a 2020 paper by Geert Bekaert of Columbia University, Eric Engstrom of the Fed Board of Governors, and Andrey Ermolov of Fordham University employed statistical methods to "extract aggregate demand and supply shocks for the US economy" during the early stages of the pandemic. The paper estimated that negative aggregate supply and demand shocks both contributed substantially to the initial output decline in 2020.

During the initial stages of the pandemic, there was much concern among economists and policymakers that the pandemic's initial negative effect on aggregate demand could be exacerbated by job destruction and firm closures. This concern was reflected in an *American Economic Review* article by Veronica Guerrieri of the University of Chicago's Booth School of Business, Guido Lorenzoni of Northwestern University, Ludwig Straub of Harvard University, and Iván Werning of Massachusetts Institute of Technology, which presented "a theory of Keynesian supply shocks: supply

shocks that trigger changes in aggregate demand larger than the shocks themselves." Their preferred policy responses included many of the measures implemented by U.S. policymakers, such as emergency loans, enhanced social insurance payments, and accommodative monetary policy.

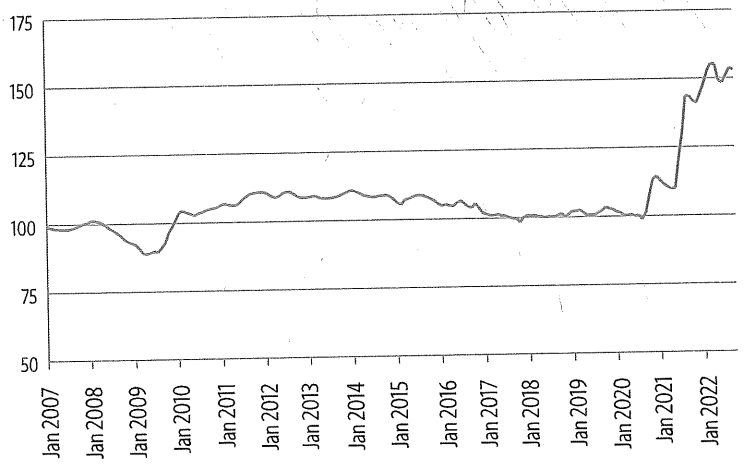
It did not take long for these measures to show results. One of their initial effects was to boost the U.S. personal savings rate. Bank accounts grew rapidly during 2020 as people received stimulus payments from the Internal Revenue Service and enhanced unemployment insurance checks — some received more from these benefits than they had been earning from their former jobs — while drastically reducing their spending on dining, entertainment, and travel. Flush with cash, many consumers quickly started to buy consumer durables.

"There was a huge surge in consumer goods demand, because households were simply unable to spend their cash on going out for a meal or going to the cinema or going on holiday," says Christopher Williamson, chief business economist at IHS Markit, a provider of data and research affiliated with S&P Global. "So, a whole lot of us spent a lot of time ordering new computers, furniture, and bicycles."

In retrospect, there is a broad consensus among economists and policymakers that the combination of increased fiscal spending and an aggressively accommodative monetary policy ultimately overshot the mark by providing excessive economic stimulus. To the extent that they did, the policies arguably constituted a second major shock to the U.S. economy. The Russian invasion of Ukraine in February of this year imposed a third major shock by restricting global oil and grain supplies, causing spikes in the two commodities' prices, which had been already increasing since mid-2020. The combination of the three shocks — the pandemic, the expansionary policy overshoot, and war — left analysts with a hard-to-identify stew in which pandemic-related foreign plant closures, heightened consumer durables demand, and increased global commodity prices have put tremendous strains on global supply networks.

Used Cars Become Hot Commodities

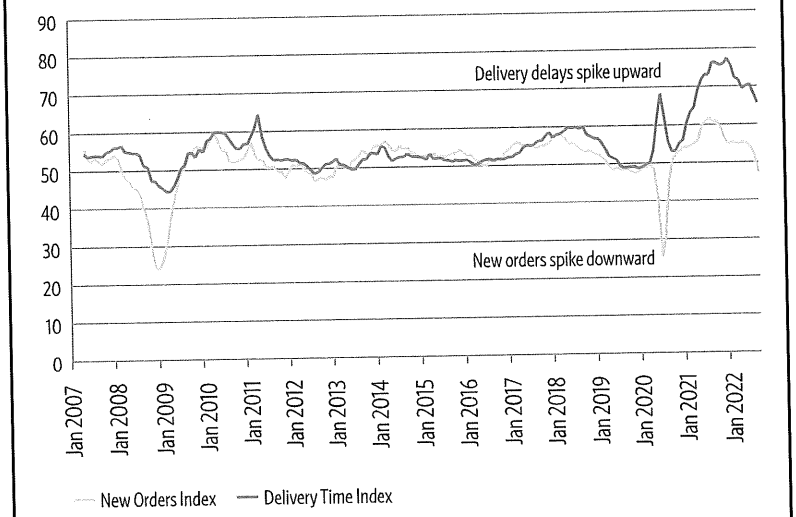
Consumer Price Index for Used Cars and Trucks (Rebased, December 2006 = 100)



SOURCE: Bureau of Labor Statistics via FRED

Unprecedented Delivery Delays

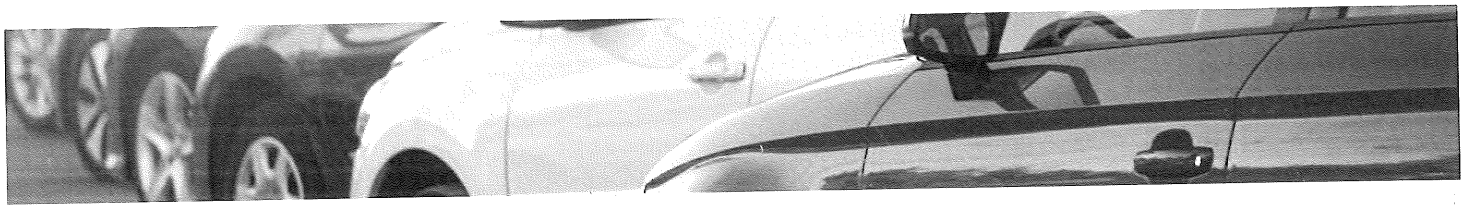
JPMorgan Purchasing Managers Indices: Delivery Time Index and New Orders Index



SOURCE: S&P Global

SUPPLY CHAIN DISRUPTIONS

There is no precedent in recent history for the supply chain disruptions that currently afflict the global economy. The scope of the problem is seen, among other places, in the recent behavior of the JPMorgan Global Purchasing Managers Indices (PMI) delivery time index, which provides a measure of delivery delays around the globe. Ordinarily, the delivery index tends to closely track the JPMorgan PMI new orders index. For example, when the new orders index declined during the 2008-2009 recession, the delivery index declined as well; and when the new orders index subsequently recovered, the delivery index followed suit. This positive correlation is just what one would expect for economic cycles that are driven primarily by fluctuations in aggregate demand: Weak demand means shorter waiting times; strong demand means longer waiting times. (See chart.)



In contrast, the two indexes moved in dramatically divergent directions at the onset of the pandemic. The new orders index plunged, signaling a collapse in aggregate demand, but the delivery time index spiked upward. This negative correlation is just what one would expect for an economic cycle driven by a combination of negative supply and demand shocks.

Supply disruptions (as reflected in the delivery time index) became even more pronounced as aggregate demand (as reflected in the new orders index) recovered. The new orders index peaked in mid-2021, and subsequently declined. Nevertheless, the delivery time index has remained near its historical peak, signaling continued supply problems.

Global companies reported reduced production due to staff shortages that peaked during each of the pandemic's various waves, according to data from S&P Global. Each wave of staff shortages gave rise to a follow-on wave of materials shortages.

Transportation snarls exacerbated the problems caused by plant closures, further disrupting global supply chains. "There were a lot of port closures — notably in China," says Williamson. "With restrictions heavily in place, the ports just couldn't function as efficiently as they could before. And it's not just ships going into ports, but trucks bringing containers in and out of the ports. A lot of containers ended up in the wrong places. It produced unprecedented congestion."

By late 2021, shipping a container through U.S. ports took more than three times longer than it normally did. The congestion at Chinese ports only worsened recently due to COVID-19 lockdowns in Shanghai and other ports. Shipping costs have remained elevated, and port congestion has had numerous effects that may have been hard to predict. California farmers, for instance, have been having a difficult time finding container capacity to export tree nuts, produce, and dairy products.

Of all the supply problems that have arisen during the pandemic, semiconductor shortages have had some of the most widespread effects. In many cases, semiconductors account for only a small part of a product's total cost. Yet they often have no close substitutes, making them indispensable to the production process. Because of this, semiconductor shortages can have an outsized effect on final-product supply shortages and the inflationary pressures they create. Recent research by economists at the St. Louis Fed indicated that the problem extended far beyond the auto industry to a broad range of other U.S. manufacturing industries. Comparing 56 industries that use semiconductors as a direct input with 170 industries that do not, they found substantially higher price changes in the semiconductor-dependent industries during 2021.

Additional research from the St. Louis Fed shows that price pressures tended to be greatest in U.S. industries with heightened exposure to foreign countries experiencing particularly severe supply bottlenecks, as measured by indexes of work backlogs and supplier delivery times. Some of the largest exposures were in the U.S. motor vehicles, petroleum, basic metals, and electrical equipment industries.

HOW MUCH INFLATION CAME FROM WHERE?

A natural question is the extent to which increased inflation is due to overly accommodative macroeconomic policies versus the supply-side shocks caused by the COVID-19 pandemic and, more recently, the war in Ukraine. The multiplicity of shocks and their staggered arrival times make this a difficult question to answer definitively.

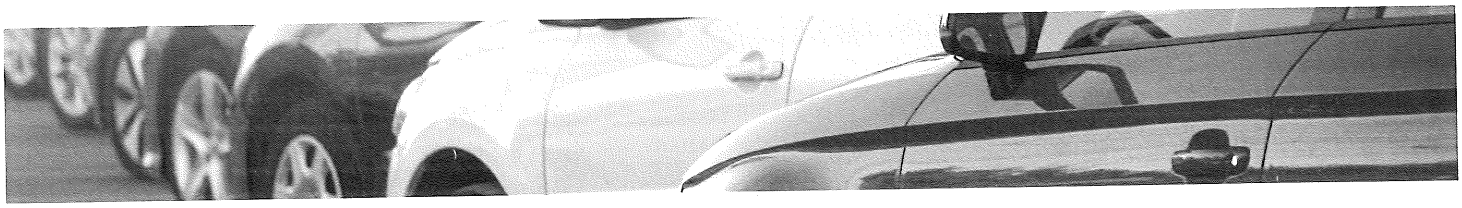
Researchers have responded to the challenge by taking a variety of approaches. One such effort was undertaken by the Richmond Fed's Alex Wolman in a recent working paper, "Relative Price Shocks and Inflation," which he co-authored with Francisco Ruge-Murcia of McGill University. Within the context of a more general analysis of the relationship between relative price shocks and inflation, the researchers presented a model that they used to break down the behavior of U.S. inflation from March 2021 through November 2021 into contributions from supply-side shocks versus overly accommodative monetary policy.

In the model, the monetary authorities do not attempt to stabilize the prices of individual goods and services, nor do they attempt to constrain overall inflation to an extremely narrow range in the short run. "If the relative price of used cars needs to go sky high because of supply disruptions, the way that's going to happen at first is for the prices of used cars to go sky high," says Wolman. "It's not going to happen by having the prices of all of the other goods in the economy decline all at once." Thus, sector-specific supply shocks can affect the economy-wide rate of inflation on a month-by-month basis, even under a monetary regime marked by low inflation and policy stability.

Over the model's long-term horizon, however, monetary policy does stabilize inflation. Although the central bank allows unusually large relative price shocks to pass through to inflation, those shocks are — by definition — unusual, so inflation tends to remain close to the Fed's target.

Wolman and Ruge-Murcia found that the inflationary increase during the period between March 2020 and November 2021 was roughly four-fifths due to supply-side shocks, with the single largest supply-side shock coming from the vehicle sector. Overly accommodative monetary policy explained the remaining one-fifth of the inflation overshoot. Although the model does not explicitly incorporate fiscal policy, Wolman believes that, in practice, their calculation of monetary policy's contribution to inflation most likely captures the combined inflationary contributions of both monetary *and* fiscal policy. "My view is that there was a big expansionary fiscal shock, and that if the Fed had followed its usual policy rule, it would have chosen a much higher interest rate than it actually did," says Wolman. "To the extent that the Fed did not raise rates in response to the fiscal stimulus, it's going to show up in our model as a monetary policy shock."

Recent research by economists at the New York Fed broadly concurs with Wolman's finding that the inflationary increase seen during 2021 owed much to supply-side factors



such as production and shipping bottlenecks and higher input prices. They also agreed in the assessment that loose monetary policy played a secondary role, concluding that the global nature of recent supply shocks suggests that "domestic monetary policy actions would have only a limited effect on these sources of inflationary pressures."

But these two studies come with an important caveat: They only cover the period through late 2021, when U.S. inflation was still behaving much like it had during 1995-2019 — a period of low and stable inflation in which relatively high monthly inflation readings were mostly accounted for by large price increases in a small share of goods and services. More recent data have deviated from this pattern. "Not only has inflation continued to be high," says Wolman, "it has also been associated with a larger share of goods with large price increases." To Wolman, this increased inflationary breadth raises concern that inflation may be becoming more of a monetary phenomenon and less a supply-side phenomenon.

Ana Maria Santacreu of the St. Louis Fed has taken a variety of approaches to understanding the recent increase in inflation. "We've done a lot of things from different angles," she says. "There's no one method that can tell us, 'how much is demand, and how much is supply?'" While some of her research has pointed to the importance of supply-side factors, she has also found evidence suggesting that expansionary fiscal policies have played an important role. She recently co-authored a working paper that examined recent increases in inflation across a sample of advanced and emerging economies. The researchers found that expansionary fiscal policies tended to increase consumption but had only a limited impact on the supply of goods as measured by industrial production indexes. "We take the results as evidence that fiscal policies contributed to inflationary mismatches between demand and supply," says Santacreu.

A MONETARY POLICY CONUNDRUM

Pinning down the precise sources of current inflationary pressure has important implications for policy. To the extent that increased inflation reflects overly stimulative policy, the antidote is apparent: Reverse course and revert to policies more consistent with past periods in which inflation was stabilized. To the extent that increased inflation reflects supply-side shocks, however, the usual tools of aggregate demand management are likely to offer little help.

In the wake of the global oil price shocks of the 1970s, economists devoted much effort to understanding the optimal monetary policy response to supply shocks. Unfortunately, however, the consensus conclusion was that the standard tools of monetary and fiscal policy are not well designed to address supply shocks. Edward Gramlich of the University of Michigan provided a summary of this viewpoint in a 1979 article that appeared in *Brookings Papers on Economic Activity*. He concluded that supply shocks are very costly, no matter what the policy response: "If their unemployment impact is minimized by accommodating policies, the shock-induced inflation can linger for several years. If their inflationary impact is minimized by an immediate recession, the cost in terms of high unemployment is sizable."

As a practical matter, economists have often advocated some degree of accommodation in response to aggregate supply shocks. But the prescription for accommodation typically rests on the assumption of an economy initially at equilibrium — that is, one with stable inflation and full employment. While that was likely the case at the onset of the pandemic, it certainly was not the case when global energy and grain supplies were disrupted at the onset of the war in Ukraine. Indeed, year-over-year U.S. inflation had already hit a nearly 40-year record before that point.

While monetary policy is generally not an effective avenue for alleviating supply shocks, companies and governments are likely to take measures designed to soften such blows in the future. Undoubtedly, changing perceptions of risk will cause some firms to reassess their supply chains, just as Japanese automakers did after their supply networks were heavily disrupted by the 2011 Tōhoku earthquake. Indeed, even before the pandemic, many companies had been already reassessing their reliance on foreign value chains, due to, among other things, increased labor costs in China and the growing importance of "speed-to-market" as a competitive factor.

Calls for government policies to decrease dependency on global supply chains have come from many circles in the United States, Europe, and Japan. Treasury Secretary Janet Yellen, for example, has raised the prospect of "friend- shoring" policies. Similarly, officials from France and Germany have spoken of "reshoring projects" and "minimizing one-sided dependencies." Within the United States, the costs and benefits of such policies will continue to be debated among researchers and politicians, while Fed officials focus on the appropriate extent of monetary tightening or accommodation. **EF**

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What Can We Learn from the Pandemic and the War about Supply Shocks, Inflation, and Monetary Policy?

Remarks by

Lael Brainard

Vice Chair

Board of Governors of the Federal Reserve System

Prepared for the conference volume of the

21st BIS Annual Conference
Central Banking after the Pandemic: Challenges Ahead

Bank for International Settlements
Basel, Switzerland

Policymakers and researchers have begun reassessing certain features of the economy and monetary policy in light of recent experience. After several decades in which supply was highly elastic and inflation was low and relatively stable, a series of supply shocks associated with the pandemic and Russia's war against Ukraine have contributed to high inflation, in combination with a very rapid recovery in demand. The experience with the pandemic and the war highlights the challenges for monetary policy in responding to a protracted series of adverse supply shocks. In addition, to the extent that the lower elasticity of supply we have seen recently could become more common due to challenges such as demographics, deglobalization, and climate change, it could herald a shift to an environment characterized by more volatile inflation compared with the preceding few decades.[1]

Inflation in the United States and many countries around the world is very high (figure 1). While both demand and supply are contributing to high inflation, it is the relative inelasticity of supply in key sectors that most clearly distinguishes the pandemic- and war-affected period of the past three years from the preceding 30 years of the Great Moderation.[2] Interestingly,

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[1] I am grateful to Kurt Lewis of the Federal Reserve Board for his assistance in preparing this text and to Kenneth Eva for preparing the figures. This text updates the views that I discussed as part of a panel at the BIS Annual Meeting on June 24, 2022. These views are my own and do not necessarily reflect those of the Federal Reserve Board or the Federal Open Market Committee.

[2] Research has generated a range of estimates on the contributions from supply and demand factors. For example, Shapiro (2022) finds that demand factors are responsible for about one-third of the surge in inflation above the pre-pandemic trend, while di Giovanni and others (2022) find a number closer to two-thirds. See Adam Shapiro (2022), "How Much Do Supply and Demand Drive Inflation?" FRBSF Economic Letter 2022-15 (San Francisco: Federal Reserve Bank of San Francisco, June), https://www.frbsf.org/economic-research/publications/economic-letter/2022/june/how-much-do-supply-and-demand-drive-inflation; and Julian di Giovanni, Sebnem Kalemli-Ozcan, Alvaro Silva, and Muhammed Yildirim (2022), "Global Supply Chain Pressures, International Trade, and Inflation," paper presented at the ECB Forum on Central Banking 2022, Sintra, Portugal, June 27–29, https://www.ecb.europa.eu/pub/conferences/ecbforum/shared/pdf/2022/Kalemli-Oezcan_paper.pdf.

inflation is broadly higher throughout much of the global economy, and even jurisdictions that began raising rates forcefully in 2021 have not stemmed the global inflationary tide.[3]

In the United States, as a result of significant fiscal and monetary support, the level of private domestic final purchases recovered extremely rapidly in 2020 and 2021 to levels consistent with the pre-pandemic trend before moving below trend in 2022 (figure 2). Although demand came in near the pre-pandemic trend on an aggregate level, the pandemic induced a shift in composition that concentrated large increases in demand in certain sectors where the supply response was constrained. The shift in consumption from services to goods was so pronounced that—despite plunging at the onset of the pandemic in March 2020—real spending on goods had already risen nearly 4 percent above its pre-pandemic trend by June of that year. While a very slow rotation back toward pre-pandemic patterns of consumption has been under way for over a year, it remains incomplete more than two and a half years after the initial shutdown: In the most recent data, the level of goods spending remains 6 percent above the level implied by its pre-pandemic trend, while services spending remains a little more than 2 percent below its pre-pandemic trend (figure 3).

The supply shocks to goods, labor, and commodities have been accompanied by unusually high volatility in monthly inflation readings since the beginning of the pandemic. Since March 2020, the standard deviation of month-over-month core inflation has been 0.22 percentage point—a level of variation not seen in a 31-month period since the 1970s and more than double the standard deviation in monthly core inflation from 1990 to 2019. The initial

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[3] The median year-to-date total policy rate hike within the group of Brazil, Hungary, New Zealand, Norway, Peru, Poland, and South Korea is 6 percentage points. All of these countries began forceful rate hikes in 2021, and the cumulative hikes have taken policy rates in some of these countries above 10 percent. Despite this, through September 2022 core inflation in these countries was 9.5 percent year-over-year, rising 3.5 percentage points since March. See Economist (2022), "Even Super-Tight Policy Is Not Bringing Down Inflation," October 28, https://www.economist.com/finance-and-economics/2022/10/23/even-super-tight-policy-is-not-bringing-down-inflation.

drivers of this high variation in monthly core inflation readings were a sharp drop in prices and subsequent bounceback in the first months of the pandemic, followed by a couple of bursts lasting three to four months each. The first burst occurred around reopening in the spring of 2021, and the second occurred amid the effects of the Delta and Omicron COVID-19 variants in the autumn of 2021 (figure 4).[4]

The evidence suggests that high concentrations of demand in sectors such as appliances, housing, and motor vehicles—where supply was constrained by the effects of the pandemic—played an important role initially in generating inflationary pressures. Acute constraints on shipping and on the supply of nonsubstitutable intermediate inputs like semiconductors were compounded by acute constraints on labor supply associated with the effects of the Delta and Omicron variants and later compounded further by sharp commodities supply shocks associated with Russia's war on Ukraine.

The standard monetary policy prescription is to "look through" supply shocks, such as commodities price shocks or shutdowns of ports or semiconductor plants, that are not assessed to leave a lasting imprint on potential output.[5] In contrast, if supply shocks durably lower potential output such that the economy is operating above potential, monetary policy tightening is necessary to bring demand into alignment with the economy's reduced productive capacity.

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[4] Pandemic fiscal measures played an important role in boosting demand, but the rapid deceleration of inflation over the summer of 2021 and subsequent rebound in inflation from October through the end of the year do not line up well with the fiscal demand impulse projected by most forecasters. For example, the Brookings Institution projected a smooth demand impulse from the American Rescue Plan that peaked at the end of last year. See Wendy Edelberg and Louise Sheiner (2021), "The Macroeconomic Implications of Biden's $1.9 Trillion Fiscal Package," Brookings Institution, *Up Front* (blog), January 28, https://www.brookings.edu/blog/up-front/2021/01/28/the-macroeconomic-implications-of-bidens-1-9-trillion-fiscal-package.

[5] See, for instance, Martin Bodenstein, Christopher J. Erceg, and Luca Guerrieri (2008), "Optimal Monetary Policy with Distinct Core and Headline Inflation Rates," *Journal of Monetary Economics,* vol. 55 (October), pp. S18–33.

Importantly, and separately from the implications for potential output, monetary policy should respond strongly if supply shocks risk de-anchoring inflation expectations.[6]

Although these tenets of monetary policy sound relatively straightforward in theory, they are challenging to assess and implement in practice. It is difficult to assess potential output and the output gap in real time, as has been extensively documented by research.[7] This is especially true in an environment of high uncertainty. The level of uncertainty around the output gap varies considerably over time, and research suggests that more muted policy reactions are warranted when uncertainty about the output gap is high.[8] The unexpectedly long-lasting global pandemic and the sharp disruptions to commodities associated with Russia's war against Ukraine have contributed to substantial uncertainty (figure 5).

Even so, the drawn-out sequence of shocks to the supply of labor, commodities, and key intermediate inputs, such as semiconductors, blurred the lines about what constitutes a temporary shock as opposed to a persistent shock to potential output. Even when each individual supply shock fades over time and behaves like a temporary shock on its own, a drawn-out sequence of adverse supply shocks that has the cumulative effect of constraining potential output for an extended period is likely to call for monetary policy tightening to restore balance between demand and supply.

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[6] Ricardo Reis makes the case that both these factors would have prescribed tighter policy in the current environment. See Ricardo Reis (2022), "The Burst of High Inflation in 2021–22: How and Why Did We Get Here?" CEPR Discussion Paper Series DP17514 (London: Centre for Economic Policy Research, July), https://cepr.org/publications/dp17514.

[7] See Athanasios Orphanides and Simon van Norden (2002), "The Unreliability of Output-Gap Estimates in Real Time," *Review of Economics and Statistics,* vol. 84 (November), pp. 569–83.

[8] For discussions of the time-varying nature of output gap uncertainty, see Travis J. Berge (2020), "Time-Varying Uncertainty of the Federal Reserve's Output Gap Estimate," Finance and Economics Discussion Series 2020-012 (Washington: Board of Governors of the Federal Reserve System, February; revised April 2021), https://doi.org/10.17016/FEDS.2020.012r1; and Rochelle M. Edge and Jeremy B. Rudd (2016), "Real-Time Properties of the Federal Reserve's Output Gap," *Review of Economics and Statistics,* vol. 98 (October), pp. 785–91. For a discussion of tempering the policy response to the output gap in response to increased uncertainty, see Athanasios Orphanides (2003), "Monetary Policy Evaluation with Noisy Information," *Journal of Monetary Economics,* vol. 50 (April), pp. 605–31.

In addition, a protracted series of supply shocks associated with an extended period of high inflation—as with the pandemic and the war—risks pushing the inflation expectations of households and businesses above levels consistent with the central bank's long-run inflation objective.[9] It is vital for monetary policy to keep inflation expectations anchored, because inflation expectations shape the behavior of households, businesses, and workers and enter directly into the inflation process. In the presence of a protracted series of supply shocks and high inflation, it is important for monetary policy to take a risk-management posture to avoid the risk of inflation expectations drifting above target. Even in the presence of pandemics and wars, central bankers have the responsibility to ensure that inflation expectations remain firmly anchored at levels consistent with our target.

In monitoring inflation expectations for purposes of risk management, not only the median but also the distribution of inflation expectations can provide important information about how inflation expectations may be changing.[10] Survey measures suggest that the median of longer-term inflation has remained within pre-pandemic ranges consistent with 2 percent inflation (figure 6). However, starting in 2021, there has been a greater dispersion than usual of views about future inflation in survey responses, as shown in figure 6. Although initially the increased dispersion reflected a rise in expectations for significantly above-target inflation, more

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[9] For two recent examples of assessing longer-term inflation expectations, see Michael T. Kiley (2022), "Anchored or Not: How Much Information Does 21st Century Data Contain on Inflation Dynamics?" Finance and Economics Discussion Series 2022-016 (Washington: Board of Governors of the Federal Reserve System, March), https://doi.org/10.17016/FEDS.2022.016; and Danilo Cascaldi-Garcia, Francesca Loria, and David López-Salido (2022), "Is Trend Inflation at Risk of Becoming Unanchored? The Role of Inflation Expectations," FEDS Notes (Washington: Board of Governors of the Federal Reserve System, March 31), https://doi.org/10.17016/2380-7172.3043.

[10] See, for example, Ricardo Reis (2021), "Losing the Inflation Anchor," *Brookings Papers on Economic Activity*, Fall, pp. 307–61, https://www.brookings.edu/wp-content/uploads/2021/09/15985-BPEA-BPEA-FA21_WEB_Reis.pdf. The Board's staff recently updated the Index of Common Inflation Expectations to include the 25th and 75th percentiles of inflation expectations over the next 12 months from the University of Michigan Surveys of Consumers.

recently, following substantial cumulative monetary policy tightening, the increased dispersion has also reflected increased expectations of no inflation or even disinflation. About one-fourth of respondents to the most recent University of Michigan Surveys of Consumers anticipate that prices are likely to be the same or below their current level 5 to 10 years in the future—roughly three times the average fraction that reported such expectations before the pandemic.

Finally, it is important to explore whether any features of the inelastic supply response associated with the pandemic and the war may have implications for potential growth and macroeconomic stability in the future.[11] In particular, despite the unprecedented pandemic policy support for businesses of all sizes that was directed at preserving the supply side of the economy, key sectors struggled to ramp up activity after reopening. The supply response was particularly impaired in sectors where supply chains are geographically fragmented and recurring foreign COVID-19 lockdowns have reduced the reliability of foreign supplies. While conditions have improved dramatically from some of the worst periods in 2021, measures like the Global Supply Chain Pressure Index from the Federal Reserve Bank of New York indicate that total supply chain pressures still are elevated relative to pre-pandemic levels (figure 7).

The supply disruptions in key goods and commodities sectors associated with the pandemic and Russia's war against Ukraine have highlighted the fragility of global supply chains and the risks of inelastic supply at moments of stress. Conditions have improved dramatically over the past year, judging by the return of the ISM Supplier Deliveries index to its pre-pandemic range of values (figure 8). That said, ongoing discussions about moving from "just in time" to "just in case" inventory management and from offshoring to "nearshoring" are raising

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[11] See, for example, Agustín Carstens (2022), "The Return of Inflation," speech delivered at the International Center for Monetary and Banking Studies, Geneva, April 5, https://www.bis.org/speeches/sp220405.htm.

important questions about the extent to which businesses are likely to reconfigure global supply chains based on a reassessment of the tradeoff between cost efficiency and supply resilience.

Similarly, some have conjectured that the slow and incomplete recovery of the workforce over the course of the pandemic may be the beginning of a longer-term change in labor supply dynamics (figure 9).[12] In addition, the potential for more frequent and severe climate events, as we are already seeing, and for frictions in the energy transition could also lead to greater volatility of supply. Together, a combination of forces—the deglobalization of supply chains, the higher frequency and severity of climate disruptions, and demographic shifts—could lead to a period of lower supply elasticity and greater inflation volatility.

To conclude, the experience with the pandemic and the war highlights challenges for monetary policy in responding to supply shocks. A protracted series of adverse supply shocks could persistently weigh on potential output or could risk pushing inflation expectations above target in ways that call for monetary policy to tighten for risk-management reasons. More speculatively, it is possible that longer-term changes—such as those associated with labor supply, deglobalization, and climate change—could reduce the elasticity of supply and increase inflation volatility into the future.

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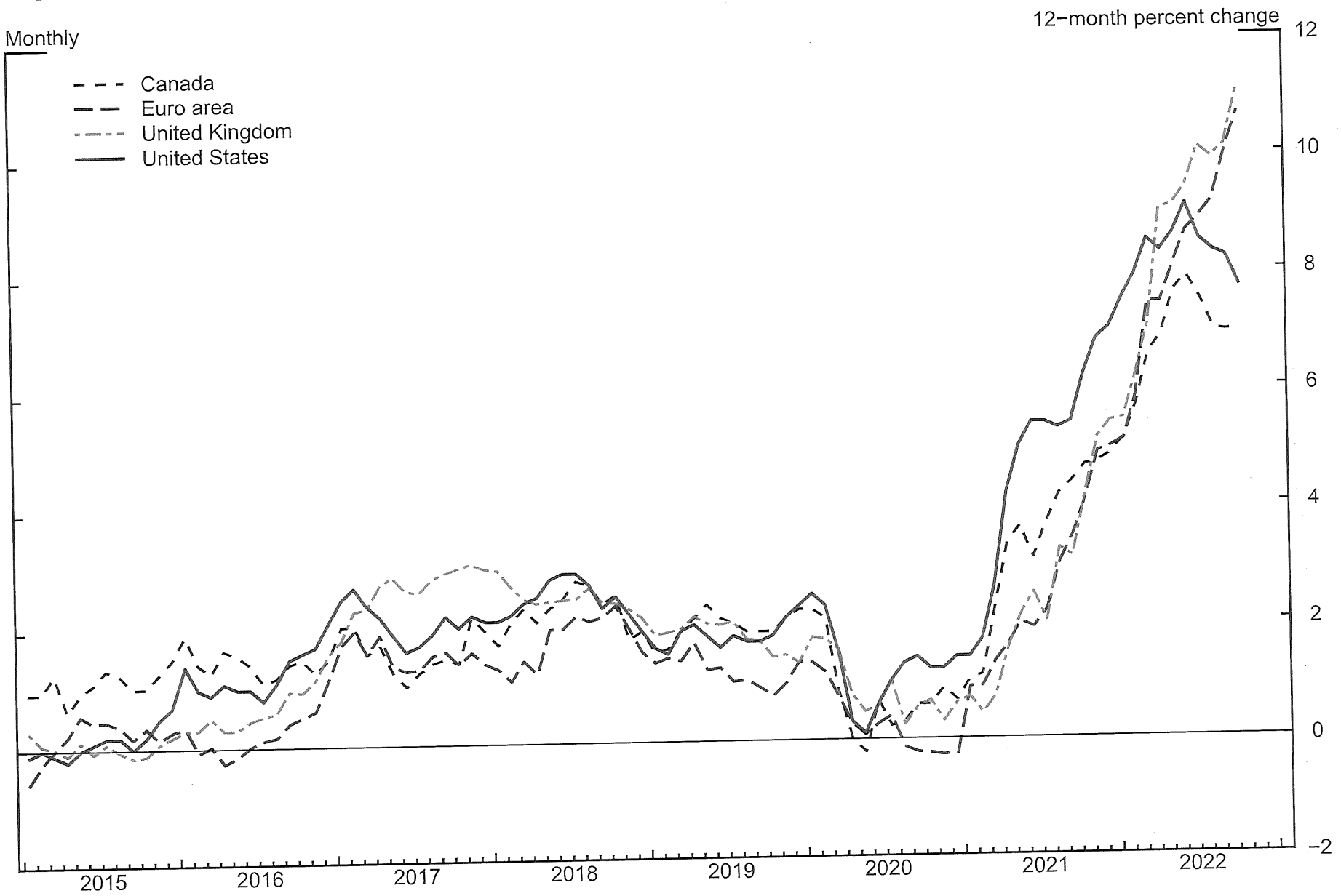
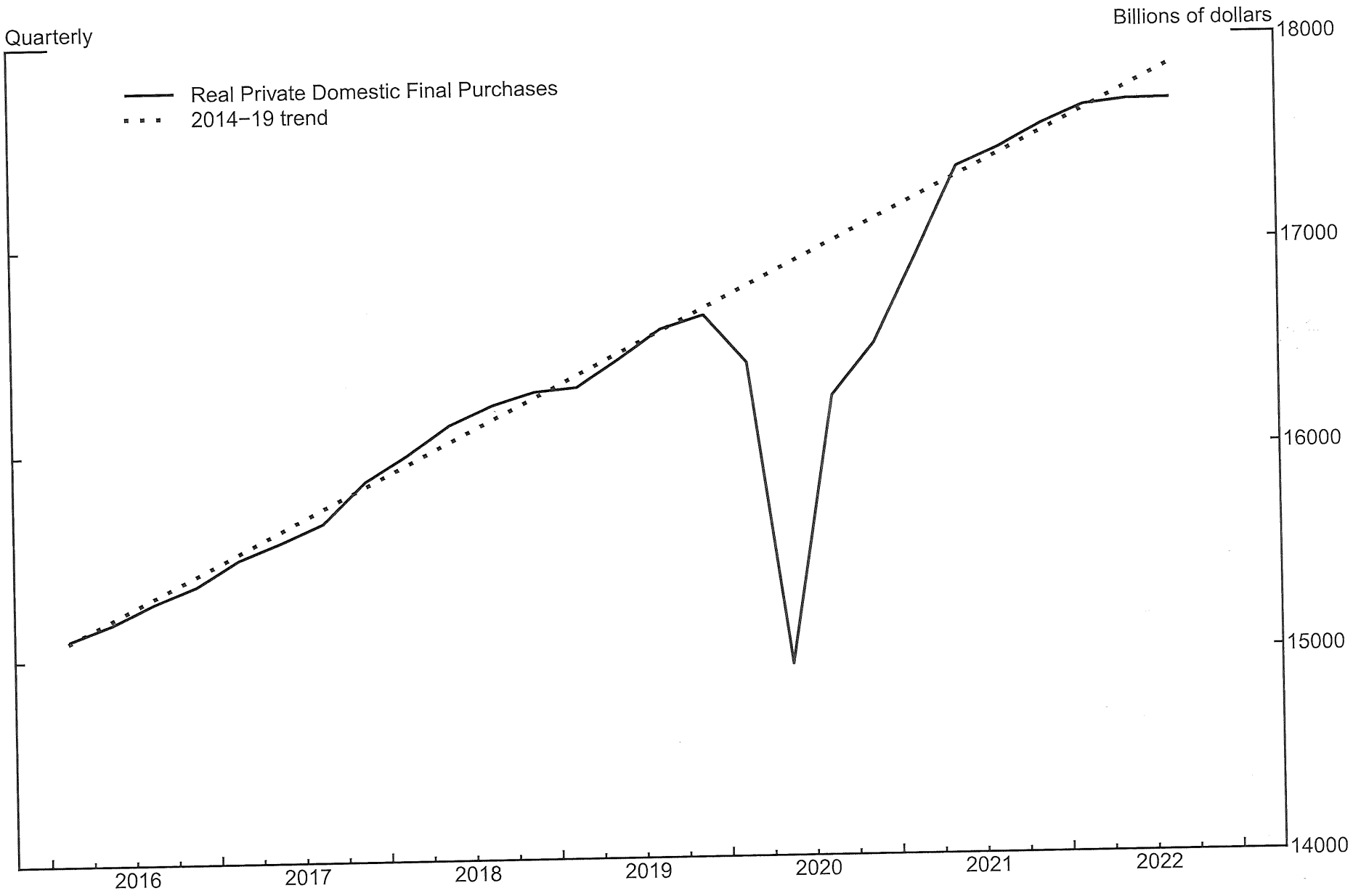
[12] See, for example, Charles Goodhart and Manoj Pradhan (2020), *The Great Demographic Reversal: Ageing Societies, Waning Inequality, and an Inflation Revival* (Cham, Switzerland: Palgrave Macmillan).

Figure 1. Headline Inflation for Selected Countries



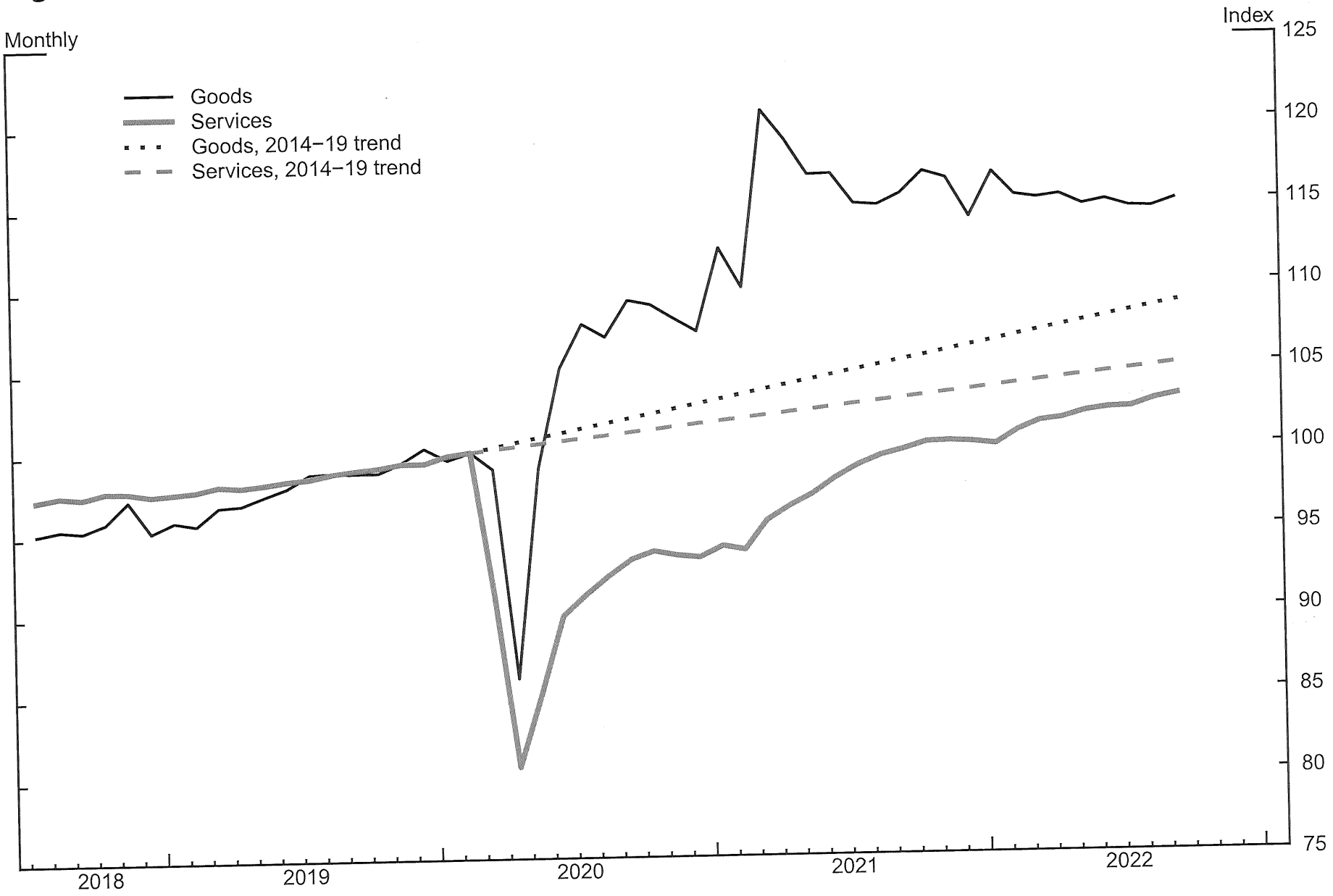
Note: Data go through October 2022.
Source: Haver Analytics.

Figure 2. Real Private Domestic Final Purchases



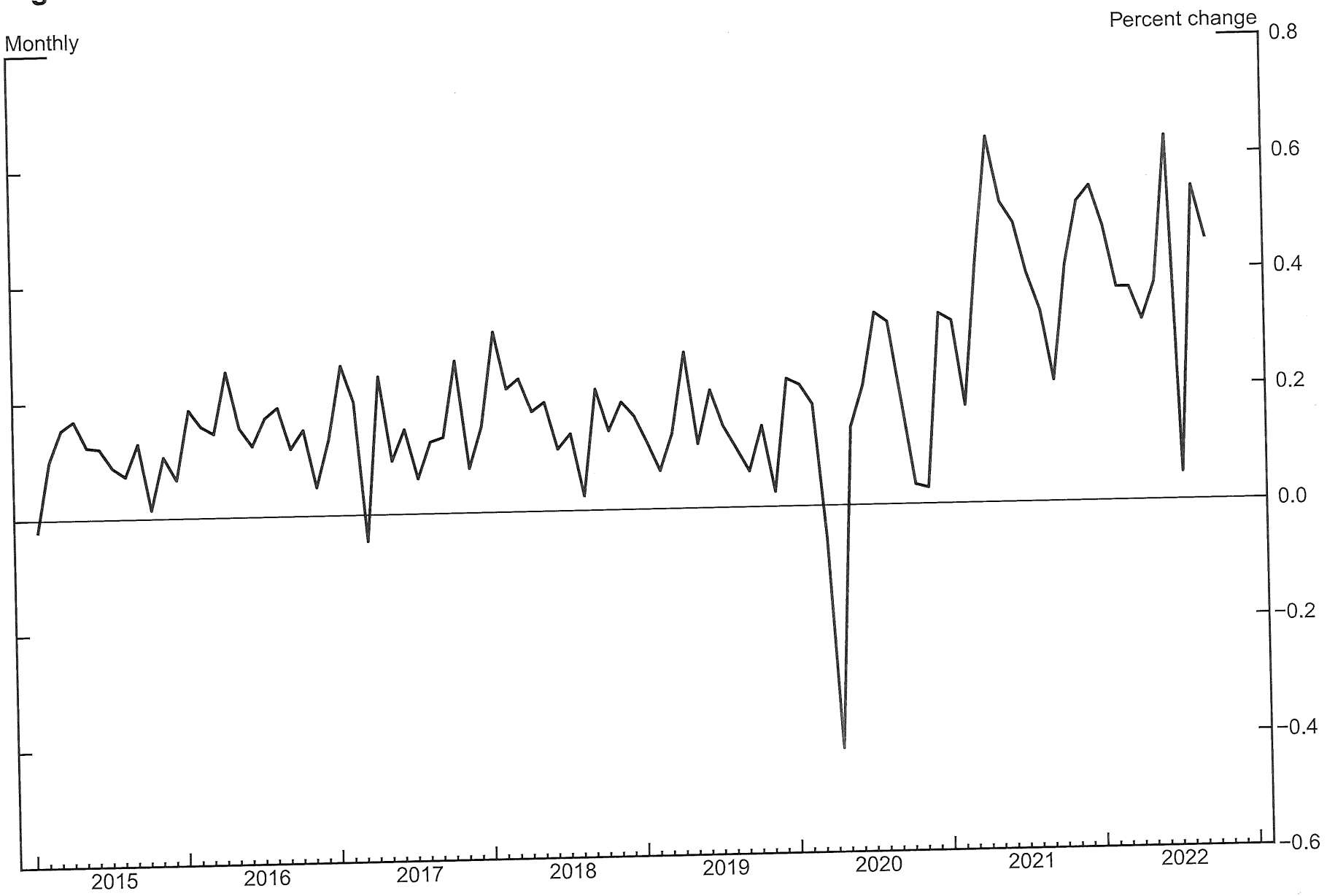
Note: Data go through 2022:Q3.
Source: Bureau of Economic Analysis.

Figure 3. Real Personal Consumption Expenditures



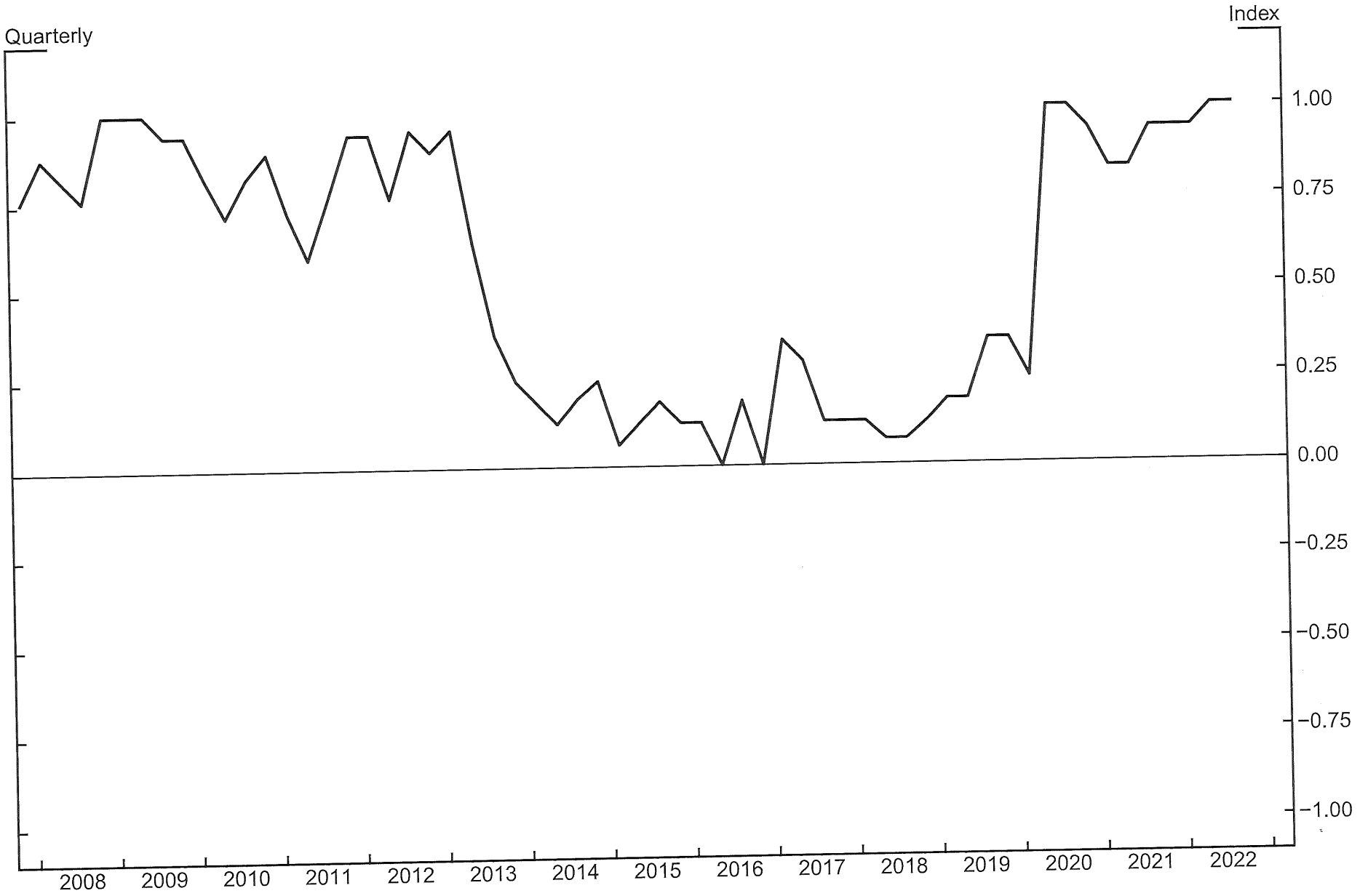
Note: Data go through September 2022.
Source: Bureau of Economic Analysis.

Figure 4. PCE Monthly Inflation Less Food and Energy



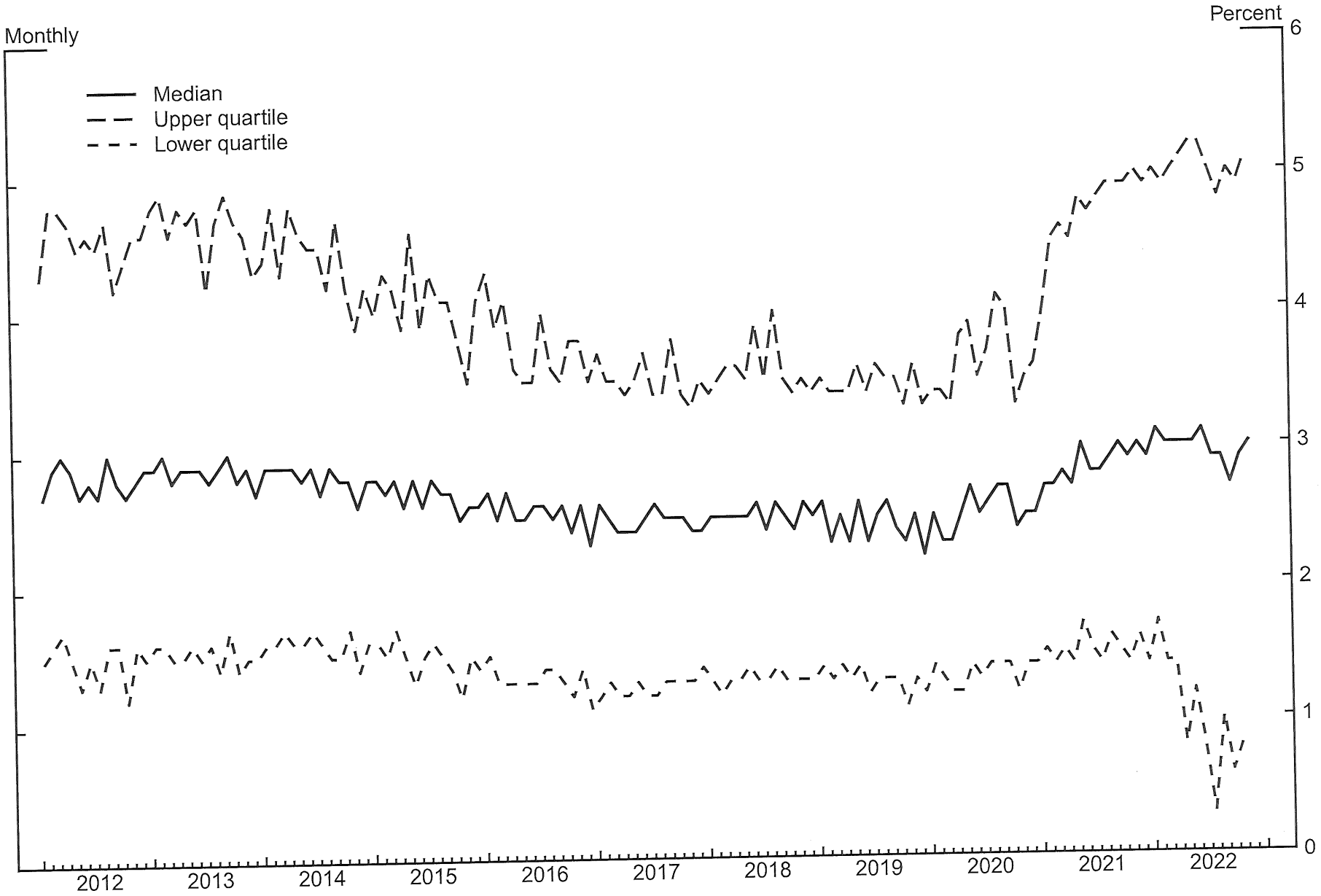
Note: Data go through September 2022. PCE is personal consumption expenditures.
Source: Bureau of Economic Analysis.

Figure 5. Diffusion Index of FOMC Participants' Uncertainty Assessments for GDP Growth



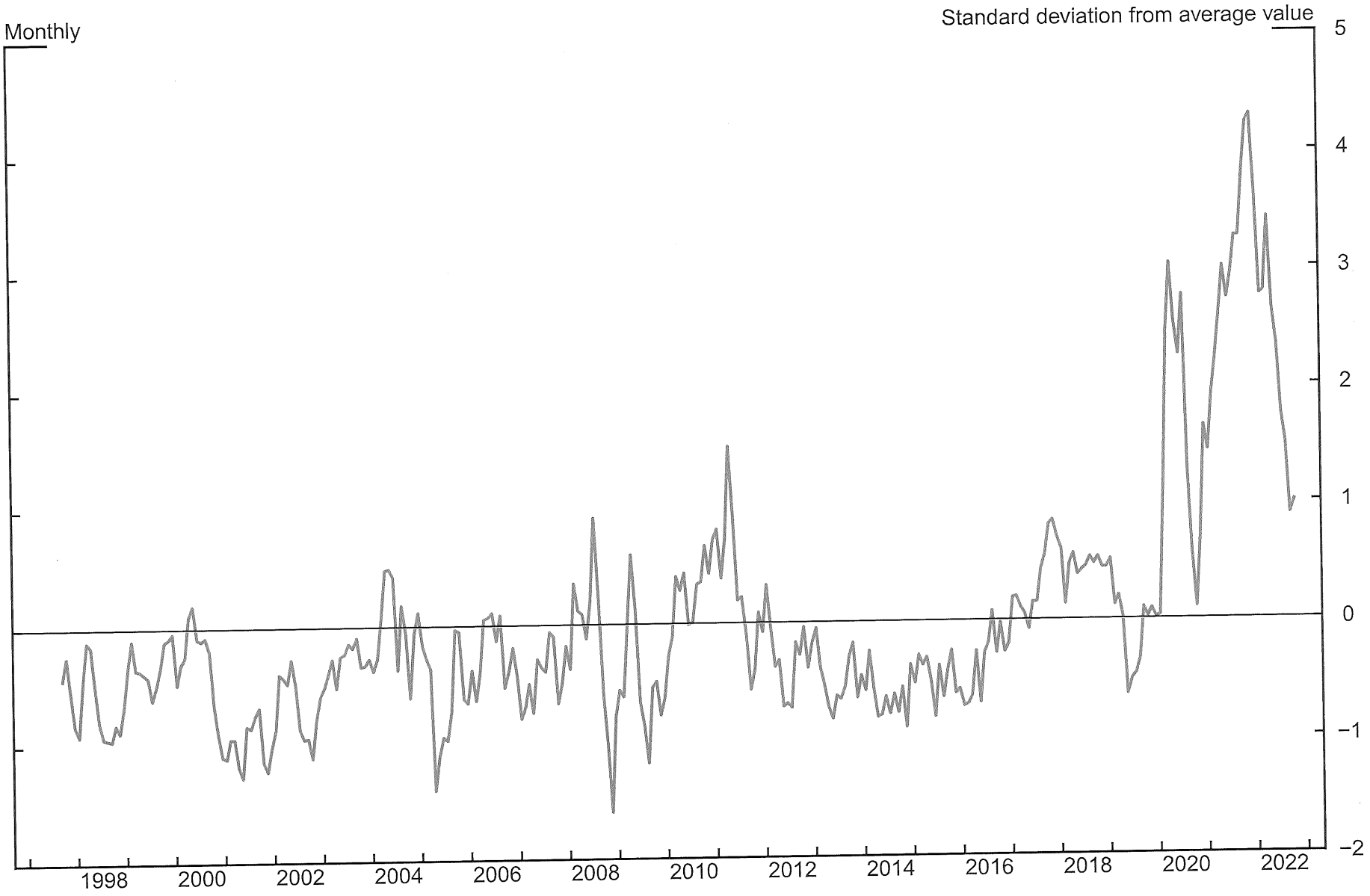
Note: Data go through 2022:Q3. FOMC is Federal Open Market Committee; GDP is gross domestic product.
Source: Federal Reserve Board.

Figure 6. Expected Price Change, Next 5 to 10 Years



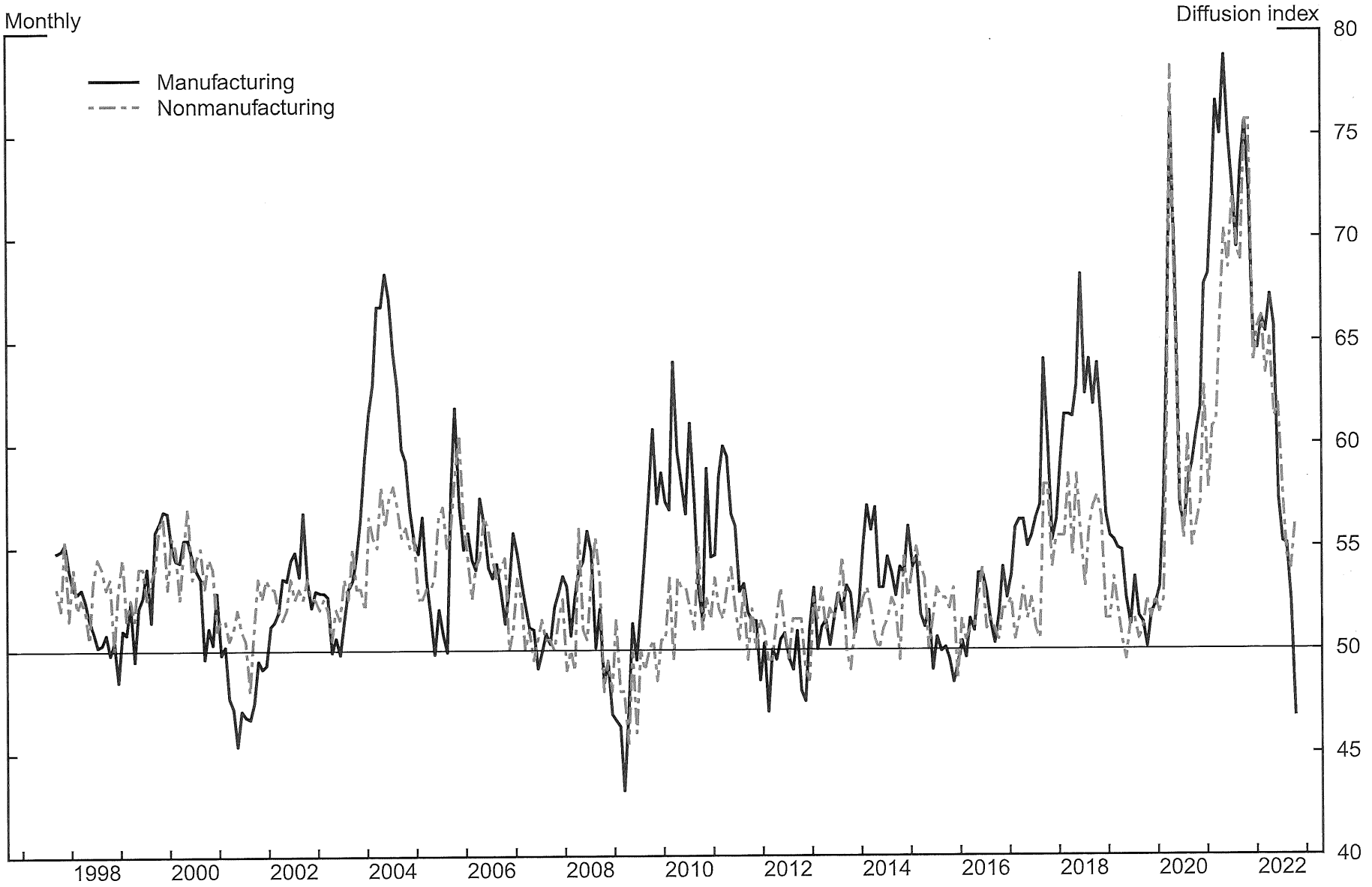
Note: Data go through November 2022.
Source: University of Michigan Surveys of Consumers.

Figure 7. Global Supply Chain Pressure Index



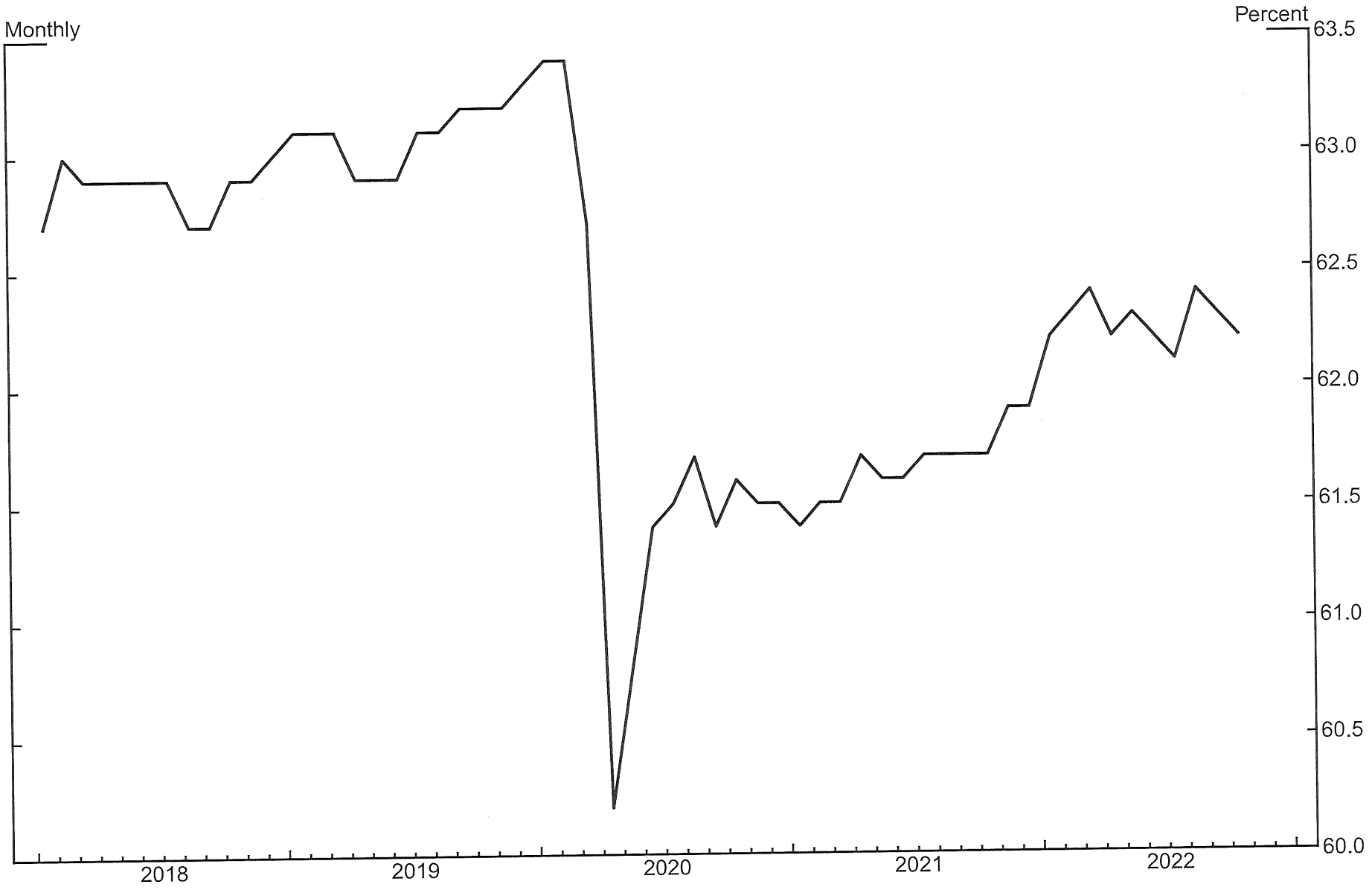
Note: Data go through October 2022.
Source: Federal Reserve Bank of New York.

Figure 8. ISM Supplier Deliveries Index



Note: Data go through October 2022. The ISM Supplier Deliveries Index is an inverse diffusion index, a reading above 50 percent indicates slower deliveries.
Source: Institute for Supply Management.

Figure 9. Labor Force Participation Rate



Note: Data go through October 2022.
Source: Bureau of Labor Statistics.