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Federal Reserve System Conference on Monetary Policy Strategy, Tools, and Communication Practices (A Fed Listens Event)

Introduction to a Special Issue of the International Journal of Central Banking

Loretta J. Mester
Managing Editor, International Journal of Central Banking
and President and CEO, Federal Reserve Bank of Cleveland

This special issue of the *International Journal of Central Banking* includes revisions of five of the papers presented at the Federal Reserve System's "Conference on Monetary Policy Strategy, Tools, and Communication Practices (A Fed Listens Event)."[1] This conference, which was held at the Federal Reserve Bank of Chicago on June 4–5, 2019, was part of the Federal Open Market Committee's 2019 review of the framework with which it pursues its monetary policy goals of price stability and maximum employment.[2] The five papers included in this volume cover some of the key issues pertinent in assessing whether, and in what ways, the Federal Reserve might refine its monetary policy strategy, tools, and communications to more effectively achieve its monetary policy goals, especially in an economic environment that has changed in a number of ways, including a higher likelihood that equilibrium interest rates will be lower than in past decades and that the policy rate will need to move to its effective lower bound more often than in the past.

Loretta J. Mester, managing editor of the *International Journal of Central Banking*, served as the editor for the papers in this volume. In the volume's first paper, Janice Eberly, James Stock, and Jonathan Wright begin with a review of the Federal Reserve's current monetary policy framework. They then use structural vector autoregression to assess how effective the current framework's monetary policy tools might have been under several counterfactual circumstances. These tools include changes in the federal funds

[1] See the conference program at https://www.federalreserve.gov/conferences/conference-monetary-policy-strategy-tools-communications-20190605.htm.

[2] For more about the review see https://www.federalreserve.gov/monetarypolicy/review-of-monetary-policy-strategy-tools-and-communications.htm.

rate and the nonconventional tools of large-scale asset purchases (LSAPs), forward guidance, and maturity extension. The authors call these nonconventional tools “slope policies,” as they are intended to affect the slope of the yield curve over and above what a change in the federal funds rate would normally do. One of the paper’s findings is that slope policies were effective but that they only partially made up for the fact that the federal funds rate was constrained by the zero lower bound.

In the volume’s second paper, Maurice Obstfeld discusses various ways in which global factors affect the setting of appropriate monetary policy in the United States and how these factors have changed over time. The paper studies the mechanisms through which international prices and global competition affect U.S. inflation; the effects of globally integrated financial markets; and the effect of U.S. monetary policy on other economies, with potential spillovers back to the U.S. economy. A key insight is that while domestic inflation over the long run is determined by domestic monetary policy, over shorter time horizons, global factors can affect the tradeoffs between price stability and maximum employment faced by U.S. monetary policymakers.

In the third paper, Lars Svensson describes and recommends forecast targeting as a particular strategy the Federal Reserve might use in setting monetary policy. This strategy involves choosing the monetary policy path that yields forecasts that best achieve the central bank’s monetary policy goals, and using communications, e.g., publication of forecasts under the chosen and alternative policy paths, to lend credibility to the policy. The paper then shows how forecast targeting could be implemented under various frameworks, including inflation targeting, price-level targeting, temporary price-level targeting, average-inflation targeting, and nominal-GDP targeting.

In the fourth paper, Eric Sims and Jing Cynthia Wu use a New Keynesian model with financial frictions to study the degree of substitutability between traditional interest rate policy and LSAPs. Based on their analysis, they conclude that the three LSAP programs that the Federal Reserve implemented during the Great Recession were equivalent to the stimulus that would have been achieved by lowering the federal funds rate to 2 percentage points below zero.

In the volume's final paper, Anil Kashyap and Caspar Siegert discuss the interlinkages between financial stability risks and monetary policy and review how monetary policymakers in the United States currently consider such risks. The authors analyze the tools that can be used by the Financial Stability Oversight Council, the U.S. body with formal responsibility for responding to emerging financial stability risks, and they conclude that these tools are not adequate. The authors offer several recommendations for addressing the current situation, including giving the Office of Financial Research enhanced powers to gather more granular data on the distribution of debt, extending the regulatory perimeter to allow for better monitoring and mitigation of financial stability risks that emerge outside of the regulated banking system, and having the U.S. Congress establish an expert commission to evaluate gaps in the macroprudential landscape in the United States.

The papers published in this volume provide very useful information that is relevant to the Federal Reserve System's review of its monetary policy framework and also to other central bankers and researchers who are interested in increasing their understanding of how monetary policy affects the economy and the tools available to implement monetary policy.

The Federal Reserve's Current Framework for Monetary Policy: A Review and Assessment*

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[c]Johns Hopkins University and NBER

The Federal Reserve's current monetary policy framework combines conventional policy that sets the level of the federal funds rate with policies that operate through the slope of the term structure, including forward guidance and large-scale asset purchases. These slope policies are particularly important when the federal funds rate is at the zero lower bound. We assess the performance of counterfactual monetary policies since the Great Recession using a structural vector autoregression, identified using high-frequency jumps in asset prices around FOMC meetings as external instruments. We find that slope policies played an important role in supporting the recovery, but only partially circumvented the zero lower bound. In our simulations, earlier and more aggressive use of slope policies supports a faster recovery. The recovery would also have been faster, with the unemployment gap closing seven quarters earlier, if the Fed had inherited a higher level of inflation and nominal interest rates consistent with a 3 percent inflation target coming into the financial crisis recession.

JEL Codes: C22, E43, E52.

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1. Introduction and Summary

The Humphrey–Hawkins Act of 1978 instructs the Federal Reserve Board (the Fed) to "promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates." The methods by which this dual mandate of maximum employment and price stability is to be achieved are left to the Fed. Those methods have evolved over time as the Fed and economists learned more about the theory and practice of monetary policy (Fuhrer et al. 2018).

The current framework for monetary policy, formally adopted in 2012, consists of a symmetric 2 percent inflation target, a commitment to support maximum employment, and a suite of policy actions that Federal Reserve officials can take to achieve those goals. Those policy actions affect current and expected future interest rates and communicate the Federal Open Market Committee's (FOMC's) intentions about monetary policy. A key element of this suite, setting the current level of the federal funds rate from one FOMC meeting to the next, has been central to Fed policy for decades. The current monetary policy framework, however, also includes newer elements developed during this century to influence term premiums and/or expectations of future Fed policy. One such element is forward guidance through measures such as statements accompanying FOMC meeting announcements, the Summary of Economic Projections, and speeches by Fed officials. Another such element is direct purchases of long-term assets (large-scale asset purchases, or LSAPs), which both directly affect the prices of long-term assets and convey information about future Fed policy.

In our empirical framework, discussed in more detail below, we identify two dimensions of monetary policy shocks using high-frequency data around FOMC announcements. The first are federal funds shocks—unexpected changes in the level of the federal funds rate. This is the classic concept of a monetary policy shock. The second shock is identified as the component of the change in the slope of the term structure around FOMC announcements that is orthogonal to the federal funds rate surprise. Shocks to the federal funds rate will affect the slope of the yield curve, but this second shock represents changes to the slope that are *not* driven by the normal response to changes in the target funds rate. Such changes in the slope could be caused by any of the newer elements of monetary policy—forward guidance, LSAPs, or maturity extensions. However, because we are identifying them from high-frequency changes in the slope of the term structure, we refer to them collectively as *slope* shocks, to differentiate them from traditional policy that sets the current level of the federal funds rate. These new tools of slope policy are particularly relevant when conventional policy—that is, the current level of the federal funds rate—is constrained by the floor on nominal interest rates, generally referred to as the zero lower bound.

This paper reviews and assesses the current monetary policy framework in the context of the experience of the expansion that began in the second quarter of 2009.[1] Our assessment draws on the large literature examining the functioning and consequences of these policies, on a review of macroeconomic performance over the expansion, and on counterfactual simulations of alternative policies using the historical record. These alternative policies draw on the elements of the current framework but implement them in a way that allows us to consider alternative policy paths. We conduct these counterfactuals using an empirical model that combines the response of the unemployment gap to monetary policy shocks with a New Keynesian Phillips curve. Although this model is newly developed for this paper, and we are basing our analysis on this particular model, we also compare our results with others in the literature. We find that the dynamics in our model are generally consistent with those obtained using other, sometimes quite different, approaches.

Examining hypothetical counterfactuals overlaid on the actual experience of the expansion, as we do, has the advantage of making concrete the plusses and minuses of these counterfactuals, including possible unintended consequences. A disadvantage of this overlay is that it could be interpreted as second-guessing the Fed: It is not. Many of the counterfactuals we consider were not available in real time, at least in part because we are able to evaluate their effects with the benefit of hindsight, and also because of data revisions. By using this evaluative method, our aim is to inform future options as the Fed evaluates its current monetary policy framework.

[1] Because our focus is on the current long-term monetary policy framework, we do not consider the special measures and facilities that provided liquidity during the financial crisis.

Our analysis leads us to five main conclusions.

First, the current monetary policy framework—in particular, its new suite of slope policies—played an important role in supporting the recovery. Absent slope policy, the recovery of the labor market would have been slower, and the rate of inflation lower, than it was. The magnitude of the effect is substantial: absent slope policy, we estimate that the unemployment rate would have crossed the Congressional Budget Office's (CBO's) estimate of the natural rate more than one year later than it did, and the rate of inflation would have been approximately 0.2 percentage point lower than it was during the latter part of the recovery.

Second, despite the efficacy of slope policy, the zero lower bound significantly restricted the scope of monetary policy during the recovery. Absent the zero lower bound, we (and others) estimate that normal Fed policy would have led to a federal funds rate of approximately –5 percent. Our estimates suggest that Fed slope policies were able to offset perhaps 1 percentage point of the zero lower bound constraint. Multiple authors have pointed to a high probability of hitting the zero lower bound again during future downturns, and our simulations suggest that, when this happens, it meaningfully limits the efficacy of Fed policy.

Third, small changes in policy would have produced small changes in realized outcomes. For example, speeding up or delaying liftoff of the federal funds rate by one year would have changed the unemployment gap, relative to actual, by a few tenths of a percentage point, and would have had a negligible effect on the inflation rate.

Fourth, of the counterfactuals we consider, the policies with the largest effect are ones with early and aggressive slope policy, undertaken roughly when the federal funds rate hits the zero lower bound. We estimate that "stronger sooner" slope policies have a relatively rapid effect on the economy, so early aggressive action to flatten the term structure could substantially speed the recovery in the labor market and support reflation. This said, more aggressive use of slope policy comes with a number of concerns and potential channels that we do not model. These include risks that driving down longer-term interest rates could lead to "reach for yield" behavior, that the Fed could end up buying such a large share of Treasury or agency mortgage-backed securities as to disrupt these markets, or that the Fed could face an extended period of reduced or zero remittances to Treasury (Carpenter et al. 2015). That might in turn undermine political support for central bank independence. These concerns could constrain the Fed's ability to implement aggressive slope policies in practice.

Fifth, the current suite of policies would have led to a substantially faster recovery and a rate of inflation closer to target had the Fed inherited higher nominal interest rates and inflation rates consistent with a higher inflation target. For example, we estimate that inheriting interest rates, inflation rates, and an inflation target 1 percentage point higher than actual, combined with the slope policies actually used over the expansion, would have resulted in the unemployment rate falling below the CBO natural rate of unemployment seven quarters earlier than it did. With inherited nominal rates, inflation, and an inflation target 2 percentage points higher than actual, we estimate that the unemployment rate would have crossed the CBO natural rate 10 quarters earlier than it did, allowing liftoff to occur in 2014.

Our analysis of real outcomes focuses on the labor market, specifically the unemployment rate. The recovery post-2009 was associated with historically slow growth of gross domestic product (GDP). As discussed in Fernald et. al. (2017) and in Eberly, Stock, and Wright (2019), the main forces behind this slow growth of GDP are trends that predate the recession. These include the slowing of the growth of the labor force because of the retirement of the baby boom and the plateau of women entering paid work, and the productivity slowdown that started in the early or mid-2000s. These trends and other factors, such as fiscal drag from 2012 to 2016, are outside the reach of monetary policy. To the extent that monetary policy could have sped up the recovery of the labor market, GDP growth would have been modestly faster, but even so, the demographic and other headwinds would have produced a growth rate of GDP below that of the 2001–07 expansion, and well below that of the expansions of the 1980s and 1990s.

Our results also have implications for fiscal policy. Even though adjustments to the long-run framework, including "stronger sooner" policies and a higher inflation target, could enhance the Fed's efforts to stabilize the economy in a future recession, as we discuss, there are limits to the Fed's use of forward guidance and LSAPs. Moreover, the federal funds rate is at historic lows for this late stage of the business cycle. These observations underscore the importance of complementary countercyclical fiscal policies, especially automatic stabilizers, in future recessions.

The remainder of the paper is organized as follows. We begin in section 2 with a brief overview of the current monetary policy framework. There is now a large literature that has examined the effect of asset purchases and forward guidance on long-term interest rates and on economic outcomes, and we review that literature in section 3. Section 4 briefly reviews the observed decline in the equilibrium real rate of interest (r^*). Section 5 presents our simulation model, section 6 presents the counterfactuals, and section 7 provides caveats and conclusions.

2. The Current Framework for Monetary Policy

The current monetary policy framework was put in place in January 2012 and, while subsequently refined operationally, remains largely unchanged. This framework is summarized on the Fed's website, including timelines of the evolution and implementation of the framework.[2]

The framework has two objectives: keeping the rate of price inflation, as measured by the personal consumption expenditure (PCE) price index, close to 2 percent, and keeping the unemployment rate close to the long-run full-employment rate, sometimes called the natural rate of unemployment or the non-accelerating inflation rate of unemployment (NAIRU). In two subsequent meetings, in 2014 and 2016, respectively, FOMC statements clarified that inflation outcomes above and below the 2 percent goal were equally costly, then explicitly referred to the inflation objective as a "symmetric inflation goal." Although there is an explicit numerical objective for inflation, there is no corresponding numerical objective for unemployment. This is because the natural rate is seen as time varying, not directly measurable, and driven by nonmonetary factors. Also, for

[2]See "Timelines of Policy Actions and Communications" at https://www.federalreserve.gov/monetarypolicy/review-of-monetary-policy-strategy-tools-and-communications-fed-listens-timelines.htm.

the unemployment rate, the FOMC has not explicitly characterized its operating policy as being symmetric around NAIRU.[3]

The historical path to the current framework reflects a trend toward greater transparency in central banking, as well as greater resolution about the use of new tools over time. As part of the trend toward greater transparency, the January 2012 monetary policy framework integrated and expanded the Summary of Economic Projections (SEP), which had been in place since October 2007. From the start, the SEP numbers were released quarterly, and they covered real GDP growth, the unemployment rate, PCE, and core PCE inflation at horizons out to three years. In 2009, projections were expanded to include long-run real GDP growth, the unemployment rate, and headline inflation. The January 2012 monetary policy framework made additional changes. It included numerical forecasts of the future path of the federal funds rate at year-end and in the longer run by individual FOMC participants, the so-called dot plots. This change is notable for publishing numerical forecasts of future policy, not only economic conditions.

In addition to the overarching framework describing monetary policy objectives, the FOMC has provided guidance about the implementation of monetary policy, or its operating policy. These operating policies govern the use of the tools to achieve the objectives. The current monetary policy framework uses short-term interest rates as the primary tool for influencing aggregate demand, but can also use forward guidance, long-term asset purchases, and other measures that affect the maturity composition of the Fed's balance sheet. As documented by Fuhrer et al. (2018), Fed operating policies have changed historically, and the FOMC has used several approaches over the past 10 years.[4]

The Fed's use of forward guidance evolved from 2007 through 2018.[5] When the FOMC lowered its target for the federal funds rate

[3] This approach allows for uncertainty in the observation of labor market conditions, as well as conditioning the response to labor market conditions on other economic conditions and shocks.

[4] We take a longer perspective for this section, as the FOMC has these tools available to it, even if not currently in use, and they are relevant for the counterfactual analysis in section 6.

[5] Forward guidance predates the financial crisis recession. FOMC statements in 2003–05 contained early forms of forward guidance. For example, at several

to a range of 0 to $\frac{1}{4}$ percent in December 2008, it communicated that conditions were likely to warrant exceptionally low levels of the rate "for some time." In addition to moving the current federal funds rate, this forward guidance potentially affects expectations of future interest rates, and hence longer horizon interest rates. In March 2009, the language "for some time" was replaced with "for an extended period." In August 2011, this qualitative language was replaced with a calendar threshold of "at least through mid-2013," which was then extended to 2014 and 2015 in January and September of 2012, respectively. The calendar-based guidance was replaced by outcome-based thresholds starting in December 2012, stating that the low range would be maintained "at least as long as the unemployment rate remains above $6\frac{1}{2}$ percent, inflation between one and two years ahead is projected to be no more than a half percentage point above the Committee's 2 percent longer-run goal, and longer-term inflation expectations continue to be well-anchored." Threshold-based guidance continued until the unemployment rate reached $6\frac{1}{2}$ percent in 2014. These three periods represent three approaches to operating policy: qualitative guidance, calendar-based guidance, and outcome- or threshold-based guidance.

The Fed's balance sheet policies have also evolved since 2007. Starting in November 2008, the Federal Reserve's balance sheet programs were announced with both quantitative amounts of asset purchases and a time horizon for the transactions. As the programs were completed, the FOMC clarified reinvestment policies and its commitment to use policy tools to meet its economic objectives, for example in September 2010, "to provide additional accommodation if needed to support the economic recovery and to return inflation, over time, to levels consistent with its mandate." This commitment was renewed throughout the LSAP and maturity extension program implementation periods. While no explicit outcome-based

meetings in 2003, the FOMC statement said that "policy accommodation can be maintained for a considerable period." Gürkaynak, Sack, and Swanson (2005) document that even before the crisis, much of the news from FOMC announcements came in the form of news about the path of future policy rather than news about the target level of the federal funds rate. However, forward guidance assumed a much greater role after the financial crisis.

thresholds were introduced, the policy was conditional on economic outcomes.[6]

The statement of a possible calendar time for slowing purchases was first broached in 2013 and announced in December 2013. A formal policy statement governing balance sheet normalization was published in September 2014. This statement was refined in the interim, and an addendum was issued in June 2017 with quantitative steps to govern balance sheet normalization. In addition to guidance for principal reinvestment, this addendum included the statement that the Committee would be prepared to resume reinvestment of principal payments if there were a "material deterioration in the economic outlook" that would warrant a sizable reduction in the target federal funds rate. The Committee affirmed that it was prepared to use "its full range of tools," including the size and composition of the balance sheet, "if future economic conditions were to warrant a more accommodative monetary policy than can be achieved solely by reducing the federal funds rate." The Federal Reserve thus retains economic conditionality for future balance sheet policies.

The Summary of Economic Projections added median forecasts starting in September 2015 and included fan charts in the expanded version of the projections that is published with the minutes, starting in March 2017. The Federal Reserve Chairman gives a press conference after every meeting, starting in 2012, and after all meetings, starting in 2019.

3. Effects of LSAPs and Forward Guidance on Yields and the Macroeconomy

The existing monetary policy framework treats short-term interest rates as the primary tool of monetary policy, but also uses forward guidance and LSAPs and related maturity policies, such as the maturity extension program and reinvestment of principal policy at the zero lower bound (ZLB). Kuttner (2018) gives a recent review of the experience of unconventional monetary policy after the financial

[6]See, for example, the FOMC statements of September 2012, March 2013, and May 2013.

crisis recession. In this section, we review evidence on their effects on yields and on macroeconomic outcomes.

3.1 Asset Purchases

Much of the evidence for the efficacy of LSAPs comes from event-study evidence, which was particularly apparent in the first round of purchases, QE1, because these announcements came as complete surprises and were immediately followed by sharp drops in yields. Gagnon et al. (2011) and Krishnamurthy and Vissing-Jorgensen (2011) find that QE1 announcements were followed by immediate drops in Treasury yields that added up to around a percentage point.

The event-study approach only measures the short-run effect of the announcement. Bond yields rose during the asset purchase implementation phases, as opposed to the announcements, of QE1, QE2, and QE3 (Greenlaw et al. 2018). This is consistent with the effects of the announcements wearing off over time, though it is hard to establish causality, as many other shocks hit the economy over the implementation phases of LSAPs. There have been studies on trying to estimate the persistence of the effects (Wright 2012, Swanson 2017, Greenlaw et al. 2018), but confidence intervals are very wide, and results are sensitive to the inclusion of the March 2009 FOMC announcement. This announcement came as a complete surprise that caused a sharp drop in yields that was, however, reversed over the next couple of months. Greenlaw et al. (2018) suggest that this may be because market participants initially interpreted the announcement as a sign of further measures that did not then come in the subsequent months. Another question about the effects of LSAP purchases on Treasury yields is the potential for Treasury to offset the effect by issuing more of the securities that the Federal Reserve is going to buy, leaving the net supply to the market unchanged. The Treasury did indeed substantially lengthen the maturity of its issuance during the LSAP period. We will study the dynamic effects not of LSAPs specifically, but of slope shocks more generally, in section 5. Federal Reserve purchases of Treasury securities reduce the effective supply of these assets to market participants. Several authors have studied the effects of overall Treasury supply on yields, including Hamilton and Wu (2012), Krishnamurthy and Vissing-Jorgensen (2012), and Greenwood and Vayanos (2014). These papers all frame the question slightly differently, but nonetheless end up with consistent results—changes in the supply of Treasuries have a small but significant effect on yields. Belton et al. (2018), reviewing the existing literature, conclude that adding to 1 percent of GDP (or around $200 billion today) to the supply of 10-year equivalent Treasuries raises the term premium by about 6 basis points. A rule of thumb like this is market conventional wisdom, and close to what was found by Hamilton and Wu (2012). Li and Wei (2013) estimate supply effects in an affine term structure model and get a somewhat larger estimate in which a 1 percent of GDP increase in the supply of Treasuries raises the term premium by about 10 basis points. They conclude that the total effect of QE1, QE2, and Operation Twist was to lower 10-year yields by about a percentage point. Note that these estimates relate yields to the stock of asset purchases, not the flow of asset purchases. Some of the QE1 announcements had announcement effects that were bigger than can readily be explained by changes in the stock of Treasuries. In particular, the March 2009 announcement of $300 billion in Treasury purchases lowered 10-year yields by 40 to 70 basis points, depending on the time window used for the event study. This is a far bigger effect than would be predicted by any of the conventional elasticities, but it happened at a time of severe market disruption when arbitrage was disrupted.

There is also evidence of LSAP effects on credit markets, which is crucial since affecting Treasury yields is not an end in itself. Di Maggio, Kermani, and Palmer (2016) document that mortgage-backed securities (MBS) purchases increased mortgage refinancing activity, at least among households that were not underwater and thus were eligible to refinance. This also underscores a limitation of MBS purchases: many homeowners were simply unable to refinance, because they were underwater or for other reasons, and so they could not benefit from the reduction in mortgage rates. Foley-Fisher, Ramcharan, and Yu (2016) and Rodnyansky and Darmouni (2017) use differences-in-differences approaches to argue that asset purchases increased bank lending.

LSAPs had an effect on bond markets, but it is less clear through what channels they worked. There are broadly two possibilities. One is that they worked by reducing term premiums on longer-term bonds as investors have demand for specific long-duration assets, as in the preferred-habitat model of Vayanos and Vila (2009). The other is that they signal that the Federal Reserve will keep policy rates low for longer (Bauer and Rudebusch 2014). There can be elements of both. But the view that LSAPs worked only through expectations and left term premiums unchanged should imply that near-term yields fell, but long-term yields should be little changed[7] unless one views the commitment to lower policy rates to last beyond a few years, which does not seem credible given FOMC turnover. However, the announcements of LSAPs lowered 10-year yields by substantially more than 2-year yields (Gagnon et al. 2011). Moreover, the announcements of asset purchases had the greatest effect on the specific securities being purchased relative to others with similar maturity that were not being purchased (D'Amico et al. 2012, D'Amico and King 2013), which also points to the importance of preferred-habitat or local supply mechanisms. A similar indicator that asset purchases operated significantly through the impact of asset supply is the fact that announcements of MBS purchases had large effects on MBS rates, but announcements of Treasury purchases alone had much more muted effects on MBS rates (Krishnamurthy and Vissing-Jorgensen 2011).

3.2 Forward Guidance

As noted in section 2, from March 2009 until June 2011 the post-meeting FOMC statements declared that exceptionally low levels of rates would be warranted for "an extended period." Surprisingly, over this period, the market appeared to continually believe that liftoff was just around the corner, as evidenced from the Survey of Professional Forecasters (SPF) and also from the fact that two-year Treasury yields remained quite sensitive to macroeconomic news (Swanson and Williams 2014). Swanson and Williams conclude from the sensitivity of Treasury yields to macroeconomic news surprises that the more explicit date-based forward guidance that came in August 2011, coupled with the introduction of the dot plot the following January, was effective in pushing the expected time of liftoff back to around two years from then. Femia, Friedman, and Sack (2013) reach a similar conclusion using survey evidence.

[7]Indeed long-term interest rates should, if anything, increase with higher inflation expectations.

The theoretical concept of forward guidance is a commitment to allow an inflationary boom in the future (Eggertsson and Woodford 2003). This is very powerful in standard dynamic stochastic general equilibrium (DSGE) models, arguably implausibly so (Del Negro, Giannoni, and Patterson 2012). Campbell et al. (2012) refer to this as Odyssean forward guidance. However, neither the Federal Reserve nor any other central bank has given this kind of forward guidance, and indeed Kohn (2009) stated that this was not the intention of FOMC forward guidance. A planned overshoot of inflation as in Eggertsson and Woodford (2003) is not envisioned in the current monetary policy framework.

3.3 Summary of Economic Projections

One of the transparency initiatives of the FOMC over the past decade or so has been the introduction of the Summary of Economic Projections and its expansion to include forecasts of interest rates in 2012. The hope was that market expectations would move in line with the SEP and give them more of a hold on longer-term interest rates.

The SEP interest rate projections, viewed as the Committee's forecasts, have turned out to be quite poor, perhaps in part because they represent up to 19 different views, many of which are quite distinct. Federal Reserve Chairs have noted that the dot plot is not a consensus forecast of the FOMC and that the statement is the mechanism that the Committee uses to express its collective judgment about the likely future path of rates. Nonetheless, the dot plot gets a lot of attention and is, not surprisingly, viewed by markets and the press as a Committee forecast, notwithstanding insistence to the contrary. This is especially true since the statement does not normally include much explicit guidance about future interest rates. Eberly, Stock, and Wright (2019) used event-study evidence to argue that a 1 percentage point higher-than-expected SEP interest rate expectation raises Eurodollar rates at that same horizon by about 18 basis points.

Faust (2016) argues that the dot plot conveys the diversity of views on the Committee but fails to represent how the Committee is likely to aggregate those views into a consensus. Consequently, he argues the dot plot gives the illusion of transparency but adds to public confusion. He cites a political science literature that maximal apparent transparency can actually be counterproductive (Stasavage 2007, Sunstein 2016).

3.4 Macroeconomic Effects

By the standards of time-series macroeconometrics, the data span available for studying the macroeconomic effects of slope shocks is relatively short, so it is perhaps not surprising that the literature has obtained a wide range of results. Using a Bayesian VAR identified via sign and zero restrictions, Weale and Wieladek (2016) found that asset purchases of 1 percent of GDP, in the United States, led to a peak increase in both real GDP and CPI (consumer price index) of 0.6 percentage point. These are very large estimated effects—the size of the Fed balance sheet increased by nearly 20 percentage points of GDP. Hesse, Hofmann, and Weber (2018) use a similar Bayesian VAR methodology but get somewhat smaller, though still very positive, effects on both economic activity and inflation. In subsample analysis, they find that the effects of asset purchases were stronger in the early stages, right after the crisis, than later on.

Nakamura and Steinsson (2018a) identify a policy news shock as the first principle component of the jump in five short-term interest rates around FOMC announcements and find that surprise *tightening* of policy is associated with an *increase* in growth expectations. This exercise does not attempt to separate shocks to the level of funds rate from shocks to the slope of the yield curve. They interpret this as being due to the possibility that tighter monetary policy reveals Federal Reserve information about the state of the economy, along the lines also indicated by Campbell et al. (2012, 2017).

Several authors have identified forward guidance, or path surprises, in structural VARs using high-frequency financial variables around announcements as instruments, with mixed results. These papers interpret shocks to the slope of the yield curve as forward-guidance surprises, but they may also include elements of LSAPs, especially since the two kinds of announcements often came out concurrently. Bundick and Smith (2018) find that forward guidance shocks that lower the path of expected policy rates lead to moderate increases in output and inflation, but Kim (2017) and

Lakdawala (2019) find that these forward guidance shocks are contractionary, which they see as supporting the information signaling view of Nakamura and Steinsson (2018a).

A number of authors use either DSGE or the FRB/US models to simulate the effects of LSAPs and forward guidance. These papers have found that LSAPs and forward guidance have modest but beneficial effects on both economic activity and inflation. We return to these papers in section 6.

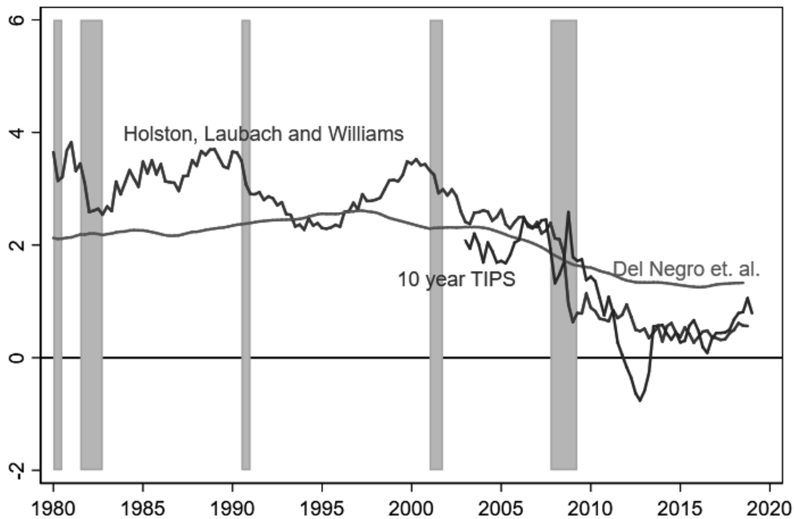
4. The Decline in r^*

Over the past 15 years, nominal interest rates have fallen by more than the rate of inflation, suggesting that the long-run equilibrium real rate of interest has declined. All else being equal, a lower equilibrium real rate implies a lower equilibrium nominal rate, which (holding constant the inflation target) implies a higher probability of hitting and staying at the zero lower bound as a result of countercyclical monetary policy.[8]

Figure 1 shows the yield on 10-year Treasury inflation-protected securities (TIPS), along with two estimates of the equilibrium rate of interest, which are updated estimates based on Del Negro et al. (2017) and on Holston, Laubach, and Williams (2017). Although the numerical values differ, all three series point to a decline both in the real rate, as measured by the return on TIPS, and on the underlying long-run equilibrium real rate, which is unobserved. The estimated equilibrium rate using the Holston, Laubach, and Williams (2017) method is approximately 50 basis points over 2017–18. The current Summary of Economic Projections has a long-run projection for the federal funds rate of 2.8 percent, implying an equilibrium real interest rate of 80 basis points. Chung et al. (2019, figure 1) plot the range of seven different estimates of r^*. While there is disagreement about the precise value of r^* currently, there is broad agreement that it has declined by 1 percentage point, or perhaps more, since the early 2000s. This decline is an international phenomenon, shared by all developed economies (Obstfeld 2019, Rachel and Summers 2019).

[8]For example, Kiley and Roberts (2017) estimate that the zero lower bound will bind about one-third of the time in the future.

Figure 1. Two Estimates of the Long-Term Equilibrium Real Rate of Interest (r^*) and the Yield on 10-Year TIPS



Source: Holston, Laubach, and Williams (2017), updated, and Del Negro et al. (2017), updated. TIPS: Federal Reserve Economic Database (FRED).
Note: Shading denotes NBER-dated recessions.

Economists have suggested multiple explanations for the decline in r^*, including the aging of the population (increasing the demand for savings), an increasing premium for safety and liquidity (perhaps due to greater global demand for safe assets), and a lower trend rate of growth of productivity; see Andrade et al. (2019) and Rachel and Summers (2019) for a discussion of these forces and relevant references. Most of these forces represent low-frequency trends that are not affected by monetary policy and can reasonably be expected to persist for an extended period of time.

5. Simulation Model

Our assessment of the performance of Fed policy over the expansion uses a model of monetary policy, interest rates, the unemployment rate, and price inflation. Section 5.1 provides an overview of the model, and sections 5.2 and 5.3 provide econometric details.

5.1 Overview of the Simulation Model

The simulation model groups monetary policy actions into two categories: traditional monetary policy circa 2000, in which the FOMC sets a range for the federal funds rate, and slope shocks, which explicitly aim to affect the slope of the Treasury yield curve.

Slope shocks comprise the multiple additional tools or actions of the current monetary policy framework, including forward guidance, releases of the SEP, LSAPs, and maturity management. The common feature of these tools is that they affect the slope of the safe-asset term structure, either by providing information about future policy and, thus, changing expectations of future short rates, or by directly affecting the value of current long rates. As discussed in section 2, these policies are nuanced, interact, and have evolved over time. Instead of trying to estimate their effects separately, we quantify the collective effect of this new suite of policies through their combined effect on the slope of the term structure, which in our base model is measured by the spread between the yield on 10-year Treasuries and the federal funds rate.

The simulation model quantifies the response of the unemployment gap and the rate of inflation over time to federal funds and/or slope monetary policy shocks. The simulation model merges two separate models, one of the CBO unemployment gap and another of core PCE inflation.

For the unemployment gap, we use a monthly structural vector autoregression (SVAR) to estimate the separate effects of federal funds and slope shocks. These effects are identified using an instrumental-variables strategy that exploits Kuttner's (2001) insight that, in a tight window around an FOMC announcement, the predominant reason for a change in interest rates or Treasury bond prices is the information about policy revealed by the announcement. From these announcement-window changes we construct two instrumental variables, one for the federal funds shock and one for the slope shock, which we use in conjunction with a vector autoregression to estimate the separate effects of federal funds and slope shocks on the unemployment rate over time.

These announcement-window changes in interest rates are directly attributable to policy shifts that are at least partially unexpected and comprise part of the overall monthly change in interest rates. We use this policy-related exogenous variation in rates to identify the effect of policy changes on relevant macroeconomic variables. With this effect in hand, we trace out the dynamic effect of the federal funds or slope shocks on the unemployment gap using a vector autoregression, using the structural vector autoregression-instrumental variables (SVAR-IV) method, as used with a single shock by Gertler and Karadi (2015).

The simulation model merges this response of the unemployment gap to federal funds and slope monetary policy with a hybrid New Keynesian Phillips curve, which relates the rate of inflation to past inflation, expected future inflation, and inflationary pressure exerted by the unemployment gap. In the combined model, a contractionary federal funds policy—that is, a tightening of monetary policy through a higher federal funds rate, holding constant the 10-year federal funds spread—implies a contractionary path of the unemployment gap. The increase in the expected discounted value of the unemployment gap then exerts negative pressure on inflation, which falls somewhat at first, then more as the inertial effects of the initial inflation rate wear off. Similarly, a contractionary slope shock—an increase in the 10-year federal funds spread, holding constant the federal funds rate—leads to an expected deterioration of macroeconomic conditions which also results in a decline in current and future rates of inflation. Thus, the simulation model can be used to compute counterfactual paths for the rates of unemployment and inflation under policies that differ from those actually implemented.

There are other useful frameworks that are widely used for evaluating monetary policy counterfactuals. The Fed's main macro model, FRB/US, is routinely used for this purpose—see Bernanke, Kiley, and Roberts (2019) and Chung et al. (2019) for recent examples. Another approach is to use a DSGE model, such as the one recently used for related simulations by Debortoli, Galí, and Gambetti (2019) and Sims and Wu (2019). An advantage of our approach is its transparency and simplicity. We view these approaches as complementary, and in section 6 we compare our results with those obtained by other researchers using other methods.

5.2 Identification and Estimation of the Effects of Federal Funds and Slope Shocks on the Unemployment Rate

We use the SVAR-IV method to estimate the dynamic effect of a federal funds shock and a slope shock on the unemployment gap.[9] Gertler and Karadi (2015) use announcement-window changes and the SVAR-IV method to identify the dynamic effect of a federal funds shock, and our model of the unemployment gap can be seen as an extension of their approach to include both a federal funds and a slope shock.[10]

In our base model, the vector autoregression consists of five monthly variables: the unemployment gap, the federal funds rate, the spread between the yield on 10-year Treasury bonds and the federal funds rate, the Gilchrist and Zakrajšek (2012) excess bond premium (EBP), and the inflation rate as measured by core PCE. The two instruments are drawn from a panel of changes in interest rates of maturities from overnight (the federal funds rate) through 10 years around FOMC monetary policy announcements. The full balanced panel of these announcement-window changes runs from 1994:M2 to 2019:M2.[11]

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[9]The SVAR-IV method (Stock 2008, Stock and Watson 2012, Mertens and Ravn 2013) consists of two steps. In the first, a reduced-form VAR is estimated, yielding the VAR innovations (residuals). In the second, instrumental-variables regression is used to estimate the causal effect of a shock by regressing the other VAR innovations (e.g., the unemployment gap innovation) on the causal variable of interest (e.g., the federal funds rate) using instrumental-variables regression. The resulting IV coefficients estimate the impact effect of a monetary policy shock, which is traced out dynamically using the VAR. See Stock and Watson (2018) for an overview and a discussion of the relation between SVAR-IV and local projections-IV (LP-IV).

[10]Kim (2017) and Lakdawala (2019) both use a two-instrument/two-shock identification approach with announcement-window changes; however, they focus on forward guidance shocks and shorter ends of the term structure.

[11]The data are from Gürkaynak, Sack, and Swanson (2005), as updated by Federal Reserve staff. The data are announcement-window changes, computed using two-hour windows, in the following interest rates: the first six federal funds futures contracts, the front eight Eurodollar futures contracts, on-the-run three- and six-month bill yields and on-the-run 2-, 5-, 10-, and 30-year Treasury coupon yields. The data also include announcement-window changes in S&P 500 futures contracts. In months with no announcement, the value of the announcement-window change is zero. In months with multiple announcements, the announcement-window changes were summed over that month for the total

For the federal funds shock, the instrument is the difference between the target decision and the expectation implied by current-month (and potentially next-month) federal funds futures contracts, constructed as described by Kuttner (2001). The effect of a federal funds shock is then estimated by instrumental-variables regression of the VAR variables on the federal funds rate.

For the slope shock, the instrument identifies policy-induced changes in the slope of the interbank/Treasury term structure, holding constant changes in the federal funds rate. To this end, the slope instrument is the residuals from a regression of announcement-window changes in the 10-year on-the-run Treasury yield onto the Kuttner shock. This residual is similar in spirit to the path surprise of Gürkaynak, Sack, and Swanson (2005), but using a much longer maturity concept of the slope. The impact effect of the slope shock is then estimated by instrumental-variables regression of the VAR variables on the 10-year federal funds spread, using the slope instrument.

The SVAR-IV method permits different estimation samples to be used for the VAR and the instrumental-variables regressions. The (reduced-form) monthly vector autoregression is estimated with four lags[12] over the period 1990:M1–2019:M2, a period that omits the Great Inflation and its immediate aftermath. The IV regression that estimates the impact effect of the federal funds shock is estimated over the period 1994:M2–2007:M12, which avoids the zero lower bound period during which there were no federal funds policy changes. The IV regression that estimates the effect of the slope shock is estimated over 2008:M1–2019:M2, the period during which the instruments of slope policy were refined and implemented.[13]

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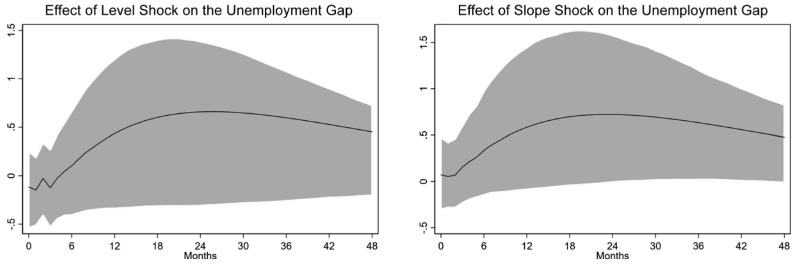
monthly announcement-window change. Otherwise, the monthly observation is the single announcement-window change in that month.

[12]The Akiake information criterion (AIC) selects four lags and the Bayesian information criterion (BIC) selects two lags, and the unemployment gap impulse response functions (IRFs) are insensitive to using either the AIC or BIC choice.

[13]As noted in section 2, the first use of slope policy in the modern era was the appearance of forward guidance in 2003; the SEP, LSAPs, and maturity policy were not developed until the crisis. Thus the period prior to 2003, and arguably prior to 2007, was one in which there was little or no reliance on slope policy. Because our instruments start in 1994:M2, this provides a period for a placebo test of our scheme for identifying the effect of slope shocks prior to 2007. Our method should not detect slope policy during that early period, and as is reported in the

Figure 2. Estimated Response of the Unemployment Gap to Unit Federal Funds and Slope Monetary Policy Shocks



Notes: The federal funds shock increases the federal funds rate by 1 percentage point. The slope shock increases the 10-year Treasury–federal funds spread by 1 percentage point. The instrument for the federal funds monetary policy shock is the difference between the pre-announcement level of the federal futures rate and the announced target (the Kuttner shock). The instrument for the slope monetary policy shock is the residual from regressing the announcement-window change in the 10-year on-the-run Treasury yield on the Kuttner shock. Estimation samples are 1990:M1–2019:M2 for the VAR, 1994:M2–2007:M12 for the federal funds shock IV regression, and 2008:M1–2019:M2 for the slope shock IV regression. Shaded area denotes one-standard-error bands, computed by parametric bootstrap.

The estimated impulse response functions are shown in figure 2. First consider the federal funds shock. The instruments are strong, with a heteroskedasticity-robust first-stage F statistic of 17.0. A 1 percentage point monetary policy increase in the federal funds rate, holding the slope of the term structure constant, is estimated to increase the unemployment rate by approximately 0.6 percentage point after 18 months; however, this effect is imprecisely estimated.[14]

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supplement, indeed it does not. (The supplement is available from the authors upon request.)

[14]Many monetary SVARs use quarterly data and/or a flow activity variable, such as industrial production, instead of the unemployment rate, complicating a direct comparison. Two papers that consider monthly monetary VARs with the response of the unemployment rate to a federal funds shock are Coibion (2012) and Ramey (2016). Ramey's figure 2(c) proxy VAR (SVAR-IV) estimate of the unemployment rate impulse response function is very close to ours, including the initial dip and a maximum value of approximately 0.4 percentage point attained after approximately two years, despite important differences (different sample period and she uses the Romer and Romer 2004 monetary policy shock

For the slope shock, the instrument is weaker than for the federal funds shock (first-stage $F = 5.8$). A 1 percentage point slope shock—that is, a shock that increases the 10-year federal funds spread by 1 percentage point—increases the unemployment rate by a peak of about 0.7 percentage point, attained after 18 to 28 months.

An issue that affects the interpretation of the slope shock impulse response function is the extent to which the elements of slope policy revealed during an announcement convey Fed inside information about the economy, as opposed to information about the future path of policy (see, for example, Campbell et al. 2012; Kim 2017; Nakamura and Steinsson 2018a, 2018b; and Lakdawala 2019). If movements in the slope of the term structure around announcement windows reflect news about the economy, rather than a reaction to policy actions and intentions, the impulse response function will be a biased estimate of the dynamic causal effect of the slope shock. We do not provide a complete analysis of this issue, but we do offer three observations. First, the sign of the news channel is the opposite of that in figure 2: to the extent that an announcement of, for example, prolonging a zero federal funds rate also conveys bad news about the economy, then the announcement-window decline in the 10-year federal funds spread would be associated with a lower future unemployment gap than expected, the opposite of what we estimate. Second, similar reasoning implies that an announcement that conveys bad economic news would increase the excess bond premium, but our estimated response of the EBP to the slope shock has the opposite sign, with moderate persistence (see section A.1 of the appendix). Third, if the announcement conveys news, then one would expect bad news (a reduced spread) to be associated with a decline in the stock market. Because our data set contains the announcement-window change in the S&P 500, we can examine this implication

as an instrument, not announcement-window changes). Coibion (2012) treats the Romer and Romer (2004) monetary policy shocks as shocks, not as instruments, which in the SVAR-IV framework is the reduced-form response to the instrument. Despite this and other important differences, Coibion's (2012, figure 7 and table 2) estimates of the peak response of the unemployment rate bracket our estimates. Using a DSGE model, Sims and Wu (2019) find that the peak response of output is about 0.5 percentage point, which translates into a quarter percentage point on unemployment with the conventional Okun coefficient, and that is in turn a bit smaller than most SVAR estimates.

empirically, and it does not hold up in the data: the announcement-window change in the S&P 500 is negatively correlated with our slope instrument, and indeed is negatively correlated with the residuals from regressions of announcement-window changes against the Kuttner shock at horizons of three or more months over the period 2008:M1–2019:M2.[15] While these observations do not rule out some potential bias from announcements having an economic news component, together they suggest that the impulse responses reported here primarily reflect the slope policy channel. To the extent that there is some potential for an information channel, the impulse responses that we report are maximal effects that assume no news effect is operative.

Section A.1 of the appendix shows estimates of these IRFs obtained using local projections with instrumental variables, which (for these instruments) does not require the SVAR assumption of invertibility. Robustness checks of the IRFs in figure 2 to various modeling assumptions are reported in the supplement.[16]

5.3 The Phillips Curve

The second part of the model quantifies the relation between the unemployment gap and inflation, which is quantified using the hybrid Phillips curve,

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f \pi^e_{t+1} + \kappa Ugap_t + e_t, \tag{1}$$

where π_t is quarter-over-quarter core PCE inflation (at an annualized rate), $Ugap_t$ is the unemployment gap, π^e_{t+1} is expected inflation as measured from the Michigan survey, and e_t is the error term.[17]

[15]The 18 correlations between the S&P 500 change and the various orthogonalized interest rate futures or yield changes (excluding the current- and next-month federal funds futures rates) range from −0.06 to –0.33, with only four being significant at the 5 percent level.

[16]The supplement is available from the authors upon request.

[17]Because the inflation rate is included in the VAR, one option would be to estimate the effect of the two monetary policy shocks on inflation by SVAR-IV, as we do for the unemployment rate. Doing so, however, has two disadvantages. First, as McLeay and Tenreyro (2019) emphasize, monetary policy has successfully stabilized the inflation rate in a range that is narrow by historical standards, but from an econometric perspective this successful management of inflation confounds the reduced-form relation estimated using a VAR or a conventional Phillips curve that

Because the unemployment gap responds to supply shocks that also affect the rate of inflation (and thus are contained in the error term e_t), the unemployment gap is endogenous and the parameters of equation (1) cannot reliably be estimated by ordinary least squares. We therefore estimate equation (1) by generalized method of moments. For instruments, we draw inspiration from Debortoli, Galí and Gambetti (2019) and, more closely, Barnichon and Mesters (2019a). Barnichon and Mesters (2019a) point out that monetary policy shocks, were they observable, would provide valid instruments because they would be uncorrelated with the supply shocks comprising e_t. Although monetary policy shocks are not observed, observable instruments for those shocks can be used instead. Because monetary policy shocks enter with a lag, a distributed lag of those instruments should be used if they are to be relevant.

Accordingly, we construct instruments from the panel of announcement-day changes described in footnote 11. Specifically, from the 20 announcement-day interest rate changes (the Kuttner shock and the 19 announcement-day changes with various maturities) we construct the first three principal components. From these, we construct two sets of instruments. The first set consists of exponentially weighted moving averages (EWMAs) of each principal component, with EWMA coefficients of 0.9 and 0.7, for a total of six instruments. The second set of instruments adopts Barnichon and Mesters' (2019a) approach and uses polynomial distributed lags, here with degree 2 and maximum lag length 12.

The estimation results are summarized in table 1. The estimates using the two instrument sets show similar coefficients. The first set

does not take into account the endogeneity of monetary policy. This is the classic problem that when a variable is controlled, the historical relationship used for that control breaks down (Kareken and Solow 1963, Goldfeld and Blinder 1972). McLeay and Tenreryo (2019) show that this can manifest as a Phillips curve that appears flat when in reality it is not. The VAR simply estimates a dynamic version of this Phillips curve and thus inherits this endogeneity problem. Second, because the Phillips curve is estimated implicitly in the VAR, it is difficult to use SVAR-IV methods to conduct sensitivity checks to changes in the Phillips curve and/or its lead-lag dynamics. Third, the VAR leaves the role of expectations implicit, but it is useful to know explicitly how important they are in the simulations. Fourth, the VAR covers a long period in which the slope of the Phillips curve is thought to have been flattening, and estimating the Phillips curve separately allows us to do so using more recent data.

Table 1. Estimated Phillips-Curve Coefficients

Instrument Set (# IVs)	$Ugap_t$	π_{t+1}	π^e_{t+1}	$\kappa/(1-\gamma_b-\gamma_f)$	First-Stage F-effective	J-statistic (p-value)
A (6)	−0.094	0.099	0.400	−0.187	43.65	4.89
	(0.024)	(0.049)	(0.092)	(0.054)		(0.43)
B (9)	−0.122	0.055	0.354	−0.206	6.94	5.18
	(0.024)	(0.044)	(0.066)	(0.043)		(0.74)

Notes: The unemployment gap is from the Congressional Budget Office. Data are quarterly. Standard errors are strong-instrument Newey-West (eight lags). All regressions include an intercept. The first-stage F statistic is the Montiel Olea and Pflueger (2013) effective F. Instrument set B: polynomial distributed lags of degree 2 of first three principal components of announcement-window changes in the panel of interest rates (including federal funds), 1994:Q2–2018:Q4 (maximum lag = 12). Instrument set B: EWMA of first three principal components using weight coefficients 0.90 and 0.70.

(the EWMA instruments) is stronger, and we use those estimates for our base model.[18] The estimates in table 1 are in the range of those in the literature; see, for example, the estimates in Crump et al. (2019) and McLeay and Tenreyro (2019, table 2). These estimates imply fairly flat Phillips curves. One measure of the implied Phillips-curve slope is the long-run effect of a sustained unit increase in the unemployment gap, which, in terms of the coefficients in equation (1), is given by $\kappa/(1-\gamma_b-\gamma_f)$. This value is reported in table 1 and is similar, approximately -0.2, for the two estimates.

5.4 Combined Simulation Model and Simulation Method

The unemployment rate impulse responses from section 5.2 are monthly, which takes advantage of the monthly data on announcement-window changes, while the Phillips-curve estimation is quarterly, the frequency of observation of the Michigan inflation expectations survey. To combine the two models, the impulse responses of the unemployment gap to the two monetary shocks were temporally aggregated by averaging the unemployment rate responses for the months within the quarter. Given these two quarterly impulse responses, the hybrid Phillips curve is solved forward.[19] Doing so yields two mutually consistent pairs of impulse responses of the inflation rate and the unemployment gap first to the federal funds shock and second to the slope shock.

The model for the federal funds shock is completed by augmenting the unemployment gap and inflation rate impulse responses by the dynamic response of the federal funds rate to the federal funds shock. Given this trio of impulse response functions, we follow Sims

[18]Results for alternative specifications, including different sample periods, using core CPI inflation and the Survey of Professional Forecasters expectations method, and different estimators are reported in the supplement.

[19]The forward solution of equation (1) involves a variant of the Blanchard and Kahn (1980) method. Assume that $\gamma_f > 0$, $\gamma_b > 0$, and $\gamma_f + \gamma_b \leq 1$. Define $z_t = \pi_t - \theta\pi_{t-1}$ and guess that $z_t = \zeta E_t z_{t+1} + \varphi Ugap_t$ for unknown parameters θ, ζ, and φ. We verify that this guess satisfies equation (1) if $\zeta = \gamma_f/\lambda$, $\varphi = \kappa/\lambda$, and $\lambda\theta = \gamma_b$, where $\lambda = 1 - \theta\gamma_f$. Solving the third of these equations gives $\theta = \left(1-\sqrt{1-4\gamma_b\gamma_f}\right)/2\gamma_f$. Then solve forward to write $z_t = (\kappa/\lambda)\sum_{j=0}^{\infty}(\gamma_f/\lambda)^j E_t Ugap_{t+j}$ and hence $\pi_t = \theta\pi_{t-1} + (\kappa/\lambda)\sum_{j=0}^{\infty}(\gamma_f/\lambda)^j E_t Ugap_{t+j}$.

(1986) and compute the sequence of federal funds shocks that would deliver a specified path of the federal funds rate, and then compute the effect of that sequence of federal funds shocks on the unemployment gap and the rate of inflation. Similarly, by augmenting the slope shock pair of impulse responses by the dynamic response of the 10-year federal funds spread to a unit slope shock, we can compute the sequence of slope shocks to obtain a stipulated path of this spread and thus their effect on the unemployment gap and the rate of inflation.

Both trios of impulse response functions imply a dynamic reduced-form Phillips relation, that is, the cumulative change in the rate of inflation divided by the cumulative change in the rate of unemployment. Because the two shocks have different dynamics, these two ratios differ for the two shocks; however, they turn out to be numerically close. For our base model after 24 months, this Phillips slope is −0.188 for the federal funds shock and –0.185 for the slope shock. The 24-month Phillips multiplier is approximately $\kappa/(1-\gamma_b-\gamma_f)$, which is reported in table 1. The estimates of McLeay and Tenreyro (2019), using pooled ordinary least squares estimation with metro area data (their table 3) imply an estimate of $\kappa/(1-\gamma_b-\gamma_f)$ of −0.308. Barnichon and Mesters (2019b), using high-frequency instruments, get a post-1990 Phillips multiplier of about −0.15 at three to four years, but they estimate a steeper Phillips curve using Romer and Romer (2004) shocks as instruments. Section A.2 of the appendix and the supplement explore the sensitivity of our counterfactual estimates to using a more responsive Phillips curve.

6. Performance Under Counterfactuals

We use this simulation model to assess how the U.S. economy would have performed under alternative monetary policies implemented using the tools of the current monetary policy framework. We start by compiling the assumptions underlying this analysis. First and most importantly, our analysis takes full advantage of the benefits of hindsight and, as such, care must be taken in interpreting the results. For example, several of our counterfactuals are infeasible hypothetical cases, and all our simulations rely on ex post data that were unavailable to Fed decisionmakers in real time. Thus, finding that macroeconomic performance is better under a given counterfactual does not imply that the Fed should or could have made different decisions in real time. Rather, such a finding, based on what we know now, can inform future Fed policy as it navigates the next recession and recovery. Second, our conclusions depend on a particular estimated structural VAR model, except that the mapping from unemployment gap to inflation impulse responses is instead described by a hybrid Phillips curve, identified by instrumental variables. We do, however, compare our results to those of other papers and find that they are broadly consistent with many other estimates in the literature. Third, we assume that we have correctly identified two shocks—a federal funds shock and a slope shock—and that these are predominantly policy surprises, not the revelation of private information by the Fed. And finally, we are assuming that counterfactual policies can be represented as a sequence of unanticipated federal funds and slope shocks. We are therefore omitting any effects that these policies might have by changing expectations. As a consequence, our framework is not suited to assessing how commitment, or even imperfect commitment, might also work through altering agents' expectations.

We begin by describing the counterfactuals, then turn to the results.

6.1 Counterfactuals

No ZLB. Our first counterfactual supposes that there is no zero lower bound on interest rates and that the Fed had followed a Taylor rule for the federal funds rate, with no LSAPS. Here and subsequently, the Taylor rule we use is $FF_t = 2 + \pi^{(12)}_{t-1} + 0.5\left(\pi^{(12)}_{t-1} - 2\right) - 2 * Ugap_{t-1}$, where FF, $\pi^{(12)}$, and $Ugap$ are, respectively, the federal funds rate, the 12-month rate of core PCE inflation, and the unemployment gap. This is based on the Taylor (1999) rule, which uses the output gap as the slack measure, with a coefficient of 1. Yellen (2012) uses this version of the Taylor rule and refers to it as the "balanced approach" rule, and this output gap coefficient of 1 is also used by Chung et al. (2019). We translate the coefficient on the output gap into a coefficient of –2 on the unemployment gap, using an Okun's law coefficient of 2.[20] This counterfactual does not, of course, simulate a feasible policy path; like Christiano, Eichenbaum, and Trabant (2015) and Gust et al. (2017), we use it to calibrate the macroeconomic cost of the zero lower bound on interest rates.[21]

[20]Our Taylor rule has no interest rate inertia, as we want to focus on how the FOMC responds to inflation and the unemployment gap. Historically, the FOMC has moved quickly to cut rates in downturns.

[21]Alternative policy scenarios are implemented as a sequence of unanticipated federal funds and slope monetary policy shocks to provide a specified path for observable variables. We provide details here for the "No ZLB" scenario; the calculations for the other scenarios are similar. For the "No ZLB" scenario, the Taylor rule determines the value of the federal funds rate in the next period and thus the value of the federal funds shock, which in turn affects the realized values of inflation and unemployment and, via the Taylor rule, the subsequent value of the federal funds rate. Solving forward recursively yields the paths of the observable variables. The "No LSAP" hypothetical is implemented by calculating the sequence of slope shocks that remove the historical effect of LSAPs on the 10-year federal funds spread. To assess the effects of LSAPs, we take the change in System Open Market Account (SOMA) 10-year equivalents as a share of nominal GDP, relative to December 2008, and multiply this by an assumed elasticity of 10-year yields of 6 basis points per percentage point of GDP (Belton et al. 2018). This assumes that LSAPs work through the stock of purchases, rather than the flow. There likely were transitory flow effects, especially in disrupted financial markets in 2009, but we omit these for the purposes of our working calibration. Our no-LSAP scenario adds slope shocks to steepen the yield curve by the required amount. Because this negation of historical slope policy is calibrated by a no-LSAPs scenario, it does not necessarily remove the effects of forward guidance. The effect of the sequence of federal funds shocks on interest rates, the unemployment gap, and inflation are computed using the IRFs for those series with respect to the levels shock, and, similarly, the slope shock IRFs are used for the sequence of slope shocks. The combined effect on all variables (interest rates, unemployment, and inflation) is the sum of the level and slope effects for each variable. For scenarios below that specify "historical slope policy," no changes are made to historical slope shocks, so the counterfactual paths for interest rates, inflation, and the unemployment gap arise solely from the federal funds shock and the federal funds shock IRFs. Slope shocks are allowed to affect the level of the funds rate after liftoff in December 2015, but not during or before December 2015 when the economy was stuck at the ZLB. Finally, for plotting purposes, results are reported in terms of the unemployment rate by adding the CBO natural rate of unemployment to the simulated path of the (CBO) unemployment gap, under the assumption that the monetary policy counterfactuals do not affect the natural rate of unemployment.

Follow Taylor (1999) Rule (Constrained by ZLB) with No LSAPs. This counterfactual is like the "no ZLB" counterfactual, except that the ZLB is imposed and there are no LSAPs, as discussed in footnote 21.

Earlier/Later Liftoff. These counterfactuals imagine that the observed path of increases in the federal funds rate started, alternatively, one year earlier or one year later. For these counterfactuals, slope policy is unchanged, that is, the realized historical slope shocks are used.

Alternative 10-Year Federal Funds Slope Policies. We consider several counterfactuals in which federal funds policy is the same as it was historically but slope policy differs. Specifically, we consider four such counterfactuals that focus on the 10-year federal funds spread: no LSAPs (computed as described in footnote 21); a slope policy that flattened the 10-year federal funds slope by 1 percentage point for two years; an earlier and stronger slope policy that flattened the slope by 2 percentage points for 18 months beginning December 2008; and a slope policy that fixed the 10-year federal funds spread at 2 percentage points for five years starting in December 2008.

Historical $\pi* = 3\%$ or 4%. This hypothetical supposes, counterfactually, that entering the recession, the Fed had inherited nominal interest rates, rates of inflation, and an inflation target either 1 or 2 percentage points higher than actual. For example, for the 10 years through 2000, core PCE inflation averaged 2.1 percent, essentially at the 2 percent target. Under the $\pi* = 3\%$ counterfactual, inflation hypothetically would have averaged 3.1 percent, essentially at a 3 percent target. More generally, we quantify the concept of inheriting an inflation target that is x percentage points higher by increasing the values of all nominal variables (interest rates and inflation) by x percentage points at an annual rate, while leaving real variables unchanged. These higher nominal rates are then combined with various policy rules or targets to provide counterfactuals. For example, one such counterfactual is inherited nominal rates 1 percentage point higher and an inherited 3 percent inflation target, historical federal funds policy (still driving the federal funds rate to the ZLB), and historical slope policy (historical slope shocks). Another counterfactual specifies a 3 percent inflation target coupled with no slope policy, which is implemented as an absence of LSAPs as described in footnote 21.[22]

Temporary Price-Level Targeting. Temporary price-level targeting involves the Fed committing to make up shortfalls in inflation when at the zero lower bound. The simplest form of temporary price-level targeting would commit the Fed to remain very accommodative until cumulative average inflation since hitting the zero lower bound reaches the target. Conventional inflation targeting (which references only the rate of inflation, not the price level) would resume once away from the ZLB. In unreported results, we simulated this version of temporary price-level targeting; however, the magnitude of disinflation in the recession was such that it would take quite extreme policies to hit the temporary price-level target by 2019, and inflation would have to go considerably above 2 percent. This finding is broadly consistent with findings in Bernanke, Kiley, and Roberts (2019), so we examine instead their proposal for temporary

[22]A mechanical alternative interpretation of the higher-inflation steady-state counterfactual is that the Fed could drive nominal rates below zero by the difference between 2 percent and the hypothesized rate. We do not endorse this interpretation, however, because such a policy would go sufficiently beyond the scope of historical experience that we would not consider our simulation model to be reliable were nominal rates to be reduced below zero by more than a small amount. Moreover, the literature that has studied negative rates concludes that when rates are negative, further cuts are less stimulative than in normal times and may even be contractionary. Negative interest rates have been in Europe and in Japan. No country has set a policy rate below –75 basis points, and only Switzerland has gone this low. The European Central Bank (ECB) has set its deposit facility rate at –40 basis points. However, deposit rates have generally been bounded at zero, and bank profits may be hurt by negative rates. Brunnermeier and Koby (2018) considered the idea of a reversal interest rate at which further cuts would hurt bank profitability and might be contractionary. Consistent with this, whereas event-study evidence has typically found that monetary policy raises bank equity returns, Ampudia and Van den Heuvel (2018) find that surprise monetary policy easing lowers bank equity prices at negative interest rates. Eggertsson et al. (2019) document that in Swedish data, for negative policy rate, cuts in policy rates have no effect on bank deposit rates and, if anything, increase bank lending rates. Eggertsson et al. (2019) and Ulate Campos (2018) both study the effects of negative interest rates on economic activity in DSGE models. Ulate Campos finds that interest rate cuts are less stimulative than when rates are positive; Eggertsson et al., who do not incorporate bank monopoly power, find that they are outright contractionary. Burke et al. (2010) concluded that, in the United States, a rate below about −35 basis points might lead banks to switch reserves into physical currency.

price-level targeting with a one-year lookback, which is equivalent to average inflation targeting where the average is computed over the prior 12 months. This policy would commit the Fed to maintain very accommodative policy until inflation over the previous year averages 2 percent. We consider two forms of temporary price-level targeting with this one-year lookback period. One promises federal funds shocks to keep the funds rate at zero until the target is reached; the other instead promises slope shocks to achieve the same effect.

Makeup Rule. Reifschneider and Williams (2000) propose that if the federal funds rate hits the zero lower bound, the Fed would keep the rate at the zero lower bound for an additional period after the Taylor-rule rate rises above zero, where the additional time is enough to make up for the excursion of the Taylor-rule rate below zero. (This makeup rule is the third rule listed on page 37 of the February 2019 Monetary Policy Report).

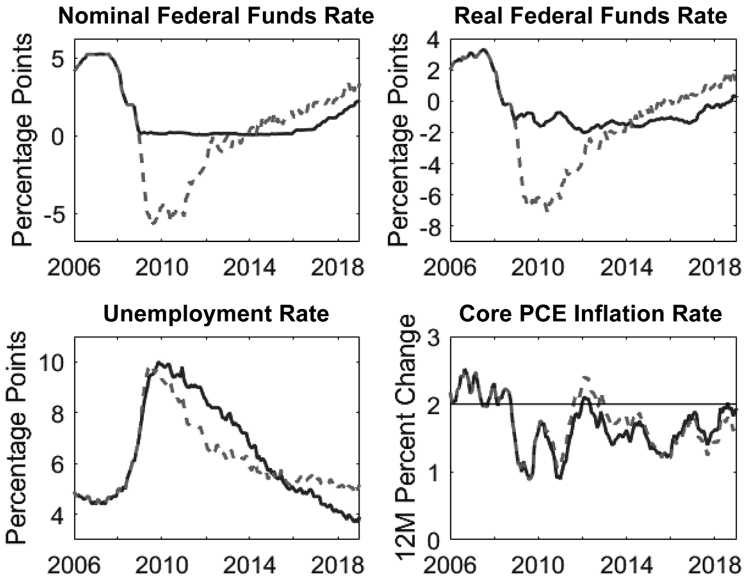
6.2 Results

The results of each counterfactual are summarized in four-panel figures, which depict the actual and counterfactual paths of the nominal federal funds rate or 10-year federal funds spread (upper left), the real federal funds rate (upper right), the unemployment rate (lower left), and the 12-month rate of core PCE inflation (lower right).

Figure 3 shows the results for the Taylor (1999) rule with no-ZLB counterfactual. Absent the ZLB, the Taylor rule would have prescribed a nominal funds rate of -5.5 percent in 2009 and 2010, resulting in a much faster decline of the unemployment rate.[23] However, the funds rate would have returned to being positive in 2012, which would have slowed the pace of progress on unemployment during the second half of the recovery, and the unemployment rate would have stabilized approximately at the CBO NAIRU. These results are very similar to the findings of Gust et al. (2017), who consider a DSGE model where the federal funds rate is the only instrument

[23]The original Taylor (1993) rule has a coefficient of 0.5 on the output gap, which translates into -1 on the unemployment gap, with the conventional Okun's coefficient. This would prescribe a funds rate of -2 percent in 2009 with a slower recovery than we obtain with the Taylor (1999) rule. We show this counterfactual in the supplement.

Figure 3. Counterfactual with Unconstrained Taylor (1999) Rule

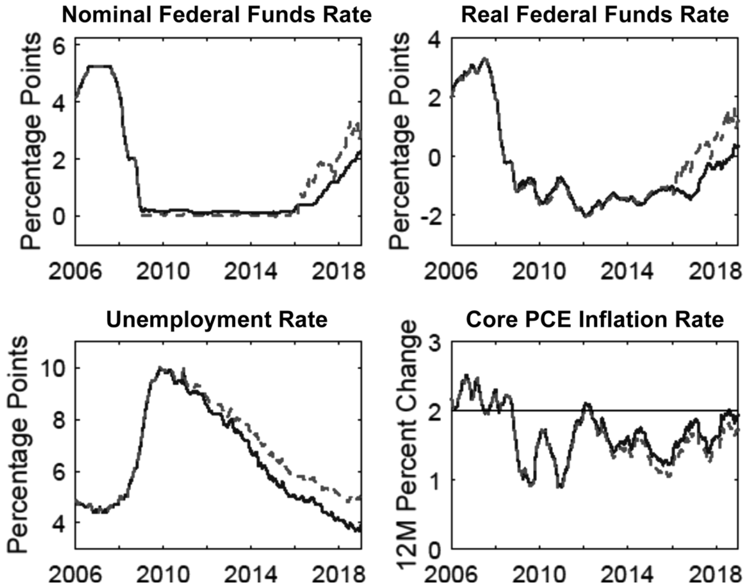


Note: Actual is solid line; counterfactual is dashed line.

of monetary policy (no forward guidance, LSAP, or other slope policy). Their monetary policy reaction function calls for a nominal funds rate falling to −5.5 percent. In their model, the inability to drive the funds rate below zero accounts for 30 percent of the fall in output in 2009 and most of the subsequent slow recovery.

Figure 4 shows the results for the Taylor rule incorporating the ZLB and undoing the effects of LSAPs, as discussed in footnote 21. The federal funds rate would have been at the ZLB until liftoff in late 2015. Progress on the unemployment rate would have been slower than was actually observed, especially later in the recovery, initially as a result of the steeper yield curve in the absence of LSAPs, then compounded by a steeper pace of tightening after liftoff. The unemployment rate would remain over 5 percent in early 2019, and the slow progress on unemployment would have further reduced the inflation rate, relative to what was actually observed.

Figure 4. Counterfactual with Taylor (1999) Rule Incorporating ZLB and No LSAPs



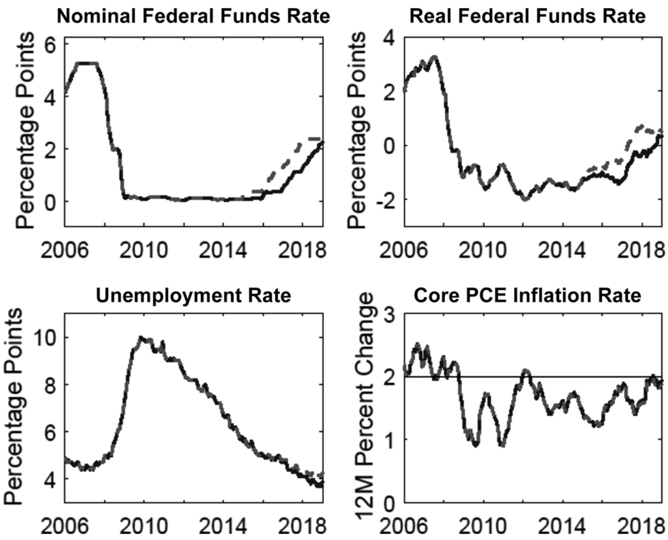
Note: Actual is solid line; counterfactual is dashed line.

Figure 5 and figure 6 envision a liftoff from the ZLB that is, respectively, one year earlier and one year later than actual, with no change in slope policy (same slope shocks as historical). Specifically, in the early liftoff simulation, we use federal funds shocks to get the funds rate starting in December 2014 to where it actually was one year later, and likewise for late liftoff. An earlier liftoff slightly slows progress on unemployment, but it has virtually no effect on inflation. Later liftoff would lower the unemployment rate at the end very slightly, but because of the lags the effect is negligible as of the end of the sample in February 2019.

Figures 7–11 simulate various alternative slope policies, combined with the actual historical federal funds policy. These counterfactuals are organized as a progression with increasingly aggressive slope policy.

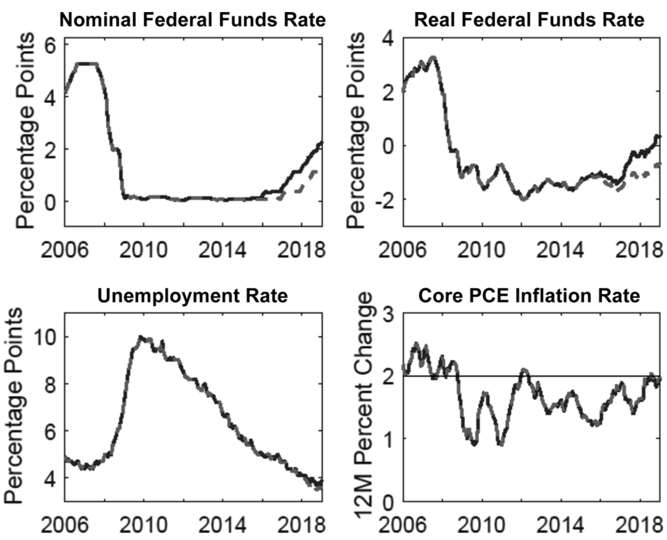
The first of these, in figure 7, contemplates a less aggressive slope policy than actual, calibrated to correspond to an absence of LSAPs.

Figure 5. Early Liftoff



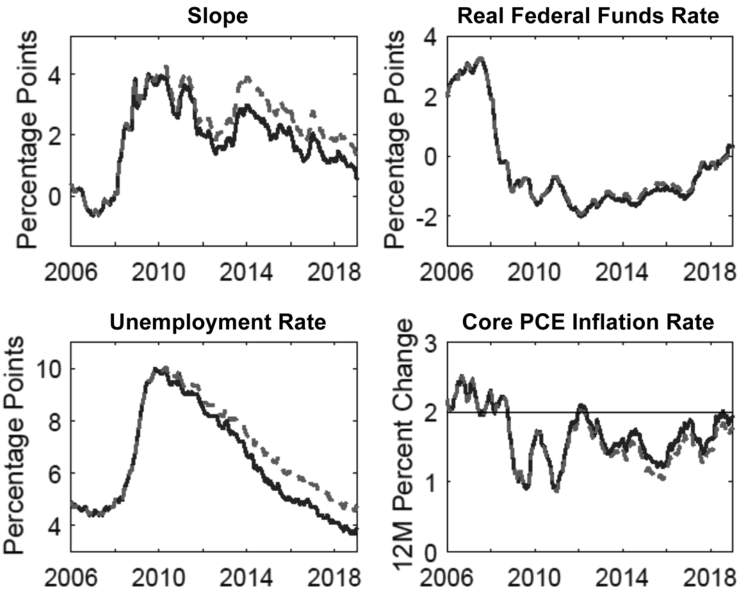
Note: Actual is solid line; counterfactual is dashed line.

Figure 6. Late Liftoff



Note: Actual is solid line; counterfactual is dashed line.

Figure 7. No LSAPs



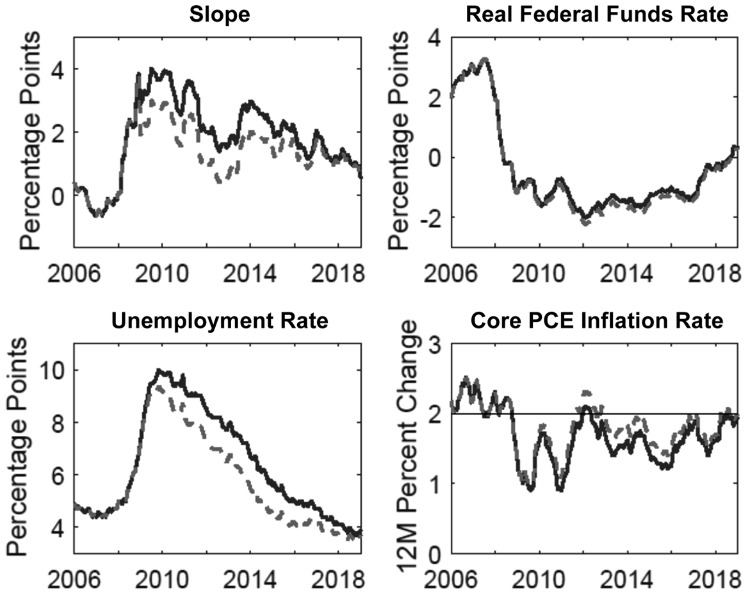
Note: Actual is solid line; counterfactual is dashed line.

This counterfactual has a steeper yield curve, especially after 2012.[24] The steeper yield curve would have slowed the improvement in the unemployment rate by more than a year, keeping the unemployment rate around 5 percent at the end of the sample, and the rate of inflation would have been even lower than it actually was.

Figures 8–11 consider more aggressive counterfactual slope policies. The first of these, in figure 8, counterfactually supposes a slope policy that flattens the yield curve by an additional 1 percentage point for five years, relative to the actual historical outcomes, starting in December 2008. Assuming an elasticity of 6 basis points per

[24]The reason why the effect on slope is largest after 2012 is that we assume that the effect of LSAPs is proportional to the stock of 10-year Treasury equivalents in the SOMA portfolio, as a share of nominal GDP, which peaked in 2014. To the extent that LSAPs might have had transitory flow effects, which might have been particularly large when financial markets were disrupted in 2009, this assumption could understate their effects in 2009 and overstate their effects later in the sample.

Figure 8. Counterfactual of Five Years of Additional Flattening



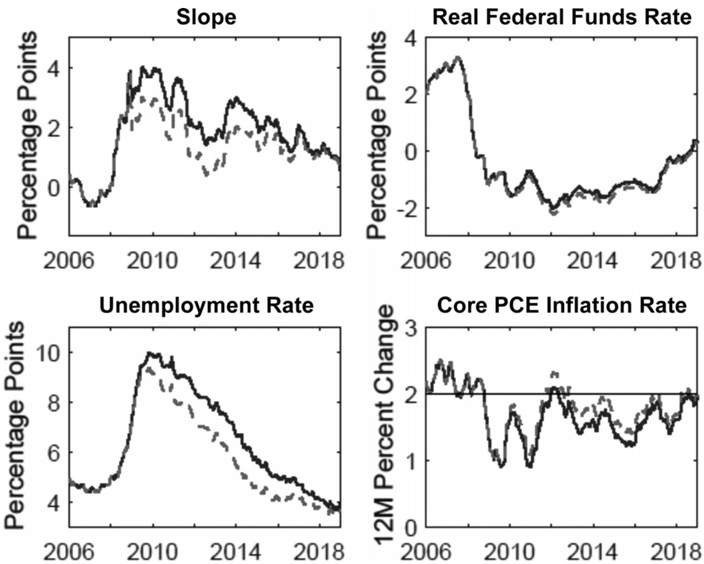
Note: Actual is solid line; counterfactual is dashed line.

percentage point of GDP 10-year equivalents, this corresponds to additional LSAPs of about \$2.5 trillion over and above the LSAPs that were actually implemented, although the slope shock could also be implemented in part by forward guidance. This slope shock would have closed the unemployment gap two years earlier and raised inflation a bit.

Figure 9 considers a threshold (state-dependent) version of the previous calendar (time-dependent) policy, in which the yield curve is flattened by 1 percentage point until either the unemployment gap falls to 1 percent or inflation exceeds 2.5 percentage points. The outcome is very similar to the simulation in figure 8, as the slope shocks get turned off after about five years.

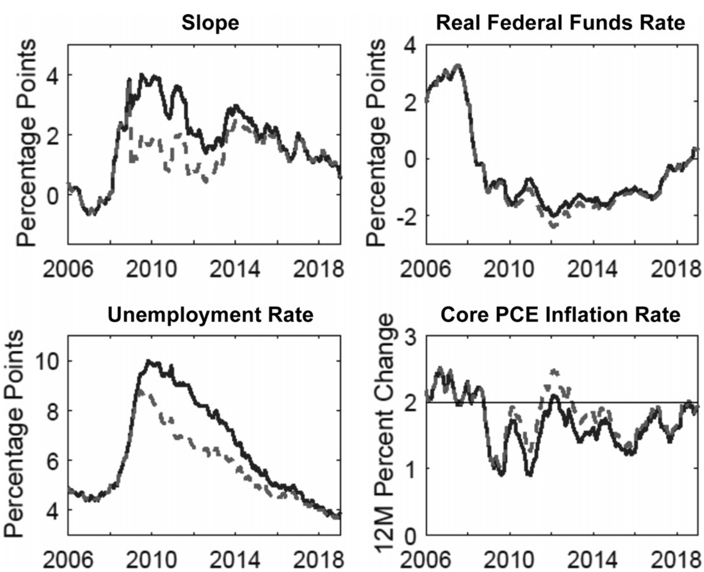
Figure 10 considers a "stronger sooner" front-loaded version of slope policy, in which slope policy flattens the yield curve by 2 percentage points but only for 18 months starting in December 2008, relative to the actual historical outcomes. It is particularly hard

Figure 9. Counterfactual of Additional Flattening until Threshold Achieved



Note: Actual is solid line; counterfactual is dashed line.

Figure 10. Front-Loaded Additional LSAPs: Yield Curve Flattened by an Additional 2 Percentage Points for 18 Months



Note: Actual is solid line; counterfactual is dashed line.

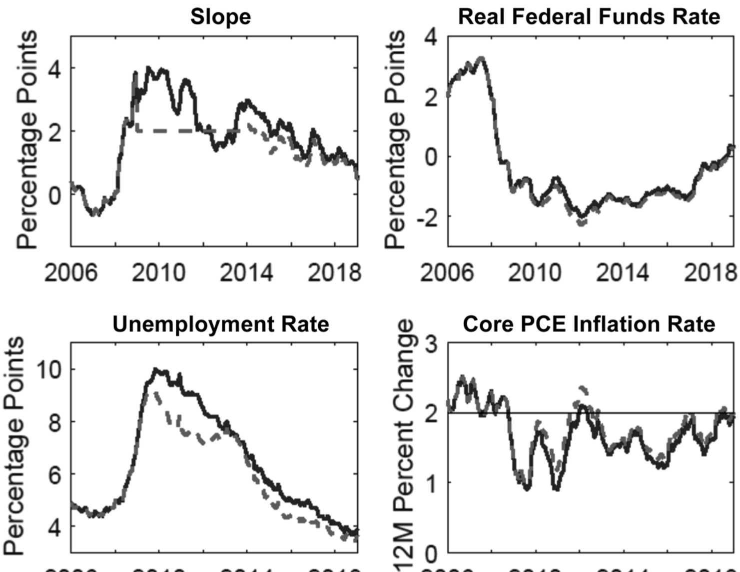
to know what kind of asset purchases would have been needed to achieve this outcome. Our working assumption from footnote 21 of the effects of the stock of asset purchases on 10-year yields would indicate that about $5 trillion of additional LSAPs would have been needed. In the disrupted financial markets of 2009 and 2010, however, it might have been possible to achieve such a flattening of the yield curve with smaller asset purchases. Additional forward guidance might also play a role in reducing the requisite volume of LSAPs. In our simulation, this early aggressive slope policy would have shaved slightly more than 1 percentage point off the cyclical peak of the unemployment rate, would have reduced the unemployment gap by an average of 1.7 percentage points over the first four years of the recovery, and inflation would have been materially higher, though still below the 2 percent target on average over the last decade.

Figure 11 considers an alternative version of front-loaded policy, which pins the slope to 2 percentage points for five years. With the funds rate at the ZLB, this is equivalent to pinning the 10-year yield to 2 percent.[25] With our illustrative assumption of the effects of the stock of asset purchases on 10-year yields, this would have required very large purchases. As pointed out by Bernanke (2016b), such a policy might not need such large purchases if it were fully credible, although it is hard to see long-term commitments as being fully credible, if only because of FOMC turnover. In our simulations, this slope shock would again have brought the unemployment rate down much faster early in the recovery.

Figures 12–15 consider counterfactuals in which the Fed had, prior to the recession, inherited a higher inflation target and, with it, initial higher rates of inflation and nominal rates of interest, without changing initial values of all real variables including real rates. These counterfactuals postulate that inflation and all nominal interest rates came into the financial crisis recession shifted up by either 1 or 2 percentage points. These are not simulations of transitioning

[25] There are precedents for policies of this sort. The Federal Reserve enforced a ceiling of 2-1/2 percent on long-term Treasury yields during and immediately after World War II (Hetzel and Leach 2001). The Swiss National Bank has long targeted three-month interest rates as a tool of policy, which goes slightly out the term structure. And the Bank of Japan is currently using a "yield-curve control" policy that simultaneously targets short- and long-term interest rates.

Figure 11. Yield-Curve Slope Set to 2 Percentage Points for Five Years

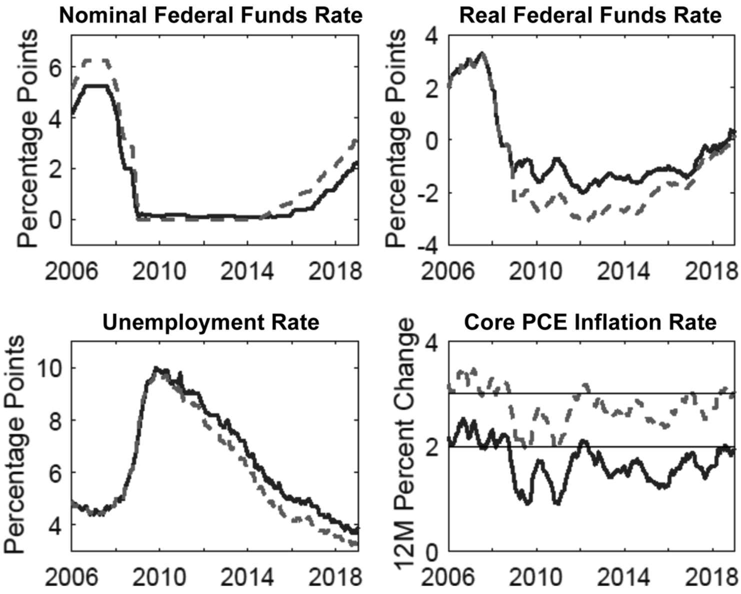


Note: Actual is solid line; counterfactual is dashed line.

from a lower to a higher inflation target during the recession or recovery.

The first of these exercises, shown in figure 12, considers inheriting a 3 percent inflation target, combined with policy that (like actual policy) goes to the ZLB after December 2008. Under this counterfactual, Fed funds policy lifts off when either of two conditions are met: the unemployment gap falls to 1 percent or the inflation rate exceeds target by 0.5 percentage point. The historical slope shocks are preserved, so implicitly the Fed conducts the same LSAPs and forward-guidance policy as it did historically. In this simulation, the inherited extra percentage point of headroom allows the real funds rate to fall by a further percentage point. In this counterfactual, liftoff comes when the unemployment gap falls to 1 percent, which happens in 2014. The unemployment gap closes seven quarters earlier than in the actual data, and inflation averages

Figure 12. 3 Percent Inherited Inflation Target with Historical Slope Shocks Counterfactual

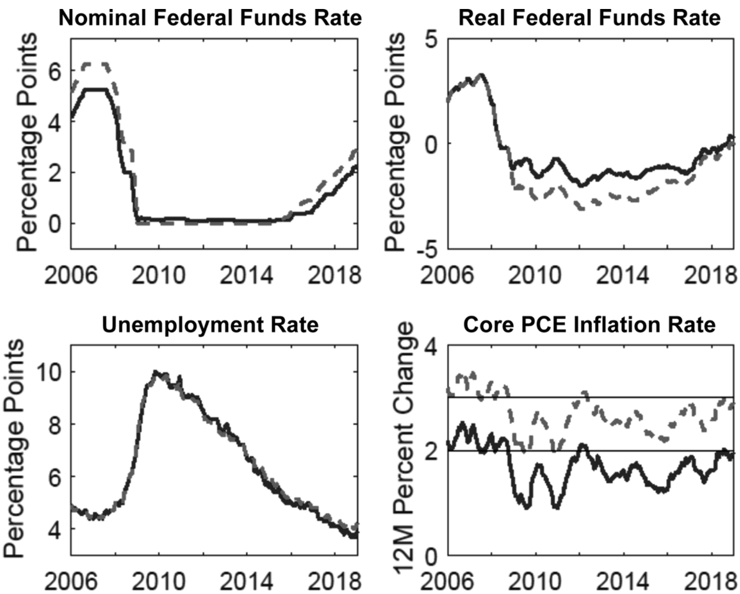


Notes: Actual is solid line; counterfactual is dashed line. In the bottom-right panel, horizontal lines denote 2 percent and 3 percent inflation levels.

1.1 percentage points higher—the 1 percent assumed nominal starting point plus a small boost from the stronger economy. Inflation still falls just short of the 3 percent hypothetical inflation target.

Figure 13 repeats the hypothetical of a 3 percent inflation target but removes historical LSAPs. Specifically, federal funds policy drops the federal funds rate to the ZLB in December 2008, where it stays until the unemployment gap falls to 1 percent or inflation exceeds the target by 0.5 percentage point. However, this simulation adds in slope shocks to reverse the effects of LSAPs. The real funds rate is reduced, but the outcome for the unemployment rate is almost identical to that actually observed in the data. The path of inflation is also almost identical to that observed in the data, except that it is shifted up by a percentage point. This simulation implies that the LSAPs that were actually conducted have about the same ability to stimulate the economy as an additional percentage-point

Figure 13. 3 Percent Inherited Inflation Target with No LSAPs

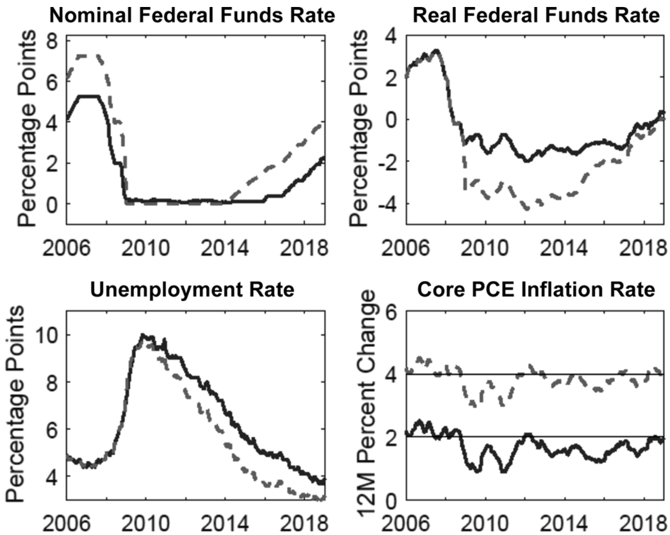


Notes: Actual is solid line; counterfactual is dashed line. In the bottom-right panel, horizontal lines denote 2 percent and 3 percent inflation levels.

cut in the real funds rate. Alternatively, had the Fed inherited a 3 percent inflation target, it could achieved the same outcomes as were actually observed without any LSAPs.

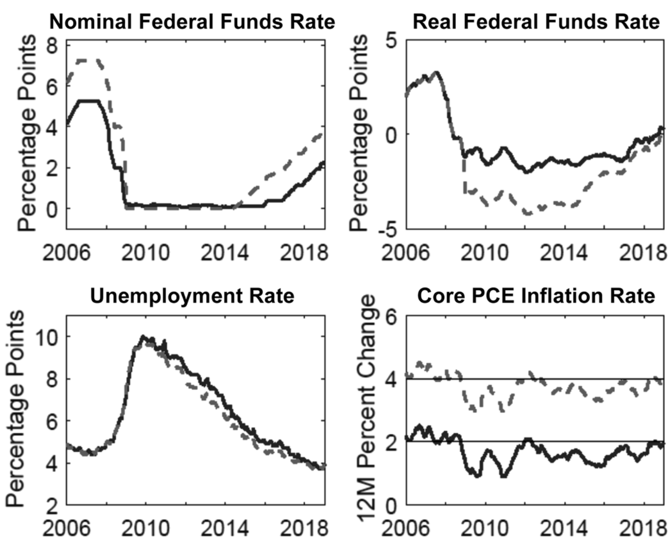
Figures 14 and 15 repeat the previous two counterfactuals, but now with an inherited 4 percent inflation target. Figure 14 keeps the historical slope shocks, while figure 15 reverses the slope shocks from LSAPs. Inheriting a 4 percent inflation target in combination with historical slope shocks would have given a much faster recovery, with liftoff arriving in early 2014 and the unemployment gap closing in the third quarter of 2014. But, because of the historically flat Phillips curve, even this would not have been enough to quite hit the 4 percent target, on average, over the last decade. A 4 percent target with no LSAPs (figure 15) would have given a slightly faster recovery than was actually observed.

Figure 14. 4 Percent Inherited Inflation Target with Historical Slope Shocks



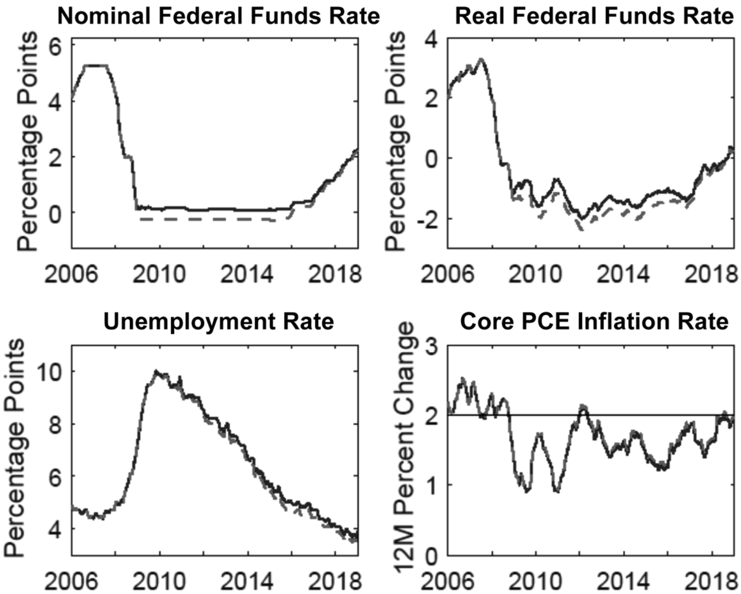
Notes: Actual is solid line; counterfactual is dashed line. In the bottom-right panel, horizontal lines denote 2 percent and 4 percent inflation levels.

Figure 15. 4 Percent Inherited Inflation Target with No LSAPs



Notes: Actual is solid line; counterfactual is dashed line. In the bottom-right panel, horizontal lines denote 2 percent and 4 percent inflation levels.

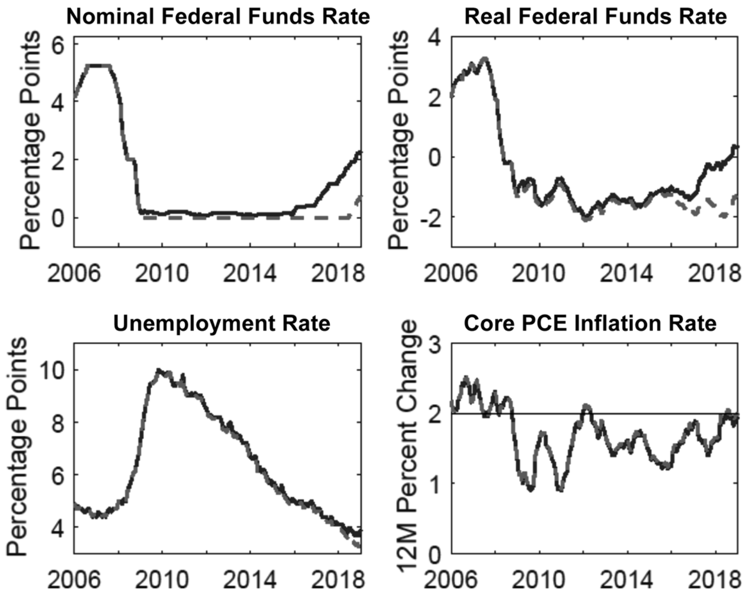
Figure 16. Federal Funds Rate of −25 Basis Points



Note: Actual is solid line; counterfactual is dashed line.

In theory, another possibility for achieving a lower real federal funds rate is to push the federal funds rate below zero, as has been done for short rates by the ECB and by the Swiss National Bank without changing the inflation target. Figure 16 considers the counterfactual of setting the federal funds rate to –25 basis points during the period that it was, in fact, at the ZLB. This would amount to more than 35 basis points of additional accommodation, as the effective funds rate was never quite at zero. We estimate the macroeconomic effect of this policy to be small, lowering the unemployment rate by at most two-tenths of a percentage point and having virtually no effect on inflation. Moreover, this counterfactual is done in the context of a linear model in which an easing of policy has, by assumption, the same incremental effect when rates are positive or negative. Easing, however, is arguably less effective when rates are negative, because of the effect on the banking system (see footnote 22). Thus, even the small effects that we find arguably overstate the benefits of cutting the federal funds rate to −25 basis points.

Figure 17. Temporary Price-Level Targeting via Federal Funds Shocks

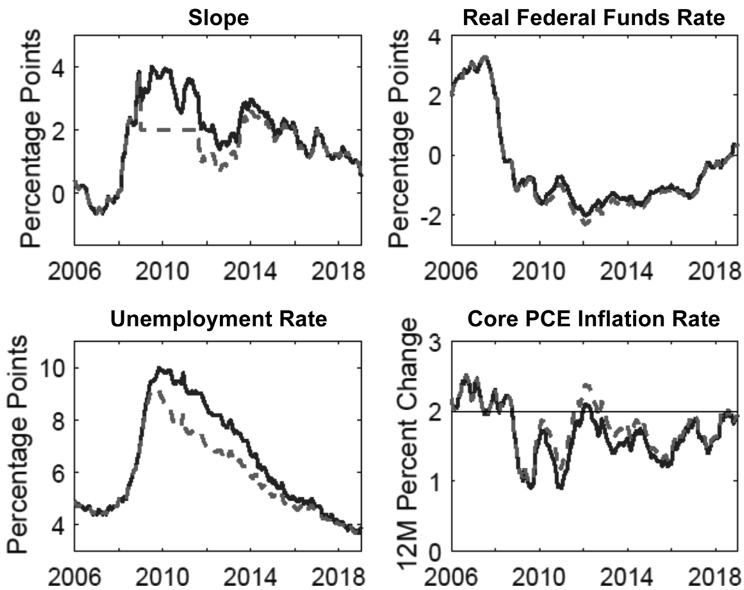


Note: Actual is solid line; counterfactual is dashed line.

The next two figures examine a form of temporary price-level targeting. Figure 17 adopts a rule of adding federal funds shocks to keep the funds rate at zero from December 2008 until the temporary price-level target with a 2 percent inflation rate and a one-year lookback period has been reached. This ends up implying a liftoff from the zero lower bound that does not come until 2018. Inflation is slightly higher at the end, and the unemployment rate falls a bit faster, but the difference is small. The disinflationary forces from the recession were too big to be easily addressed by federal funds shocks alone, even with temporary price-level targeting. Figure 18 adopts a rule of adding slope shocks to keep the slope of the yield curve at 2 percent from December 2008 until the same temporary price-level target has been reached. This enables a faster recovery, and the target is reached in 2012.

We conclude this section with two simulations that examine the Reifschneider and Williams (2000) makeup rule, where the federal

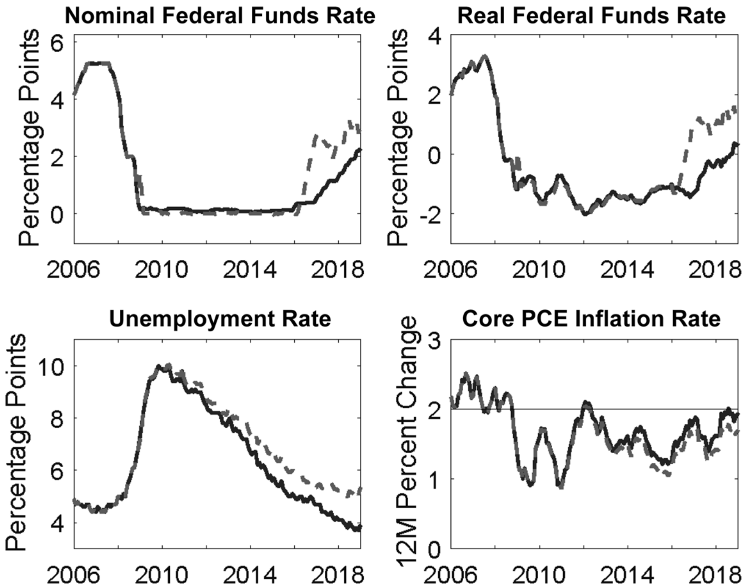
Figure 18. Temporary Price-Level Targeting via Slope Shocks



Note: Actual is solid line; counterfactual is dashed line.

funds rate remains at zero long enough to make up for the cumulative miss of the funds rate from the Taylor (1993) rule rate created because of the zero lower bound. We consider two cases: in figure 19, with r* = 2%, and in figure 20, modifying the Taylor (1993) rule to have r* take on the Holston-Laubach-Williams (2017) value. Both cases are illustrated for the case of no LSAPs, so that the makeup rule is the only adjustment the Fed makes to policy as a result of the zero lower bound. Comparing the two figures, the liftoff date depends heavily on the value of r^* used to implement the makeup rule, with the 2 percent value leading to higher federal funds rates after 2015 than actual, and the Holston-Laubach-Williams (2017) r^* leading to staying at the zero lower bound longer than actual. The main feature of both of these simulations, however, is that the policy does not compensate for the effect of shutting down LSAPs; that is, the makeup policy alone prolongs the recession, and suppresses inflation, relative to actual historical policy.

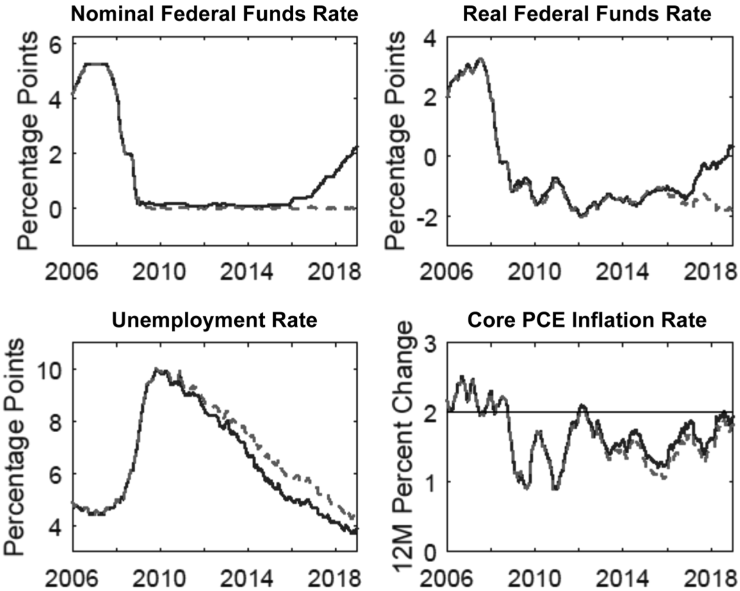
Figure 19. Makeup Rule, with $r^* = 2\%$



Note: Actual is solid line; counterfactual is dashed line.

Expectations and a Caveat. In principle, much of the potential advantage of average inflation targeting and makeup rules arises because the rule changes agents' expectations of future Fed policy, which is then reflected in lower medium- and long-term interest rates. In addition, these policies have the potential to affect inflation expectations directly. Because we implement these policies through a sequence of unanticipated federal funds shocks, these channels are shut down in our SVAR counterfactuals. As a result, our estimates could understate the effects of temporary price-level targets. This said, those expectational channels require the Fed to have a credible ability to commit to future policy and for that commitment to be well understood by markets and, in the case of price expectations, price setters. Because of these commitment and informational challenges, expectational mechanisms that are powerful in theory may be less so in reality.

Figure 20. Makeup Rule, with Holston, Laubach, and Williams (2017) Value of $r*$



Note: Actual is solid line; counterfactual is dashed line.

6.3 Comparison to Other Simulations

A number of authors have considered the effects of asset purchases in the FRB/US model. Engen, Laubach, and Reifschneider (2015) simulate the effects of all the quantitative easing programs from the financial crisis until the end of 2014.[26] Their results come from an entirely different methodology, and yet are quite close to ours. They find that the peak effect of asset purchases on the unemployment rate is to lower it by $1\frac{1}{4}$ percentage points, while the peak effect on inflation is to raise it by $\frac{1}{2}$ a percentage point. We get almost exactly the same effect on unemployment, but our effect on inflation is only $\frac{1}{4}$ percentage point, because of our flat Phillips curve. Our estimated effect of a slope shock on the unemployment rate comes faster than in the FRB/US simulations, perhaps because of sluggish adjustment

[26]Earlier FRB/US analyses of LSAPs include Chung et al. (2012) and Durdu et al. (2013).

of real variables in FRB/US. This comes notwithstanding the fact that we are modeling policies by a sequence of unanticipated shocks which shut down expectational mechanisms in FRB/US which allow term premium effects to be frontloaded.

Sims and Wu (2019) find that quantitative easing of 4 percent of GDP would raise output by about half a percentage point at the peak in a DSGE model. This is difficult to compare precisely with our estimates, but with our assumed elasticity of 10-year yields to asset purchases and the conventional Okun coefficient, it ends up being roughly comparable to our estimate that a 1 percentage point slope shock should raise the unemployment rate by 0.7 percentage point.

Chung et al. (2019) consider balance sheet and other policies in FRB/US in a hypothetical future zero lower bound scenario, and Chen, Cúrdia, and Ferrero (2012) simulate the effects of the QE2 program specifically in a DSGE model. Our counterfactuals are not directly comparable to the specific counterfactuals considered in these two papers. However, our conclusions are qualitatively consistent with theirs. Shocks that flatten the yield curve move unemployment and inflation in the right direction, but even very large balance sheet actions have quite limited macroeconomic effect. For example, Chung et al. (2019) consider an expansion of the balance sheet to 33 percent of GDP in a future fairly severe downturn and find that this balance sheet policy would close the output gap just four quarters earlier and raise inflation by half a percentage point. Our estimated responses to slope policy are comparable in magnitude to those in FRB/US but take effect more quickly.

Our counterfactual simulations also relate to the question of the relevance or irrelevance of the ZLB over the period since the financial crisis. Different authors have posed this question somewhat differently. Gust et al. (2017) compare scenarios with an unconstrained federal funds rate with that incorporating the ZLB, but where there are no policy alternatives like forward guidance or LSAPs. They find that macroeconomic conditions would have improved more rapidly with the ability to drive rates below zero, and we find something very similar in figure 3. Swanson (2018) argues that the Fed always had room to drive intermediate-term interest rates lower by additional forward guidance and asset purchases, and in this sense argues that the Fed never really hit the limits of unconventional monetary policy. This too is consistent with our simulations, especially in figure 10, in which a "stronger sooner" slope policy would have fostered a quicker recovery. Debortoli, Galí, and Gambetti (2019) provide evidence that the ZLB did not change the time-series properties of key economic variables, which theory suggests should change if the ZLB was a substantial constraint on monetary policy. We interpret this finding as consistent with the evidence in figure 13, which indicates that actual slope policy provided roughly the equivalent of 1 percentage point of easing of the ZLB. While the Fed, through its new tools of slope policy, was able to offset partially the effect of the ZLB, the presence of the ZLB did constrain the macroeconomic outcomes the Fed was able to achieve.

7. Caveats and Discussion

The results presented in section 6 are subject to important caveats. First, the proper interpretation of the counterfactuals in section 6 is not as second-guessing the decisions of the Fed, but rather informing Fed decisionmaking going forward about the efficacy of its monetary policy tools in a low-inflation environment, calibrated to the experience of the current recovery. Indeed, the counterfactual simulations in section 6 are conducted with the benefit of hindsight, and many of the scenarios would not or might not have been feasible in real time. For example, some of the scenarios consider more aggressive slope policy than was actually taken. But the macroeconomic effects of those policies were not known at the time and are still quite uncertain. Some observers of monetary policy as well as some members of the FOMC expressed concerns that the expansion of the balance sheet was setting the stage for a surge in inflation. That this surge never transpired is only known with the benefit of hindsight. Another potential concern was that the size of the balance sheet would make it difficult for the Fed to control short-term interest rates. In hindsight, this fear was also not realized, although the Fed did make some minor adjustments to the spread between interest on excess reserves and the federal funds target.

Second, because the model is estimated on historical data, there is uncertainty about the responses of both the unemployment gap and inflation to monetary policy interventions. The dynamic response of the unemployment gap to a federal funds shock has been well studied, and our estimate is consistent with other estimates in the literature. The history available to study slope shocks is shorter. Our estimated effect of a slope shock is consistent with that in FRB/US, although our estimates suggest shorter lags than in FRB/US. Perhaps the greatest source of uncertainty in our estimates concerns the response of inflation to changes in slack. Our Phillips curve is consistent with others estimated using time-series data, and this flat Phillips curve is consistent with the small fluctuations in the rate of inflation that have been observed over the past 20 years despite large fluctuations in slack. Against this aggregate evidence, regional evidence on price inflation, as well as national evidence on wage inflation, suggests that the Phillips curve could be steeper than estimated using aggregate time-series price data. The simulations in section A.2 of the appendix consider a Phillips curve estimated from regional data, with a long-run response of inflation to a change in the unemployment gap twice as large as in our base model. With this steeper Phillips curve, the more expansionary policies considered in section 6 result in higher rates of inflation, but even so, those rates generally remain at or below the Fed's inflation target.

Third, in our model, expectations of future policy affect the inflation process through their effect on expected future unemployment gaps. We do not, however, consider mechanisms whereby expectations change about the target rate of inflation. Bernanke (2019) and Bernanke, Kiley, and Roberts (2019) point out that imperfect credibility of the Fed can constrain the sorts of policies it undertakes and in particular motivates temporary price-level targeting with a short and rolling lookback period, which is the version of temporary price-level targeting we consider here.

Fourth, several of our counterfactuals posit using slope policy more aggressively. Doing so, however, comes with potential risks that are not in our model. As discussed in Carpenter et al. (2015), if the Federal Reserve has a portfolio of long-duration assets, then its remittances to the Treasury will decline as short-term interest rates increase; the larger the balance sheet, the bigger is this effect. While a period of zero remittances is operationally possible, it could pose other institutional challenges. Unconventional monetary policy also had international spillover effects.[27] Announcements of easing of monetary policy by the United States led to sharp drops in foreign yields but also depreciation of the dollar relative to foreign currencies. They also led to portfolio inflows into emerging markets where interest rates remained well away from the zero lower bound. These international spillovers are relevant because international financial markets can in turn affect U.S. economic conditions. Another concern associated with very low interest rates (both short and long) is that financial institutions will be led to take on more risk. To some degree, more risk-taking is the intended consequence of monetary policy easing (e.g., Chodorow-Reich 2014). But very low rates could lead institutions to invest in riskier assets than is socially optimal in order to achieve a target promised return.[28]

A central finding of our analysis is that, despite the efficacy of slope policy, the zero lower bound significantly restricted the scope of monetary policy during the recovery. Absent the ZLB, we (and others) estimate that normal federal funds policy would have led to a federal funds rate of approximately –5 percent. Our estimates suggest that the suite of Fed slope policies was able to offset perhaps 1 percentage point of the ZLB constraint. Although we do not undertake any probability estimates ourselves, simulation evidence in the literature suggests a high probability of hitting the ZLB in future recessions.[29] In short, the ZLB imposes

[27]See, for example, Ait-Sahalia et al. (2012), Rogers, Scotti, and Wright (2014), Bowman, Londono and Sapriza (2015), Bhattarai and Neely (2016), Fratzscher, Lo Duca, and Straub (2017), and Dell'Ariccia, Rabanal, and Sandri (2018).

[28]Some evidence for this "reach for yield" behavior was found by Becker and Ivashina (2015) for insurance companies and Di Maggio and Kacperczyk (2017) for money market mutual funds. Chodorow-Reich (2014) also found evidence for some "reach for yield" behavior for money market mutual funds and private defined-benefit pension funds, but argued that it was modest and short-lived.

[29]Kiley and Roberts (2017) conclude that with a 1 percent neutral real rate and 2 percent inflation target, FRB/US would imply that the effective lower bound will bind 30 percent of the time. Bernanke, Kiley, and Roberts (2019) find that it binds between 15 and 40 percent of the time, depending on the monetary policy reaction function, with temporary price-level targeting being effective at keeping the economy away from the ZLB. Chung et al. (2019) find a probability between 20 and 50 percent of the ZLB binding at some point within the next decade. The model of Mertens and Williams (2018) has a probability of being at the ZLB of at least 30 percent.

significant constraints on the efficacy of Fed policy, and our estimates suggest that those constraints are only partially offset by the new slope policies. The costs imposed by the ZLB underpin our finding that the current suite of policies would have led to a substantially faster recovery had the Fed inherited higher nominal interest rates and inflation consistent with a higher inflation target.

Although there might be benefits to a higher inflation target, there are potential costs as well. With staggered price setting, higher trend inflation causes greater resource misallocation. It could be that inflation does not enter into the decisionmaking of households and firms at very low levels, but there might be a threshold level beyond which this changes. Higher trend inflation will have distributional effects, and poorer households especially may be less able to protect their savings against inflation (Bernanke 2016a). And a higher inflation target might be seen as inconsistent with the Fed's congressional mandate of price stability.

Our framework is not suited to address the question of an optimal inflation target. Coibion, Gorodnichenko, and Wieland (2012) consider an optimal inflation target with a constant equilibrium real interest rate in a DSGE microfounded DSGE model and find that it is low—less than 2 percent. Andrade et al. (2019) study the effect of a reduction in r^* on optimal inflation and find that, calibrating the model to current U.S. or euro-area conditions, it results in an increase in the inflation rate that is slightly less than one-for-one. Given the widespread view that r^* has fallen, that would call for a higher inflation target, although it does not tell us what the right level is.

Our conclusion that the tools in the current monetary policy framework would have been more effective over the past decade had the Fed inherited a higher inflation target raises the question of how the Fed might reach a higher inflation target, should it choose to do so. We do not model such a transition process, but we do offer some thoughts based on historical experience. The decline in inflation from 1985 through 2005 was gradual, with the rate of core PCE inflation falling from an average of 3.6 percent in the second half of the 1980s to 1.7 percent in the first half of the 2000s. This decline was largely a result of policy of opportunistic disinflation (Orphanides and Wilcox 2002), in which the Fed did not actively use monetary policy to lower inflation but at the same time did not seek to reverse declines in inflation when they occurred. During this period of opportunistic disinflation, inflation expectations of both professionals and the public also fell gradually, tracking the slow decline in inflation: from the first half of the 1990s through the first half of the 2000s, the Survey of Professional Forecasters expected 10-year rate of CPI inflation gradually declined from 3.6 percent to 2.5 percent, and the Michigan survey measure of inflation expectations fell from 3.2 percent to 2.6 percent. This period of slowly falling rates of inflation and inflation expectations was accompanied by historically low inflation volatility. Moreover, from 1990 to 2005, inflation expectations also exhibited low volatility, with quarterly standard deviations of 0.2 percentage point and 0.4 percentage point for the long-term SPF and Michigan survey measures, respectively, around their slowly declining trend.

In the same way, the Fed might now accept opportunistic reflation (Brainard 2019), where it does not seek to reverse increases in inflation coming from, for example, a tight labor market or supply-side price shocks. A policy of opportunistic reflation could have challenges. Given the flat Phillips curve that has been observed over the past two decades and which is the source of the sluggish response of inflation to slack in our simulations, sustained unemployment rates below current estimates of the natural rate could, by themselves, have modest and slow effects in raising the inflation rate to a higher target: like the disinflation, the reflation would likely be slow. The policy would need to be clearly communicated so that inflation expectations could adjust accordingly, as they did during the period of opportunistic disinflation. Sustained low interest rates could raise other potential concerns such as asset bubbles (Brainard 2017). These and other potential challenges warrant additional study.

Appendix. Additional Results

A.1 Additional Impulse Response Functions

Figures A.1 and A.2 provide additional results related to the SVAR-IV estimates of the unemployment rate impulse responses to the federal funds and slope shock.

Figure A.1. Unemployment Gap Response to the Federal Funds Shock (left) and Slope Shock (right), Estimated by LP-IV

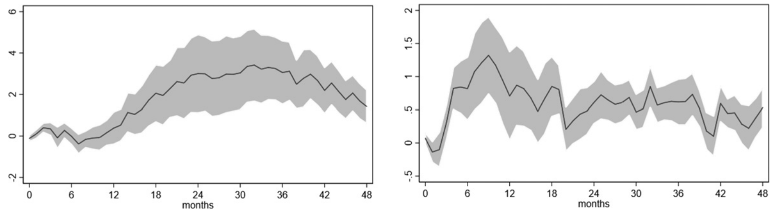


Figure A.1 shows the local projections-instrumental variables (LP-IV) estimates of the IRFs. Note that these are estimated only over the sample period of the IV regression (1994:M2–2007:M12 for the federal funds shock, 2008:M1–2019:M2 for the slope shock), not the full VAR period used for the SVAR-IV. The LP-IV IRFs are generally similar in shape to the SVAR-IV IRFs. For the federal funds shock, the LP-IV estimates indicate a greater effect of the shocks than the SVAR-IV estimates. For the slope shock, the LP-IV estimates are similar in magnitude, but the LP-IV predicts the effect on the unemployment rate to occur somewhat more quickly than does the SVAR-IV.

Figure A.2 presents the SVAR-IV estimates of the effect of the two shocks on the Gilchrist-Zakrajšek (2012) excess bond premium. The SVAR-IV predicts that both contractionary shocks increase financial market risk premiums, as measured by an increase in the EBP, with an effect that decays within a year. LP-IV estimates (reported in the supplement) are generally similar to the SVAR-IV estimates.

The supplement reports multiple checks of the robustness of the unemployment rate IRFs to changes in specification, estimation date, and control variables.

A.2 Counterfactual Simulation Results Using a Steeper Phillips Curve

For these counterfactuals, the Phillips curve in the first line of table 1 is replaced by a Phillips curve with a greater long-run slope, estimated using MSA-level data. Specifically, we take the

Figure A.2. Response of the Gilchrist-Zakrajšek Excess Bond Premium to a Federal Funds Shock (left) and a Slope Shock (right), Estimated by SVAR-IV

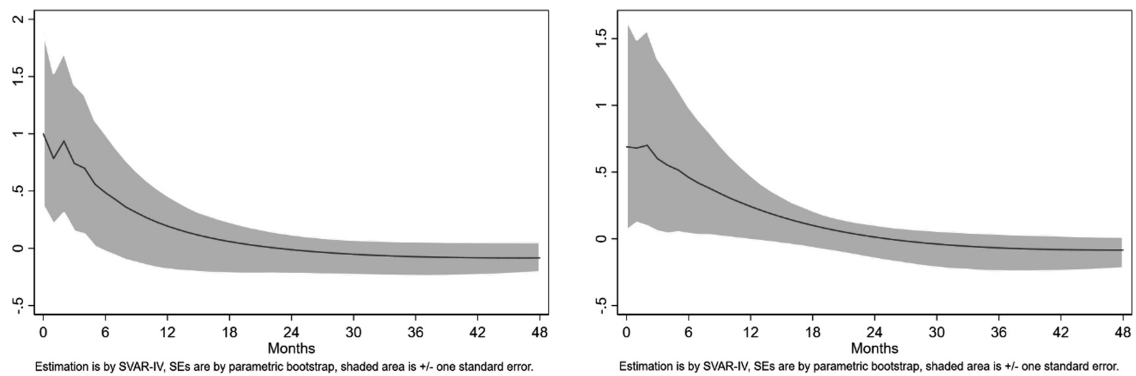
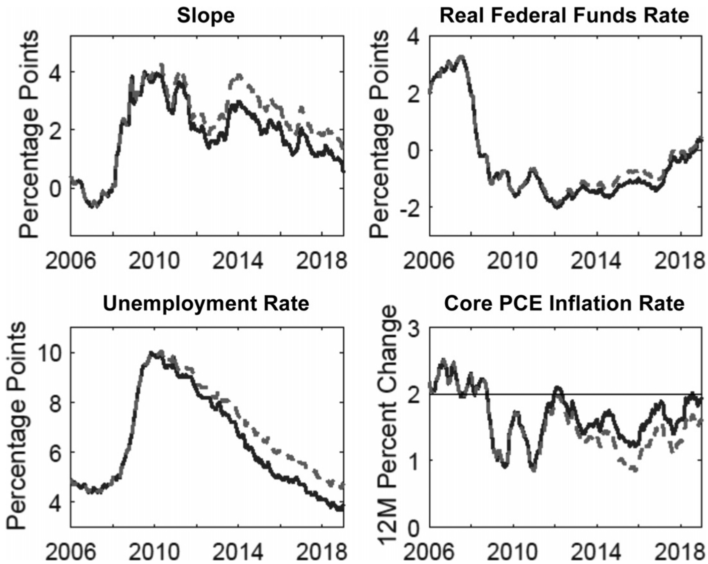


Figure A.3. No LSAP Counterfactual: Steeper Phillips Curve



estimated coefficients from column 4, table 3 in MacLeay and Tenreyro (2019), which has the hybrid Phillips-curve coefficients $\kappa = -0.367, \gamma_f = -0.067$, and $\gamma_b = 0.073$, which have a long-run slope of $\kappa/(1 - \gamma_{f-}\gamma_b) = -0.369$, approximately twice that of the time-series estimate used for the simulations in the paper. Results for selected counterfactuals are shown in figures A.3–A.5; a complete set of results for all the counterfactuals is given in the supplement.

Figure A.3 shows the "no LSAP" counterfactual (compare with figure 7). Compared with the base model with the flatter Phillips curve, the PCE core inflation rate is estimated to be substantially lower, that is, farther from the 2 percent target.

Figure A.4 shows the "stronger sooner" policy counterfactual of figure 10. With the aggressive early flattening and declining unemployment rate in this scenario, inflation overshoots its target but then returns to 2 percent. The lack of persistence of shocks to inflation is a consequence of the small dynamic coefficients in the McLeay-Tenreyro MSA-based estimate.

Figure A.5 shows the counterfactual in figure 12, in which the Fed inherits a 3 percent inflation target and additionally uses the

Figure A.4. Front-Loaded Additional LSAPs: Yield Curve Flattened by an Additional 2 Percentage Points for 18 Months, Steeper Phillips Curve

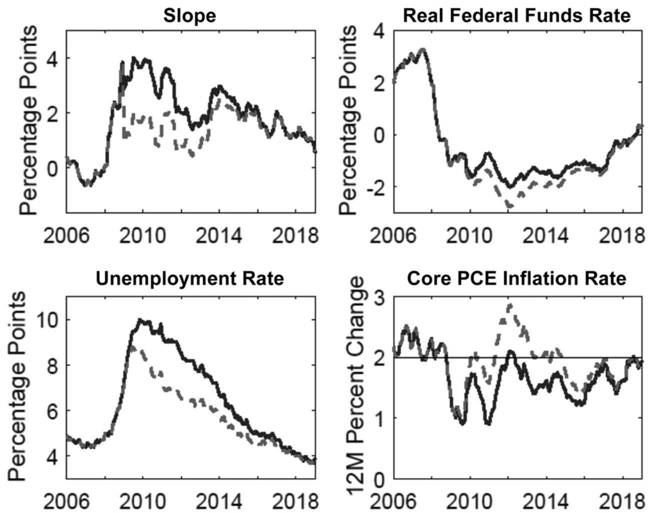
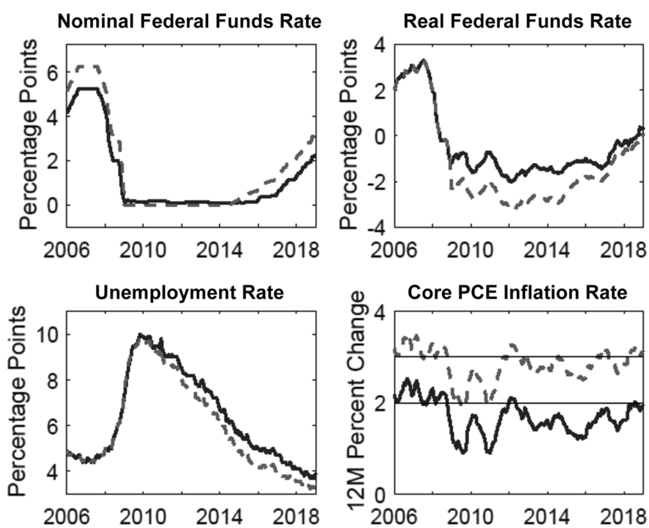


Figure A.5. 3 Percent Inherited Inflation Target with Historical Slope Shocks Counterfactual: Steeper Phillips Curve



slope policies it actually did use. With the steeper Phillips curve, the rate of inflation returns to its 3 percent target in the middle of the expansion, then fluctuates around that target.

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Global Dimensions of U.S. Monetary Policy*

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This paper is a partial exploration of mechanisms through which global factors influence the tradeoffs that U.S. monetary policy faces. It considers three main channels. The first is the determination of domestic inflation when international prices and global competition play a role alongside domestic slack and inflation expectations. The second channel is the determination of asset returns (including the natural real safe rate of interest, r^*) and financial conditions in integrated global financial markets. The third channel, particular to the United States, is the potential spillback onto the U.S. economy from the disproportionate influence of U.S. monetary policy on the outside world. In themselves, global factors need not undermine a central bank's ability to control the price level over the long term—after all, it is the monopoly issuer of the numeraire in which domestic prices are measured. Over shorter horizons, however, global factors do change the tradeoff between price-level control and other goals such as low unemployment and financial stability, thereby affecting the policy cost of attaining a given price-level path.

JEL Codes: E52, F32, F41.

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1. Introduction

Under the postwar Bretton Woods system of fixed exchange rates that prevailed through the early 1970s, the external constraint of preserving official dollar convertibility into gold figured explicitly and importantly in U.S. monetary policymaking (Eichengreen 2013). The conflict between this commitment and the domestic macroeconomic policy priorities of successive U.S. administrations ultimately helped wreck the fixed exchange rate system. The move to pure fiat money and floating exchange rates did not insulate U.S. monetary policy (or other countries' monetary policies) from global factors, however. As became immediately clear through the first OPEC (Organization of the Petroleum Exporting Countries) oil price shock, foreign disturbances can feed through to U.S. prices and output over the medium term, perhaps posing more difficult tradeoffs for the Federal Reserve (the Fed). If anything, the importance of global influences seems to have grown over time.

The Federal Reserve's legal policy mandate focuses explicitly on three domestic variables: U.S. employment, price stability, and long-term interest rates (although the last of these is hardly independent of the second, and the first two may be closely linked). That focus does not imply, however, that foreign events are not significant drivers of Fed actions. As a young staffer at the Federal Reserve Bank of New York, Charles P. Kindleberger, put it more than 80 years ago, "A monetary policy based entirely upon the requirements of the internal economy will be based at one remove on external factors."[1] Moreover, the Fed's leaders are hardly reticent about citing global events for their potential U.S. effects. At a speech in Berkeley during the global financial turbulence of 1998, Chairman Greenspan memorably stated, "It is just not credible that the United States can remain an oasis of prosperity unaffected by a world that is experiencing greatly increased stress" (Greenspan 1998). Later that month, the Fed cut rates.[2] Ferrara and Teuf (2018) find a systematic

[1]Kindleberger (1937, pp. 230–31).

[2]According to the accompanying Federal Open Market Committee (FOMC) explanation, "The action was taken to cushion the effects on prospective economic growth in the United States of increasing weakness in foreign economies, and of less accommodative financial conditions domestically."

relationship between references to international factors in FOMC minutes and accommodative monetary moves.

This paper is a partial exploration of mechanisms through which global factors influence the tradeoffs that U.S. monetary policy faces.[3] It considers three main channels. The first is the determination of domestic inflation in a context where international prices and global competition play a role, alongside domestic slack and inflation expectations. The second channel is the determination of asset returns (including the natural real safe rate of interest, r^*) and financial conditions, given integration with global financial markets. The third channel, which is special to the United States, is the potential spillback onto the U.S. economy from the disproportionate influence of U.S. monetary policy on the outside world. In themselves, global factors need not undermine a central bank's ability to control the price level over the long term—after all, it is the monopoly issuer of the numeraire in which domestic prices are measured. Over shorter horizons, however, global factors do change the tradeoff between price-level control and other goals such as low unemployment and financial stability, thereby affecting the policy cost of attaining a given price-level path.

The paper is organized as follows. Section 1 presents some basic data on the U.S. economy's evolving economic integration with world product and asset markets. Section 2 explores the changing nature of consumer price inflation, which is shown to depend importantly on import price inflation but seems ever less dependent on domestic wage inflation since the early 1990s. I argue that it is unclear how important globalization is in explaining the apparently declining importance of domestic economic slack in the U.S. Phillips curve. In section 3, I explore how the global determination of rates of return matters for monetary policy. One lesson is that the determination of r^* is inherently global, and tied up with movements in current account balances, which therefore can offer important clues about the real natural rate. However, global markets also determine the returns on an array of risky assets. While events that create

[3]Some areas that the paper does not discuss in detail are mentioned in context below. The paper also does not attempt an evaluation of particular monetary policy frameworks, unlike the studies in Adrian, Laxton, and Obstfeld (2018).

incipient imbalances in the foreign exchange market may be offset to some degree by exchange rate adjustments, two-way gross cross-border flows can have important asset market effects—carrying macroeconomic and financial stability implications—without much effect on exchange rates. The last substantive section, section 4, explains how the dollar's singular international roles as an invoicing and funding currency, as well as a benchmark for currency stabilization, confer on the Federal Reserve a unique global amplification mechanism for its monetary policy actions. Even a purely self-oriented perspective must take into account the resulting potential spillbacks onto the U.S. economy. Section 5 offers concluding thoughts.

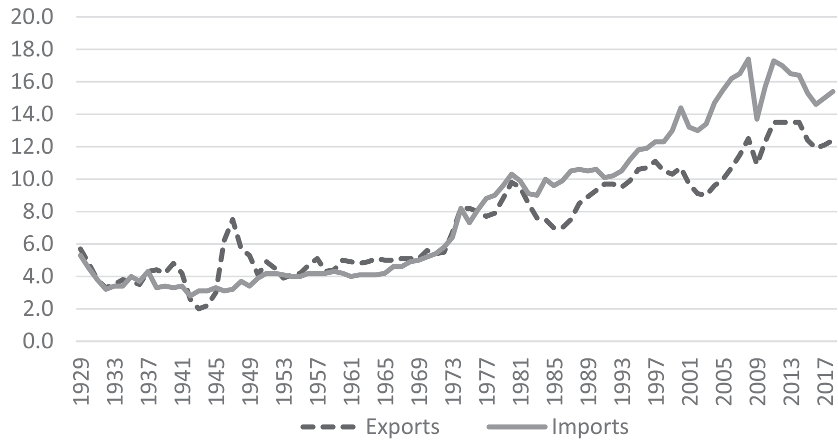
2. The U.S. Economy in a Global Context

During the postwar period, the world economy has evolved in a context of ever-broader and deeper markets for goods, services, and securities. At the end of World War II, the United States stood uniquely dominant as an economic and financial power. Over nearly 75 subsequent years, global recovery and development have left it embedded in a world of much more comparable economic powers, linked by interdependent and complex networks for trade and finance. That interdependence has far-reaching implications for U.S. monetary policy: its domestic effects, its influence on the rest of the world, and the range of shocks that it faces.

The evolution of U.S. interconnections with foreign economies, along with U.S. exposure to foreign shocks, could be measured in several ways. In this section I set out some basic quantity indicators of economic openness.

Take trade first. As is well known, and as figure 1 reaffirms, the dollar values of U.S. exports and imports have risen substantially over time relative to dollar GDP (gross domestic product), with the most dramatic acceleration starting in the early 1970s as the industrial economies abandoned fixed exchange rates. These numbers mix valuation and volume effects—for example, the dollar's sharp depreciation in the 1970s boosted both export and import values relative to GDP—but over time there has clearly been an increase in trade volumes. Compared with other OECD (Organisation for Economic Co-operation and Development) members, and

Figure 1. U.S. Exports and Imports (GDP shares, percent)

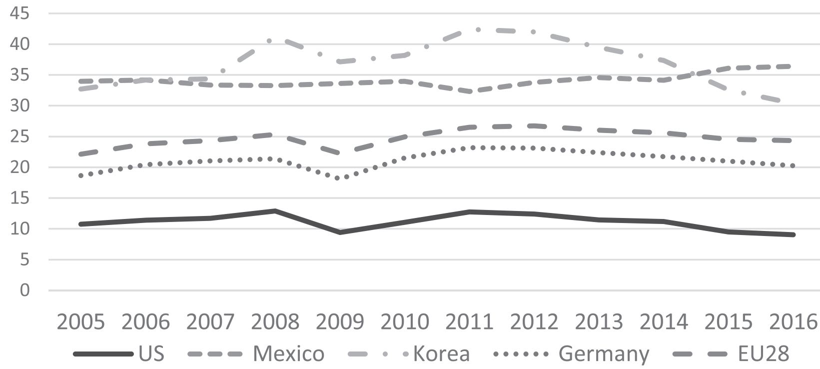


Source: Bureau of Economic Analysis (BEA).

even most high-income countries, the United States remains relatively closed on the trade side. Increasingly around the world, for example, non-commodity exports depend on imported intermediate inputs, with resulting increases in trade volumes. But U.S. exports rank low in this respect (figure 2). That being said, imported intermediate inputs do play an increasingly important role in overall U.S. production (not just in exports). Consider industrial supplies and capital goods. They made up about half of all U.S. goods imports in 2018, roughly the same share as in 1999, but imports have expanded by half as a share of GDP over the past 25 years, outpacing the growth of exports (figure 1). The rising importance of intermediate imports implies a growing channel for foreign price developments to influence U.S. product prices.

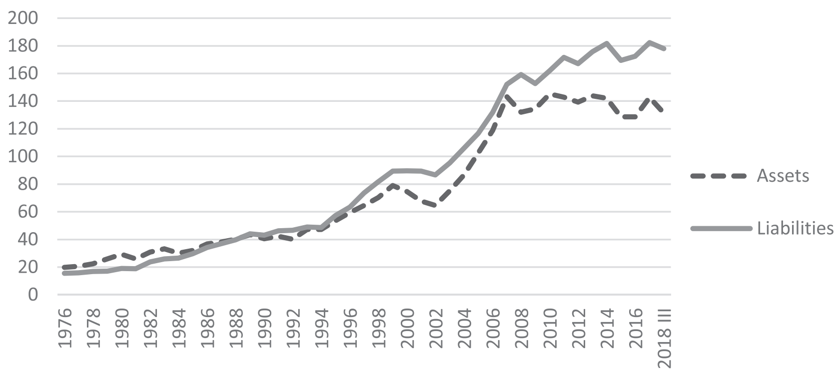
If the United States looks closed on the trade side in comparison with other countries, the same is not nearly as true of its international financial links. Figure 3 shows U.S. gross external assets and liabilities relative to GDP. These grow sharply (but roughly commensurately) up until the global financial crisis, reaching ratios to

Figure 2. Import Content of Exports (percent of value)



Source: OECD.

Figure 3. U.S. Gross Foreign Assets and Liabilities (percent of GDP)



Source: BEA.

GDP in the neighborhood of 150 percent. Since then, assets have leveled off but liabilities have continued to grow.[4]

[4]Lane and Milesi-Ferretti (2018) survey international financial integration since the crisis.

The balance between assets and liabilities changes not only because of current account flows but also because of asset price developments that can sharply alter gross asset and liability stocks. Specifically, U.S. foreign liabilities are mostly denominated in U.S. dollars, whereas assets are mostly in nondollar currencies. In addition, U.S. foreign assets are more heavily skewed toward equity (portfolio equity and foreign direct investment) than are liabilities. An implication is that unexpected dollar strength tends to transfer wealth from the United States to foreigners, as do global stock market declines (Gourinchas and Rey 2007). And with gross external positions so extensive, the wealth transfers can be very big.

Compared with the flow change in the net international investment position (NIIP) due to the current account, the stock revaluation due to asset price changes is indeed large and volatile. Over 2008, the United States sacrificed nearly 14 percent of GDP in wealth to the rest of the world, only to gain back 12 percent over 2009. These are very large economic shocks, though their macroeconomic effect may be muted if they are temporary and hit mostly deep-pocketed and lightly leveraged investors.

The balance of this paper looks more closely at some macroeconomic implications of trade and financial openness.

3. Global Aspects of the Inflation Process

It is well known that in recent years—and certainly predating the global financial crisis—inflation has seemed less responsive to domestic economic activity gaps, in the United States and other industrial countries alike. For example, the International Monetary Fund (2013) chronicled the limited downward response of inflation to the crisis and its aftermath. Conversely, even as activity has returned to or exceeded pre-crisis levels and monetary policies have remained accommodative, inflation has generally been slow to respond in advanced economies.

Numerous potential explanations have been offered (see Kiley 2015 for a survey). These explanations include better-anchored inflation expectations (for example, Del Negro, Giannoni, and Schorfheide 2015; Jordà et al. 2019) or expectational shifts driven by commodity prices (Coibion and Gorodnichenko 2015); mismeasurement of economic slack (Yellen 2015); the domestic influence of global activity and labor market conditions (International Monetary Fund 2006, 2016; Auer, Borio, and Filardo 2017; Forbes 2019); and flatter price Phillips curves, albeit perhaps only at relatively low inflation rates (Blanchard, Cerutti, and Summers 2015; Gagnon and Collins 2019). While admittedly these factors are potentially interrelated—for example, better anchoring can itself potentially flatten the Phillips relationship, as can international competition, with mutually reinforcing spillovers among countries—a natural starting point for assessing the influence of global factors is to ask how the basic architecture of the price Phillips curve could change in an international context.

In standard closed-economy macroeconomic models, the expectations-augmented price Phillips curve links consumer price inflation to expected future inflation and some measure of the output or employment gap. Compared with the hypothetical closed-economy case, an open-economy price Phillips curve adds two dimensions:

(i) *The global competitive environment*: Firms' willingness to change prices as marginal cost changes can fall when they face more intense competition due to potential imports. At the same time, aspects of global competition may affect the responsiveness of marginal cost—especially wages—to economic slack.

(ii) *Foreign prices*: Consumer-level inflation will reflect not just the nominal cost of domestic value-added but also nominal import prices, which affect consumer prices directly as well as domestic production costs. In turn, import prices are a mix of those set directly in terms of local currency and those set in other currencies, translated using the domestic-currency prices of those currencies (i.e., exchange rates).

3.1 Global Competition

Writing in the inflationary mid-1970s, Dornbusch and Krugman (1976) seemingly viewed the Phillips curve facing monetary policy in an open economy as being steeper under floating exchange rates. As they put it:

> The link between exchange-rate deterioration and domestic inflation takes on importance in the context of our earlier argument that an expansionary monetary policy leads to a fall in the exchange rate. The present line of argument establishes a direct, short-run link between monetary policy and inflation. The conventional case for stabilization policy, including monetary policy — that it acts promptly on quantities and only slowly on prices — is, therefore, lost.

Their account focuses on the inflation-activity tradeoff traced out by monetary shocks, and it depends on both of the open-economy dimensions listed above: the inflation responsiveness to costs and the effect of import prices based on the exchange rate response. It also brings to mind another possible gap that I will not discuss—a credibility gap in monetary policy, such that wage settlements may respond rapidly and strongly to monetary policies. Leaving that last important topic aside, it is still helpful to break the first two mechanisms down, starting with the role of global competition.

Many international macro models simplify by assuming that price-setting firms face demand curves with constant elasticities. In this case, markups of price over marginal cost do not vary, including in the face of more intense international competition. Allowing for demand elasticities that vary along the demand curve is one way to introduce strategic pricing complementarities for different firms, such that a firm's optimal price depends on what its competitors are charging. Various specifications can lead to this result (see Arkolakis and Morlacco 2017), and firm-level empirical evidence is supportive. When competing firms' prices are strategic complements, a firm will hesitate to maintain its full markup when its costs rise for fear of losing customers to competitors. The phenomenon is central to understanding exchange rate pass-through (e.g., Gust, Leduc, and Vigfusson 2010) and other macroeconomic implications of globalization (e.g., Erceg, Gust, and López-Salido 2010).

Such models also imply a muted response of inflation to departures of real marginal cost from the "natural" or full-employment level. Sbordone (2010) offers a very instructive formalization of this effect. In New Keynesian models with Calvo pricing and constant firm markups, the response of domestic output price inflation π to a deviation $\widehat{mc}$ of (log) real marginal cost from its natural value is given by

$$\pi_t = \xi \widehat{mc}_t + \beta \mathrm{E}_t \pi_{t+1}, \tag{1}$$

where $\beta < 1$ is a real discount factor and ξ is a structural slope coefficient. This equation leads to a price Phillips curve if activity gaps are closely associated with deviations of real marginal costs from full-employment levels. In Sbordone's model with variable markups, instead of the preceding equation, the approximate inflation equation is

$$\pi_t = \widetilde{\xi} \widehat{mc}_t + \beta \mathrm{E}_t \pi_{t+1},$$

where

$$\widetilde{\xi} = \frac{\xi}{1 + \overline{\theta}\overline{\varepsilon}} < \xi,$$

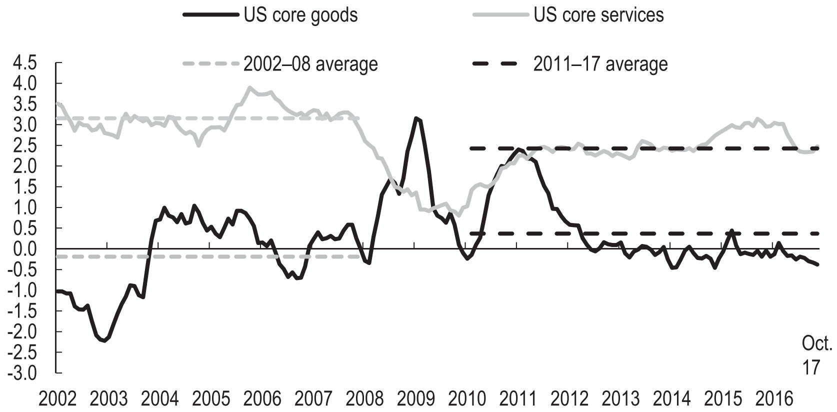
with $\overline{\theta}$ being the natural value of the firm's demand elasticity and $\overline{\varepsilon} > 0$ the elasticity of its markup with respect to its market share. The implication is that pricing complementarity flattens the Phillips curve compared with the constant-markup case.

The question of globalization's effect is a different one, however, and turns on whether more intense competition (including, specifically, more intense international competition) actually lowers $\widetilde{\xi}$ *further* relative to ξ. If so, we would have one mechanism through which increasing openness flattens the Phillips curve. However, while more foreign competition (as measured by a lower global market share, x) clearly raises the demand elasticity $\theta(x)$ (i.e., $\theta'(x) < 0$), it can lower the elasticity $\varepsilon(x)$.[5] The net effect depends on which effect is proportionally larger.

Therefore, even when more import competition lowers average markups, it also can lower the responsiveness of markups to competition—and the latter factor is also key for the slope of the Phillips curve. An additional contrary consideration is that more import competition could drive out smaller and less productive domestic firms, leaving in business firms with more market power

[5]Note that $\varepsilon(x) = x\theta'(x)/\theta(x)[1 - \theta(x)] > 0$.

Figure 4. U.S. Core Goods and Core Services Consumer Price Inflation (year-on-year; percent)



Source: IMF staff calculations.

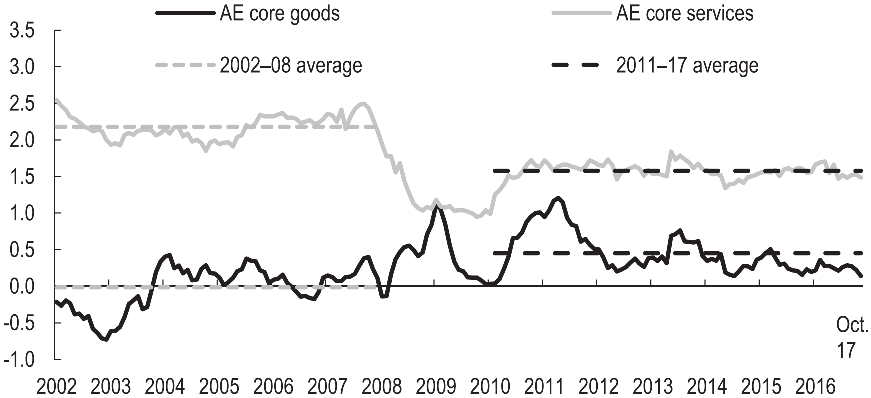
that might be less inclined to shave markups when costs rise.[6] All told, there is little clear evidence yet that international price competition is behind the flatter U.S. Phillips curve.[7]

A related hypothesis about the Phillips curve's flattening is an increasing economic role for those goods, primarily tradable goods, that might be less cyclically sensitive due to competitive pressures (Stock and Watson 2018). A recent IMF study (IMF 2018b, box 1.2) looks at the behavior of broad aggregates of core goods and services prices across 16 advanced economies, before and after the crisis. The U.S. data (figure 4) are similar to the 16-country average data

[6]Feenstra and Weinstein (2017) argue that trade has reduced markups in U.S. tradable industries. Their indirect method of measuring demand elasticities via concentration indexes, however, yields results that are seemingly different from more direct approaches such as the one in IMF (2019). In any case, the overall effect of trade competition on the Phillips curve's slope depends not only on how much it reduces the *level* of markups but also on the effect on the *responsiveness* of markups to costs—that is, on the pass-through of costs into prices—and without such responsiveness ($\varepsilon(x) \equiv 0$), the pro-competitive effect of imports leaves the slope of the Phillips curve unchanged. For evidence on trade and markups in the European Union, see Chen, Imbs, and Scott (2009).

[7]This is not, of course, to deny that a one-time surge in import competition could depress inflation over a limited horizon. But the latter effect is at most a necessary, not a sufficient, condition to establish global competititon as a potential cause of a flatter Phillips curve.

Figure 5. Advanced-Economy Core Goods and Core Services Consumer Price Inflation (year-on-year; percent)



Source: IMF staff calculations, as reported in IMF (2018b).
Note: The sample includes 16 advanced economies: Australia, Austria, Canada, Denmark, Finland, France, Germany, Japan, Italy, Netherlands, Norway, Portugal, Spain, Sweden, the United Kingdom, and the United States.

(figure 5), and seem somewhat consistent with the Stock-Watson decomposition, in that it is the post-crisis average level of services core inflation, not goods core inflation, that is lower since the crisis (indeed, the latter is slightly higher). But there are also significant short-run fluctuations in both inflation series in response to known macroeconomic shocks. The IMF authors conclude that "disaggregated inflation trends suggest that enhanced tradability and global competition are unlikely to have been the main culprits behind the sluggishness in inflation in recent years." Furthermore, given the secular upward trend in the weight of services in consumption, enhanced output tradability over time (even allowing for the enhanced tradability of services) seems an implausible explanation for a flatter Phillips curve.

Some New Keynesian models imply another potential reason for a flatter Phillips curve. This mechanism centers on the relationship between real marginal cost and the output gap. A bigger output gap will depress the terms of trade if a country's exporters must lower their prices to sell more of their output on global markets.

This development, however, both raises the product wage (pushing firms toward raising prices) and lowers real income (compared with the situation in a closed economy), encouraging labor supply and thereby a *lower* real product wage. If the second effect dominates, then the New Keynesian Phillips curve will be flatter (Clarida 2009). The empirical relevance of this effect has not been studied. In the open economy, the relation between output and inflation may be decoupled to the extent that spending can diverge more readily from output (Razin and Yuen 2002).

An important caveat regarding some of the preceding arguments is that they hold constant the degree of price stickiness as the economy becomes more open. It seems plausible, however, that one way global competitive pressures (and greater exposure to global risks) might work is by leading firms to adjust prices more frequently. If this happens, the Phillips curve will steepen. This possibility deserves more empirical attention. Looking at one extreme, we certainly believe that price flexibility is relatively high in smaller, very open economies (which is why economies like Hong Kong can do well with pegged exchange rates).

3.2 Wage Behavior

Wage behavior is a key underlying determinant of inflation, and it provides another potential reason for a flatter price Phillips curve. A typical *wage* Phillips curve might take the form

$$\widehat{w}_t = \phi GAP_t + A(L)\pi_t, \tag{2}$$

where $\widehat{w}$ is the change in the (log) nominal wage, the output gap GAP (however measured) is negatively related to unemployment via Okun's law, and $A(L)$ is a lag-operator polynomial.[8] The positive relation between the gap and wage growth, coupled with the influence of wages on marginal cost, provides the channel through which the gap also drives price inflation, as in equation (1). If globalization reduces ϕ in equation (2), it will likely also reduce the slope of the price Phillips curve.

[8] See Galí (2011) for derivation of a similar expession in a New Keynesian dynamic model.

A common hypothesis is that globalization has eroded the bargaining power of labor—outsourcing is more widespread than was the case several decades ago, and the intensified engagement with world market by China, the ex-Soviet bloc, and India and other reforming emerging-market and developing economies (EMDEs) may have doubled the world's effective labor force in the early 1990s. There is not much micro-level evidence; an exception is the study of French manufacturing firms by Kramarz (2017) concluding that "strong unions caused offshoring which in turn caused employment and wage losses." It nonetheless seems plausible that reduced bargaining power in a more global environment would work to the disadvantage of workers.

Once again, however, establishing that an aspect of globalization has reduced wages does not directly establish that it also reduces the *response* of wages to slack. The latter effect must also be present if we are to conclude that growing globalization has flattened the wage Phillips curve over time.[9]

There is some evidence that the U.S. wage Phillips curve has flattened, but probably not as much as the price Phillips curve. Galí and Gambetti (2019), for example, report moderate flattening, although they do not link their results to globalization. Other research suggests that the recent apparent flattening of the wage Phillips curve may be a phenomenon common to other recession aftermaths (see, e.g., Daly and Hobijn 2014), and therefore possibly temporary. Hong et al. (2018) attribute the low nominal wage growth in advanced economies after the global financial crisis to expectations of continuing low inflation, low productivity growth, and mismeasured slack. Stock and Watson (2018, p. 12) conclude: "Unlike core PCE inflation, the correlation between wage inflation and contemporaneous slack measures falls only slightly, and for some slack measure does not fall at all, from the pre-2000 period to the post-2000 period." The same applies comparing 1960–83 (when globalization was less advanced) with subsequent data.[10] All in all, the conjecture that

[9] A fall in wages could *indirectly* reduce the effect of wages on overall consumer inflation if it leads to a decline in the share of wages in production costs (for example, due to inelastic business demand for labor). The result could manifest as a muted response of consumer inflation to labor market slack.

[10] Other evidence consistent with this view includes that of Knotek and Zaman (2014) and of Hooper, Mishkin, and Sufi (2019).

globalization has flattened the U.S. wage Phillips curve remains just that—a conjecture. More study is needed.

3.3 Foreign Prices

Import prices directly affect consumer price index (CPI) inflation through two main channels: they (i) enter into consumer prices and (ii) enter production costs for domestic producers, and hence affect the marginal cost term in equation (1).[11] If the roles of imports in consumption and production rise over time, as they have for the United States, the Phillips curve will very likely flatten—in the sense that the response of consumer inflation to domestic slack will fall.

There are several ways to formalize this argument, but to be concrete, I adopt a simple but flexible approach.[12] Let $\widehat{p}_{PM}$ denote the change in (log) *producer* prices of intermediate imports and $\widehat{p}_{CM}$ the same concept for *consumer* imports. Let us suppose that domestic output is produced out of labor (which I assume tentatively to be the source of all domestic value-added) and intermediate imports. In this case, and assuming a Cobb-Douglas production function for simplicity, the change in the log nominal marginal cost of producing home goods is (up to an additive constant)

$$\alpha\widehat{w} + (1-\alpha)\widehat{p}_{PM} - g,$$

where g reflects growth in input productivity (for example, through technical progress). The change in the nominal price of final home output, now denoted π_H, will be the change in marginal cost plus the markup change, $\widehat{\mu}$, so that

$$\pi_H = \alpha\widehat{w} + (1-\alpha)\widehat{p}_{PM} - g + \widehat{\mu}.$$

This equation is an identity, because the markup term is just a catch-all residual that will incorporate all the effects implied by the specific underlying dynamic pricing model—possibly a New Keynesian model, but possibly something else. In reality, of course, the

[11] Over time, foreign prices can also influence wage growth through their effect on expected future inflation and wage demands, but this channel is likely to be weak when expectations are well anchored.

[12] See Monacelli (2010) for a more structured approach.

term $\widehat{\mu}$ incorporates a competitive cost of capital as well as rents to firms' owners.

Assume, in addition, that consumer imports are delivered to retail outlets from the dock with the help of labor. Assuming perfect competition in distribution and a Cobb-Douglas weight γ on the labor input, inflation in consumer import prices, π_M, is equal to

$$\pi_M = \gamma\widehat{w} + (1-\gamma)\widehat{p}_{CM}$$

(up to an additive constant).

Overall consumer price inflation is denoted $\pi_C \equiv \theta\pi_H + (1-\theta)\pi_M$, where θ is the CPI weight of domestically produced goods and $1-\theta$ that of consumer imports. Combining the preceding equations for π_H and π_M yields consumer price inflation,

$$\pi_C = [\theta\alpha + (1-\theta)\gamma]\,\widehat{w} + \theta(1-\alpha)\widehat{p}_{PM} + (1-\theta)(1-\gamma)\widehat{p}_{CM} - \theta g + \theta\widehat{\mu}. \tag{3}$$

As it is likely that α (the share of labor in final output) exceeds γ (the share of labor in consumer imports), the implication is that the sensitivity of consumer inflation to wage pressures—and thus to the output gap, via equation (2)—will very likely decline as θ (the consumption share of domestic goods) and α (the weight of domestic factors in final production) decline. Thus, the more open the economy, the lower the sensitivity of overall inflation to domestic slack, other things being equal. Of course, it is also possible that greater domestic slack discourages markup growth $\widehat{\mu}$, and as we have seen, while it is possible that this effect increases with openness, further flattening the Phillips curve, it is not inevitable. One additional implication of equation (3) is that higher slack abroad may affect domestic inflation through import prices or through $\widehat{\mu}$, even conditional on domestic slack, as suggested by Auer, Borio, and Filardo (2017) and Forbes (2019). These mechanisms are in principle *relative* price effects, and the strength and time-pattern of any effect on inflation depends on the reaction of the exchange rate and the nature of pass-through to domestic-currency import prices. There is an associated conceptual problem of interpreting the statistical significance of an external slack measure in a causal sense. However, an independent external driver of domestic inflation, not directly controllable by monetary policy, could make it less likely that there is a "divine coincidence" in monetary policy, whereby the best policy for price stability is also the best for stabilizing the output gap. Instead, the central bank would face a harsher policy tradeoff.[13]

3.4 Marginal Cost Correlates of U.S. Consumer Price Inflation

Discussion of the Phillips curve and its evolution often draws inferences about the implications for monetary policy tradeoffs. But conventional Phillips-curve estimates are not structural relationships and can shift over time for reasons not directly related to exogenous factors such as globalization—for example, due to changes in the monetary policy reaction function (McLeay and Tenreyro 2019). For this reason, an assessment of the effect of globalization on the policymaker's predicament is hard to deduce from the so-called Phillips-curve tradeoff. More reliable approaches (albeit more laborious) would evaluate expected policy loss under different degrees of openness, or the effect on tradeoffs between competing objectives (for an example of the latter approach, see Erceg, Gust, and López-Salido 2010). These metrics depend on taking a stand on a particular dynamic model, and I will not attempt such an exercise here.

Rather than reporting Phillips-curve estimates—ground amply covered in other studies—I instead will report the partial correlations suggested by the pricing relationship (3), with the markup term being considered as a regression error. Of course, that error is correlated with the included regressors, and therefore the resulting estimates do not have a structural interpretation. They certainly do not describe a policy-invariant constraint in a central bank optimization problem. The findings are suggestive, however, and do furnish a set of empirical regularities that theories of an evolving inflation process should explain.

Table 1 reports ordinary least squares regressions over 1964–2018 of quarterly U.S. CPI inflation on three variables: nominal wage growth (measured by average hourly earnings of production and nonsupervisory employees in the nonfarm private sector, as reported by the Bureau of Labor Statistics, or BLS); growth in overall import

[13]Ihrig et al. (2010) and Mikolajun and Lodge (2016) find no evidence that foreign activity variables directly enter domestic Phillips curves.

Table 1. Correlates of CPI Inflation, 1964–2018

	(1) 1964:Q1–2018:Q4	(2) 1964:Q1–1992:Q1	(3) 1964:Q1–1973:Q1	(4) 1973:Q1–1992:Q1	(5) 1992:Q1–2018:Q4	(6) 1992:Q1–2008:Q1	(7) 2008:Q1–2018:Q4
Wage Growth	0.856***	0.792***	0.444	0.940***	0.399***	0.118	0.245*
	(0.118)	(0.154)	(0.291)	(0.127)	(0.114)	(0.141)	(0.141)
Import Price Growth	0.128***	0.099***	0.111	0.080***	0.140***	0.109***	0.144***
	(0.021)	(0.030)	(0.139)	(0.028)	(0.012)	(0.012)	(0.007)
Productivity Growth	−0.255***	−0.454***	−0.347***	−0.328**	−0.045	−0.088*	−0.199***
	(0.088)	(0.133)	(0.112)	(0.132)	(0.066)	(0.051)	(0.033)
Constant	0.001	0.004**	0.005	0.003**	0.003***	0.006***	0.003***
	(0.001)	(0.002)	(0.004)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	216	108	32	76	108	64	44
R^2	0.822	0.766	0.536	0.856	0.766	0.610	0.923

Notes: Newey-West standard errors (four lags) are in parentheses. *, **, and *** denote $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively.

Table 2. Correlates of CPI Inflation, 1992–2018

	(1) 1992:Q1–2018:Q4	(2) 1992:Q1–2008:Q1	(3) 2008:Q1–2018:Q4
Wage Growth	0.419***	0.251**	0.231
	(0.116)	(0.113)	(0.164)
Consumer Import Price Growth	0.006	0.004	0.082**
	(0.033)	(0.040)	(0.034)
Producer Import Price Growth	0.051***	0.046***	0.065***
	(0.008)	(0.014)	(0.008)
Productivity Growth	−0.111**	−0.139***	−0.226***
	(0.049)	(0.035)	(0.041)
Constant	0.003***	0.005***	0.004***
	(0.001)	(0.001)	(0.001)
Observations	104	60	44
R^2	0.805	0.698	0.902

Notes: Newey-West standard errors (four lags) are in parentheses. *, **, and *** denote $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively.

prices (as measured by the IMF's aggregate import price index); and the growth in labor productivity in the nonfarm business sector (real output per hour of all persons, as reported by the BLS). The BLS reports disaggregated U.S. import price indexes starting in 1992, and table 2 will use those data to separate total import price growth into consumer and producer goods. However, table 1 gives an indication of very long-term changes in the inflation process. All variables are four-quarter trailing moving averages, to eliminate any seasonality, and the table reports Newey-West standard errors.

Over the entire 1964–2018 period (table 1), wages have a very large and highly significant positive partial correlation with inflation, import prices have an economically and statistically significant coefficient, and inflation tends to fall when labor productivity rises. However, the coefficients appear unstable over time. Most notably, the role of wages falls dramatically over time, as (to a somewhat lesser degree) does that of labor productivity. The role of overall import prices fluctuates, possibly trending downward until the post-crisis period. This pattern seems contrary to the idea of import prices playing a growing role in U.S. inflation.

In qualitative terms, the results are remarkably similar when, instead of average hourly earnings, the labor-cost measure is the growth in compensation per hour. (That measure allows an extended sample starting in 1957. I do not report those results here.)

Table 2 focuses on the post-1992 period and breaks import prices into consumer and producer goods. I construct import price indexes for those two categories by defining consumer goods (admittedly, approximately) as those the U.S. Census classifies in the categories food, feeds, and beverages; automotive vehicles, parts, and engines; and consumer goods. Imported producer goods are those falling under the categories industrial supplies and materials; and capital goods, except automotive. The overall inflation rates for consumer and producer imports, $\widehat{p}_{CM}$ and $\widehat{p}_{PM}$, are then constructed from disaggregated index changes using import-value shares as weights.

Table 2, like table 1, shows a declining coefficient of wage growth over time, but within the 1992–2018 subsample a growing coefficient of productivity growth (also seen in table 1 for that same subsample). In these estimates, it is the prices of imported producer goods rather than consumer imports that show the more consistent correlation with CPI inflation, with the coefficient on imported consumer goods inflation becoming significant only in the post-crisis period. This finding echoes that of Auer, Levchenko, and Sauré (2018) on the role of input-output linkages in propagating PPI (producer price index) inflation globally. When compensation per hour is the labor-cost variable, the results (not reported) are generally similar.

Returning to the U.S. Phillips curve, these findings would be consistent with a declining coefficient on labor market slack over time in the regression for overall inflation. The finding that wages and productivity have become less correlated with inflation over the 1964–2018 period is consistent with the conclusion of King and Watson (2012) that unit labor costs have become less important in explaining prices, although their study did not explicitly consider import prices; see also Bidder (2015) and Peneva and Rudd (2015). The coefficient of import price inflation does not seem to have grown over time, in line with the findings of Ihrig et al. (2010).

The several-trillion-dollar question is to understand what explains the residual $\widehat{\mu}$ in equation (3)—which captures compensation of nonlabor productive factors as well as noncompetitive rents. More research on the apparently reduced role of labor costs is needed, including possible links to globalization through a secular fall in the U.S. income share of labor (IMF 2017b). Answering this question has important implications for inflation forecasting and monetary policy.

3.5 The Monetary Transmission Mechanism

Coming back to Dornbusch and Krugman (1976), if import prices respond strongly to exchange depreciation and firms have little capacity to absorb higher costs in markups, then the overall inflation response to monetary expansion may well be greater than in a hypothetical closed economy. For this reason, Dornbusch and Fischer (1986, p. 493) stated: "Theory suggests and empirical evidence supports the notion that under flexible exchange rates the Phillips curve is much steeper." But to say that the inflation response to a positive monetary shock is greater in an open economy is not the same as saying that the response of inflation to the output gap is greater—indeed, it very likely will be smaller.[14] Furthermore, the conditions of high pass-through that Dornbusch, Fischer, and Krugman assumed do not well describe the U.S. economy today (Gopinath 2016).

This is not to deny that the broader issue these authors addressed—the monetary transmission mechanism in the open

[14]That is probably why Dornbusch and Krugman (1976, p. 573) distinguish between a "conventional" short-run Phillips curve and a Phillips curve "in terms of market prices." Their concept seems related to what Barnichon and Mesters (2019) call the "Phillips multiplier." Different understandings of what a "steep" Phillips curve means may explain some confusion in the literature. Thus, Rogoff (2006, p. 269) writes that "globalization creates [a] favorable milieu for maintaining low inflation by steepening the output-inflation (Phillips curve) tradeoff faced by central banks." His discussant, Bean (2006, p. 308), finds this remark puzzling and observes: "I am less convinced . . . that globalization will result in a steepening of the short-run output-inflation tradeoff. Extant analyses of the tradeoff in open economies instead suggest that the increased specialization resulting from globalization *reduces* the response of inflation to the domestic output gap and makes it more sensitive to the world output gap, leading to a flatter tradeoff." They are likely both right, but they are talking about different things.

economy—is of central importance. In the closed economy, monetary policy directly affects domestic aggregate demand. Three main qualitative differences apply to any open economy, however:

(i) The aggregate demand effects on market interest rates and asset prices will be intermediated by the exchange rate and depend on global financial market conditions.

(ii) Some aggregate demand will spill onto imports while some output is sold abroad, with the effects again intermediated by the exchange rate.

(iii) The pass-through of exchange rates to import prices will be a critical determinant of the inflation response.

There are several illuminating studies of these mechanisms and their quantitative impact—for example, the one by Erceg, Gust, and López-Salido (2010). Since that ground has been ably covered by others, I will be selective and focus next on an aspect of item (i) above, the influence of international financial markets.

Later on, however, I will look at one further global dimension of monetary policy that applies primarily to the United States: the outsized global effect of U.S. monetary policy due to the unique international roles of the dollar and of U.S. financial markets. This channel should be considered as an important additional transmission mechanism.

3.6 Summary

The U.S. price Phillips curve has flattened over time—a development not confined to the United States. The reason for this is unclear—the Phillips relationship between inflation and slack is not structural but is policy dependent through multiple mechanisms. The evidence is weak that increasing globalization, as opposed, say, to better-anchored expectations (something common to many countries), is responsible. The evidence of a flatter wage Phillips curve is more tenuous.

Import prices are a robust correlate of U.S. CPI inflation and could provide a mechanism (along with markup changes) for foreign slack measures to correlate with U.S. inflation over some time spans.

The policy implication of such a correlation is not obvious (Woodford 2010). Ultimately, though (once sticky-price and pricing-to-market rigidities have been worked through), exchange rate changes induced by monetary shocks will feed proportionately into import prices, ensuring domestic monetary policy long-run control over domestic prices (except in implausible circumstances). The process could be relatively lengthy, however, confronting the central bank with harsher medium-term tradeoffs.

One strong pattern in the data is a smaller role of U.S. wage changes in explaining CPI inflation. The reasons behind this also are unclear. They could be related to globalization, to the extent that the mechanism lowering labor's GDP share depends on global factors (for example, low-wage imports or firms' capacity to move labor-intensive operations offshore).

4. International Financial Linkages and Monetary Policy

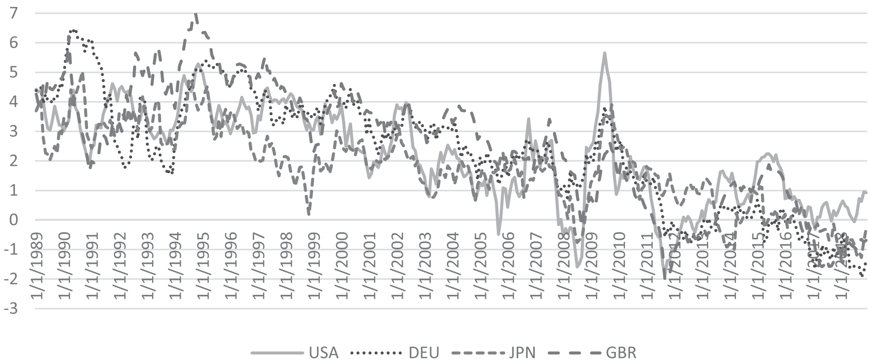
Because U.S. financial markets are closely intertwined with markets abroad, developments in those markets will buffet the U.S. economy and could call for monetary policy responses—either through interest rate changes or central bank balance sheet adjustments. Sometimes those responses serve to offset or temper shocks, sometimes to accommodate global trends that could destabilize U.S. inflation if not properly reflected in the monetary policy reaction function. The range of potential policy issues is broad, so here I will limit my discussion to two main transmission channels for global influences: the natural real rate of interest and financial factors more broadly construed.

Connections with foreign financial markets complicate the central bank's quest for financial stability, with potential monetary policy implications (see, for example, Obstfeld 2015). However, I will touch on financial stability considerations only in passing, as they are the focus of a separate paper at this conference.

4.1 The Natural Real Interest Rate

The "natural" or "neutral" real rate of interest r^*, a concept that has been central to monetary theory from Wicksell (1898)

Figure 6. Selected Real Long-Term Interest Rates (percent per year)



Source: U.S. Treasury, Bank of England, Deutsche Bundesbank, Japan Ministry of Finance.

to Woodford (2003) and beyond, provides a key benchmark for monetary policy. It is typically defined as the real rate of interest consistent with full employment in a hypothetical world with perfectly flexible prices and wages. The general precept most inflation-targeting central banks follow approximates the following approach: set the nominal policy interest rate less forecast inflation—the expected *real* policy rate—above r^* when inflation is forecast to be above target, and below r^* in the opposite case. Because r^* is not directly observable as the actual market return on any instrument, central banks face a challenge in estimating it, and especially so when r^* is not stable, as changes can be hard to detect in real time (even when there is inflation-indexed government debt). In any financially open economy, interest rates are determined in part by global market forces, and so developments abroad can exert a decisive pull on domestic r^*. This dependence is a double-edged sword for policymakers: purely domestic factors that might move r^* will be muted, but by the same token, foreign factors that could be much harder to monitor will play significant roles.

For a sample of large industrial countries, figure 6 illustrates the coherence and remarkable secular decline toward very low levels of long-term real rates.[15] Del Negro et al. (2019) develop a methodology for estimating trend real interest rates, which likewise show convergence and decline over recent decades.

4.1.1 Global Determination of Real Interest Rates

Popular methodologies for estimating r^* recognize potential global interdependence but most proceed on a national basis, as if each economy were a self-contained unit (e.g., Holston, Laubach, and Williams 2017). Even such exercises tend to yield r^* estimates which, like market real interest rates, are highly correlated across countries—unsurprisingly, because the underlying real data inputs are generated in a market setting that enhances co-movement among national macroeconomic variables, including interest rates.

A simple textbook diagram based on Metzler (1968) can elucidate the main forces at play. It uses the same underlying model that informs Bernanke's (2005) account of a global saving glut starting in the late 1990s.

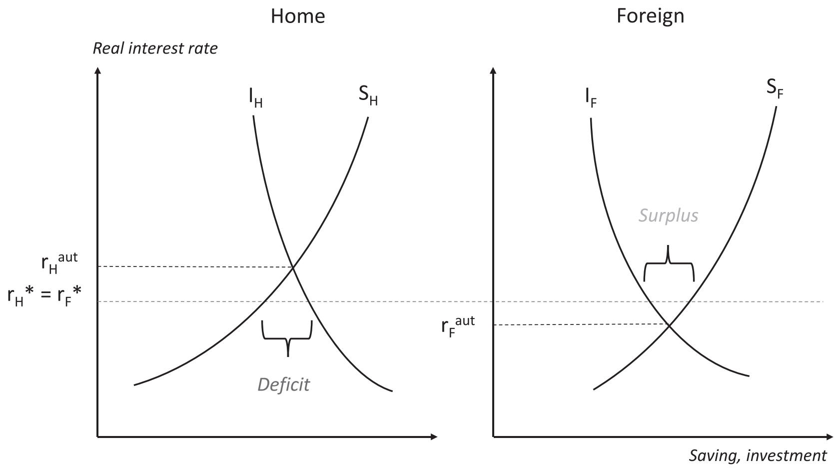
Figure 7 illustrates the global determination of the full-employment real interest rate in a hypothetical flexible-price world with two regions, Home (think of it as the United States) and Foreign (the rest of the world). In each region, saving is increasing, and investment decreasing, with the real interest rate. In the simplified case shown in figure 7, there is a homogenous world output—said differently, purchasing power parity (PPP) holds—so that with an integrated world financial market, the real interest rates prevailing in Home and Foreign will be fully equalized by net international capital flows. Importantly, there is also only a single (tradable) asset available—the real bond indexed to the single output—so that no other asset returns influence economic behavior. Moreover, countries' consumption and investment opportunities are constrained only by their full-commitment intertemporal budget constraints—there is no question of asymmetric information or default.[16]

Global equilibrium means that *world* saving equals *world* investment—not that saving and investment coincide country by

[15] Figure 6 adjusts for the temporary inflation effects of Japanese increases in consumption tax in April 1997 and April 2014. In the figure, expected inflation is proxied by inflation over the preceding 12 months.

[16] For microfoundations of the Metzler model, see Obstfeld and Rogoff (1996).

Figure 7. Global Equilibrium Interest Rate and Current Accounts



country. Figure 7 shows the equilibrium world natural rate of interest as $r_H^* = r_F^*$. In this equilibrium, Home's deficiency of saving compared with investment—its current account deficit—must be precisely offset by Foreign's excess of saving over investment—its current account surplus.

Figure 7 also indicates the hypothetical *autarky* natural rates of interest, r_H^{aut} and r_F^{aut}, that would prevail in Home and Foreign, respectively, if they were excluded from international borrowing and lending. These real interest rates force saving to equal investment in each country. Notice how the equilibrium world interest rate necessarily falls between the two autarky rates: Home, with the higher autarky rate, has a current account deficit and thus capital inflows, whereas Foreign, with the lower autarky rate, has a current account surplus and thus capital outflows.

4.1.2 Role of the Current Account Balance

Figure 7 makes the key point that the natural real rate of interest is intimately tied to the current account. Albeit simplified, the model has an important immediate implication: because the global equilibrium interest rate is a weighted average of national autarky rates, shocks to autarky rates anywhere will affect current account balances and the natural real rate everywhere.

Advanced countries no longer focus directly on the current account balance (or other balance of payments flows) when setting monetary policy—though, of course, foreign official liabilities were a major consideration for U.S. monetary policy throughout the 1960s and until 1971. There are thus relatively few formal studies of the interaction between the current account and monetary policy, notable exceptions being Ferrero, Gertler, and Svensson (2010) and Corsetti, Dedola, and Leduc (2018). Those central banks for which the current account remains an important consideration tend to be in emerging market economies, which are more vulnerable to capital-flow sudden stops. Even in those countries, provided the exchange rate is flexible, the simultaneous preservation of internal and external balance is in principle the joint responsibility of monetary and fiscal policy, with monetary policy ideally focusing relatively more on the internal balance, at least outside of crisis situations.

There are at least two reasons why central banks should monitor current account developments closely, however. First, changes in natural real rates are likely to have current account implications, so significant sustained current account shifts will give clues about changes in the natural rate.

Second, significant sustained current account shifts may be driven by developments with implications for financial stability. These can have dramatic effects on output and prices down the road, as the events preceding the global financial crisis illustrate (Obstfeld and Rogoff 2009; Obstfeld 2012). To begin, I take up the first of the preceding motivations for attention to the current account.

As an initial illustration, consider Bernanke's (2005) account of how a rise in East Asian saving after the late-1990s regional crises changed the United States' external equilibrium. If we identify Foreign with Asia, we can visualize an outward shift in the Asian saving schedule in figure 7, say, from the schedule labeled S_F to a new schedule S_F' lying to its right. That shift lowers the autarky interest rate in Asia, raising its desired current account surplus. At the same time, the natural real rate in the United States necessarily falls, swelling its full-employment current account deficit. Had the Federal Reserve (in the real world with sticky prices and wages) not accommodated this fall in the natural rate, the result would have been currency appreciation, deflationary pressure, an incipient rise in the real rate of interest, and a slump.

4.1.3 Role of the Real Exchange Rate

Of course, PPP (as assumed in figure 7) does not hold in reality: real exchange rates, which I will define for my purposes as the ratios of national consumer price levels when measured in a common currency, are quite variable. Their variability reflects a range of factors, including trade impediments in merchandise and services markets; moreover, changes in relative goods prices can drive real exchange rate changes when national CPI baskets differ in composition. The framework's basic qualitative insights still hold when PPP fails, however, but with quantitative modifications.[17]

To extend the model, let q denote the log price of the Foreign consumption basket in terms of the Home basket—the Home–Foreign *real exchange rate*—so that a rise in q (the Foreign basket becomes relatively more expensive) is a real depreciation of the Home currency. The uncovered interest parity condition linking countries' *nominal* interest rates is equivalent to a real interest parity condition linking their *real* interest rates, of the form

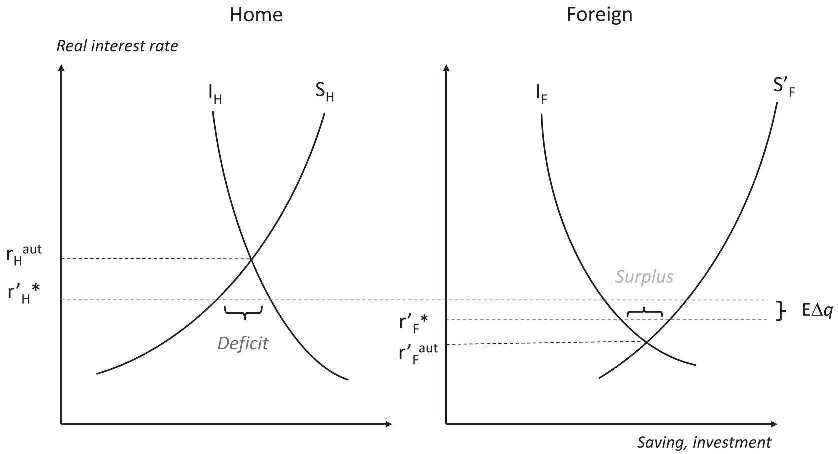
$$r_H^* = r_F^* + \mathrm{E}\Delta q$$

under conditions of full employment. The validity of this condition relies on risk neutrality and an absence of differential liquidity benefits attached to safe national debt instruments (Del Negro et al. 2019).

The expected rate of relative Home currency depreciation, $\mathrm{E}\Delta q$, effectively drives a wedge between the Home and Foreign real rates of interest. Figure 8 shows how this change alters the effect of a rise in Foreign saving, which would shift the Foreign saving schedule rightward in figure 7 from S_F to a new schedule S'_F. Figure 8 relies

[17] Clarida's (2009, 2017) New Keynesian framework elucidates the influence of global forces on natural real rates in a setting that allows for PPP deviations. But his closed-form model solution makes several special assumptions that obscure some of the forces at work in the interest of algebraic tractability. (For example, his model does not permit current account imbalances in equilibrium.) His discussion is, however, fully consistent with mine.

Figure 8. Allowing for Exchange Rate Expectations

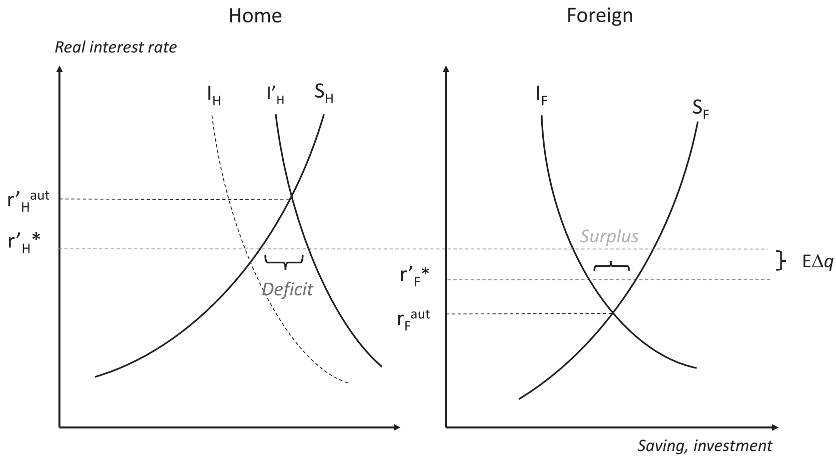


on two assumptions. First, it assumes that a rise in Foreign saving will lead to a real appreciation of Home currency, which is necessarily also a depreciation of Foreign currency. Generally a country's consumers have a home bias in favor of home-produced goods, so a rise in their saving will depress the price of their preferred consumption basket relative to those of consumers elsewhere. Second, the figure assumes, consistent with a large body of empirical research, that real exchange rates are mean reverting (see also Del Negro et al. 2019). Thus, a rise in Foreign saving is most likely to produce an immediate fall in q coupled with an expected future increase, that is, with a rise in EΔq—just as figure 8 shows. (The assumed behavior of q can be rationalized even under flexible prices.)

In the absence of any real exchange rate change, the (unique) global real interest rate would settle between $r_H^{*'}$ and $r_F^{*'}$, implying a bigger Home deficit and counterpart Foreign surplus. A positive value of EΔq, however, creates a wedge between the countries' equilibrium natural rates, pushing them closer to autarky rates while reducing the size of the current account responses. Obstfeld and Rogoff (2001) explored how goods-market impediments can mute the response of capital flows to shocks.

In the case that figure 8 shows, a bigger U.S. deficit is a signal of a fall in foreign autarky interest rates, necessarily bringing down

Figure 9. An Increase in Home Investment



the U.S. natural real rate in response to global deflationary pressure. The appropriate policy response is to cut U.S. nominal rates.

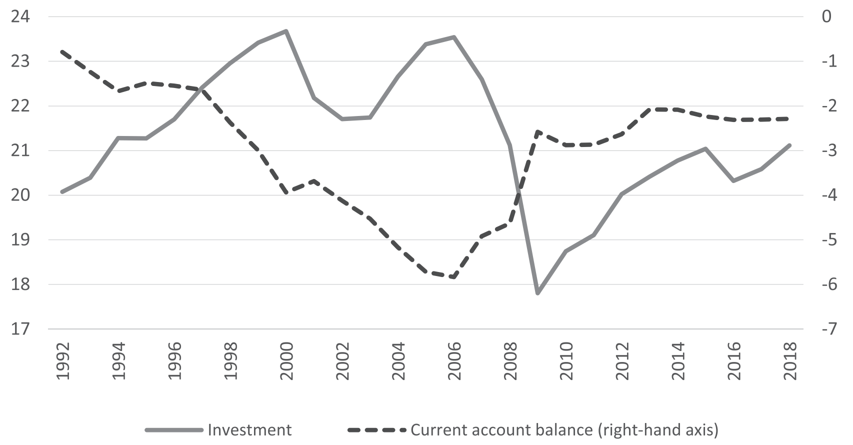
But the U.S. current account deficit may rise for other reasons. Figure 9 shows the effects of an outward shift in the U.S. investment schedule (from I_H to I'_H). That change raises the U.S. autarky rate, raises the foreign level of real rates by less, and thereby results in a larger U.S. deficit. The implication is that if the initial position is one of full employment, the central bank should tighten monetary policy—if it does not, then despite the currency's appreciation, the result will be a positive output gap followed eventually by inflation.[18]

4.1.4 The Current Account and Financial Imperfections

I have presented figures 8 and 9 as reflecting independent developments, but in the case of the United States in the 2000s, they were not: the first promoted the second. Low U.S. interest rates (coupled with forward guidance) early in the 2000s arguably encouraged a

[18]In discussing figures 7 through 9, I do not sketch out the subsequent dynamics, driven by the evolution of the NIIP and the need for countries to service their foreign debts in the long run. Those developments will require long-run shifts in the saving and investment schedules (for the deficit country, for example, toward more saving and less investment).

Figure 10. U.S. Current Account and Investment (percent of GDP)



Source: IMF, *World Economic Outlook* database, April 2019.

house price and residential investment boom, coupled with symbiotic financial innovation in mortgage securitization. The result could well have been an outward shift in the U.S. investment schedule (as in figure 9) and a further deterioration in the U.S. external balance. This is essentially the story that Obstfeld and Rogoff (2009) and Obstfeld (2018) tell. Figure 10 shows the time series of U.S. investment and the current account, highlighting the strong "second leg" of current account deterioration from roughly 2003–06.

This brings me back to the financial stability motivation for central banks to be aware of the current account. In retrospect, the sharp drop in the current account starting around 2003 may have been signaling a domestically driven rise in the natural real rate and a need for monetary tightening. The lesson is that monetary policy, perhaps especially at low nominal interest rates, cannot be divorced from financial evolutions that not only impinge on financial stability but also can generate structural shifts in the saving and investment schedules that determine the natural rate r^*. Thus, notable current account developments can furnish clues to perhaps dangerous financial-sector developments.

Indeed, recent research has shown how financial development can itself be a further determinant of autarky interest rates, not captured in the preceding simple model. In the model of Caballero, Farhi, and Gourinchas (2008), an enhanced ability of a country's financial markets to securitize income flows into a tradable form directly raises the autarky interest rate and, thus, the country's current account deficit. A challenge for central bank policy is that such financial innovation may itself be endogenous to the monetary stance and may promote instability down the road.[19]

4.1.5 Low Global Real Rates: Implications for Monetary Policy

As Del Negro et al. (2019) illustrate, and as figure 6 suggests, trend real interest rates (and the trend real "world" rate, which they estimate) have moved sharply downward since the 1980s, and in concert among advanced economies. Synchronicity is expected in a world of internationally integrated capital markets, but recent research points to a range of common factors driving interest rates lower, including aging work forces, slower productivity growth, and relative scarcity of safe assets (see, e.g., IMF 2014; Council of Economic Advisers 2015; Yi and Zhang 2016; Rachel and Smith 2017; Brand, Bielecki, and Penalver 2018; Rachel and Summers 2019).[20]

The long-term forces that these papers document, complemented by the recent work of Gourinchas and Rey (2018) documenting the historical tendency for low consumption-wealth ratios to predict future low real interest rates, suggest that low values of r^* could remain on the global scene for some time, especially in the advanced economies. The global determination of real interest rates implies that, given their inflation targets, foreign events may drive central banks to their effective lower bounds (ELBs) on policy interest rates, making it impossible for monetary policy to respond with further interest rate cuts to deflationary shocks from abroad (see Caballero, Farhi, and Gourinchas 2016). With medium-term inflation targets at around 2 percent per year, a central bank that relied only on *conventional* monetary tools would be unable to counter a shock that drove r^* to -2 percent or below, even in the favorable case that inflation expectations remained anchored at 2 percent rather

[19] On the long-run relationship between business cycle develoments and financial evolution, see Jordà, Schularick, and Taylor (2017).

[20] For a longer-term perspective, see Jordà et al. (2017) and Jordà and Taylor (2019).

than declining. As a result, the possibility of monetary policy being constrained when faced with either domestic or foreign deflationary shocks is higher—perhaps even higher than Kiley and Roberts (2017) estimate—and clearly justifies a rethink of policy frameworks to reduce potential ELB episodes and, thereby, to expand monetary policy space.

4.2 Broader Financial Forces

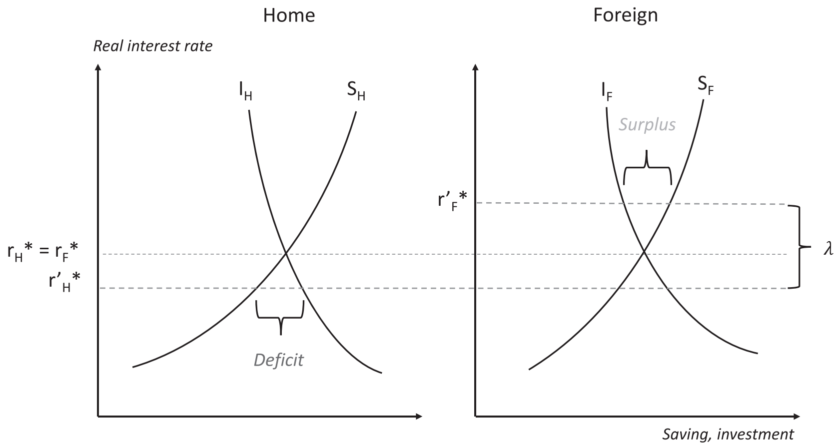
In standard models, the real rate of interest r is a safe rate, set in markets to equate the *flows* of saving and investment at the global level. As has been especially evident in the recent era of large-scale asset purchases, monetary policy works in part by altering the relative prices of a range of generally risky assets, where prices are determined to equate global investors' portfolio demands for particular assets to the *stocks* that are available worldwide. The perspective of an integrated stock-flow equilibrium with multiple assets, due in its essentials to Tobin (1961), draws attention from the *net* flow of international lending measured by the current account balance, and toward the *gross* two-way flows which, in equilibrium, finance that balance and which in turn derive from desired changes in stock positions given global changes in asset prices, in wealth, in financial constraints, and, importantly, in investor preferences and sentiment.

Shifts in foreign asset demands are therefore a potential source of disturbances with monetary policy implications, as are domestic residents' shifts between domestic and foreign assets. At the same time—as the next section takes up in greater detail—financial market structures imply that Federal Reserve actions are likely to propagate powerfully abroad, much more so than for other central banks, with important potential spillbacks onto the U.S. economy itself.

4.2.1 Dollar "Liquidity" Shocks

As I will discuss further in the next section, the U.S. dollar has a unique role in the international monetary system as an official reserve currency, a funding currency, an invoicing currency for trade, and a vehicle currency in the foreign exchange market. As a result, safe dollar assets (including U.S. Treasury securities, but not necessarily restricted to those) are thought to offer convenience yields over

Figure 11. A Rise in Perceived Liquidity of Home Assets



and above their pecuniary returns (see, for example, Krishnamurthy and Vissing-Jorgensen 2012; Canzoneri et al. 2013; Jiang, Krishnamurthy, and Lustig 2018). These liquidity yields are variable and rise in periods of global stress as the dollar plays the role of a safe haven. Conversely, a big selloff of dollar assets (for example, due to political factors) could pose particular challenges for monetary policy if the result is a U.S. spending decline coupled with higher depreciation and inflation (as modeled by Canzoneri et al. 2013).

Figure 11 takes a first look at a rise in the global demand for U.S. dollar assets within the simplified flexible-price theoretical framework of the last subsection. (Initially, I assume that PPP holds.) The underlying modeling assumption is that in each region, the rate of return primarily influencing saving and investment is the nominal home-currency bond rate less the expected rate of domestic consumer price inflation, notwithstanding the possibility that some actors transact in foreign securities.[21] If initially current accounts are

[21]Even if dollar interest rates are low due to a liquidity factor, foreign dollar borrowers will pay the same foreign-currency rate as through home borrowing if they hedge those dollars in the foreign exchange (FX) swap market and covered interest parity (CIP) holds. Otherwise, they will bear currency risk. Since the global financial crisis, substantial deviations from CIP have, however, become commonplace (Cerutti, Obstfeld, and Zhou 2019). Nonetheless, for most currencies, most issuers are unable to arbitrage that "dollar basis" by borrowing dollars

balanced, the emergence of a liquidity premium λ on Home bonds creates a gap between the two countries' natural real rates, with the U.S. rate falling to r'_H, the Foreign rate rising to r'_F, and the Home current account moving into deficit, while Foreign generates the counterpart surplus. The driving mechanism in this example is not the effect of asset demand shifts on the exchange rate but the movement in interest rates necessary to reflect the gap λ, which, in turn, moves the countries along their saving and investment schedules. Were the real exchange rate variable, however, as in figures 8 and 9, the Home currency would appreciate in the short turn, leading to an expected future depreciation which, in turn, would require a somewhat higher r'_H and lower r'_F in equilibrium, and, overall, a smaller short-run Home deficit and Foreign surplus.

One source of the U.S. liquidity premium is the U.S. dollar's status as the world's premier reserve currency. Warnock and Warnock (2009), Krishnamurthy and Vissing-Jorgensen (2012), and others have documented effects of foreign official demand on U.S. Treasury yields. Of USD 10.7 trillion of 2018:Q4 allocated foreign exchange reserves covered in the IMF's COFER database, USD 6.6 trillion (62 percent of global reserves) were held in dollars. Foreign official reserve behavior thus could be a significant source of shocks to U.S. bond markets. Another source of the U.S. dollar liquidity premium is the dollar's unique role as a vehicle currency in FX markets. The last (2016) Triennial Central Bank Survey of Foreign Exchange and Over-the-Counter (OTC) Derivatives Markets showed the U.S. dollar share in daily FX turnover to be 88 percent (out of 200 percent, given that every deal involves two currencies).

The structurally low required return on U.S. liabilities may also be related to the U.S. global safe-haven role—which, in turn, may be due to the greater liquidity of dollar assets and the depth of U.S. financial markets. Gourinchas, Rey, and Govillot (2017) observe that when the dollar appreciates unexpectedly in an environment of global distress, the resulting decline in the U.S. NIIP is a transfer of wealth to foreigners that effectively acts as an insurance payout when the world economy is in turmoil. If dollar securities have higher real

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and swapping into their domestic currencies. For example, the difference between lower-medium-grade corporate bond yields and Treasury yields wipes out much or all of the dollar basis.

payouts when global wealth takes a hit, however, then average dollar yields should be lower. On this theory, the "exorbitant privilege" of low dollar borrowing costs is matched by an "exorbitant duty" to transfer wealth to foreign holders when global financial conditions tighten. If so, changes in foreign risk aversion or perceptions of risk would impinge on U.S. interest rates.

Consistent with this "exorbitant duty" view, the 1980–2018 correlation coefficient between the Fed's broad nominal dollar index and the IMF's measure of real global growth is -0.53, meaning that the dollar does have a meaningful tendency to appreciate when global growth is low.[22]

4.2.2 Other Global Influences over Financing Conditions

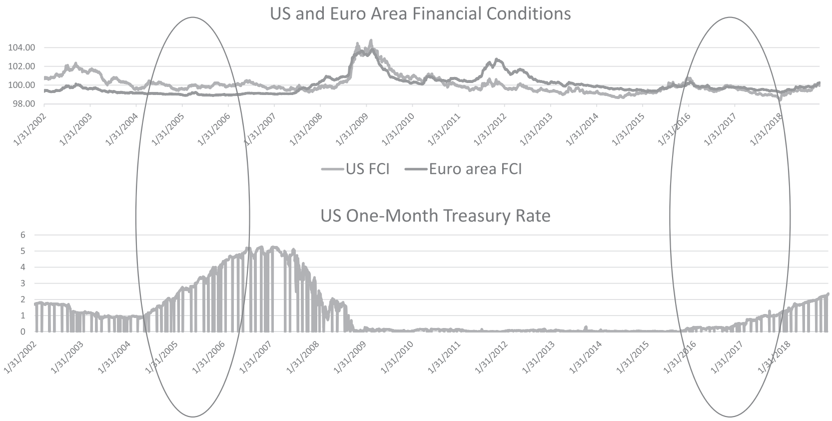
Federal Reserve control of the policy interest rate is meant to influence the entire term structure, as well as the prices of other risky assets, in order to steer inflation and employment. Financial impulses from abroad can, however, weaken the links between the policy interest rate, other asset prices, and activity, and in this case, confront the Fed with harsher policy tradeoffs—for example, whether to tighten policy, even though inflation is quiescent, in order to deter financial excesses in some markets. This type of dilemma is present even in a closed economy, of course, but financial openness increases the United States' exposure to foreign financial influences, for example, via shifts in foreign demand for U.S. assets, driven by changing portfolio preferences or by financial conditions abroad.[23]

Figure 12 illustrates the potential divergence between Fed interest rate policy and overall financial conditions. Both of the major hiking cycles since the early 2000s show overall financial conditions lagging well behind interest rate tightening. The cycle beginning in

[22]The IMF weights countries' growth shares in world GDP growth using their PPP-adjusted income levels. Using market exchange rate GDP weights instead, the preceding correlation is -0.25. It is lower because when global growth slows and the dollar appreciates, non-U.S. countries' weights in global growth get systematically downweighted when evaluated at market exchange rates.

[23]Adrian, Stackman, and Vogt (2019) operationalize this tradeoff in a particular way, as a tradeoff between average growth and growth volatility. They argue that, empirically, countries with greater exposure to global financial market sentiment (as represented by the VIX) face a steeper tradeoff (i.e., more extra output growth volatility for each additional percentage point of growth).

Figure 12. Overall Financial Conditions May Diverge from Monetary Policy



Source: Bank for International Settlements (BIS), *Quarterly Review*, December 2018, box A; Federal Reserve historical data. The BIS financial conditions index comprises short- and long-term interest rates; corporate spreads; equity prices; and trade-weighted exchange rate.

June 2004 featured a much-noted failure of longer-term interest rates to respond commensurately—the "Greenspan conundrum," which many attributed to the influence of foreign demand for safe U.S. longer-term securities. The cycle that began in December 2015 is followed by a similar failure of U.S. financial conditions to adjust in the same direction—instead, financial conditions loosen through the end of December 2018. Again, foreign conditions certainly played some role—whether through the European Central Bank's (ECB's) asset purchase program, foreign appetite for U.S. corporate debt, or other factors.

Caballero, Farhi, and Gourinchas (2017) offer an integrated framework for thinking about the evolution of rates of return in a world of multiple assets, traded in world markets. They argue that, especially since 2008, a global shortage of safe assets (driven in part by higher risk aversion) helps to explain the nontrending rate of return on U.S. capital coupled with a declining risk-free rate and rise in the equity premium. While this account is stylized, it does illustrate the potential role of global financial conditions beyond the interest rate channel featured in the Metzler model. Moreover, these factors will shift saving and investment rates *given* the risk-free rate of interest, and thereby move the natural rate r^* consistent with full employment. There is no general "divine separability" under which policy interest rates can be set independently of other financial conditions.

Financial conditions and, through them, economic activity thus will be influenced by a range of financing terms and conditions beyond any single measure of the interest rate. This fact has implications for how policymakers should think about international capital flows. For a given *net* capital account balance, the volume and nature of *gross* inflows—the gross financing that foreign markets make available—is also critical in determining relative asset prices and the availability of credit. In general equilibrium there can be an effect on the current account balance, of course, but that net balance does not by itself reveal the underlying gross flows, which are all-important for economic activity and financial stability.[24] Another way to express this is to think about the role of a floating exchange rate. In advanced economies, at least, a floating exchange rate can help buffer economic shocks by automatically maintaining balance of payments equilibrium. However, compositional mismatches between gross capital outflows and inflows can have important effects on financial markets without the changes in incipient *net* capital flows that are more likely to move exchange rates.

Bernanke et al. (2011), for example, document how European banks recycled outflows from U.S. money market funds (MMFs) back into U.S. markets in the mid-2000s, pushing down yields on mortgage-backed securities (and other substitutable assets) and helping to fuel the U.S. housing bubble. Consistent with my earlier claim that such inflows may have materially raised U.S. housing investment, Bernanke et al. (2011) suggest that " the strong demand for apparently safe assets by both domestic and foreign investors not

[24]On this point, see Obstfeld (2012) and Borio and Disyatat (2015). Forbes and Warnock (2012) document surges and retractions in gross flows, and their correlation with risk aversion (as measured by the VIX). For a simple model of how foreign investor preferences can determine the macroeconomic effect of capital inflows, see Blanchard et al. (2017); but the types of effects they highlight can arise even from gross, not just net, inflows.

only served to reduce yields on these assets but also provided additional incentives for the US financial services industry to develop structured investment products that 'transformed' risky loans into highly-rated securities." These flows also helped set up a potentially destabilizing nexus of financial interconnection among U.S. MMFs, European banks, and the U.S. housing market.[25]

4.2.3 Links among Long-Term Nominal Yields

Global influences over long-term interest rates may reflect forces beyond global current account imbalances or reserve accumulation by EMDEs, including investor sentiment, central bank large-scale asset purchases, and government financing needs. Not just long-term *real* interest rates, but also long-term *nominal* interest rates, are surprisingly highly correlated across countries.

At one level this may not be so surprising. Even EMDEs have converged in recent years toward lower inflation rates (IMF 2018a; Ha, Kose, and Ohnsorge 2019), real exchange rate changes are eventually mean reverting, and there are strong global common factors driving countries' real interest rates and, likely also, term premiums.[26] Moreover, other things being equal, the exchange rate movements necessary to allow substantial changes in long-term interest differentials are very big. In a world of uncovered interest rate parity, for example, a relatively small expected exchange rate change can allow big international differences in one-month interest rates; but by the same token, a very large cumulative expected change would be needed to support big differences in 10-year rates.

One way to illustrate the coherence of long-term rates is through regressions of interest rate changes on changes in a base-country interest rate—either the United States or an alternative "natural" anchor currency. In Obstfeld (2015), I reported quarterly pooled nominal interest rate regressions of the change in country j's

[25] See also Acharya and Schnabl (2010).

[26] Cohen, Hördahl, and Xia (2018) review alternative term premium models and conclude that U.S. and euro-area term premiums are more correlated than are the components of long-term rates explained by expected interest rates. See also Hellerstein (2011) and Jotikasthira, Le, and Lundblad (2015).

nominal interest rate (ΔR_{jt}) on the change in its base country's rate (ΔR_{bt}),

$$\Delta R_{jt} = \alpha + \beta \Delta R_{bt} + \gamma' X_{jt} + \varepsilon_{jt},$$

where the controls X_{jt} are current and lagged output growth and inflation in country j, variables suggested by the Taylor rule. I explored regressions with only the United States as a base country as well as regressions in which different countries are allowed to have distinct base partners (for example, the euro area for non-euro emerging Europe). The latter setup allows panel regressions in which a time fixed effect can soak up common global shocks to interest rates, as well as regressions that control explicitly for likely common shocks, such as the change in the VIX, often viewed as a measure of shifts in global risk sentiment.

The message from these regressions (Obstfeld 2015, table 1) is that global long-term nominal interest rates co-move closely with their base-currency rates (usually the dollar or euro long-term rates), and much more so than short-term rates. The correlation of long-term rates with base long-term rates appears even higher when controlling for VIX rises, which have a significant positive effect on global long-term (nonbase) nominal rates. This shift could reflect the safe-haven roles of the main reserve currencies. Other authors find high correlations for long-term rates with U.S. rates, and higher correlations than these for short-term rates, even controlling explicitly for U.S. macroeconomic conditions and the VIX. Those results are consistent with a causal impact of U.S. rates on foreign rates (Hofmann and Takáts 2015).

The correlations of long-term interest rates with center-country rates raise the question of how strongly changes in foreign long-term rates spill over to U.S. rates and, in particular, how U.S. rates have responded to specific foreign shocks, such as the ECB's unconventional policies, including large-scale asset purchases. There is considerable evidence of significant spillover from U.S. quantitative easing to foreign asset prices, particularly in EMDEs (Bauer and Neely 2014; Rogers, Scotti, and Wright 2014, 2018; Bowman, Londono, and Sapriza 2015). In their initial roll-outs (for example, through 2012), ECB unconventional policies appear to have had a more limited effect on bond yields outside of the euro area, certainly when compared with the external effect of Fed policies (Rogers, Scotti, and Wright 2014; Fratzscher, Lo Duca, and Straub 2016). The evidence for more recent ECB quantitative easing seems more mixed (Coeuré 2018).

A growing literature points to the dollar's unique global role as a likely factor in the asymmetrically strong global response to U.S. unconventional measures. The dollar's role has other far-reaching implications for U.S. monetary policy, to which I now turn.

5. Implications of the Dollar's Global Role

The last section documented the U.S. dollar's unique global position as a reserve currency and a vehicle currency. Those roles are intimately tied to the two additional roles in which the dollar occupies first rank: invoice currency and funding currency. Parallel to section 2 of this paper, the dollar's invoice-currency role affects the international price mechanism by influencing how U.S. monetary policy will move real exchange rates, inflation, and export competitiveness throughout the world. Parallel to section 3, the dollar's funding currency role mediates the transmission of U.S. monetary policy to global financing conditions.

The U.S. dollar also stands out from other currencies as the prime "anchor" or "base" currency for exchange rate stabilization. In other words, the many (mostly emerging and developing) countries that intervene to limit their currencies' foreign-exchange flexibility often see their bilateral U.S. dollar exchange rate as the most appropriate benchmark for stability. Ilzetzki, Reinhart, and Rogoff (2019) reckon that for about 60 percent of the world's countries (even more on a GDP-weighted basis), the dollar is the anchor currency. Thus, to the extent that these countries value exchange stability and intervene in the foreign exchange market to limit fluctuations, Federal Reserve policy, more than the monetary policies of other major central banks, will have an immediate effect on domestic financial conditions.

Through these mechanisms, U.S. monetary policy has an outsized effect on global economic activity—consistent with the evidence on unconventional policy spillovers that the last section reviewed. The Federal Reserve, even more than other central banks, should therefore consider spillbacks from the global economy as a relevant transmission mechanism for its policies.[27]

5.1 Dollar Invoicing

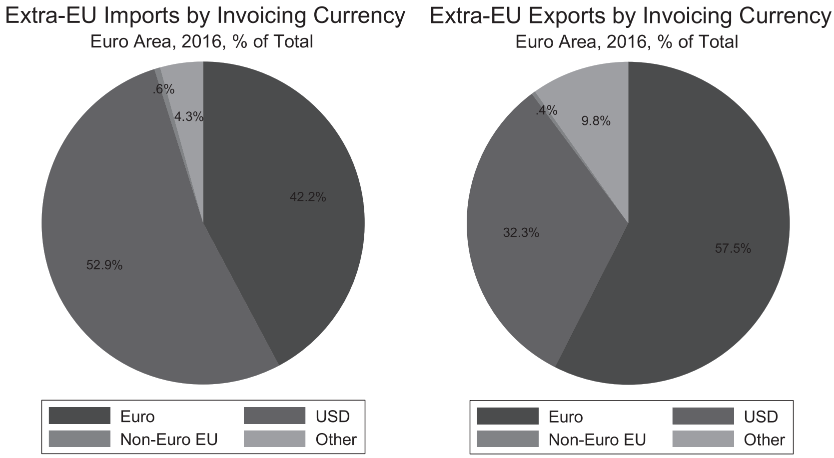
Much international trade is invoiced in U.S. dollars, even when the United States is not a party to the trade. Only the euro is at all a rival in this respect, but the share of world trade invoiced in euros is much lower. And for the United States, of course, the dollar dominates for both imports and exports, with 93 percent of imports and 97 percent of exports invoiced in dollars (Gopinath 2017).

A large literature has focused on how the choice of invoice currency affects the exchange rate adjustment mechanism, given that import and export prices tend to be set, and typically are at least somewhat sticky, in invoice currencies (see the survey by Corsetti, Dedola, and Leduc 2011). As pointed out by Goldberg and Tille (2006, 2008) and Gopinath (2016), invoicing in a dominant international currency will imply that exchange rate changes can have unexpected relative-price effects on trade flows. For example, if a country's imports and exports are both largely invoiced in dollars, a depreciation of its currency against the dollar will sharply raise the domestic price of imports but will not in itself make its exports cheaper for foreign buyers, who will face unchanged dollar prices for those goods. As a result, all near-term trade adjustment will take place on the import side. (Exporters' domestic-currency profits per unit sold will, however, rise, but while that might induce expansions of export supply and employment over time, the process is likely to be slower than an export expansion powered by external demand.) The United States' singular invoicing pattern implies, in contrast, that a dollar depreciation means lower prices worldwide for U.S. exports but little near-term increase in the import prices that U.S. buyers face. Gopinath (2016) documents the low pass-through of exchange rate change into U.S. import prices.

Invoicing patterns seem broadly not too different from 25 years ago, with the main structural change being the advent of euro use for intra-euro-area trade since 1999. But even a look at the euro area's 2016 trade with partners outside of the European Union (EU)

[27]Carney (2019) stresses the spillback channel of advanced-economy policies.

Figure 13. Invoicing Patterns for the Euro Area's Extra-EU Exports and Imports



Source: Eurostat.

gives a sense of the dollar's disproportionate importance, with 32.3 of extra-EU exports and 52.9 of extra-EU imports invoiced in dollars (figure 13).[28] These numbers compare with the euro area's trade shares in goods with the United States in 2018, which were 14 percent of exports and only 9 percent of imports, according to Eurostat.[29]

From the standpoint of U.S. monetary policy, a key need is to understand how fluctuations in the dollar's exchange rate may affect activity in countries, many of them emerging markets, that extensively use the dollar to invoice exports, or that face dollar-denominated import prices in their trade with non-U.S. partners.

[28]Energy imports, heavily invoiced in U.S. dollars, account for about 16 percent of total euro-area imports. Subtracting these from total extra-EU imports invoiced in dollars leaves a share roughly comparable to extra-EU exports invoiced in dollars, and still far above the euro-area import share originating in the United States.

[29]These aggregate numbers conceal considerable diversity across EU member countries. To understand the patterns, we need much more analysis of microlevel data, along the lines of Goldberg and Tille (2016), Amiti, Itskhoki, and Konings (2018), and Corsetti, Crowley, and Han (2018). For monetary policy analysis, a major question is to what degree invoice currencies are chosen to minimize ex post deviations from efficient pricing, given the distribution of possible shocks.

A U.S. monetary tightening that generally strengthens the dollar will raise domestic-currency import prices for countries with imports invoiced in dollars. But if its exports are invoiced in dollars as well, the prices of those exports will rise against goods priced in other currencies—for example, competing exports invoiced in euros, or other countries' domestic products in general.[30] For such countries, the net trade effects of a stronger dollar could therefore be contractionary—adding to the contractionary financial effects that I will discuss below.[31] Related to this possibility, dollar strengthening also can reduce the volume of world trade by switching demand toward domestic goods and away from dollar-priced imports, absent offsetting global export promotion for countries that invoice exports in nondollar currencies. Boz, Gopinath, and Plagborg-Møller (2017) show that, empirically, a U.S. dollar appreciation leads rapidly to a decline in the volume of global trade between other countries (conditioning on the world business cycle, in case safe-haven appreciations and declining trade are both driven by global output contraction). However, an alternative interpretation may be that dollar appreciation tightens global financial conditions, with a direct effect on trade. An emerging literature indeed suggests that dollar appreciation is associated with tighter global financial conditions.

5.2 Dollar Funding

The U.S. dollar's dominance as a funding currency (and a currency for corporate borrowing) is another key channel through which Federal Reserve monetary actions (and U.S. financial conditions more

[30]An open question is the extent to which invoicing choices reflect firms' desire that their pre-set prices approximate ex post optimal levels on average, so as to avoid the menu costs of frequent price change. Particular shocks, however, could leave planned prices far from the ex post optimum, leading firms to deviate from ex ante price intentions. In general, therefore, the response of nominal prices and markups to exchange rate changes could reflect the nature or size of the shocks that drive the exchange rate.

[31]In a two-country dynamic stochastic general equilibrium model, Canzoneri et al. (2013) find a magnified effect of a key currency's monetary policy abroad, due to multiple channels. Akinci and Queralto (2018) also model an especially strong foreign spillover from U.S. monetary policy due to dollar invoicing.

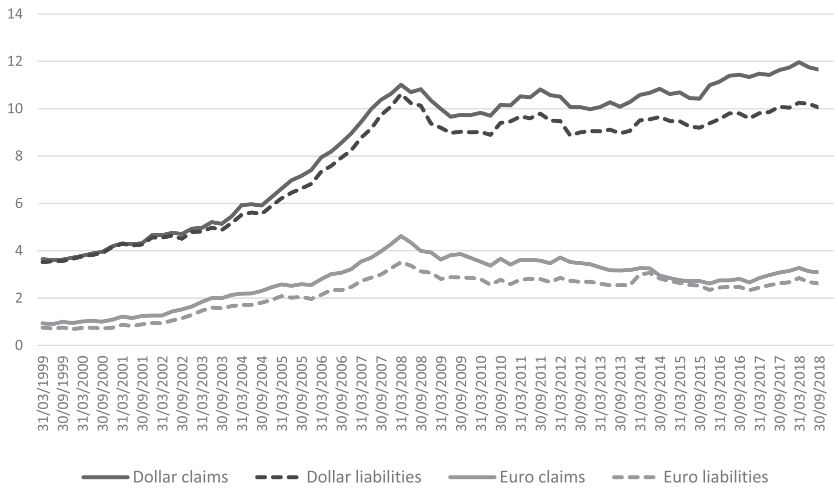
generally) are communicated disproportionately to the world outside U.S. borders. As discussed above, the U.S. economy is subject to financial forces from abroad, with significant implications for monetary policy. On the other hand, U.S. monetary policy has a distinctively powerful effect on financial conditions in the outside world—indeed, much of the co-movement in global financial indicators may be a reflection of U.S. policy's foreign influence. Recent research has documented the United States' driving role.

As Gopinath and Stein (2018) emphasize, the U.S. dollar's financial dominance, its vehicle currency role, and the safety and liquidity of dollar assets—far from being independent—are all interrelated and mutually reinforcing. For example, dollar invoicing makes dollar assets "safer" in real terms, lowering their yields and promoting dollar funding; at the same time, dollar-denominated export revenues are more easily collateralized to take advantage of lower dollar interest rates, leading to more dollar invoicing in equilibrium. Beyond their model, the unique depth and breadth of U.S. financial markets also play a role. All of these factors help explain the dollar's dominance as an anchor currency (while that role reinforces the tendency to invoice and fund in dollars, as well as to hold dollar reserves, in a positive feedback loop).[32]

Figure 14 gives some indication of the footprint of dollar-denominated financial transactions in global banking and in global credit markets. The figure shows BIS data on cross-border dollar and euro bank claims and liabilities. Dollar aggregates are much higher and are large even relative to the size of the U.S. economy. Cross-border dollar banking in both currencies grew very quickly in the financial cycle leading up to the global financial crisis, and while dollar assets have continued to grow in nominal terms since—albeit much more slowly—euro balance sheets have retracted.

[32]Theoretically speaking, a government need not trade dollar reserves to manage its currency's exchange rate against the dollar. For example, because the dollar/euro cross-rate is exogenous to a small country, arbitrage could in principle ensure that the authorities hit a desired dollar exchange rate target by intervening with euros to manage their currency's bilateral euro exchange rate. In view of exchange market frictions and the variability of the euro/dollar rate, however, it is more efficient for a country that wishes to manage flexibility against the dollar to hold dollar reserves and to intervene in dollars.

Figure 14. Cross-Border Dollar Bank Positions (USD trillions, all reporting banks)



Source: BIS Locational Banking Statistics.

Recent research papers (for example, Rey 2014; Bruno and Shin 2015; Avdjiev, Koch, and Shin 2017; IMF 2017a; Jordà et al. 2019; Miranda-Agrippino and Rey 2019) point to a global financial cycle in asset prices, bank leverage, and cross-border dollar lending related to the dollar's foreign exchange value and U.S. monetary policy shocks. U.S. monetary policy and dollar exchange rate changes can work through both the supply and the demand for offshore credit. For borrowers with dollar liabilities, a dollar depreciation can enhance net worth, easing informational frictions that impede the flow of credit. A cut in the U.S. policy interest rate (one possible cause of dollar depreciation) will directly encourage demand for dollar credit by making it cheaper to borrow and reducing inherited interest burdens. Changes in borrowers' financial strength also affects banks' willingness to lend through a risk-taking channel, for example, by reducing default risks perceived by banks that operate subject to a value-at-risk constraint (Adrian and Shin 2013).

The dollar's unique status makes U.S. monetary shifts uniquely powerful to affect global financial conditions. Avdjiev, Koch, and

Shin (2017) document the role of U.S. dollar strength (on both a bilateral and a nominal effective basis) in discouraging cross-border dollar lending. In other work, they suggest knock-on negative effects on investment. Empirical work claiming a causal role for the dollar's exchange rate faces the challenge that negative global shocks can drive the dollar higher through safe-haven effects. Miranda-Agrippino and Rey (2019) show that a high-frequency measure of U.S. monetary policy surprises has important effects globally, even for countries with floating exchange rates. They find that a contractionary U.S. shock reduces global asset prices, induces global financial intermediaries to delever, and reduces cross-border credit flows and domestic credit. This is a powerful multiplier amplifying U.S. monetary shock effects globally, and additionally to any effects related to dollar invoicing. Given the size and scope of international financial transactions, it is hard to believe that these effects do not swamp the more conventional net export effects of the associated dollar movements.[33]

The prevalence of cross-border dollar funding has an important implication for Federal Reserve balance sheet policy: the need possibly to act as a global lender of last resort in dollars (Obstfeld 2009; Farhi, Gourinchas, and Rey 2011). The Fed's swap lines played a key stabilizing role in the global financial crisis and could well need to be extended again should global financial tensions emerge anew. Unfortunately, the central bank's freedom of action looks likely to be more constrained in the future.

6. Concluding Remarks

This paper has explored key avenues through which the global economy impinges on the policy landscape facing the Federal Reserve, possibly altering the tradeoffs among different policy objectives its

[33]The financial spillovers can be especially destabilizing for emerging markets. There, higher global liquidity can lead to a buildup of financial fragilities that are revealed when capital inflows reverse. See, for example, Aoki, Benigno, and Kiyotaki (2009) and Diamond, Hu, and Rajan (2018). Durdu, Martin, and Zer (2018) find that for emerging market economies with substantial U.S. trade links or a large share of dollar-denominated liabilities, U.S. monetary tightening raises the likelihood of a banking crisis.

leaders face. These objectives include, of course, the "dual mandate" objectives of price stability and full employment, but also the more subjective goal of financial stability, which we know to have an immense influence on inflation and activity in the longer term. In a complex world made even more complex by global influences and linkages, there is unlikely to be a "divine coincidence" according to which monetary policy can attain all goals at once without tradeoffs, nor a "divine separability" such that monetary policy should be set with reference to a hypothetical natural real interest rate r^* independently of other considerations—even leaving aside ELB constraints.

More policy tools obviously can help, including effective macroprudential tools, and in some cases their effectiveness can be enhanced by multilateral international cooperation among central banks and other regulators. I have not explored that important dimension of policy here, except to mention (briefly) one aspect that explicitly deploys the Fed's balance sheet, the use of central bank currency swaps to enable lender-of-last resort operations abroad.

My three areas of focus were the role of global factors in the U.S. inflation process; the role of international financial integration on U.S. financial conditions; and the role of the dollar's pre-eminence as a global currency in amplifying the cross-border impact of Fed actions. The discussion has perhaps made most clear how much we still have to learn about all of these channels.

For example, there remains fundamental uncertainty as to the U.S. inflation process and possible longer-term structural drivers, such as labor's share in national income; about the global determinants of financial conditions and their implications for U.S. activity; and about the strength of the U.S. policy effect on the rest of the world. Regarding the last topic, how much of the documented common trends in global macroeconomic time series simply reflect U.S. policy dominance? And notwithstanding the key role of the U.S. dollar, and of short-run U.S. policy choices, the United States is only about a fourth of the world economy when outputs are measured at market exchange rates (and much less at PPP). This means that global saving and investment trends will be influential for the U.S. economy. There is considerable uncertainty around the estimation of r^*, however, particularly in a global context that takes into account the continuing relatively strong growth of emerging market economies.

That is not to deny substantial research progress in understanding key aspects of the global policy environment the United States faces. But advances often occur in distinct subliteratures that do not always communicate with each other. An integrated picture of this "elephant" remains elusive and so scholars rightly continue to toil in search of a synthesis.

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Monetary Policy Strategies for the Federal Reserve*

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The paper finds that the general monetary policy strategy of "forecast targeting" is more suitable for fulfilling the Federal Reserve's dual mandate of maximum employment and price stability than following a simple "instrument" rule such as a Taylor-type rule. Forecast targeting can be used for any of the more specific strategies of annual-inflation targeting, price-level targeting, temporary price-level targeting, average-inflation targeting, and nominal-GDP targeting. These specific strategies are examined and evaluated according to how well they may fulfill the dual mandate, considering the possibilities of a binding effective lower bound for the federal funds rate and a flatter Phillips curve. Nominal-GPD targeting has substantial principal and practical disadvantages and is found to be inferior to the other strategies. Average-inflation targeting is found to have some advantages over the other strategies.

JEL Codes: E52, E58.

1. Introduction

The Federal Reserve is undertaking a broad review of the Federal Reserve's monetary policy framework this year. As explained by Vice Chair Clarida (2019), the Federal Reserve will examine the policy strategy, tools, and communication practices that it uses

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to pursue its dual-mandate goals of maximum employment and price stability. The review is not provoked by any dissatisfaction with the existing policy framework, but given the unprecedented events of the past decade, the Federal Reserve believes it is a good time to step back and assess whether, and in what possible ways, it can refine its strategy, tools, and communication practices to achieve and maintain these goals as consistently and robustly as possible. By conducting the review, the Federal Reserve wants to ensure that it is well positioned to continue to meet its statutory goals in coming years. The review will also evaluate the new policy tools and communication practices that the Federal Reserve has used in response to the financial crisis of 2008–09 and the Great Recession.

A significant background for the review is that neutral interest rates appear to have fallen in both the United States and other advanced economies, and this global decline is widely expected to persist for years. All else being equal, a fall in neutral rates increases the likelihood that a central bank's policy rate will reach its effective lower bound (ELB) in future economic downturns (Kiley and Roberts 2017). That development, in turn, could make it more difficult during downturns for monetary policy to support spending and employment and keep inflation from falling below the inflation target.

Another key development in recent decades is that inflation appears less responsive to resource slack. The short-run Phillips curve appears to have flattened. A flatter Phillips curve reduces the role of aggregate demand and increases the role of inflation expectations in controlling inflation and keeping inflation close to its target.

The Federal Reserve has been charged by the U.S. Congress with a dual mandate to achieve maximum employment and price stability. Clarida (2019) notes that the review will take this mandate as given. It will also take as given that a 2 percent rate of inflation in the price index for personal consumption expenditures (PCE) is the operational goal most consistent with the Federal Reserve's price stability mandate. Furthermore, the review will focus on three broad questions, highlighted by events of the past decade.

The first question is, "Can the Federal Reserve best meet its statutory objectives with its existing monetary policy strategy, or should it consider strategies that aim to reverse past misses of the inflation objective?" The background for this is that the Federal Reserve's current approach, like that of other central banks conducting flexible inflation targeting, treats past deviations of inflation from the target—including the persistent shortfalls of inflation from the target that many advanced economies have experienced over most of the past decade—as "bygones." There is no attempt to offset past inflation undershoots of the inflation target with future overshoots, or vice versa. Given the fall in the natural interest rate and the resulting increase in the probability that the ELB will bind in the future, persistent undershoots may be more likely. This may move inflation expectations below the inflation target and make it more difficult to achieve the target.

Several academics and central bankers have suggested various "makeup" strategies for the Federal Reserve, such as price-level targeting, temporary price-level targeting, and average-inflation targeting. Under these, policymakers seek to undo, in part or in whole, past inflation deviations from target. To the extent such strategies become credible, a shortfall of inflation from the target will raise inflation expectations, lower the real interest rate also if the ELB is binding, and this way provide stimulus to the economy and help increasing inflation back toward the target. Furthermore, the direct effect of inflation expectations on inflation in the Phillips curve may raise inflation, in spite of the Phillips curve being flat.

This "automatic" stabilization property of makeup strategies makes them attractive as a remedy against a binding ELB. In models, it has also been shown that they can provide better general performance—improved stability of both inflation and employment—including in situations when the ELB does not bind. However, the automatic stabilization requires that the strategies have become credible and that the private sector believes that the central bank will deliver and make up according to the strategy. This probably requires that economic agents need to see the policy practiced and its principles obeyed for some time, in order to believe that it will be maintained and be successful in the future. This is similar to how the first inflation-targeting central banks had to earn the credibility of their inflation target.

The second question is, “Are the existing monetary policy tools adequate to achieve and maintain maximum employment and price stability, or should the toolkit be expanded?” The third question is, “How can the Federal Open Market Committee’s (FOMC’s) communication of its policy framework and implementation be improved?”

This paper will mainly deal with the first question, on makeup monetary policy strategies. It will also discuss the general strategy of “forecast targeting” and compare it to some extent to the alternative of following a simple “instrument rule” such as a Taylor-type rule. The discussion of the communications part of forecast targeting will touch on the third question. The second question will not be dealt with.

First, relying on a more extensive treatment in Svensson (2019), the paper briefly summarizes why forecast targeting is a better general strategy to achieve the Federal Reserve’s mandate—interpreted as flexible inflation targeting—than following a Taylor-type rule. Then, the paper considers the pros and cons relative to standard flexible inflation targeting of four specific “makeup” monetary policy strategies: flexible price-level targeting, a temporary price-level target when the ELB binds, flexible average-inflation targeting, and nominal-GDP targeting. The main conclusion is that, on balance, flexible average-inflation targeting has some advantages over the other strategies. Nominal-GPD targeting has substantial principal and practical disadvantages and is found to be inferior to the other strategies.

The paper is outlined as follows: Section 2 summarizes the Federal Reserve’s mandate—interpreted as flexible inflation targeting (Clarida 2019)—and a loss function consistent with the mandate. Section 3 summarizes why forecast targeting dominates Taylor-type rules as a general strategy to fulfill the mandate. Section 4 further contrasts forecast targeting with the common habit of representing alternative monetary policy strategies not with loss functions of target variables to be minimized but with simple instrument rules where the policy rate responds to the target variables. Section 5 examines price-level targeting, section 6 discusses temporary price-level targeting when the ELB binds, and section 7 considers average-inflation targeting. Section 8 examines nominal-GDP targeting, and section 9 presents some conclusions. An appendix contains some technical details.

2. The Federal Reserve's Mandate

The one-page well-written FOMC "Statement on Longer-Run Goals and Monetary Policy Strategy" (FOMC 2019) clarifies the Federal Reserve's monetary policy goals and strategy. The Federal Reserve's statutory mandate is to promote maximum employment and price stability.[1] The FOMC has decided that a "symmetric 2% inflation goal" is most consistent over the longer run with its statutory mandate.[2] Regarding maximum employment, the FOMC notes that the maximum level of employment, in contrast to the rate of inflation, is largely determined not by monetary policy but 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 maximum level of employment must be estimated from a range of indicators, and such estimates are uncertain and subject to revision. An important indicator is the FOMC's estimate of what it calls the longer-run normal rate of unemployment.

The FOMC provides further clarification on how it sets monetary policy:

> 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. (FOMC 2019)

As discussed in Svensson (2019), given this, the mandate can be well formalized by a standard quadratic loss function of inflation and

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[1] More precisely, Congress has given the Federal Reserve the statutory mandate "to promote effectively maximum employment, stable prices, and moderate long-term interest rates." Moderate long-term interest rates will normally follow from low and stable inflation.

[2] The word "symmetric" was added in January 2016.

employment representing flexible inflation targeting (where "flexible" means some weight on also stabilizing the real economy; "strict" would refer to stabilizing inflation only). If, for simplicity, the labor market participation rate is assumed to be independent of monetary policy, maximum employment can be replaced by the (minimum) longer-run normal unemployment rate (appendix A). The mandate can then be expressed in terms of a standard quadratic loss function of inflation and unemployment.

Furthermore, the "balanced approach" can be interpreted as an equal weight on stabilization of inflation and stabilization of unemployment—especially given several statements of "equal weight," "equal footing," and "neither one takes precedence over the other" by, respectively, Bernanke (2015b), Yellen (2012), and Clarida (2019).

Then the quarter-t loss, L_t, can be represented by the quadratic loss function,

$$L_t = (\pi_t - \pi^*)^2 + (u_t - u_t^*)^2. \tag{1}$$

Here π_t denotes the annual (four-quarter) inflation rate in quarter t,

$$\pi_t \equiv p_t - p_{t-4}, \tag{2}$$

where p_t denotes the natural logarithm of the price level. Furthermore, π^* denotes the 2 percent inflation target, u_t denotes the unemployment rate (measured so that, for example, 0.04 is 4 percent), and u_t^* denotes the FOMC's (latest) estimate of the longer-run normal unemployment rate, which I will call the (minimum) long-run sustainable unemployment rate. The inflation rate, π_t, and the unemployment rate, u_t, can be seen as the two target variables of monetary policy (target variables are the variables that enter the loss function).[3] In line with the "balanced approach," the loss function (1) has equal weights on stabilizing unemployment around the long-run sustainable unemployment rate and inflation around the inflation target.[4]

[3]Because the FOMC's estimate of the long-run sustainable rate may change over time, it could be indexed by the quarter of the latest estimate.

[4]It should be noted that if the Okun coefficient is assumed to be 2, such that the unemployment gap is related to the GDP gap by $u_t - u_t^* = -(1/2)(y_t - y_t^*)$

In a given quarter t, the mandate can then be formalized as setting monetary policy so as to minimize the intertemporal loss function

$$\mathrm{E}_t \sum_{\tau=0}^{T} \delta^{\tau} L_{t+\tau} = \mathrm{E}_t \sum_{\tau=0}^{T} \delta^{\tau} [(\pi_{t+\tau} - \pi^*)^2 + (u_{t+\tau} - u^*_{t+\tau})^2], \qquad (4)$$

where E_t denotes FOMC expectations conditional on its information in quarter t, T denotes a finite horizon (measured in quarters), and δ is a discount factor that satisfies $0 < \delta \leq 1$. In practice, it is close to or equal to one.[5]

3. Fulfilling the Mandate: Forecast Targeting

How should the Federal Reserve conduct monetary policy so as to best fulfill its mandate of price stability and maximum employment? What decisionmaking process should the Federal Reserve follow, what information should it rely on, and how should it set its policy instruments? What of its information, deliberations, and decision should the Federal Reserve publish? How can the Federal Reserve's policy conduct best be reviewed and how can the Federal Reserve most effectively be held accountable for fulfilling its mandate?

Svensson (2019) argues that the general policy rule—or general policy framework—of *forecast targeting* best achieves the Federal Reserve's mandate. In particular, it better fulfills the mandate than the common suggestion to follow a Taylor-type rule, where by a Taylor-type rule I mean variants of the original Taylor (1993) rule. Forecast targeting also provides answers to the other questions above.

(where y_t and y^*_t denote GDP and an estimate of potential GDP, respectively), the loss function in terms of the GDP gap will be

$$L_t = (\pi_t - \pi^*)^2 + (1/4)(y_t - y^*_t)^2, \qquad (3)$$

that is, with a relative weight on $^1\!/_4$ rather than unity on GDP-gap stabilization. Thus, it matters that the "balanced approach" refers to employment rather than GDP.

[5]The horizon, T, can in theory be infinite, but in practice it is finite—for example, 20 quarters. Central banks often publish forecasts for up to 12 quarters. A finite horizon also implies that the intertemporal loss function converges not only for $0 < \delta < 1$ but also for $\delta = 1$.

Forecast targeting means selecting a policy rate and policy rate path so that the forecasts of inflation and employment "look good." Here "looking good" means best fulfilling the dual mandate of price stability and maximum employment, that is, best stabilizing inflation around the inflation target and employment around its maximum level. Forecast targeting also means publishing the policy rate path and the forecasts of inflation and employment forecasts and, importantly, explaining and justifying them. This justification may involve demonstrations that other policy rate paths would lead to worse mandate fulfillment. Publication and justification will contribute to making the policy rate path and the forecasts credible with the financial market and other economic agents and thereby more effectively implement the Federal Reserve's policy. With such information made public, external observers can review Federal Reserve policy, both in real time and after the outcomes for inflation and employment have been observed, and the Federal Reserve can be held accountable for fulfilling its mandate. In contrast to simple policy rules that rely on very partial information in a rigid way, such as Taylor-type rules, forecast targeting allows all relevant information to be taken into account and has the flexibility and robustness to adapt to new circumstances. Forecast targeting can also handle issues of time consistency and determinacy.[6]

As argued in some detail in Bernanke (2015a) and Svensson (2019), the Federal Reserve is already to some extent practicing forecast targeting. In particular, Bernanke (2015a) states:

> The FOMC's policy framework corresponds to what Lars Svensson has called a targeting rule (see my 2004 speech, "The Logic of Monetary Policy" [Bernanke (2004)] for further discussion). In a targets-based framework, the central bank forecasts its goal variables—inflation and employment, in the case of the Fed—and describes its policy strategy for bringing the forecasts in line with its stated objectives. Although targeting rules are not mechanical, they do provide a transparent framework that, importantly, is robust to changes in the structure of the economy or the effectiveness of monetary policy, so long as those

[6]Forecast targeting rather than Taylor-type rules is discussed and promoted in, for example, Svensson (1997, 2003b, 2011), Bernanke (2004, 2015a), Woodford (2004, 2007, 2012), Qvigstad (2006), and Kohn (2007, 2012).

changes can be incorporated into forecasts. Targeting rules also conform to the basic economic dictum that principals (in this case, Congress and the public) are better off monitoring their agents' outputs (in the case of the FOMC, the outcomes of policy choices) rather than their inputs (the specific settings of policy instruments).

The terminology used may need some clarification. I believe "forecast targeting" is the most appropriate name for this general policy framework—or general policy rule. I have previously also used the term "targeting rule, forecast-targeting rule, or general forecast-targeting rule."[7] Bernanke (2004) and Erceg et al. (2012) use the term "forecast-based targeting." Some confusion is possibly caused by the practice in some of the literature of using the term "forecast-based policy rules" for simple instrument rules in which the policy rate responds to forecasts of the target variables, as in Levin, Wieland, and Williams (2003). Using such forecast-based *instrument* rules is different from forecast targeting.

3.1 Accountability and Commitment

The publication and justification of the FOMC's policy rate path and inflation and unemployment forecasts make it possible to hold the FOMC accountable for fulfilling the mandate. The policy rate path and forecasts of inflation and unemployment, the FOMC's justification of them, and its fulfillment of its mandate can be scrutinized and reviewed both in real time and after the fact—that is, after the outcome for inflation and unemployment have been observed—by external observers and experts and at the usual hearings in congressional committees (Svensson 2012). Altogether, forecast targeting can be seen as a case of "constrained discretion" (Bernanke and Mishkin 1997), where the constraint to fulfill the mandate is most explicit.

The transparency of forecast targeting—with the publication, explanation, and justification of policy rate paths and forecasts of inflation and unemployment—may allow the FOMC a substantial degree of commitment. This may be especially so if it becomes

[7] The term "inflation-forecast targeting" was introduced in Svensson (1997) and the term "forecast targeting" in Svensson (2003b).

established that deviations and shifts from previously published policy rate paths and forecasts come with good explanations. Forecast targeting may imply a policy that is approximately optimal under commitment.[8]

3.2 The Reaction Function

It is common to argue that central banks should convey their reaction function to the market participants and other economic agents. However, under forecast targeting, the reaction function—meaning how the policy rate *and* the policy rate path respond to information available to the central bank—is far too complex to write as a simple formula such as a Taylor-type rule. It is actually too complex to write down, period. The policy rate and policy rate path will normally respond to all relevant information, that is, all information that shifts the forecasts of inflation and unemployment. This is a long and changing list, with response coefficients that cannot be specified in advance.[9]

But the reaction function can be conveyed in more general but still both systematic and simple terms. If initially the forecasts look good, for any piece of information that shifts the inflation forecast up (down) and/or shifts the unemployment forecast down (up), policy will normally be tightened (eased), meaning that the policy rate path will shift up (down). If this response is understood by and credible with the market participants, any new information that is deemed to shift up (down) the inflation outlook or shift down (up) the unemployment outlook may result in a market response that shifts up (down) the yield curve. This way the financial conditions may shift in the appropriate direction—perhaps even of the

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[8]Issues of time consistency, discretion, and commitment with forecast targeting are discussed in some detail in Svensson and Woodford (2005) and Svensson (2011, 2019). Appendix B shows how the intertemporal loss function can be modified to be consistent with optimal policy under commitment.

[9]Svensson (2019, section 3.2) includes examples in two empirical models of the U.S. economy of how forecast targeting performs much better than a Taylor rule when there is information about future shocks to inflation and demand that forecast targeting but not a Taylor-type rule responds to.

appropriate amount—even before the central bank has responded with a new policy rate and policy rate paths at the next decision.[10]

3.3 Forecast Targeting Summarized

Forecast targeting can be summarized and simplified as these three steps:

(i) For a given policy rate path (for example, the policy rate path from the previous decision), construct new inflation and unemployment forecasts, taking into account new information received since the previous decision.[11]

(ii) If the new inflation and unemployment forecasts "look good" (meaning that they best fulfill the mandate), select the given

[10]To an outside observer, it would look like the FOMC would be mechanically following the market. But it would actually be the market anticipating FOMC policy decisions.

[11]Svensson (2011, 2019) discusses how some issues of determinacy with an exogenous policy rate path can be managed. Regarding determinacy, by the well-known result of Sargent and Wallace (1975), for an exogenous policy rate the (rational-expectations) equilibrium may be indeterminate. Uniqueness of policy simulations with exogenous policy rate paths in forward-looking models can be ensured by a terminal condition at a future quarter, $\bar{T}$, beyond the forecast horizon, T, where (i) either policy is assumed to switch to a reaction function for which the equilibrium is unique, or (ii) the forecasts of inflation and unemployment are restricted to reach a steady state in which they are equal to, respectively, the inflation target and the long-run sustainable unemployment rate, that is, $\pi_{t+\bar{T},t} = \pi^*$ and $u_{t+\bar{T},t} = u^*$ (Svensson 2005; Svensson and Tetlow 2005; Laséen and Svensson 2011).

Furthermore, as discussed in detail in Svensson and Woodford (2005), theoretically, the announcement of a policy rate and a policy rate path and forecasts of inflation and unemployment—even if these are credible with economic agents and their expectations are aligned with the announcement—may not be sufficient to ensure determinacy. Instead an explicit or implicit out-of-equilibrium commitment, understood by and credible with the economic agents, may be required. Such a commitment is typically quite intuitive, such that it is understood that the central bank will—all else being equal—raise (lower) the actual policy rate sufficiently above (below) the previously announced policy rate path, if realized inflation exceeds (falls short of) the forecast or realized unemployment falls short of (exceeds) the long-run sustainable unemployment rate. Such a commitment can thus be seen as a kind of Taylor principle applied to realized deviations of inflation and unemployment from the previous forecasts. Similar results to those in Svensson and Woodford (2005) have later appeared in Atkeson, Chari, and Kehoe (2010).

policy rate path as the decision; if the new inflation and unemployment forecasts do not look good, adjust the policy rate path so that they do look good.

(iii) Publish the policy rate path and inflation and unemployment forecasts and justify the decision in order to make the published path and forecasts credible, meaning making market participants' and other economic agents' expectations align with the published path and forecasts. The justification of the decision may include the publication of inflation and unemployment forecasts for alternative policy rate paths different from the selected one and the demonstration that these forecasts do not fulfill the mandate to the same degree.[12]

In support of the view that the Federal Reserve is already to some extent practicing forecast targeting, one can note that, regarding steps (i) and (ii) about the selection of an appropriate policy rate path, the tools and techniques needed are already on display in the many simulations presented in the Tealbook B document prepared by the Federal Reserve Board staff for FOMC meetings, especially the simulations of the so-called constrained and unconstrained optimal control policy shown in Federal Reserve Board (2013, p. 9) (reproduced as figure 1).[13]

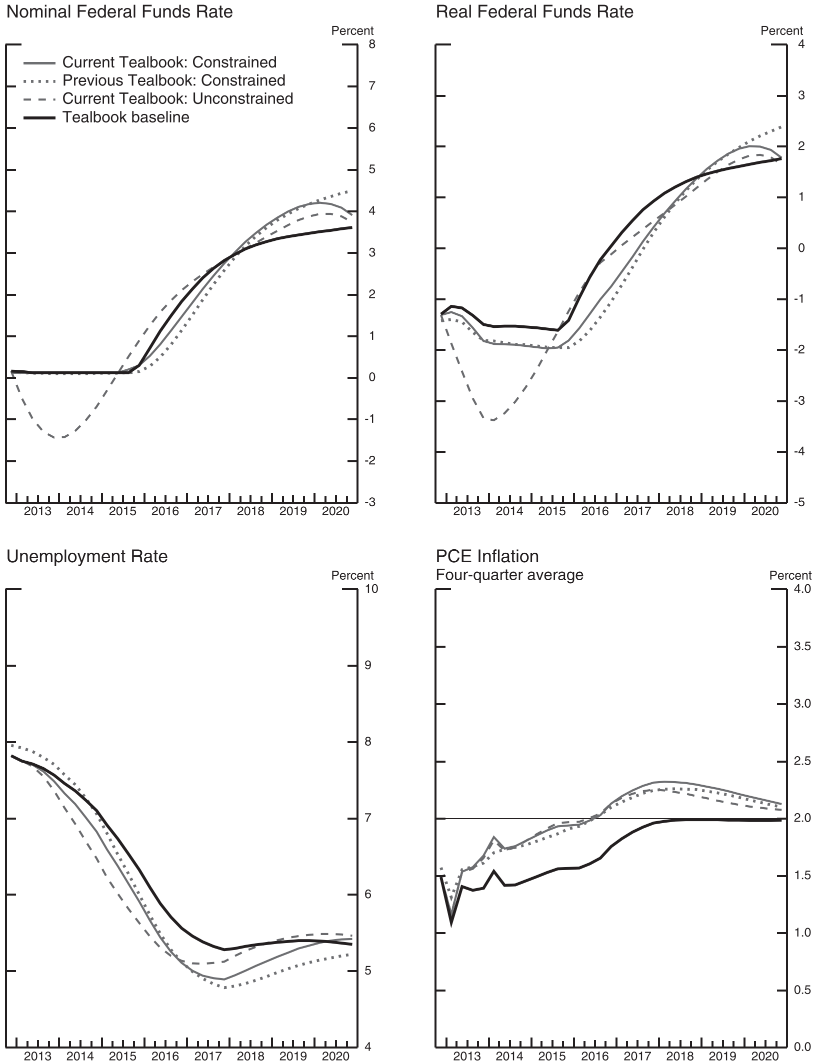
Regarding step (iii), the publication and justification of the decision, the FOMC is already publishing its Summary of Economic Projections (SEP), which includes economic projections of the FOMC participants under their individual assessments of projected appropriate monetary policy. These projections receive considerable emphasis in the Chair's press conference after policy meetings.[14]

[12] Mean squared gaps (MSGs) for inflation and unemployment as quantitative measures of the degree of mandate fulfillment may be used (appendix B). An example is given by a then-typical figure in the Riksbank minutes of the February 2013 policy meeting, discussed in Svensson (2019, section 4.1).

[13] The Federal Reserve staff's optimal-control simulations have been described and discussed in Brayton, Laubach, and Reifschneider (2014). See Svensson and Tetlow (2005) for the technique of incorporating various assumptions as judgment and "add factors" in optimal policy projections.

[14] See Svensson (2019) for examples.

Figure 1. Constrained versus Unconstrained Optimal Control Policy



Source: Federal Reserve Board (2013, p. 9).

Notes: The figure compares optimal control simulations derived for the January 2013 Tealbook with those for the December 2012 Tealbook. Assumptions about underlying economic conditions used in the staff's baseline forecast and about balance sheet policies are incorporated. Policymakers are assumed to place equal weights on keeping headline PCE inflation close to the Committee's 2 percent goal, on keeping the unemployment rate close to the staff's estimate of the effective natural rate of unemployment, and on minimizing changes in the federal funds rate.

Even if the SEP is conceptually different from the forecast-targeting policy rate path and forecasts of inflation and unemployment, it is not clear how quantitatively different it is from a joint FOMC decision. Majority voting about paths in a committee may result in medians consisting of sections from different committee members, but it is not clear whether this would be problem of quantitative importance.[15] But it is clear that the SEP is more of a snapshot of the different views of the FOMC participants and does not represent a joint decision by the FOMC members.[16]

Nevertheless, the FOMC can to some extent be held accountable in real time with the current SEP. With some reservations due to the problems mentioned, it is possible to compare the median projection of the federal funds rate with market expectations and the median projections of inflation and unemployment with, respectively, the 2 percent target and the FOMC's estimate of the long-run sustainable

[15]Svensson (2007) discusses majority voting on forecast paths and argues that they are completely feasible and already occurring in a few central banks. For example, the nine-member Monetary Policy Committee of the Bank of England makes decisions on the quarterly forecast paths of inflation, unemployment, and GDP growth three years out. It is not obvious that a 12-member FOMC could not do the same and include a policy rate path as well.

[16]The FOMC has undertaken some experiments in constructing a consensus policy rate path and forecasts of inflation and unemployment. They are discussed in some detail under the heading "Experimental Consensus Forecast" in the October 2012 transcripts (FOMC 2012, pp. 201–79). There were several difficulties noted about constructing consensus forecasts, including that that the policymaking environment was unusually complex, with both unconventional portfolio actions and forward guidance being important policy tools. Some, but not all, disagreements among participants might be because they would disagree about the likely future evolution of asset purchases. There were also some production-related challenges. Because the Committee's policy decisions are not known in advance of the meeting, it would not be possible to guarantee the production of a forecast that incorporates the Committee's policy decision in time for the Chair's press conference. In view of these difficulties, the FOMC abandoned the consensus forecast exercise at the time—perhaps not permanently—and instead focused on improvements on the SEP.

It is obvious that such a decision process that includes reaching a decision on the policy rate path faces difficulties when the FOMC also decides on balance sheet policies and thus has several policy instruments. However, when the balance sheet reduction is set on autopilot and the FOMC has the federal funds rate as its one policy instrument, perhaps such a decisionmaking process is possible and can be followed. From a production point of view, having the press conference the next day—as is done at the Riksbank—may help with the production problems.

unemployment rate and assess whether the FOMC is best fulfilling its mandate.

4. Alternative Monetary Policy Strategies, Forecast Targeting, and Simple Instrument Rules

Forecast targeting has been discussed above as a general monetary policy strategy to fulfill the Federal Reserve's mandate. The mandate has been interpreted as the specific strategy of flexible inflation targeting, corresponding to a loss function such as (1), with annual inflation and the unemployment rate (or the employment rate) as the two target variables. But forecast targeting can obviously be applied to alternative interpretations of the mandate, such as the specific strategies of flexible price-level targeting, flexible temporary price-level targeting, flexible average-inflation targeting, and nominal-GDP targeting, when these alternative strategies are associated with corresponding alternative loss functions. For the first three alternative strategies, annual inflation is replaced as a target variable by the price level or average inflation; for nominal-GDP targeting, the two target variables of inflation and unemployment are replaced by the single target variable of nominal GDP.

However, it is important to note that using forecast targeting and a loss function to implement these alternative strategies is very different from the common practice of using a specific simple "instrument" rule to represent and implement the alternative strategies. As discussed in detail in Svensson (2003b, 2011), a problem and source of confusion in the literature on monetary policy is that it remains quite common to specify monetary policy strategies *not* primarily in terms of a loss function that is increasing the deviations of the target variables from their target levels. Instead the strategies are specified in terms of a simple instrument rule where the policy instrument—the policy rate—*responds* to the target-variable gaps, that is, the gaps between the target variables and their target levels. Then, by "targeting" a variable is not meant *minimizing* the deviation from its target level but *responding* to the deviation. There are actually several examples of this in the staff memos presented to the FOMC when alternative policy strategies have been discussed in 2011 and 2012 (Erceg, Kiley, and López-Salido 2011, 2012; Erceg et al. 2012).

Indeed, many simple instrument rules that have been used in the literature can be written on the form

$$i_t = \rho i_{t-1} + (1-\rho)[r^* + \pi_t + R_t], \tag{5}$$

where the coefficient ρ satisfies $0 \leq \rho < 1$ and denotes the degree of inertia (the degree of policy rate smoothing). Such inertia serves to introduce some history dependence in the policy (Woodford 2003b). Furthermore, r^* denotes an estimate of the neutral real interest rate, and the term R_t includes the response to the target-variable gaps.

In this approach, flexible *inflation* targeting, aiming to stabilize the inflation and GDP gaps, is then represented by a Taylor-type rule, for which

$$R_t = a(\pi_t - \pi^*) + b(y_t - y_t^*), \tag{6}$$

and $a, b > 0$ denote the response coefficients of the inflation and GDP gaps, respectively. In particular, for the Taylor (1993) rule, $\rho = 0$ and $a = b = 0.5$. For an inertial Taylor (1999) rule, instead $\rho > 0$, $a = 0.5$, and $b = 1$. *Strict* inflation targeting would then be characterized by a response to the inflation gap only, that is, $a > 0$ and $b = 0$.[17]

Along this approach, flexible *price-level* targeting would be characterized by a response to both the price-level gap and the GDP gap,

$$R_t = a(p_t - p_t^*) + b(y_t - y_t^*), \tag{7}$$

where $p_t - p_t^*$ denotes the price-level gap, that is, the gap between (the log of) the price level, p_t, and (the log of) the price-level target, p_t^*. Then *strict* price-level targeting might be represented by responding to the price-level gap only, that is, $b = 0$.

[17] In contrast, Svensson (1997) includes an example of a simple model in which the optimal reaction function that minimizes the loss function corresponding to strict inflation targeting, $L_t = (\pi_t - \pi^*)^2$, is of the form $i_t = r^* + \pi_t + a(\pi_t - \pi^*) + b(y_t - y_t^*) + cx_t$. Here, x_t is an exogenous variable that affects inflation and aggregate demand, and the nonzero coefficients a, b, and c depend on the parameters of the Phillips curve, the aggregate-demand function, and the dynamics of the exogenous variable. Optimal policy requires a response to all relevant state variables—the state variables that affect the forecasts of the target variable(s)—not just the target variable(s).

Flexible *average-inflation* targeting could be represented by responding to the average-inflation and GDP gaps,

$$R_t = a(\bar{\pi}_t - \pi^*) + b(y_t - y_t^*), \tag{8}$$

where, for example, $\bar{\pi}_t = (p_t - p_{t-20})/5$ denotes average inflation over the last five years (20 quarters) at an annual rate.

In particular, *nominal-GDP* (level) targeting would be represented by responding to the nominal-GDP gap,

$$R_t = a(Y_t - Y_t^*), \tag{9}$$

where $Y_t - Y_t^*$ denotes the nominal-GDP gap, that is, the gap between (the log of) nominal GPD, $Y_t \equiv p_t + y_t$, and (the log of) the nominal-GDP target, $Y_t^* \equiv p_t^* + y_t^*$.[18]

However, because

$$a(Y_t - Y_t^*) = a[(p_t + y_t) - (p_t^* + y_t^*)] = a(p_t - p_t^*) + a(y_t - y_t^*), \tag{10}$$

it follows that, for the special case when the response coefficients are equal, $b = a$, the instrument rule corresponding to flexible price-level targeting, (7), would be identical to the rule corresponding to nominal-GDP targeting, (9).

For a concrete example, consider the memo on alternative monetary policy frameworks for the November 2011 FOMC meeting (Erceg, Kiley, and López-Salido 2011). There, an analysis of flexible inflation targeting, price-level targeting, and nominal-GDP targeting is not done in terms of forecast targeting and the minimization of the corresponding loss functions. Instead, it is done in terms of alternative simple policy rules, more precisely (Erceg, Kiley, and López-Salido 2011, footnote 10) using (5) with $\rho = 0.9$ and

$$R_t = 0.5(\pi_t - \pi^*) + (y_t - y^*), \quad \text{flexible inflation targeting,} \tag{11}$$

$$R_t = p_t - p_t^*, \quad \text{strict price-level targeting,} \tag{12}$$

$$R_t = (p_t + y_t) - (p_t^* + y^*). \quad \text{nominal-GDP targeting.} \tag{13}$$

[18]Here p_t refers to (the log of) the GDP deflator.

As we observed above, if *flexible* price-level targeting had been represented with an additional unitary response to the GDP gap in (12), the simple instrument rule would have been identical to that for nominal-GDP targeting, (13). This is in spite of the very different loss function (20) for flexible price-level targeting and (21) for nominal-GDP targeting—illustrated in the corresponding figures 9 and 10—to be examined in section 8. Clearly, two very different loss functions can hardly be minimized with the same reaction function.

Above in section 3, several reasons have been given why forecast targeting is a better way to achieve the mandate interpreted as flexible inflation targeting—with the period loss function (1) and the intertemporal loss function (4)—than following a simple instrument rule such as a Taylor-type rule. For the same reasons, forecast targeting is a better way also to achieve the mandate when interpreted as the alternative strategies to be examined. Good monetary policy implies responding to all relevant state variables, that is, responding to all information that affects the forecasts of the target variables, which includes much more information than the current values of the target variables.

5. Price-Level Targeting

Flexible inflation targeting—with a loss function such as (1)—implies that past inflation deviations are disregarded, "bygones are bygones." Even if there has been a long period of inflation undershooting the target—because policy has not been sufficiently expansionary, for example, because of a binding ELB—there is no attempt to later undo the undershooting by overshooting the target for some time. If average inflation falls below the target for long periods, inflation expectations may fall below the target and make achieving the target more difficult in the future.

To avoid such outcomes, some economists and policymakers have advocated various "makeup" strategies, where the policy involves undoing, partly or completely, past inflation deviations from the target. These strategies are also referred to as "history dependent" (Woodford 2003a). Flexible price-level targeting, in which past inflation deviations eventually are completely undone, is prominent among these strategies and has been much discussed recently (for example, Bernanke 2017; Williams 2017; Bullard 2018; Evans 2019).

Instead of stabilizing inflation around an inflation target, it involves stabilizing the price level around a price-level target. The price-level target is not constant but follows a deterministic increasing path corresponding to a steady positive inflation rate.[19]

Flexible price-level targeting can be represented by the loss function

$$L_t = (p_t - p_t^*)^2 + (u_t - u_t^*)^2, \tag{14}$$

where p_t^* denotes the (log) price-level target and is given by

$$p_t^* = p_{t-1}^* + \pi^*. \tag{15}$$

Thus, the price-level target corresponds to a price-level target path that increases by the constant rate π^*, for example, 2 percent. Importantly, using forecast targeting to minimize the period loss (14) and intertemporal loss (4) is different from applying the simple instrument rule (7).

In (14), it is assumed that the FOMC reinterprets the "balanced" approach to refer to unemployment relative to the price-level gap rather than to the inflation gap. An alternative is that the FOMC retains the balanced approach to refer to the inflation gap, in which case a non-unity weight on unemployment-gap stabilization relative to price-level stabilization may be appropriate.[20]

If inflation targeting means that past inflation deviations from the target are disregarded and not undone by policymakers, this should in principle introduce a unit root in the price level. This means that price level would not be trend stationary. That is, it would be nonstationary also after the removal of a deterministic trend. This in turn implies that the conditional variance of the future

[19] There is a considerable amount of past research on price-level targeting and the relative performance of inflation targeting and performance, discussed, for instance, in the surveys by Ambler (2009) and Hatcher and Minford (2014).

[20] The determination of such a relative weight is complicated (Vestin 2006). Depending on the dynamics of the economy and expectations formation, price-level targeting may decrease inflation variability and reduce any negative inflation-gap bias because of the ELB. Simulations with realistic models and assumptions about expectations formation are required to settle the issue of whether a non-unity relative weight is warranted. It is also possible to consider variants of flexible price-level targeting with some remaining weight on inflation stabilization.

price level would increase without bound with the horizon. The price level would in principle behave like a random walk with drift. Given this, it is a bit ironic that inflation targeting with a low inflation target is widely referred to as "price stability." "Low inflation" might be a more appropriate name.

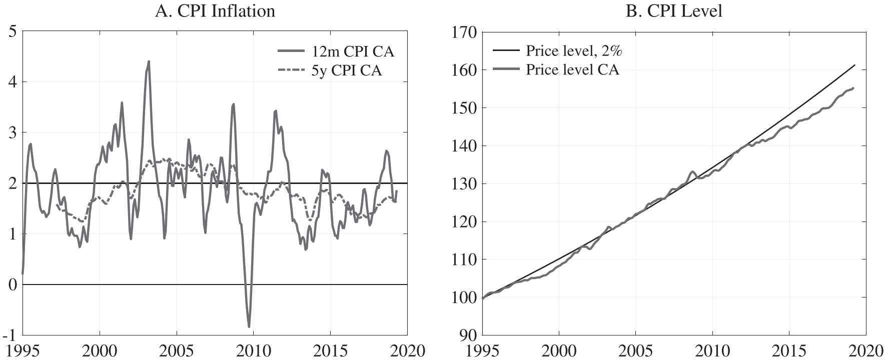
In contrast, price-level targeting would make the price level trend stationary, and the price level would display mean reversion toward the price-level target path. The conditional variance of the future price level would be bounded and long-run price-level uncertainty would be much less than under inflation targeting. Price-level targeting would make long-run inflation stable and close to the implicit inflation target.

The second paragraph above—starting with "If inflation targeting. . . "—uses the expression "in principle" twice. This is because the *practice* looks quite different for several advanced economies. Figures 2B–6B of the price levels of Canada, Australia, the euro area, the United Kingdom, and the United States show that the price-level outcomes for these economies, up to around the financial crisis of 2008–09, do not look like that of a random walk but look surprisingly similar to that of price-level targeting (Rosengren 2013; Ruge-Murcia 2014). In fact, Canada looks like price-level targeting further, into 2014, and the euro area also looks much like this into 2014. (Figures 2A–6A show the corresponding annual and five-year inflation rates. Figure 7 allows a comparison between the PCE core and PCE deflator outcomes of inflation and the price level for the United States.)

Canada stands out among these economies. Using data from 1993:M1 to 2013:M3, Ruge-Murcia (2014) can indeed *reject* the hypothesis that the Canadian consumer price index (CPI) has a unit root, and he *cannot reject* that the CPI is trend stationary.[21] The reasons why the Canadian price level has so closely followed a price-level target path have been discussed in several papers,

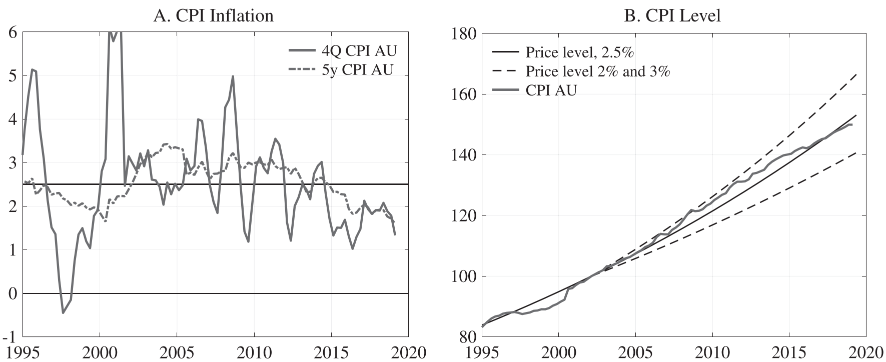
[21]In contrast, Ruge-Murcia (2014) cannot reject a unit root for the price levels of Australia, New Zealand, Sweden, and the United Kingdom, and he rejects the hypothesis of trend stationarity. In a previous working paper with a shorter sample of 1992:M10–2009:M12, he could reject a unit root for the United Kingdom. This is consistent with the U.K. price level overshooting the implicit price-level target from 2009 onward (figure 5B).

Figure 2. Canada: Inflation and Price Level



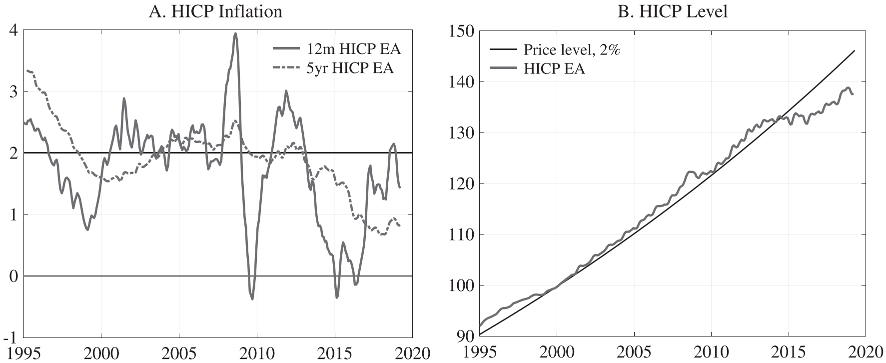
Source: Thomson Reuters Datastream.
Notes: Three-month trailing moving average. The Bank of Canada has an "inflation-control" target of 2 percent for the CPI.

Figure 3. Australia: Inflation and Price Level



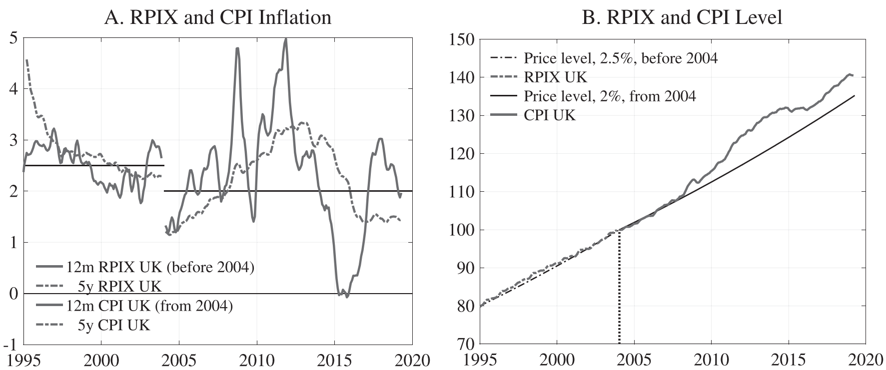
Source: Thomson Reuters Datastream.
Notes: Three-month trailing moving average. The Reserve Bank of Australia has an inflation target of 2–3 percent over the "medium term" (previously over the "[business] cycle"). On July 1, 2000, a 10 percent goods-and-services tax was introduced in Australia. As a result, the CPI price level increased by 3 percent. Hence the annual inflation rate was increased by 3 percentage points for the next four quarters, and the five-year inflation rate was increased by 0.6 percentage point for the next five years. The increase in the price level was fully anticipated by the public and financial markets, and the Reserve Bank of Australia did not seek to offset the effect on the price level (Debelle 2018).

Figure 4. Euro Area: Inflation and Price Level



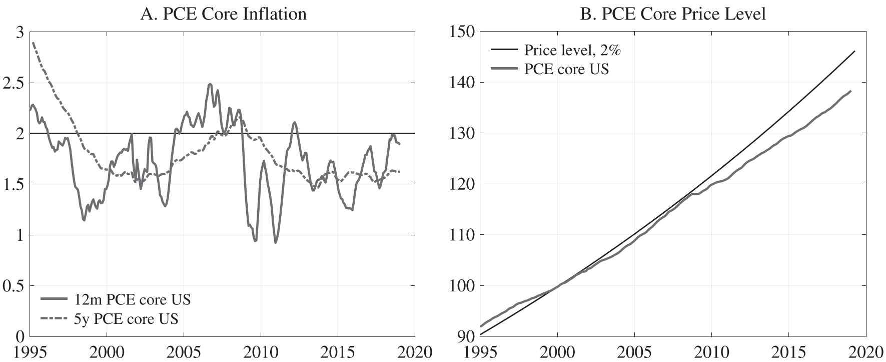
Source: Thomson Reuters Datastream.
Notes: Three-month trailing moving average. The European Central Bank (ECB) aims to maintain HICP (Harmonised Index of Consumer Prices) inflation "below, but close to, 2 percent over the medium term."

Figure 5. United Kingdom: Inflation and Price Level



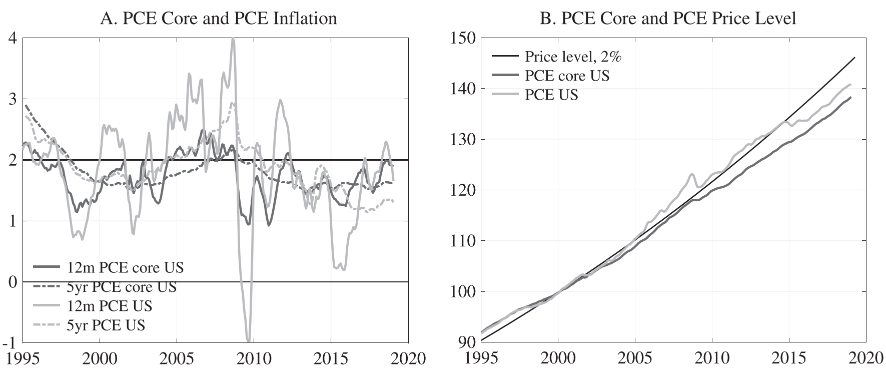
Source: Thomson Reuters Datastream.
Notes: Three-month trailing moving average. From 2004, the Bank of England has had an inflation target of 2 percent for the CPI, which is the name used for the HICP in the United Kingdom. Before 2004, it had a target of 2.5 percent for the RPIX.

Figure 6. United States: Inflation and Price Level



Source: Thomson Reuters Datastream.
Notes: Three-month trailing moving average. The Federal Reserve was considered by many to have an unofficial inflation target of 2 percent from around 2000. From 2012 it has an official inflation goal of 2 percent for the PCE deflator.

Figure 7. United States: PCE Core and PCE Inflation and Price Level



Source: Thomson Reuters Datastream
Note: Three-month trailing moving average.

including Kamenik et al. (2013) and Ruge-Murcia (2014).[22] The reasons mentioned include small symmetric shocks or some inherent error-correcting behavior in the policy setting—for example, a high

[22]See Ruge-Murcia (2014) for a summary of the discussion.

degree of interest rate smoothing—but not that the Bank of Canada has covertly and consciously pursued price-level targeting.

One benefit of price-level targeting compared with inflation targeting is that long-run uncertainty about the price level is smaller. Another much-discussed benefit is that, if the price level falls below a *credible* price-level target, inflation expectations would rise and reduce the real interest rate even if the nominal interest rate is unchanged. The reduced real interest rate would stimulate the economy and bring the price level back to the target. Furthermore, to the extent that the Phillips curve is similar to an expectations-augmented Phillips curve, the increase in inflation expectations would have a separate direct effect on inflation, parallel to the interest rate effect. Thus, credible price-level targeting may imply some—or even substantial—"automatic" stabilization. Theoretical research (summarized in Ambler 2009, Bank of Canada 2011, and Hatcher and Minford 2014) has shown that this automatic stabilization may result in less variability of both inflation and output.

The automatic stabilization would be highly desirable, especially in situations when the ELB is binding and the nominal interest rate cannot be further reduced. This attractive property of price-level targeting has increased the interest in price-level targeting in recent years.

However, the automatic stabilization would work to the extent that the price-level target is *credible*, in the sense of the private sector believing that the central bank will take action to limit deviations of the price level from the target and successfully bring the price level back to the target. For such credibility to develop, economic agents probably need to see price-level targeting being operated and consistently applied over time by the central bank, in the same way as inflation-targeting central banks have had to achieve credibility of their inflation target by consistently operating inflation targeting over some time.

As Bernanke (2017) notes, the "bygones are not bygones" aspect of price-level targeting is a double-edged sword. Under symmetric price-level targeting, the central bank cannot "look through" shocks to the Phillips curve—"cost-push" shocks—that temporarily drive up inflation, but must commit to tightening policy in order to reverse the effects of the shock on the price level. This reversal could be gradual and responsive to real-side conditions, as indeed flexible price-level targeting implies. Nevertheless, it implies a possibly painful tightening even as the negative supply shock depresses employment and output. The real cost is reduced if the price-level target is credible and inflation expectations shift down, but if not, offsetting possible supply shocks and positive inflation shocks would be more costly.

The Bank of Canada has done considerable research on price-level targeting and seriously considered it in its 2011 five-yearly review of the "inflation-control" target (Bank of Canada 2011). It concluded (p. 14):

> Recent research has shown that modest, but economically significant, potential gains from price-level targeting can be found in the most favourable model simulations, with these gains prospectively enhanced once the costs and risks of the ZLB are incorporated. However, these models assume that agents are forward-looking, fully conversant with the implications of price-level targeting and trust policy-makers to live up to their commitments. While positive, albeit smaller, net gains from price-level targeting may still be available if these conditions are not fully satisfied, it is not presently clear that they would be sufficiently satisfied in the real world for the Bank to have confidence that price-level targeting could improve on the current inflation-targeting framework.

Thus, the bank did not take the leap. Explicit price-level targeting may only have occurred in real life in Sweden during the 1930s, but the period of explicit price-level targeting is too short and too special for any general conclusions to be drawn.[23]

However, the evaluation of price-level targeting in Canada was done up to 2011, when the actual outcome was more or less indistinguishable from that of price-level targeting (figure 2B). Furthermore, when the Bank was doing theoretical model simulations to compare the performance of inflation targeting and price-level targeting, it apparently used a policy reaction function with a large coefficient on the lagged interest rate (close to a "difference rule") in the simulations, which generated results that were very close to

[23] See Berg and Jonung (1999) for a discussion of the good Swedish experience of price-level targeting during the Great Depression.

those of price-level targeting. As a result, the net benefits of moving to inflation targeting may have seemed smaller for Canada than they would for other economies. In particular, an increased probability of being constrained by the ELB would increase the net benefit of moving.[24]

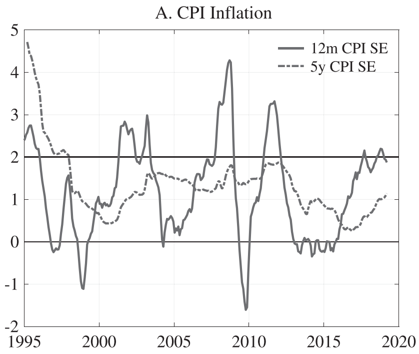
In any case, the Federal Reserve needs to do its own cost-benefit analysis to assess the pros and cons of a move to flexible price-level targeting, regardless of the Canadian one, while taking into account the relevant parameters, including the probability of being constrained by the ELB.

As seen in figure 8, Sweden and the Riksbank represent a clear outlier among inflation targeters in terms of price-level and inflation performance, with a persistent downward inflation bias. Because inflation expectations have nevertheless been well anchored at the target until around 2011, inflation persistently undershooting the target has likely had costs in the form of persistently higher unemployment (Svensson 2015). Already in an evaluation of Swedish monetary policy 1995–2005, commissioned by the Swedish Parliament, Giavazzi and Mishkin (2006, pp. 77–78) warned about this downward bias and its associated loss in output and employment. Some reasons for the undershoot and possible remedies—including a five-year average-inflation target to avoid the persistent downward bias—are discussed in Svensson (2013, 2018).

To paraphrase FOMC (2019), in setting monetary policy under flexible price-level targeting, the FOMC would seek to mitigate deviations of the price level from its longer-run goal and deviations of

[24] According to John Murray—previously Deputy Governor of Bank of Canada—Douglas Laxton, at the International Monetary Fund (IMF), was the first to uncover this result and the first to imply that the Bank of Canada was doing price-level targeting. Murray (2019) further says: “We were surprised and noted that if we had been price-level targeting, we were completely unaware of it. At first, we credited it to the symmetric nature of the shocks that must have been hitting the economy. It was only later, when we were doing some simulations to compare the performance of inflation targeting and price-level targeting, that we realized that our existing policy reaction function generated results that were very close to those of price-level targeting. Adding a lagged interest rate term to the reaction function with a large coefficient on it was the reason. The downside of this result was that it made selling a move to price-level targeting more difficult—though, clearly, if you’re not doing it intentionally and it’s not well advertised, you never get the full benefit.”

Figure 8. Sweden: Inflation and Price Level



Source: Thomson Reuters Datastream
Notes: Three-month trailing moving average. The Riksbank had a target of 2 percent for CPI inflation since 1995. In September 2017 it switched to a 2 percent target for the CPIF (which excludes effects of changes in mortgage rates on the housing-cost component in the CPI).

employment from the FOMC's assessments of its maximum sustainable level. These objectives would generally be complementary. However, under circumstances in which the FOMC would judge that the objectives are not complementary, it would follow a balanced approach in promoting them, taking into account the magnitude of the deviations and the potentially different time horizons over which employment and the price level are projected to return to levels judged consistent with its mandate.[25]

It is often said that price-level targeting would be more difficult to communicate than inflation targeting. I am not convinced that this need be so. First, financial markets should not have any difficulties in understanding price-level targeting. Second, I don't see why it necessarily would be more natural for the general public to think in terms of the rate of change of the price level than in terms of price level itself. Already now, much discussion about prices of goods, services, and assets—in particular, exchange rates—and of wages is as much in terms of levels as in rates of change. Much discussion of macroeconomic aggregates—such as employment, unemployment, and GDP—is in terms levels and not only in terms of changes. With

[25]However, as noted above in the text and in footnote 20, the appropriate degree of "balance" needs to be carefully considered.

a price-level target, much discussion would focus on the current and future price level and its relation to the price-level target path rather than the rate of inflation. Graphs of price-level paths will likely be more common in the media than graphs of inflation rates. In any case, if the price level has fallen below the path, it can be said both that the price level needs to go back up toward the path and that inflation will have to be above the long-run average for a while.

The move from inflation targeting to full-fledged price-level targeting may nevertheless seem too risky to many central bankers. An intermediate alternative and a smaller move is to temporary price-level targeting when the ELB is binding.

6. Temporary Price-Level Targeting When the ELB Binds

At the September 2010 meeting of the FOMC, Federal Reserve Bank of Chicago President Evans proposed a temporary price-level target for the Federal Reserve (Evans 2010a).[26] The proposal included a mockup of a potential FOMC announcement from the upcoming November 2010 meeting, which described the economic situation, the rationale, the specific policy actions, additional commentary, and some frequently asked questions posed in discussions with his staff. The background for the proposal was that, in Evans's opinion, much more policy accommodation was appropriate at the time. He believed that the U.S. economy was best described as being in a bona fide liquidity trap. Evans (2010b) also presented the temporary price-level target at a conference at the Federal Reserve Bank of Boston.

Evans proposed a state-contingent price-level target consistent with an average annual increase of 3 percent from the core PCE index value in December 2007, when the recession began. Monetary policy actions were to be taken to achieve this target path. Specifically, this state-contingent policy objective was to be pursued until actual core PCE prices had attained the target-level path. Once this condition had been achieved with sufficient

[26]The original 2010 proposal was authorized for public release by the FOMC Secretariat on November 20, 2017, after the publication of Bernanke (2017) in October.

confidence, policy would return to an affirmed normal response patterns to achieve 2 percent PCE inflation over the medium term. The policy would be supported by large-scale asset purchases. The mockup FOMC announcement also stated that "in the event other supporting actions are deemed helpful or necessary to meet the target-price-level path within a reasonable time frame, the Committee will take all necessary actions"—a "do whatever it takes" statement close to two years before that of ECB President Draghi.

Thus, this was a temporary price-level target with an exit—once the target had been achieved with sufficient confidence—to a 2 percent inflation target over the medium term. Had the FOMC taken the leap and the proposal been adopted in the fall of 2010, we would no doubt have been a bit wiser today. Its outcome would have been an obvious major discussion point at this conference, if today's conference had indeed still taken place—and had not been considered redundant.[27]

More recently, Bernanke (2017) has proposed that, in a situation away from the ELB, the FOMC should announce that it will apply a temporary price-level target when the ELB is binding in the future. In future situations in which the policy rate is at or near the ELB, a necessary condition for raising the policy rate would be that average inflation since the date at which the policy rate first hit the ELB be at least 2 percent. Beyond this necessary condition, in deciding whether to raise the policy rate from zero, the FOMC would consider the outlook for the labor market and whether the return of inflation to target appears sustainable.

The average-inflation criterion is equivalent to a temporary price-level target, which applies only during the ELB episode. The criterion is couched in the language of inflation targeting, which

[27]I am naturally very favorably inclined to Evans's proposal. My own 2000 proposal for Japan, the Foolproof Way of Escaping from a Liquidity Trap (further discussed in Svensson 2003a), has two similarities and one major difference. It involved an upward-sloping price-level target path to undo the undesired deflation; a currency depreciation and a temporary crawling peg (the major difference) in order to achieve the price-level target; and, once the price-level target had been achieved, an exit to a floating exchange rate and normal inflation or price-level targeting. The Czech National Bank has successfully used a variant of the Foolproof Way—with a currency depreciation and temporary peg, but without a price-level target—to achieve its inflation target (Al-Mashat et al. 2018).

Bernanke considered to be an advantage from a communications perspective.

Hebden and López-Salido (2018) (HLS) and Bernanke, Kiley, and Roberts (2019) (BKR) provide evaluations of variants of Bernanke's proposal in the form of simulations of Federal Reserve models. Unfortunately, from my point of view—and typically, given the discussion in section 4—they interpret Bernanke's proposal not in terms of forecast targeting and approximately optimal policy but in terms of alternative simple instrument rules, more precisely as a temporary deviation from Taylor-type rules (see appendix C for details).

HLS interpret Bernanke's proposal as a Taylor-type policy rule where the response to an average-inflation gap since the start of the ELB episode is added. Under the assumption of model-consistent expectations and thus that the policy is credible, HLS show that, when the responses coefficient of the average-inflation gap is chosen optimally, the temporary price-level/average-inflation targeting rule gives better macroeconomic outcomes than most other instrument rules considered in the literature, including the Taylor (1993) and Taylor (1999) instrument rules.

BKR also discuss variants of Bernanke's proposal in terms of a simple instrument rule. Here, an inertial Taylor (1999) rule is augmented by the price-level gap, which is given by the accumulated (not average) inflation shortfall since the quarter when the ELB started to bind. The price-level gap is included as long as it is negative.

For these policies with a negative average-inflation or price-level gap added to Taylor-type rules, liftoff may occur while these gaps still are negative, if the inflation and GDP gaps are sufficiently positive. However, BKR also consider variants of Bernanke's original "threshold rule," according to which the policy rate would remain at zero regardless of GDP and current inflation until a threshold condition such as non-negative average-inflation or price-level gap obtains, at which point the policy is determined by a Taylor-type rule and the ELB condition. They furthermore consider both the case when all private agents have model-consistent expectations, and understand and believe the policy rule, and the case when only asset-market participants have such expectations.

In particular, under the threshold rule, they take into account that, if the ELB period is extended and the cumulative inflation shortfall is large, the implied commitment to overshoot inflation may be correspondingly large. This they consider could be problematic and risk possible unanchoring of inflation expectations. To mitigate such risks, they consider a price-level gap with limited memory and shorter "lookback."

Overall, the simulations of BKR confirm earlier results that the modified Taylor-type rules, the "low-for-longer" rules, deliver better economic performance than the traditional rules. The relative advantage of low-for-longer policies is generally somewhat less with less-than-complete model-consistent policies, but several policies still retain a substantial advantage over traditional rules. In particular, rules with price-level gaps with shorter lookbacks of three years or even one year deliver significant improvements over traditional rules under both expectations assumptions.

These proposals for temporary price-level/average inflation can be seen as compromises between inflation targeting with a higher inflation target and permanent price-level targeting. However, if they are only applied occasionally and temporarily, economic agents will not be very used to them, and considerable explanation and communication may be necessary. But this may still not be sufficient for the temporary price-level target to be credible, in which case the favorable effect of raised inflation expectations will be reduced or not occur. Credibility normally needs to be earned, meaning that economic agents need to see the policy put into practice and its principles obeyed for some time, in order to believe that it will be maintained and be successful in the future. A permanent compromise may be preferable, such as permanent average-inflation targeting.

7. Average-Inflation Targeting

Average-inflation targeting here means flexible inflation targeting when the central bank has a target for average inflation over a period longer than a year. For simplicity and concreteness, let me assume a five-year averaging period, without forgetting that the appropriate averaging period remains to be determined.[28] The

[28]In particular, the results of BKR for a temporary price-level targeting with a shorter lookback indicates that a shorter averaging period, such as three years, may be appropriate.

five-year (20-quarter) average inflation rate (at an annual rate) in quarter t, $\bar{\pi}_t$, is then given by

$$\bar{\pi}_t = (p_t - p_{t-20})/5 = (\pi_t + \pi_{t-4} + \pi_{t-8} + \pi_{t-12} + \pi_{t-16})/5, \quad (16)$$

where we recall that π_t by (2) denotes the annual inflation rate in quarter t, $p_t - p_{t-4}$.

The central bank may want to put some weight on both the five-year and the one-year inflation rate, corresponding to the loss function

$$L_t = \mu_{\bar{\pi}}(\bar{\pi}_t - \pi^*)^2 + (1 - \mu_{\bar{\pi}})(\pi_t - \pi^*)^2 + (u_t - u_t^*)^2, \quad (17)$$

where $\mu_{\bar{\pi}}$ denotes the relative weight on five-year inflation and satisfies $0 < \mu_{\bar{\pi}} \leq 1$, with a value less than 1 corresponding to the situation when there is weight on both the five-year and the one-year inflation rate. Even if the central bank wants to stabilize the five-year inflation rate, it may want to avoid too much variability of the one-year rate. Furthermore, (17) assumes that the FOMC would interpret its balanced approach to imply a unitary relative weight on unemployment stabilization. Whether or not the appropriate relative weight on unemployment stabilization is unity under flexible average-inflation targeting is an issue that remains to be settled.

Nessén and Vestin (2005) have examined the properties of average-inflation targeting in a model with a Phillips curve with both forward- and backward-looking elements.[29,30] Svensson (2013) has proposed some weight on a five-year inflation target for the Riksbank as a way of mitigating the persistent downward bias in the inflation

[29]Under the assumption of optimization under discretion, Nessén and Vestin (2005) find that, in a purely forward-looking economy, price-level targeting dominates average- and annual-inflation targeting. For a more backward-looking economy, there are intermediate cases when average-inflation targeting with an appropriate choice of the relative weight on output-gap stabilization dominates both price-level targeting and annual-inflation targeting. The more backward looking the economy becomes, the shorter the optimal averaging period. The optimal relative weight on output-gap stabilization under average-inflation targeting needs to be chosen with care.

[30]The approach to average-inflation targeting in Nessén and Vestin (2005) is closely related to the work on “hybrid” price-level targeting in Batini and Yates (2003), Cecchetti and Kim (2005), and Røisland (2006).

outcome since 1996 (clearly visible in figure 8). Svensson (2018) has proposed some weight on a five-year average-inflation target for the ECB.[31]

Most recently, Williams (2018) and Mertens and Williams (2019a, 2019b) have discussed average-inflation targeting as a possible policy for the Federal Reserve in handling future problems of a binding ELB. However, they model average-inflation targeting not as a loss function with average inflation as an argument but as an instrument rule with a lower intercept when the ELB does not bind. This is equivalent to raising the implicit annual inflation target. Reifschneider and Williams (2000) used the same method to increase the inflation target, referring to the reduction of the intercept as "risk adjustment."[32] This results in inflation overshooting the original inflation target when policy is not constrained by the ELB. In order to result in average inflation equal to the original target, the increase in the inflation target/reduction in the intercept has to be calibrated to the estimated future level and binding frequency of the ELB.

Flexible average-inflation targeting as in (17) would involve the FOMC putting some weight on keeping five-year inflation close to the target and include a forecast of the five-year inflation rate in the SEP. It is not necessary but may be natural to extend the forecast horizon from three to five years for at least annual and five-year inflation but perhaps also for the other variables in the SEP.

To paraphrase FOMC (2019), in setting monetary policy under average-inflation targeting, the FOMC would seek to mitigate deviations of [both] average [and annual] inflation from its longer-run goal and deviations of employment from the FOMC's assessments of its maximum sustainable level. These objectives would generally be complementary. However, under circumstances in which the FOMC

[31]For the Riksbank and the ECB, Svensson (2013, 2018) has proposed that the phrase "without prejudice to the objective of price stability" in the mandate should not be interpreted as some kind of a hierarchical mandate. Instead it should simply be fulfilled by keeping the five-year inflation rate close to a symmetric inflation target and otherwise allow standard flexible inflation targeting and a dual mandate. Such an interpretation would be fully consistent with the Maastricht Treaty and the 2018 texts on the ECB's website (Svensson 2018).

[32]For details, see appendix D.

would judge that the objectives are not complementary, it would follow 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.[33]

In mitigating deviations of average inflation from the inflation target, the FOMC would have incentives to prevent annual inflation from persistently under- or overshooting the inflation target for longer periods. Any undershooting of annual inflation for a couple of years would normally be followed by some overshooting, in order to stabilize average inflation around the target. More precisely, if average inflation during the past $2\frac{1}{2}$ years has undershot the target, normally average inflation over the coming $2\frac{1}{2}$ would overshoot the target, in order to bring the five-year average inflation closer to the target—while also always taking into account the outlook for the labor market, corresponding to the last term in (17).[34]

Several central banks seem to have some (arguably irrational) "fear of overshooting," which may cause an undershooting bias of inflation. Average-inflation targeting would normalize overshooting after undershooting and help against this fear.

In the current situation in the United States, five-year average inflation has undershot the inflation target for some eight years (figure 6A with core PCE inflation).[35] Under average-inflation targeting, monetary policy would—all else being equal—aim to make annual inflation overshoot the target for a few years in order to bring five-year inflation closer to the target.

A five-year average-inflation target is similar to having a five-year price-level target that exceeds the current price level by about

[33]As implied by footnote 29, again the appropriate degree of "balance" needs to be carefully considered.

[34]Doyle (2018) has suggested an "error-correcting inflation target" for the Federal Reserve, to replace its current fixed 2 percent objective. The new target would be a 10-year rolling average centered on the latest month's data, therefore encompassing the past 5 years of data and a 5-year projection. So, if inflation was systematically below target in the preceding half decade, the target would adjust upward to hit the full-decade target, correcting the earlier error. Monetary policy, anticipating the next five years, would have to be set accordingly.

[35]Figure 7A shows that five-year PCE inflation has undershot the target even more the last few years.

10 percent.[36] In a situation when the ELB starts binding, this would correspond to the temporary price-level target proposed by Bernanke (2017)—in particular, when the latter is couched in terms of average inflation—except that Bernanke's temporary average-inflation target does not have a fixed horizon. This is because a necessary condition for raising the policy rate would be that average inflation since the date at which the policy rate first hit zero be at least 2 percent, regardless of how soon or how late that occurs. However, as noted by BKR and mentioned in section 6, a fixed averaging period may be preferable also when policy is constrained by the ELB.

An important difference to the temporary price-level target is that the flexible average-inflation targeting will be permanent and operate all the time. Market participants and the general public will see the policy put into practice and its principles obeyed. This makes it more likely that it will be credible and incorporated in normal expectations formation. Then it is more likely to be credible also when the ELB is binding, and thus that it will help in achieving a better economic performance in such situations.

Furthermore, suppose that the average-inflation target becomes credible. Then, away from the ELB and under normal circumstances, inflation expectations may move in favorable directions, and some of the automatic stabilization under a credible price-level target would also occur under average-inflation targeting. If annual inflation has been undershooting the target for a couple of years, expectations of annual inflation for the next couple of years would move above the target, thus inducing more expansionary monetary policy by reducing the real interest rate at unchanged nominal interest rates.

In particular, with inflation expectations entering the Phillips curve, higher inflation expectations would through this channel independently increase inflation. This may be particularly advantageous if the Phillips curve is now flatter and inflation is less responsive to slack in the labor market and other relevant markets.

In a way, the desired outcome is for expectations of annual inflation to be less anchored to the inflation target and move around

[36] $1.02^5 - 1 = 10.4\%$.

in desirable ways, whereas inflation expectations over several years ahead would remain anchored to the inflation target.

However, if annual inflation has overshot the target for several years, symmetric average-inflation targeting requires that—all else being equal—annual inflation should be brought down to undershoot the target for a couple of years. If the automatic stabilization is working, inflation expectations would come down and in this way reduce the required tightening of policy and possible associated employment cost. Furthermore, the weight on unemployment stabilization implies a gradual, optimal return to the average inflation target. Nevertheless, there are situations—such as some positive cost-push shocks—when tightening may be rather undesirable and when it may be justified to allow average inflation to overshoot for some time and allow a corresponding permanent increase in the price level.

A clear example is provided by the introduction of a 10 percent goods-and-services tax in Australia on July 1, 2000, figure 3A. As a result, the CPI price level increased by 3 percent. Hence the annual inflation rate was increased by 3 percentage points for the next four quarters, and five-year inflation was—all else being equal—increased by 0.6 percentage point for the next five years. The increase in the price level was fully anticipated by the public and financial markets, and the Reserve Bank of Australia did not seek to offset the effect of it on the price level (Debelle 2018).[37]

Another possible example is from the United Kingdom (figure 5A). In the United Kingdom, annual inflation and five-year inflation was high and above the target during the financial crisis of 2008–09 and several years after—in contrast to what was the case in several other economies. Although the high inflation was involuntary, overshooting the target when unemployment is high is consistent with successful flexible inflation targeting.[38] A thorough

[37]The Reserve Bank of Australia (RBA) has an inflation target of 2–3 percent over the "medium term" (previously over the "[business] cycle"). A question is whether this should be interpreted as an average-inflation target, especially because the typical business cycle may be five to six years long. As far as I can see, the actual practice of the RBA is hardly different from that of a standard flexible inflation targeter with a 2.5 percent inflation target.

[38]The unemployment rate rose from 5.2 percent in 2008:Q2 to 7.8 percent in 2009:Q2 and stayed around 8 percent until 2013:Q2, when it started to drop rapidly. Inflation overshot the target during 2010–13.

counterfactual analysis of average-inflation targeting is required to assess how average-inflation targeting would have performed during this period and whether it would have been costly to stabilize average inflation more. In particular, one should not forget that, with a five-year average-inflation target, five-year inflation is a bygone after five years.

Given these examples, I believe that it needs to be considered whether or not some explicit escape clause should be included in average-inflation targeting. Furthermore, the appropriate weights on average and annual inflation, the appropriate length of the averaging period, and the relative weight on employment stabilization require further and thorough studies and considerations.

Flexible average-inflation targeting represents considerable continuity of current inflation targeting but contains considerable potential for improvements. In particular, credibility of an average-inflation target would imply movements of inflation expectations and automatic stabilization that would improve performance when the ELB binds and possibly improve inflation control for flatter Phillips curves.

Furthermore, if average-inflation targeting works well, it allows possible further benefits by evolution toward a longer averaging period and an even larger relative weight on average inflation than on annual inflation, thus approaching price-level targeting. If it does not work well, it allows a retreat back to current annual-inflation targeting.

8. Nominal-GDP Targeting[39]

Nominal-GDP (NGDP) targeting has been suggested as a suitable monetary policy over the years, for example, by Taylor (1985), Hall and Mankiw (1994), McCallum and Nelson (1999), Frankel (2012),

[39]In the previous conference version of the paper, nominal-GDP targeting was briefly examined in the appendix of the paper and found to be inferior to flexible price-level targeting. During the audience question-and-answer session of the paper (Federal Reserve Bank of Chicago 2019), Eric Sims, Evan Koening, and James Bullard suggested that a monetary policy strategy of nominal-GDP targeting might have better properties than suggested by the paper. In response to this, the discussion of nominal-GDP targeting has been expanded and put in the main text.

Garín, Lester, and Sims (2016), and Frankel in Bernanke et al. (2018). It has never been tried in practice.

Recently, several papers have proposed NGPD targeting with the argument that it may contribute to more complete financial markets by making noncontingent nominal contracts state contingent in a welfare-improving way (Koenig 2013; Sheedy 2014; Azariadis et al. 2019; Beckworth 2019; Bullard and DiCecio 2019; Bullard and Singh 2019). The papers argue that this would create better risk sharing between debtors and creditors, make nominal loans more like equity and nominal debt less risky, stabilize the ratio of nominal debt and nominal debt payments to nominal incomes, and improve financial stability. The idea is that the countercyclical inflation created by NGDP targeting would cause real debt burdens to vary in a procyclical manner. As a result, debtors would benefit during recessions and creditors would benefit during booms. Fixed nominal-priced loans would act more like equity than debt and thereby promote financial stability.[40] However, proposing completion of financial markets, improved risk sharing, and financial stability as goals for monetary policy is clearly proposing a new and different mandate for the Federal Reserve, not consistent with the current dual mandate of both stable prices and maximum employment. The Federal Reserve's review of its monetary policy framework takes the existing mandate as given. Furthermore, there is by now considerable evidence and reasons why financial stability is not a suitable goal for monetary policy and why financial stability and financial market efficiency must be achieved with macro- and microprudential policy (Bernanke 2015c; IMF 2015; Williams 2015; FOMC 2016; Svensson 2017a).[41]

[40]Persson and Svensson (1989) provide an early analysis of how monetary and exchange rate policies may change the risk characteristics of nominal bonds and in some cases allow a completion of asset markets. Nominal-GDP stabilization and resulting countercyclical price movements make nominal bonds have risk characteristics like shares of GDP.

[41]In particular, monetary policy leaning against the wind (LAW)—meaning tighter policy for financial-stability purposes—has been much discussed and examined. The costs of LAW include lower inflation and higher unemployment; the benefits include possibly lower probability and magnitude of financial crises. Using a robust framework with a minimal number of assumptions together with conventional benchmark estimates of the effect of the policy rate on unemployment and debt, and of the effect of debt on the probability and magnitude of

Targeting the level of nominal GDP can be represented by the loss function

$$L_t = (Y_t - Y_t^*)^2, \tag{18}$$

where Y_t denotes the log of nominal GDP and Y_t^* denotes the log of the NGDP target. The latter may be given by

$$Y_t^* = Y_{t-1}^* + G^*,$$

corresponding to a deterministic path for nominal GDP that grows at the constant rate G^*. Nominal GDP satisfies $Y_t \equiv p_t + y_t$, where y_t denotes the log of (real) GDP and p_t (in this section) denotes the log of the GDP deflator. The NGDP target satisfies $Y_t^* \equiv p_t^* + y_t^*$,

---

crises, Svensson (2017a) shows that the costs of LAW exceed the benefits by a large margin. To overturn this result, policy rate effects on the probability and magnitude of crises need to be more than 5–40 standard errors larger than the benchmark estimates. Adrian and Liang (2018) have challenged the robustness of this result and argued that alternative "reasonable assumptions" about the effect of the policy rate on the probability or magnitude of a crisis would overturn it. However, as is shown in Svensson (2017a, 2017b), these alternative assumptions require estimates that are 12–43 standard errors larger than the estimates of Schularick and Taylor (2012), Jordà, Schularick, and Taylor (2013), and Flodén (2014).

After a thorough discussion of the evidence at its April 2016 meeting, the FOMC reached a similar conclusion about the costs and benefits of LAW: "Most participants judged that the benefits of using monetary policy to address threats to financial stability would typically be outweighed by the costs . . . ; some also noted that the benefits are highly uncertain" (FOMC 2016).

It is always possible to construct more complicated calibrated models with a number of special and unrealistic assumptions in which the configuration of costs and benefits implies that some positive LAW is optimal. But then the results are not robust to alternative and more realistic assumptions. Gourio, Kashyap, and Sim (2018) present such a model, in which a financial crisis results in a permanent drop of 10 percent in productivity, capital, output, and consumption and a permanent rise in the marginal disutility of labor so as to keep employment and unemployment unchanged. In spite of this large cost of a financial crisis, the optimal LAW is nevertheless small, corresponding to a reduction of the annual probability of crises of only 9 basis points, from 2.08 percent to 1.99 percent, implying on average one crisis in 50.3 years instead of one in 48.1 years. Such small LAW is hardly economically significant.

I have not yet seen a robust and convincing empirically based demonstration that the benefits of LAW would exceed the costs. This of course does not exclude that new future estimates or unforeseen situations could arise in which the benefits do exceed the costs.

where y_t^* denotes an estimate of potential output and p_t^* denotes an implicit price-level target determined by the difference between Y_t^* and y_t^*.

Importantly, NGDP targeting implies a single mandate, stabilizing NGDP, which treats prices and GDP as perfect substitutes, with a one-to-one tradeoff. In contrast, the dual mandate implies stabilizing two variables independently, prices and employment, which treats prices and employment as imperfect substitutes. As then Federal Reserve Bank of San Francisco President Williams put it in the discussion of the staff memo by Erceg, Kiley, and López-Salido (2011) on alternative monetary policy framework at the FOMC's November 2011 meeting (FOMC 2011, p. 71):[42]

> Nominal income targeting seems to muddy the waters. Investors care separately about prices and about quantities. And, importantly, we care separately about prices and about quantities. Looking at only nominal income, which mashes together prices and quantities, seems to me at this time to be counterproductive and could undermine the anchoring of inflation expectations.

8.1 Comparing NGDP Targeting and (Flexible) Price-Level Targeting

It is instructive to compare NGDP targeting to (flexible) price-level targeting, with the loss function (14), where the "balanced approach" to price-level targeting is interpreted to imply equal weight on stabilizing prices and unemployment.

First, the price-level loss function (14)—which is in terms of prices and unemployment—needs to be converted to a loss function in terms of prices and GDP. Assume an Okun coefficient of 2 and that GDP and unemployment gaps satisfy

$$y_t - y_t^* = -(u_t - u_t^*)/2. \tag{19}$$

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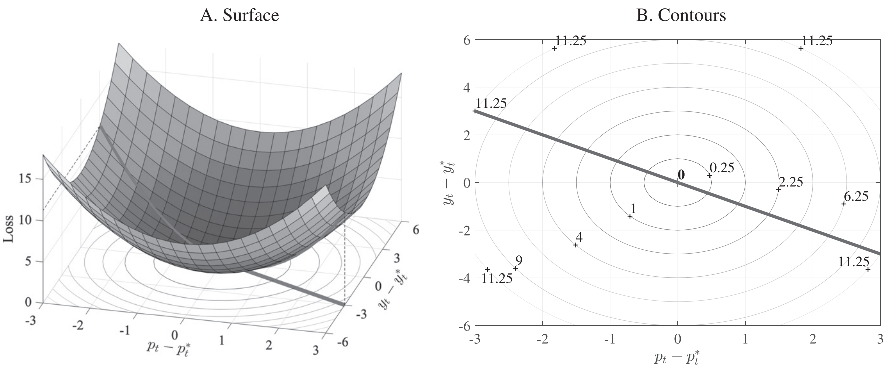
[42]However, as mentioned in section 4, NGDP targeting in Erceg, Kiley, and López-Salido (2011) is not modeled as a loss function to be minimized but implemented with a Taylor-type rule where the policy rate responds to the NGDP gap, (5) and (13). This is in turn indistinguishable from implementing flexible price-level targeting with a Taylor-type rule with the coefficients of the price-level and GDP gaps being equal, (10).

Figure 9. Loss as Function of Price and GDP Gaps: Flexible Price-Level Targeting



Notes: Surface and contours of the loss $L_t = (p_t - p_t^*)^2 + (1/4)(y_t - y_t^*)^2$ as a function of the price gap, $p_t - p_t^*$, and GDP gap, $y_t - y_t^*$. The thick gray line shows the combinations of price levels and GDP for which the (log of) nominal income $Y_t = p_t + y_t$ equals the target $Y_t^* = p_t^* + y_t^*$.

Then, the loss function in terms of prices and GDP that corresponds to price-level targeting can be written

$$L_t = (p_t - p_t^*)^2 + (1/4)(y_t - y_t^*)^2, \tag{20}$$

with a relative weight on stabilizing the GDP gap equal to $^1/_4$. The surface and contours of the price-level-targeting loss function (20) are shown in figure 9 as functions of the price and GDP gaps, $p_t - p_t^*$ and $y_t - y_t^*$.

The loss function for NGDP targeting, (18), can be expanded in terms of the price-level gap and the GDP gap as

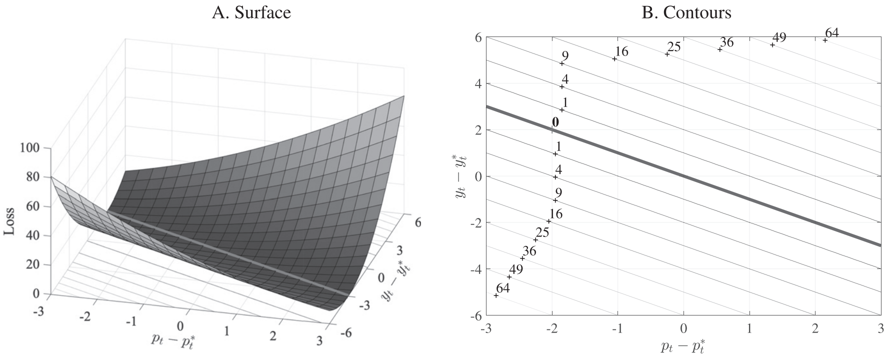
$$L_t = (Y_t - Y_t^*)^2 = [(p_t + y_t) - (p_t^* + y_t^*)]^2 = [(p_t - p_t^*) + (y_t - y_t^*)]^2. \tag{21}$$

The surface and contours of the loss function (21) are shown in figure 10 as functions of the price and GDP gaps.

We see a rather dramatic difference between the loss functions for price-level targeting and NGDP targeting.[43] Under NGDP targeting,

[43]For simplicity, the difference between PCE-deflator and GDP-deflator price gaps is disregarded.

Figure 10. Loss as Function of Price and GDP Gaps: Nominal-GDP Targeting



Notes: Surface and contours of the loss $L_t = (Y_t - Y_t^*)^2 = [(p_t - p_t^*)^2 + (p_t - p_t^*)]^2$ as a function of the price gap, $p_t - p_t^*$, and GDP gap, $y_t - y_t^*$. The thick gray line shows the combinations of price levels and GDP for which the (log of) nominal income $Y_t = p_t + y_t$ equals the target $Y_t^* = p_t^* + y_t^*$.

the loss is zero along the straight line in $(p_t - p_t^*, y_t - y_t^*)$—space that corresponds to a zero NGDP gap,

$$(p_t - p_t^*) + (y_t - y_t^*) = (p_t + y_t) - (p_t^* + y_t^*) = Y_t - Y_t^* = 0. \quad (22)$$

This is the straight thick gray line from the point $(p_t - p_t^*, y_t - y_t^*, \text{Loss}) = (-3, 3, 0)$ to the point $(3, -3, 0)$ in figure 10.

In contrast, under price-level targeting, the loss is zero only for the point $(p_t - p_t^*, y_t - y_t^*) = (0, 0)$ but rises rapidly to $3^2 + (1/4)3^2 = 11.25$ at the points $(p_t - p_t^*, y_t - y_t^*) = (3, -3)$ and $(-3, 3)$; see the thick gray line in figure 9.

This reflects that the price level and the GDP level are perfect substitutes under NGDP targeting, the result of there being only *one* target variable, nominal GDP, and thus a single mandate, stabilizing NGDP. Instead, under (flexible) price-level targeting, there are *two* independent target variables, the price level and employment (where the latter may be replaced by the corresponding GDP level), and thus a dual mandate. Under NGDP targeting, there is a constant unitary tradeoff between prices and GDP. Under price-level targeting, there is a variable tradeoff. In addition, the relative weight on stabilizing the GDP gap in (20) is 1/4 rather than unity, implying that for price and GDP gaps of equal size, the marginal rate of substitution of GDP for prices, $dy_t/dp_t|_{L_t = \text{ const.}}$, is 4 in absolute value rather than unity.[44]

The fact that the loss functions are so different indicates that the optimal reaction functions would be different, counter to the tendency of representing NGDP targeting and flexible price-level targeting with similar—or even identical—simple instrument rules as discussed in section 4.

8.2 Further Issues

Some proponents of NGDP-growth targeting, such as Frankel (2012) and Frankel in Bernanke et al. (2018), seem to confuse inflation targeting with *strict* inflation targeting—that is, with the loss function $L_t = (\pi_t - \pi^*)^2$ with zero weight on stabilizing employment and GDP and thus a single mandate, inflation stabilization. Compared with strict inflation and strict price-level targeting, NGDP targeting has the apparent advantage of putting some implicit positive weight on stabilizing GDP and employment. But the relevant comparison is with *flexible* inflation or price-level targeting, in which comparison NGDP-growth or NGDP-level targeting is at a disadvantage.

Importantly, there are serious practical problems with NGDP targeting, as discussed in some detail by then Vice Chair of the Board Yellen at the November 2011 FOMC meeting (FOMC 2011, pp. 80–82). She noted that that there would be enormous practical challenges in implementing this framework, which may help explain why no other central bank has ever followed such an approach. In particular, it would not be appropriate for the target path to be permanently fixed. Rather, it would need to be revised whenever there were significant changes in the estimated level or growth rate of potential output. Importantly, such revisions would need to be retrospective as well as prospective. There would be public confusion on such occasions, and people would complain that the Federal Reserve is changing the goal posts.

[44]The loss function (20) for flexible price-level targeting has a variable marginal rate of substitution of GDP for prices, $dy_t/dp_t|_{L_t = \text{ const.}} = -(\partial L_t/\partial p_t)/(\partial L_t/\partial y_t) = -4(p_t - p_t^*)/(y_t - y_t^*)$, whereas the loss function (21) for flexible price-level targeting has a constant unitary marginal rate of substitution of GDP for prices, $dy_t/dp_t|_{L_t = \text{ const.}} = -(\partial L_t/\partial p_t)/(\partial L_t/\partial y_t) = -1$.

Additional problems, noted by Mishkin (1998), are that data on nominal GDP are reported with a larger lag and less frequency than consumer prices and unemployment. Also, the concepts of consumer-price inflation and unemployment are much better understood by the public than the concept of nominal GDP, which can easily be confused with real GDP. Consequently, communication may be more difficult.

In summary, NGDP-level or NGDP-growth targeting has substantial practical and principal disadvantages relative to flexible price-level or inflation targeting, including not being consistent with the Federal Reserve's dual mandate. There are good reasons why no central bank has chosen NGDP targeting.

9. Conclusion

This paper has argued that forecast targeting is a better general strategy to achieve the Federal Reserve's mandate than following a Taylor-type rule. In particular, the transparency of forecast targeting—with the publication, explanation, and justification of policy rate paths and forecasts of inflation and unemployment, and the possibility of holding the FOMC accountable for its policy and forecast—may allow the FOMC a substantial degree of commitment. This may be especially so if it becomes established that deviations and shifts from previously published policy rate paths and forecasts come with good explanations.

Furthermore, the paper has considered the pros and cons relative to standard flexible inflation targeting of four "makeup" strategies: flexible price-level targeting, a temporary price-level target when the ELB binds, flexible average-inflation targeting, and nominal-GDP targeting.

Nominal-GPD targeting has substantial principal and practical disadvantages and is found to be inferior to the other strategies. In particular, by making GDP and prices perfect substitutes, it actually implies a single mandate and is not consistent with the dual mandate, which makes stable prices and maximum employment two separate and independent goals. The practical disadvantages include longer reporting lags and large ex post revisions of data. The latter will require both retrospective and prospective revisions of the target path, with large communication difficulties.

On balance, I find that average-inflation targeting has some advantages over the other strategies. Relative to inflation targeting, it has some desirable automatic stabilization properties, if it would become credible. Then inflation expectations would move in a way that would mitigate problems of both a binding ELB and a flatter Phillips curve. Furthermore, average-inflation targeting would normalize overshoots of the annual inflation target after undershoots, thereby help against the irrational fear of overshooting the inflation target that several central banks have displayed.

Relative to a temporary price-level target when the ELB binds—which can alternatively be described as a temporary average-inflation target—average-inflation targeting has the advantage that it would be operating all the time and not just when the ELB is binding. This means that economic agents would see it in continuous operation over time, which makes it more likely that it would be well understood and also be credible. Realistically, credibility may have to be earned over time and may not come immediately, which implies a strong argument for a strategy that operates all the time.

Relative to price-level targeting, average-inflation targeting is a smaller step from annual-inflation targeting. There is a considerable continuity with annual-inflation targeting in that average-inflation targeting can be seen as just a matter of extending the inflation-averaging period, from one year to a few years. This is likely to be an advantage in communicating it. Nevertheless, it can be also seen as a halfway step toward price-level targeting.

Furthermore, average-inflation targeting as described here is quite flexible. It allows for some weight on both the annual and the multi-year average-inflation target, keeping some aspect of annual-inflation targeting. If average-inflation targeting is successful, the averaging period can be extended, this way getting closer to price-level targeting. If less successful, average-inflation targeting allows for a retreat to annual-inflation targeting.

The choice of the appropriate weights on stabilizing average inflation, annual inflation, and employment—in order to best correspond to the Federal Reserve's "balanced approach" and "equal footing," once average inflation has entered the loss function—has been left open in this discussion. This choice needs careful and thorough examination by the Federal Reserve before a move to average-inflation targeting. The choice of the averaging period also needs consideration. I have used a five-year period as an example, but the appropriate averaging period could be longer or shorter than that.

Another issue left open is whether or not there is a case for some escape clause for special situations where it may be inappropriate to enforce the symmetry of the makeup mechanism. This issue would also be relevant for a move to price-level targeting.

Appendix A. Endogenous or Exogenous Labor Market Participation Rate

Let the quarter-t loss, L_t, be represented by the quadratic loss function,

$$L_t = (\pi_t - \pi^*)^2 + (\ell_t - \ell_t^*)^2, \tag{A.1}$$

where ℓ_t denotes the employment rate and ℓ_t^* denotes the FOMC's estimate of the maximum (sustainable) employment rate.

Let $u_t \equiv \bar{\ell}_t - \ell_t$ denote the unemployment rate, where $\bar{\ell}_t$ denotes the labor market participation rate. Let $u_t^* \equiv \bar{\ell}_t^* - \ell_t^*$ denote the FOMC's estimate of the minimum (sustainable) unemployment rate, where $\bar{\ell}_t^*$ denotes the FOMC's estimate of the maximum (sustainable) participation rate. Then

$$\ell_t - \ell_t^* \equiv (\bar{\ell}_t - u_t) - (\bar{\ell}_t^* - u_t^*) = (u_t^* - u_t) - (\bar{\ell}_t^* - \bar{\ell}_t). \tag{A.2}$$

If the labor market participation rate is exogenous to monetary policy, we can set $\bar{\ell}_t^* = \bar{\ell}_t$, so then

$$\ell_t - \ell_t^* = u_t^* - u_t, \tag{A.3}$$

and the loss function can be written as in (1).

Appendix B. Forecast Targeting: The Intertemporal Forecast Loss Function

Forecast targeting can be presented a bit more precisely with some notation and definitions, following Svensson (2011, 2019). First, let $i^t \equiv (i_{t,t}, i_{t+1,t}, \ldots, i_{t+T,t}) \equiv \{i_{t+\tau,t}\}_{\tau=0}^{T}$ denote the policy rate path in the current quarter t. Here $i_{t,t}$ denotes the current policy rate and $i_{t+\tau,t}$ for $\tau = 1, 2, \ldots, T$ denotes the FOMC's quarter-t mean forecast of, or plan for, the policy rate in future quarters $t+\tau$. Second, let $\pi^t \equiv \{\pi_{t+\tau,t}\}_{\tau=0}^{T}$ and $u^t \equiv \{u_{t+\tau,t}\}_{\tau=0}^{T}$ denote the FOMC's mean forecasts of inflation and unemployment.

Third, define the forecast loss, $L_{t+\tau,t}$, as

$$L_{t+\tau,t} = (\pi_{t+\tau,t} - \pi^*)^2 + (u_{t+\tau,t} - u^*)^2. \tag{B.1}$$

It represents the loss from deviations of quarter-t forecasts of quarter-$(t+\tau)$ inflation and unemployment from, respectively, the inflation target and the long-run sustainable unemployment rate. Then the quarter-t intertemporal forecast loss, $\mathcal{L}_t$, is given by

$$\mathcal{L}_t = \sum_{\tau=0}^{T} L_{t+\tau,t} = \sum_{\tau=0}^{T}(\pi_{t+\tau,t} - \pi^*)^2 + \sum_{\tau=0}^{T}(u_{t+\tau,t} - u^*)^2, \tag{B.2}$$

where the discount factor, δ, for simplicity has been set equal to one.

Furthermore, the deviations of inflation forecast from its target and the unemployment forecast from its long-run sustainable rate can be measured by the mean squared gaps for inflation and unemployment, defined as follows. The intertemporal forecast loss, (B.2), divided by the horizon, can be written

$$\mathcal{L}_t/T = \mathrm{MSG}_t^{\pi} + \mathrm{MSG}_t^{u}, \tag{B.3}$$

where MSG_t^{π} and MSG_t^{u} denote the mean squared gaps (MSGs) for, respectively, inflation and unemployment and are defined as

$$\mathrm{MSG}_t^{\pi} \equiv \sum_{\tau=0}^{T}(\pi_{t+\tau,t} - \pi^*)^2/T, \tag{B.4}$$

$$\mathrm{MSG}_t^{u} \equiv \sum_{\tau=0}^{T}(u_{t+\tau,t} - u^*)^2/T. \tag{B.5}$$

Thus, the MSG for a variable is the average deviation of the forecast of the future variable from the target for the variable. A smaller MSG for a variable indicates better (expected) mandate fulfillment for the variable, with a zero MSG indicating (unlikely) perfect (expected) mandate fulfillment.[45]

The issue of time consistency in this context is discussed in detail and resolved in Svensson and Woodford (2005) and summarized in Svensson (2011, section 3). The desired history dependence under commitment can be imposed in two ways. First, the intertemporal forecast loss, (B.2), can be modified by the addition of a term that represents the cost of deviating from previously announced policy. The MSGs, (B.4) and (B.5), can then be adjusted by adding to each MSG this term divided by $2T$.

The intertemporal forecast loss, (B.2), is then replaced by

$$\mathcal{L}_t = \sum_{\tau=0}^{T} (\pi_{t+\tau,t} - \pi^*)^2 + \sum_{\tau=0}^{T} (u_{t+\tau,t} - u^*)^2 + \ell_t, \tag{B.6}$$

where ℓ_t here is the cost of deviating from previous promises, more precisely a history-dependent function of the difference between the quarter-t realization of the forward-looking variables and the previous forecasts and expectations of these variables; see Svensson (2011, equation (B.1)). Then the definition of the MSGs, (B.4) and (B.5), is replaced by

$$\mathrm{MSG}_t^{\pi} \equiv \sum_{\tau=0}^{T} (\pi_{t+\tau,t} - \pi^*)^2/T + \ell_t/(2T), \tag{B.7}$$

$$\mathrm{MSG}_t^{u} \equiv \sum_{\tau=0}^{T} (u_{t+\tau,t} - u^*)^2/T + \ell_t/(2T). \tag{B.8}$$

Alternatively, as shown in Giannoni and Woodford (2003) and Svensson and Woodford (2005) and summarized in Svensson (2011), a history-dependent restriction on the policy rate path and the forecasts can be added. This means that (B.2) is minimized for a restricted set of policy rate paths and forecasts that satisfy this restriction in addition to the equations of the model used; see Svensson (2011, equations (28) and (29)). If the FOMC decides to restrict

[45] Division by the horizon T to get mean squared gaps instead of cumulative squared gaps is not necessary but allows a convenient analogy with the well-known concept of mean squared errors in statistics.

its policy choices to those consistent with such commitment, the Federal Reserve staff would then present policy alternatives that either have modified MSGs or are subject to the restriction mentioned.

Appendix C. Temporary Price-Level Targeting When the ELB Binds

Hebden and López-Salido (2018) (HLS) examine the policy rule[46]

$$i_t = \max[\, i_t^T + \min(f\, \mathrm{AIG}_{t,t_1}, 0), 0\,] \quad f > 0, \text{ where} \tag{C.1}$$

$$i_t^T = (1-\rho)r^* + \pi_t + a(\pi_t - \pi^*) + b(y_t - y_t^*) \text{ and} \tag{C.2}$$

$$\mathrm{AIG}_{t,t_1} = \sum_{j=t_1}^{t} \frac{\pi_j - \pi^*}{j+1-t_1}. \tag{C.3}$$

That is, the ELB is set at zero, i_t^T denotes the interest rate for a Taylor-type rule; AIG_{t,t_1} denotes the average-inflation gap since the quarter in which the ELB started to bind, quarter t_1; and f denotes the response coefficient of the average-inflation gap. Then the policy rate equals zero when $i_t^T + f\,\mathrm{AIG}_{t,t_1} \leq 0$, equals $i_t^T + f\mathrm{AIG}_{t,t_1}$ when this expression is positive and $\mathrm{AIG}_{t,t_1} \leq 0$, and equals i_t^T when i_t^T and AIG_{t,t_1} are both positive. HLS also examine an optimal version of the rule, where the response coefficient f—but not the other coefficients—is chosen to minimize a quadratic loss function of inflation and unemployment gaps.

Bernanke, Kiley, and Roberts (2019) (BKR) also discuss variants of Bernanke's proposal in terms of a simple instrument rule.

$$\begin{aligned} i_t = \max\{\, &(1-\rho)i_{t-1} + \rho[r^* + \pi_t + 0.5(\pi_t - \pi^*) + (y_t - y_t^*) \\ &+ \alpha \min(\mathrm{PLG}_{t,t_1}, 0)],\, 0\},\ \alpha > 0, \end{aligned} \tag{C.4}$$

where

$$\mathrm{PLG}_{t,t_1} = \sum_{j=t_1}^{t} (\pi_j - \pi^*)/4. \tag{C.5}$$

[46]The notation of Hebden and López-Salido (2018) and Bernanke, Kiley, and Roberts (2019) has been modified to agree with the one used in the present paper.

Here, an inertial Taylor (1999) rule is augmented by the price-level gap, PLG_{t,t_1}, which is given by the accumulated (not average) inflation shortfall since the quarter, t_1, when the ELB started to bind. The price-level gap is included as long as it is negative.

For a policy rule such as (C.1)–(C.3) or (C.4) and (C.5), liftoff may occur while the price-level gap is negative if the inflation and GDP gaps are sufficiently positive. However, BKR also consider variants of Bernanke's original "threshold rule," according to which the policy rate remains at zero regardless of GDP and current inflation until a threshold condition such as $\mathrm{PLG}_{t,t_1} \geq 0$ obtains, at which point the policy is determined by a Taylor-type rule and the nonnegativity condition. They furthermore consider both the case when all private agents have model-consistent expectations, and understand and believe the policy rule, and the case when only asset market participants have such expectations.

In particular, under the threshold rule, they take into account that if the ELB period is extended and the cumulative inflation shortfall is large, the implied commitment to overshoot inflation may be correspondingly large, which they consider could be problematic and risk possible unanchoring inflation expectations. To mitigate against such risks, they consider a price-level gap with limited memory, n, and thus a shorter "lookback" given by

$$\mathrm{PLG}_{t,t-n} = \sum_{j=0}^{n} (\pi_{t-n+j} - \pi^*)/4. \tag{C.6}$$

Appendix D. An Interest Rate Rule with a Lower Intercept

When the ELB does not bind, Mertens and Williams (2019a, 2019b) consider interest rate rules of the form

$$i_t = \theta_0 + \theta_E \mathrm{E}_t \pi_{t+1} + \theta_\varepsilon \varepsilon_t + \theta_\mu \mu_t, \tag{D.1}$$

where $\theta_E > 1$ and ε_t and μ_t are zero-mean i.i.d. shocks to the New Keynesian aggregate-demand function and Phillips curve, respectively. The inflation target is initially set to zero.

The corresponding interest rate rule with a nonzero inflation target, π^*, can be written

$$\begin{aligned} i_t &= r^* + \pi^* + \theta_E(\mathrm{E}_t\pi_{t+1} - \pi^*) + \theta_\varepsilon\varepsilon_t + \theta_\mu\mu_t \\ &= [r^* - (\theta_E - 1)\pi^*] + \theta_E\mathrm{E}_t\pi_{t+1} + \theta_\varepsilon\varepsilon_t + \theta_\mu\mu_t, \end{aligned} \tag{D.2}$$

where r^* is the neutral real interest rate.

Comparing (D.1) and (D.2), we can identify θ_0,

$$\theta_0 \equiv r^* - (\theta_E - 1)\pi^*. \tag{D.3}$$

Thus, we see that, because $\theta_E > 1$, lowering the intercept θ_0 implies raising the inflation target π^*.

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Are QE and Conventional Monetary Policy Substitutable?*

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Yes! We study the substitutability between conventional monetary policy based on the adjustment of a short-term policy interest rate with quantitative easing (QE). We do so in a four-equation New Keynesian model featuring financial frictions that allows QE to be economically relevant. We analytically derive how much QE versus conventional policy is necessary to implement an inflation target. Quantitatively, the observed expansion of the Federal Reserve's balance sheet over the zero lower bound (ZLB) period provides stimulus equivalent to cutting the policy rate to 2 percentage points below zero. This is in line with the decline in the empirical shadow federal funds rate series. Moreover, we show that the amount of QE required to achieve price stability depends on the expected duration of the ZLB.

JEL Codes: E32, E52, E58.

1. Introduction

Prior to the financial crisis and ensuing Great Recession of 2007–09, the Federal Reserve (Fed) in the United States and other central banks around the world implemented monetary policy via the adjustment of short-term interest rates. In response to the crisis, central banks pushed short-term policy rates to the zero lower bound (ZLB) or, in some cases, slightly below zero. Lacking the ability to pursue conventional easing policies by pushing short-term rates even lower, central banks instead resorted to a sequence of unconventional

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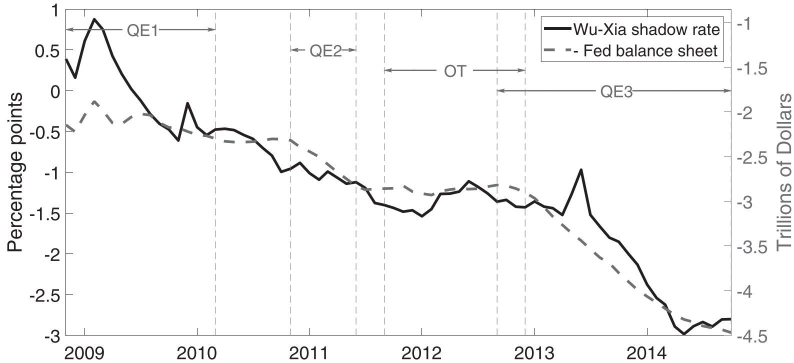
policy interventions. The most prominent unconventional intervention has been large-scale asset purchases, more commonly known as quantitative easing (QE).[1] In the United States, for example, the Fed bought longer-maturity Treasury and residential mortgaged-backed securities and ended up with an unprecedentedly large balance sheet of 4.5 trillion dollars.

In spite of its expansive use and the likelihood that QE operations will be deployed again to fight future economic downturns, economists' understanding of the magnitudes and mechanisms by which QE affects the economy remains somewhat limited. In particular, there is no consensus on how much QE is equivalent to a conventional policy rate cut. Our paper contributes to this important question. Not only do we provide an affirmative answer to the question posed in the title, we also calculate a direct quantitative mapping between QE and conventional policy.

The starting point of our analysis is the shadow federal funds rate. The shadow rate is an older concept originally introduced by Black (1995) to circumvent issues arising in term structure models from the ZLB on the short end of the yield curve. It has more recently been used by a number of researchers as a summary statistic for the overall stance of monetary policy during periods in which policy rates are at their lower bound. A shadow rate series uses information from longer-term interest rates to infer a hypothetical short-term interest rate were there no ZLB. Wu and Xia (2016), for example, compute a shadow rate series for the United States and find that it reaches a nadir of approximately 3 percentage points below zero at the end of the Fed's QE operations. This is suggestive that unconventional operations have provided a significant amount of economic stimulus and that perhaps the ZLB has not been much of a constraint on policy. Indeed, as we document in figure 1, visually there is a tight connection between the size of the Fed's balance sheet and the shadow rate series. Without more structure, however,

[1] Another widely used unconventional tool has been forward guidance, which involves the central bank communicating its expected path of short-term policy rates after a ZLB episode has ended. We focus on QE in this paper. For excellent reviews and discussions of forward guidance, see Campbell et al. (2012) or Del Negro, Giannoni, and Patterson (2015).

Figure 1. Shadow Rate and the Fed's Balance Sheet



Data Sources: Wu-Xia/Federal Reserve Bank of Atlanta and Federal Reserve Economic Data.
Notes: We reproduce Wu and Zhang's (2017) figure 1 between November 2008 and October 2014. Solid line: the Wu-Xia shadow rate; dashed line: the negative of the Fed's balance sheet. Left scale: shadow rate in annualized percentage points; right scale: negative Fed's balance sheet in trillions of dollars. QE1: the first round of QE from November 2008 to March 2010; QE2: the second round of QE from November 2010 to June 2011. OT: Operation Twist from September 2011 to December 2012. QE3: the third round of QE from September 2012 to October 2014.

it is impossible to move beyond interpreting the tight temporal connection between the two series as more than coincidental. Further, since the term structure models upon which the construction of the shadow rate is based are mute about structural economic mechanisms, it is not possible to draw a tight, quantitative link between QE purchases and movements in the shadow rate.

Our paper seeks to fill this void. We do so using the four-equation linearized New Keynesian model of Sims and Wu (2019b). The model features an IS curve summarizing aggregate demand and a Phillips curve describing aggregate supply, along with policy rules for the short-term interest rate as well as the size of the central bank's long bond portfolio. The underlying environment features two types of households, short- and long-term debt, and financial intermediaries subject to a leverage constraint. Bond market segmentation in conjunction with a leverage constraint on intermediaries allow the central bank's long bond portfolio to be economically relevant. Linearization about the non-stochastic steady state gives rise to the four key equations. They look similar to their counterparts in the textbook three-equation model (e.g., Galí 2008), except the IS and Phillips curve contain additional terms related to credit market disturbances and the central bank's long bond portfolio. Though substantially simpler and more tractable, the four-equation model is based on similar building blocks to more complicated quantitative dynamic stochastic general equilibrium (DSGE) models like those of Gertler and Karadi (2011, 2013); Carlstrom, Fuerst, and Paustian (2017); and Sims and Wu (2019a).

We focus on a framework in which conventional policy entails adjusting the short-term interest rate to implement a strict inflation target. Inflation targeting is the explicit mandate for many of the world's central banks, and since 2012 the Fed in the United States has adopted an official target of 2 percent. With no QE, implementing the inflation target absent a ZLB constraint in our model requires adjusting the interest rate one-for-one with fluctuations in the natural rate of interest and moving the policy rate to counterbalance credit market disturbances. An inability to adjust the policy rate because of a binding ZLB causes the central bank to miss on its inflation target and results in substantial fluctuations in the output gap in response to both natural rate and credit shocks.

We then derive an expression for the central bank's QE holdings so as to implement its inflation target when the policy rate is constrained by the ZLB. In our model, QE should move in the opposite direction of how the policy rate ordinarily would in response to shocks. From the perspective of implementing an inflation target, QE is perfectly substitutable with conventional interest rate policy in a ZLB environment. The implications of the two policies for the behavior of the output gap are different, however. Nevertheless, the output gap reacts significantly less to both natural rate and credit shocks with our endogenous QE rule compared with a policy of doing nothing at the ZLB.

Relating back to the empirical shadow federal funds rate, we derive an analytical substitution factor between QE and conventional monetary policy in the model. Calibrated to U.S. data, we find that a doubling of the central bank's long bond portfolio is approximately equivalent to a cut in the policy rate of 3 percentage points at an annualized rate. Feeding the observed time series of the Fed's balance sheet into our analytical substitution expression results in an implied shadow rate series that aligns closely with Wu and Xia's (2016) empirical series. In particular, our model predicts that QE1 through QE3 provided stimulus equivalent to cutting the policy rate to roughly 2 percentage points below zero, a number that is consistent with Wu and Xia (2016).

The remainder of the paper proceeds as follows. Section 2 reviews the current monetary policy framework. This includes a discussion of conventional policy rate adjustment relative to unconventional tools like QE, a review of some of the recent literature, and a description of the empirical shadow federal funds rate and its close connection to the size of the Fed's balance sheet. Section 3 describes the model, and section 4 discusses both conventional monetary policy and QE at the ZLB. Section 5 discusses the analytical conversion between conventional policy rate movements and QE and quantitatively documents how the shadow rate implied by our substitution factor using the Fed's balance sheet closely aligns with empirical shadow rate series. Section 6 concludes.

2. Review of the Monetary Policy Framework

In this section, we provide a brief intuitive review of the past and current monetary policy framework employed by the Federal Reserve and other leading central banks. We compare and contrast the framework prior to the financial crisis with one based on QE policies deployed to circumvent the constraints on conventional policy posed by the ZLB. Next, we review some of the empirical literature on the effects of large-scale asset purchases. We then tie these frameworks into the empirical shadow rate literature typified by Wu and Xia (2016).

2.1 Conventional Monetary Policy versus QE

Although most macro models only feature one interest rate, in reality there are myriad interest rates facing consumers and firms. The interest rates relevant for the most cyclically sensitive components of expenditure are long term and account for default risk. Prior to the crisis, in contrast, central banks implemented policy largely through the adjustment of short-term, risk-free rates.

Riskless, short-term rates are related to economically relevant longer-term rates through the simple decomposition expressed as follows:

$$Long\ rate = expectation + risk\ premium. \tag{1}$$

Long-term rates can be broken into two components. The expectations component is based on the expected sequence of short-term policy rates. The risk premium component accounts for duration and default risk associated with longer-term, risky debt. Conventional monetary policy works through the expectations component of (1)—adjusting short-term rates in the present affects long rates through the expected path of policy rates, and in turn affects spending categories that are especially sensitive to long-term rates (e.g., consumer durables and residential investment).

Unconventional policies were deployed to circumvent constraints on conventional policy posed by the ZLB in the wake of the financial crisis. Loosely speaking, unconventional policies seek to influence economically relevant long-term rates independently of adjusting current short-term rates. Because such policies seek to influence the long end of a yield curve without adjusting the "short" end, Eberly, Stock, and Wright (2019) refer to them as "slope policies." Like conventional interest rate policy, forward guidance seeks to influence relevant rates through the expectations component of (1), albeit by changing expectations of future policy rates rather than current rates.

Quantitative easing seeks to influence economically relevant rates instead through the risk premium channel. From the perspective of conventional macroeconomic theory with unconstrained agents and frictionless markets, it is not clear why central bank purchases of long bonds might be beneficial. It is against this background that Ben Bernanke famously said, "The problem with QE is that it works in practice but not in theory."[2]

A number of authors have advanced different theories for how QE policies might work to lower long-term rates. Vayanos and Vila (2009) develop a preferred-habitat theory of the term structure in which central bank purchases or sales of bonds can affect supply and demand in particular segments of the bond market. Ray (2019)

[2]See the transcript associated with Ahamed and Bernanke (2014).

incorporates this preferred-habitat environment into an otherwise standard New Keynesian model. The framework upon which our model is based relies upon financial market segmentation with constrained intermediaries (see, e.g., Gertler and Karadi 2011, 2013; Carlstrom, Fuerst, and Paustian 2017; and Sims and Wu 2019a). In this type of framework, bond purchases by a central bank can ease constraints facing intermediaries, resulting in an expansion of credit supply and lower credit spreads.[3]

There is by now an expansive empirical literature on the effects of QE. Much of this literature has converged to the conclusion that QE has been effective. Gagnon et al. (2011) find that QE purchases were successful in driving down long-term interest rates primarily through lower risk and term premiums. Hamilton and Wu (2012), Bauer and Rudebusch (2014), and Greenwood and Vayanos (2014) study the empirical effects of QE on the term structure. Gagnon et al. (2011), Krishnamurthy and Vissing-Jorgensen (2011), and D'Amico and King (2013) use an event-study methodology to quantify the effects of QE in the United States on a variety of different interest rates. Eberly, Stock, and Wright (2019) employ a reduced-form statistical model to conclude that so-called slope policies provided substantial stimulus to the U.S. economy during the ZLB period. Among these, Gagnon et al. (2011), Hamilton and Wu (2012), and Greenwood and Vayanos (2014) highlight the risk premium channel as described in (1). Different from the rest of the literature, Greenlaw et al. (2018) offer a more skeptical view on the efficacy of QE.

2.2 Shadow Rate

It has become increasingly popular to summarize the overall stance of monetary policy at the ZLB with the so-called shadow rate. We focus on the Wu and Xia (2016) shadow rate, which has been widely used by researchers, policymakers, and media. For empirical studies, see Nikolsko-Rzhevskyy, Papell, and Prodan (2014), Aizenman,

[3]An alternative theory of the transmission of QE rests on a so-called signaling hypothesis—expansive QE operations can serve as a credible signal of lower future policy rates, thereby affecting long rates through the expectations channel. See, e.g., Bauer and Rudebusch (2014), Bhattarai, Eggertsson, and Gafarov (2015), or some of the associated discussion in Krishnamurthy and Vissing-Jorgensen (2011).

Chinn, and Ito (2016), and Aastveit, Natvik, and Sola (2017), and Basu and Bundick (2017). For policy analyses, see Altig (2014) and Hakkio and Kahn (2014). For media discussions, see articles in *Bloomberg Businessweek* (Coy 2014), the *Wall Street Journal* (Lahart 2014), *Forbes* (Wakatabe 2015), *Bloomberg News* (Miller 2016), and *Business Insider* (2016).

Initially, the shadow rate was a concept introduced by Black (1995) into the term structure literature to circumvent issues arising from the ZLB. In particular, let

$$r_t = \max\{0, s_t\}, \tag{2}$$

where r_t is the short-term policy rate and s_t is the shadow rate. Although the policy rate is subject to a zero lower bound, the shadow rate is not. When above zero, both of them are the same, whereas when r_t is at its ZLB, the shadow rate still displays variation and contains economically meaningful information.

Empirically, the shadow rate is extracted from the term structure of interest rates. At the ZLB, the short end of the yield curve is at or very close to zero. However, medium- and long-term interest rates still contain economically relevant information. The shadow rate inferred from longer-term interest rates represents the hypothetical short end of the yield curve if the ZLB were not a constraint. Kim and Singleton (2012) and Ichiue and Ueno (2013) apply such a model to Japan, whereas Lombardi and Zhu (2014), Christensen and Rudebusch (2015), Bauer and Rudebusch (2016), and Wu and Xia (2016) focus on the United States. Kortela (2016), Lemke and Vladu (2016), and Wu and Xia (2018) extend the model to Europe.

2.3 QE and the Shadow Rate

Figure 1 plots the empirical shadow rate series as the solid black line from November of 2008 through October of 2014. This corresponds to the time frame over which the Fed was actively engaged in large-scale asset purchases.

After an initial upward blip at the very beginning of the sample period, the shadow rate series exhibits a sustained downward trajectory, ultimately falling to about 3 percentage points below zero. Several authors, most notably Bullard (2012), Wu and Xia (2016), Mouabbi and Sahuc (2017), and Wu and Zhang (2017, 2019), have interpreted the large and persistent decline in the shadow rate as evidence of the efficacy of unconventional monetary policies deployed in the wake of the Great Recession. This work aligns with a growing literature arguing that unconventional policies have served as a good substitute for conventional monetary policy and that the ZLB on policy rates has ultimately not been much of a hindrance to effective stabilization policy. See, for example, Swanson and Williams (2014), Debortoli, Galí, and Gambetti (2016), Swanson (2018a, 2018b), Garín, Lester, and Sims (2019), and Sims and Wu (2019b).

The construction of a shadow rate series is based on empirical term structure models that do not have an explicit mapping back into structural economic models or particular unconventional tools. Nevertheless, a number of the papers cited above have associated the Fed's expansive QE operations with the observed empirical behavior of the shadow rate. The dashed line in figure 1 plots the negative of the Fed's balance sheet from the end of 2008 through 2014. The balance sheet is measured in trillions of dollars and is on the right scale. The two series are obviously highly correlated. From QE1 through QE3, the Fed expanded its balance sheet from under 2 trillion dollars to more than 4.5 trillion dollars. Over the same time period, the shadow rate goes from slightly positive to about 3 percentage points below zero. This figure is suggestive, though of course not dispositive, that QE operations contributed significantly to the monetary easing as captured by the shadow rate.

Next, we formalize the relationship between the shadow rate and QE. In particular, we use the four-equation New Keynesian model of Sims and Wu (2019b) to theoretically derive a conversion factor between QE and conventional monetary policy. We show in section 5 that a conventionally calibrated version of our model is quantitatively consistent with the expansion in the Fed's balance sheet explaining much of the downward drift in the empirical shadow rate.

3. Model

Our analysis is based on the New Keynesian model developed in Sims and Wu (2019b). The model features short- and long-term bonds as well as financial intermediaries standing between borrowers and savers. Bond market segmentation combined with intermediaries being subject to a risk-weighted leverage constraint allows QE operations to have real economic effects. The model captures features of more involved DSGE models of intermediation (e.g., Gertler and Karadi 2011, 2013; Carlstrom, Fuerst, and Paustian 2017; Sims and Wu 2019b) while retaining the elegance and tractability of the textbook three-equation model.

The model reduces to four linearized equations.[4] For details, see Sims and Wu (2019b). It consists of an IS curve,

$$x_t = E_t x_{t+1} - \frac{1-z}{\sigma}\left(r_t - E_t\pi_{t+1} - r_t^f\right) \\ - z\left[\bar{b}^{FI}(E_t\theta_{t+1} - \theta_t) + \bar{b}^{cb}(E_t qe_{t+1} - qe_t)\right], \tag{3}$$

and a Phillips curve,

$$\pi_t = \gamma\zeta x_t - \frac{\gamma\sigma z}{1-z}\left[\bar{b}^{FI}\theta_t + \bar{b}^{cb} qe_t\right] + \beta E_t\pi_{t+1}, \tag{4}$$

together with two policy rules, one characterizing the behavior of the short-term interest rate, r_t, and one the central bank's long bond portfolio, which we denote qe_t.

Lowercase variables with a t subscript denote log-deviations about the nonstochastic steady state. π_t is inflation and $x_t = y_t - y_t^f$ denotes the output gap, where y_t^f is the equilibrium level of output consistent with price flexibility and no credit shocks. Similarly, r_t^f denotes the natural rate of interest—i.e., the real interest rate consistent with output equaling potential. θ_t captures credit conditions in the financial market; positive values correspond to more favorable conditions. We refer to it as a credit shock. qe_t denotes the real market value of the central bank's long-term bond portfolio.

Letters without t subscripts are parameters or steady-state values. σ, β, and γ are standard parameters—σ measures the inverse intertemporal elasticity of substitution, β is a subjective discount factor, and γ is the elasticity of inflation with respect to real marginal cost. ζ is the elasticity of real marginal cost with respect to

[4]To reduce the model to four equations, we make a number of simplifying assumptions. These assumptions are not crucial for the qualitative properties of the model.

the output gap.[5] $\bar{b}^{FI}$ and $\bar{b}^{CB}$ are parameters measuring the steady-state long-term bond holdings of financial intermediaries and the central bank, respectively, relative to total outstanding long-term bonds. These coefficients sum to one, i.e., $\bar{b}^{FI} + \bar{b}^{CB} = 1$.

In Sims and Wu's (2019b) model, there are two types of households, and the parameter $z \in [0, 1)$ represents the share of non-standard households (who are relatively impatient) in the total population. The model collapses to the standard three-equation New Keynesian model when $z = 0$. In this case, credit shocks θ_t and the central bank's long bond portfolio qe_t are irrelevant for the equilibrium dynamics of output and inflation.

We assume that the credit shock obeys an exogenous autoregressive process with one lag, AR(1),

$$\theta_t = \rho_\theta \theta_{t-1} + s_\theta \varepsilon_{\theta,t}. \tag{5}$$

The natural rate of interest is driven by fundamental shocks to preferences and technology, but can be thought of as exogenous with respect to output and inflation. We therefore model it as an exogenous AR(1) process,

$$r_t^f = \rho_f r_{t-1}^f + s_f \varepsilon_{f,t}. \tag{6}$$

The autoregressive parameters ρ_θ and ρ_f lie strictly between zero and one; the shocks are drawn from standard normal distributions, and are scaled by s_θ and s_f.

To close the model, it is necessary to specify policy rules for the short-term interest rate and the central bank's long bond portfolio. We turn to such specifications, as well as the potential substitutability between the two kinds of policy instruments, next in section 4 and section 5.

[5]In particular, $\gamma = \frac{(1-\phi)(1-\phi\beta)}{\phi}$, where $\phi \in [0, 1)$ measures the probability of nonprice adjustment. This is exactly the same expression as in the three-equation model. The elasticity of real marginal cost with respect to the output gap is $\zeta = \frac{\chi(1-z)+\sigma}{1-z}$, where χ is the inverse Frisch labor supply elasticity. When $z = 0$, this would also be the same as in the three-equation model.

4. Policy Rules

For our analysis, we focus on a central bank that adopts a strict inflation target. Inflation targeting is the working framework for many central banks. Among advanced economies, leading examples include New Zealand, Canada, and the United Kingdom. While the Federal Reserve in the United States officially has a dual mandate of price stability and maximum employment, since 2012 it has adopted an explicit inflation target of 2 percent. In addition to being a realistic description of central bank policies in actual economies, inflation targeting permits a clean analytical expression for the substitutability between conventional interest rate policy and QE.

4.1 Conventional Monetary Policy

As a starting point, suppose that the central bank is free to adjust the short-term interest rate but does not engage in QE operations, i.e., $qe_t = 0$. This provides a good characterization of central bank policies in advanced economies prior to the financial crisis. The central bank endogenously adjusts r_t so as to implement $\pi_t = 0$. Doing so requires the following path of the policy rate:

$$r_t = r_t^f + \frac{\sigma z \bar{b}^{FI}(1-\rho_\theta)\chi}{(1-z)\zeta}\theta_t, \tag{7}$$

where $\chi \geq 0$ is the inverse Frisch labor supply elasticity.

To implement the inflation target, the policy rate must respond one-for-one to movements in the natural rate of interest. This is the same as in the standard three-equation New Keynesian model. However, in the four-equation model, the policy rate must also react to the credit shock in order to fully stabilize inflation. The required policy rate reaction to credit shocks is positive—that is, a tightening of credit conditions (i.e., a decrease in θ_t) should be met by a decrease in the policy rate to stabilize inflation. In the special case in which $z = 0$, the model collapses to the textbook model and the reaction to the credit shock is zero.

With the policy rule described in (7), the output gap follows

$$x_t = \frac{\sigma z \bar{b}^{FI}}{(1-z)\zeta}\theta_t, \tag{8}$$

which depends on the credit shock, but not on the natural rate shock. The so-called divine coincidence (Blanchard and Galí 2007) holds conditional on natural rate shocks, wherein stabilizing inflation about target automatically closes the output gap. But the divine coincidence does not hold conditional on credit market disturbances. As discussed in Sims and Wu (2019b), it is therefore not possible to simultaneously stabilize both inflation and the output gap with only one policy instrument. See derivations in appendix A.

4.2 The ZLB

Now let us suppose that the nominal interest rate is stuck at zero for a deterministic number of periods, H. This is the policy experiment considered in Carlstrom, Fuerst, and Paustian (2014) to approximate the effects of a binding ZLB. There is no uncertainty over the duration of the interest rate peg, H. In this experiment, the policy rate is held fixed for the current and subsequent $H-1$ periods, after which time it reverts to the rule necessary to implement a strict inflation target as described above, (7). Formally,

$$r_{t+j} = \begin{cases} 0 & \text{if } j < H \\ r^f_{t+j} + \frac{\sigma z \bar{b}^{FI}(1-\rho_\theta)\chi}{(1-z)\zeta}\theta_{t+j} & \text{if } j \geq H. \end{cases} \tag{9}$$

Starting in period $t+H$, the central bank reverts to implementing an inflation target, where $\pi_{t+H+j} = 0$ and $x_{t+H+j} = \frac{\sigma z \bar{b}^{FI}}{(1-z)\zeta}\theta_{t+H+j}$ for $j \geq 0$. Assuming there is no possibility of using QE (i.e., $qe_{t+j} = 0$ $\forall\, j$), we can use these terminal conditions to then solve backwards for the paths of inflation and the output gap.

To illustrate the consequences of a binding ZLB, we parameterize and solve the model. The parameterization is described in table 1. The discount factor takes on a standard value of $\beta = 0.99$. The share of impatient households is set as in Sims and Wu (2019b), at $z = 1/3$. The elasticity of intertemporal substitution is unity. The inverse Frisch elasticity is set to $\chi = 1$. The parameterization of $\bar{b}^{FI}$ and $\bar{b}^{cb}$ follows Sims and Wu (2019b). The parameters γ and ζ imply a slope of the Phillips curve of 0.22, which is fairly standard.

Figure 2 plots impulse responses to a 1 percentage point negative shock to the natural rate of interest. Solid lines are responses when

Table 1. Parameter Values of Linearized Model

Parameter	Value	Description
β	0.99	Discount Factor
z	0.33	Consumption Share of Impatient Households
σ	1	Inverse Elasticity of Substitution
$\bar{b}^{FI}$	0.70	Weight on Leverage in IS/PC Curves
$\bar{b}^{cb}$	0.30	Weight on QE in IS/PC Curves
γ	0.086	Elasticity of Inflation w.r.t. Marginal Cost
ζ	2.5	Elasticity of Gap w.r.t. Marginal Cost
χ	1	Inverse Frisch Elasticity
ρ_f	0.9	AR Natural Rate
ρ_θ	0.9	AR Leverage

Note: This table lists the values of calibrated parameters of the linearized four-equation model.

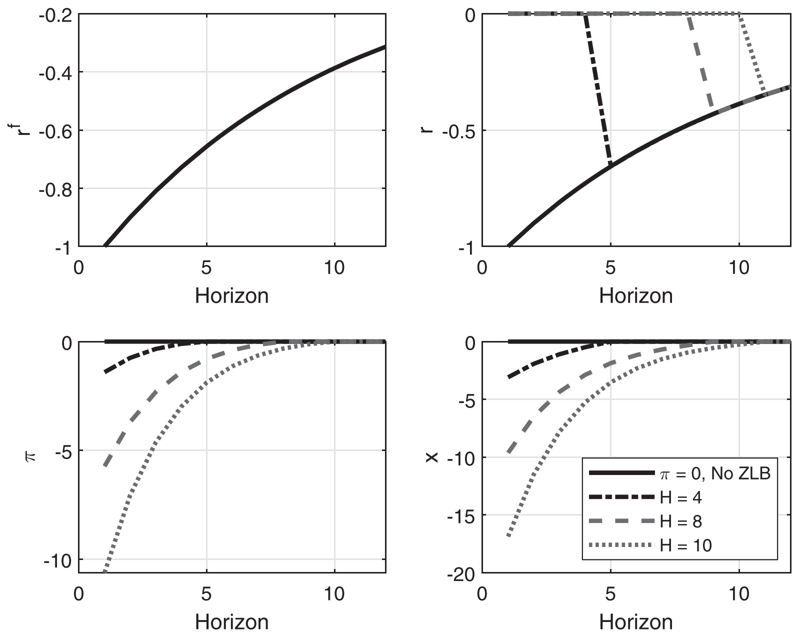
there is no constraint on the policy rate and the central bank implements the inflation target. Alternative line styles show responses when the policy rate is constrained for H periods. We consider peg lengths of $H = 4$ (dash-dotted), $H = 8$ (dashed), and $H = 10$ (dotted).

Absent a ZLB constraint, the central bank would lower the policy rate one-for-one with the natural rate, resulting in no movements in either inflation or the output gap. At the ZLB, the inability to lower the interest rate means that monetary policy is too tight for H periods, resulting in both inflation and the output gap falling significantly. The longer is the expected duration of the ZLB, the more output and inflation decline in response to the shock. After H periods, the policy rate declines to match the natural rate and the output gap and inflation return to zero.

Figure 3 shows impulse responses to a contractionary credit shock of 20 percent.[6] The figure is constructed similarly to figure 2.

[6] As discussed in Sims and Wu (2019b), θ_t has the interpretation as the log-deviation of a risk-weighted leverage requirement on intermediaries. In their baseline calibration, the steady-state leverage requirement is set to 5. Hence, a 20 percent decline in θ_t is equivalent to the mandatory leverage ratio falling from 5 to 4.

Figure 2. Impulse Responses to Natural Rate Shock at ZLB

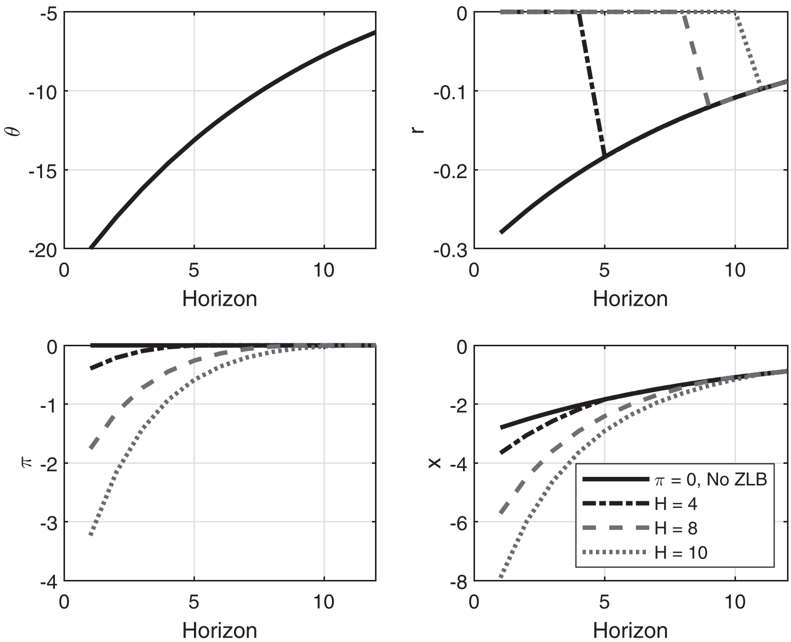


Notes: This figure plots impulse responses to a negative shock to the natural rate under a strict inflation target (solid line) and when the policy rate is constrained for H periods. After H periods policy reverts to implementing the strict inflation target via adjustment of the short-term interest rate. Dash-dotted lines correspond to $H = 4$, dashed lines to $H = 8$, and dotted lines to $H = 10$.

Absent any constraints, the central bank would lower the policy rate. This would stabilize inflation about target, but the output gap would still decline somewhat. When the policy rate is constrained, in contrast, the inability to lower the policy rate results in inflation declining and the output gap falling by substantially more. Once again, these effects are exacerbated the larger is H.

Figure 2 and figure 3 make the simple and well-known point that an inability to adjust policy rates has adverse consequences—inflation does not hit target and the output gap declines more in response to both types of shocks. These effects are larger the longer is the duration of the ZLB constraint. In other words, the ZLB is

Figure 3. Impulse Responses to Credit Shock at ZLB



Notes: This figure plots impulse responses to a negative credit shock under a strict inflation target (solid line) and when the policy rate is constrained for H periods. After H periods policy reverts to implementing the strict inflation target via adjustment of the short-term interest rate. Dash-dotted lines correspond to $H = 4$, dashed lines to $H = 8$, and dotted lines to $H = 10$.

quite costly when the central bank has no additional tools at its disposal and simply has to wait until the ZLB lifts.

4.3 Endogenous QE

In reality, central banks did not just sit idly by when policy rates hit the ZLB during the recent financial crisis. And in our four-equation model, they need not—it is possible for QE to adjust so as to hit the same target for inflation when the policy rate is constrained.

When the policy rate is constrained for H periods as in (9), the strict inflation target can be implemented via the following QE rule.

Details are in appendix B.

$$qe_{t+j} = \begin{cases} -\frac{\bar{b}^{FI}}{\bar{b}^{cb}}(1-\rho_\theta^{H-j})\theta_{t+j} - \frac{(1-z)\zeta}{\sigma z \bar{b}^{cb}\chi}\frac{1-\rho_f^{H-j}}{1-\rho_f} r_{t+j}^f & \text{if } j < H \\ 0 & \text{if } j \geq H \end{cases} \tag{10}$$

According to (10), QE reacts to both natural rate and credit shocks during the periods in which the policy rate is pegged, and returns to steady state thereafter. The required reaction to credit shocks is opposite the sign of the shock (i.e., when θ_t goes down, qe_t must increase). The necessary reaction to the natural rate shock is also negative. Rather naturally, QE moves in the opposite direction as the policy rate would absent a ZLB constraint in response to both shocks.

With QE policy so implemented, inflation will remain at target but the dynamics of the output gap will depend on the path of qe_t. In particular, the path of x_t can be solved for from (4):

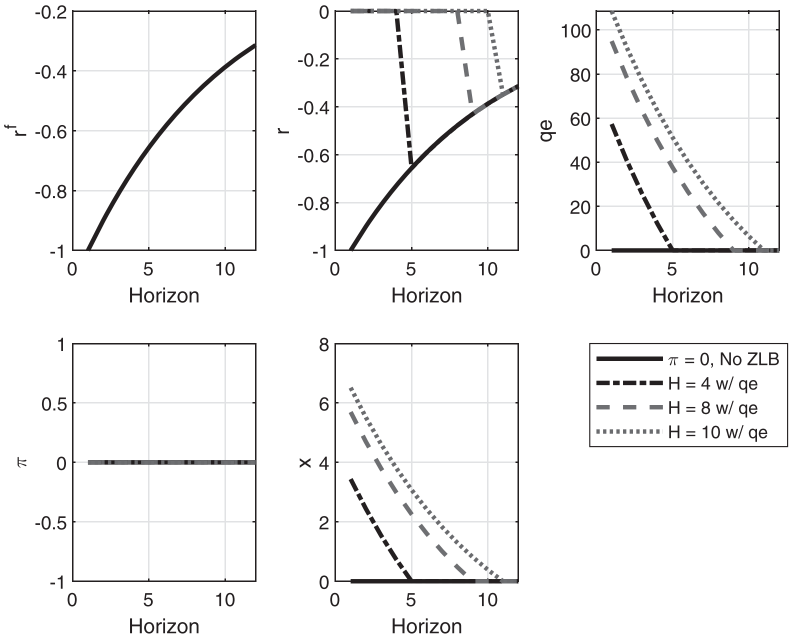
$$x_t = \frac{\sigma z}{(1-z)\zeta}\left[\bar{b}^{FI}\theta_t + \bar{b}^{cb} qe_t\right]. \tag{11}$$

From (11), $qe_t > 0$ will be expansionary for output. This means that x_t ought to fall less (in comparison with the ZLB with no unconventional policy reaction) in response to both contractionary natural rate and credit shocks when QE is deployed so as to stabilize inflation.

Figure 4 plots impulse responses to contractionary natural rate shocks. Solid lines show the base case of no ZLB and no QE, with the policy rate adjusting to implement a zero inflation rate. Alternative line styles plot responses when the ZLB binds but endogenous QE is implemented as described in (10). We again do so for three different durations of the ZLB: $H = 4$ (dash-dotted), $H = 8$ (dashed), and $H = 10$ (dotted).

As shown in figure 2, inflation and output both decline in response to a negative natural rate shock at the ZLB. Figure 4 shows that, to offset the decline in inflation, the central bank can increase its long bond holdings. The amount by which it must increase its bond holdings depends on the duration of the peg, a point to which we return below. Engaging in bond purchases keeps inflation at target. Consistent with (11), output declines by less and indeed rises

Figure 4. Impulse Responses to Natural Rate Shock at ZLB with Endogenous QE

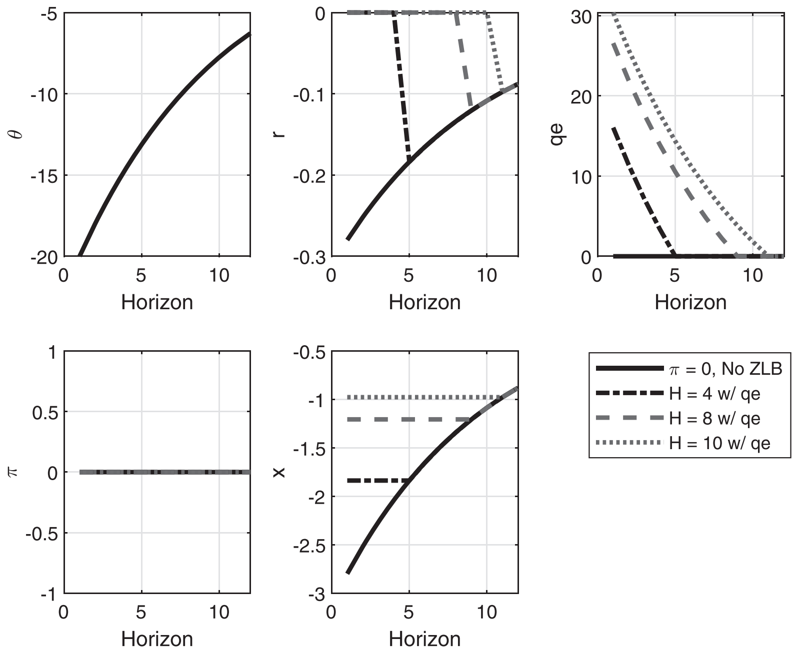


Notes: This figure plots impulse responses to a negative shock to the natural rate under a strict inflation target (solid line) and when the policy rate is constrained but endogenous QE is undertaken via (10). Dash-dotted lines correspond to $H = 4$, dashed lines to $H = 8$, and dotted lines to $H = 10$. After H periods policy reverts to implementing the strict inflation target via adjustment of the short-term interest rate with no QE.

(instead of falling) when positive bond purchases are undertaken so as to stabilize inflation at target.

Figure 5 plots responses to contractionary credit shocks. It is structured similarly to figure 4. At the ZLB with no QE, the output gap and inflation both decline in response to the shock. In contrast, figure 5 illustrates that when the central bank engages in endogenous QE, inflation remains at target and the output gap declines significantly less during the ZLB period in comparison to what happens when the central bank does nothing. Interestingly, the output

Figure 5. Impulse Responses to Credit Shock at ZLB with Endogenous QE



Notes: This figure plots impulse responses to a negative credit shock under a strict inflation target (solid line) and when the policy rate is constrained but endogenous QE is undertaken via (10). Alternative line styles show responses for different constraint lengths: dash-dotted lines correspond to $H = 4$, dashed lines to $H = 8$, and dotted lines to $H = 10$. After H periods policy reverts to implementing the strict inflation target via adjustment of the short-term interest rate with no QE.

gap responds less negatively to the credit shock at the ZLB with endogenous QE than it does absent a ZLB with conventional policy.

One will also note that the path of the output gap during the ZLB conditional on a credit shock is constant with endogenous QE. Combining (10) with (11), one can show that the path of the gap during the ZLB period is given by

$$E_t x_{t+j} = \frac{\sigma z \bar{b}^{FI}}{(1-z)\zeta} \rho_\theta^{H-j} E_t \theta_{t+j} \text{ for } j < H. \tag{12}$$

Since $E_t\theta_{t+j} = \rho_\theta^j\theta_t$, this expression reduces to

$$E_t x_{t+j} = \frac{\sigma z \bar{b}^{FI}}{(1-z)\zeta}\rho_\theta^H \theta_t, \tag{13}$$

which does not vary with j. Further, the bigger is H, the more qe_t reacts to the credit shock, and hence the output gap response is less negative during the period of the peg. When $H \to \infty$, (13) becomes

$$E_t x_{t+j} = 0. \tag{14}$$

In other words, if the ZLB persists forever, then stabilizing inflation conditional on credit shocks implies completely stabilizing the output gap. This may seem non-intuitive but is consistent with the results in Sims and Wu (2019b) that QE policy can completely neutralize the consequences of credit market shocks with no movement in the short-term policy rate. The reason why the gap is not completely stabilized for finite peg values here is that the central bank in these experiments reverts to using interest rate policy to stabilize inflation after the peg. This implies fluctuations in future output gaps that in turn affect the current output gap. When $H \to \infty$, future gaps are constant because interest rate policy is never resumed, and so the current output gap does not move.

The results in this section demonstrate that a central bank can significantly mitigate the costs of the ZLB by engaging in long bond purchases in our model. Inflation remains at target in response to both natural rate and credit shocks, and the response of the output gap is smaller compared with the case of engaging in no unconventional policy action. The response of the output gap is also smaller compared with normal times when QE is deployed in response to the credit shock. How much bond buying the central bank must do, and how this relates to the expected duration of the ZLB and the actual practice of the Federal Reserve in the wake of the financial crisis, are issues to which we turn next.

5. Substitutability between QE and the Shadow Rate

In this section, we expound upon the substitutability of QE with conventional monetary policy. In particular, we show how to map QE purchases into a shadow rate measure and compare this conversion with the observed patterns in U.S. data.

5.1 Theory

How to convert between QE purchases and the shadow rate—i.e., how much bond purchases are equivalent to a reduction in the policy rate of a given amount—remains a key question of interest for central banks. We address this question utilizing (7) and (10).

Suppose the economy is only subject to a natural rate shock. Then the ratio of the required QE purchase to stabilize prices relative to the necessary policy rate reaction is

$$\frac{qe_t}{r_t} = -\frac{(1-z)\zeta}{\sigma z \bar{b}^{cb}\chi}\frac{1-\rho_f^H}{1-\rho_f}. \tag{15}$$

Alternatively, suppose there is only the credit shock. Then the same ratio is

$$\frac{qe_t}{r_t} = -\frac{(1-z)\zeta}{\sigma z \bar{b}^{cb}\chi}\frac{1-\rho_\theta^H}{1-\rho_\theta}. \tag{16}$$

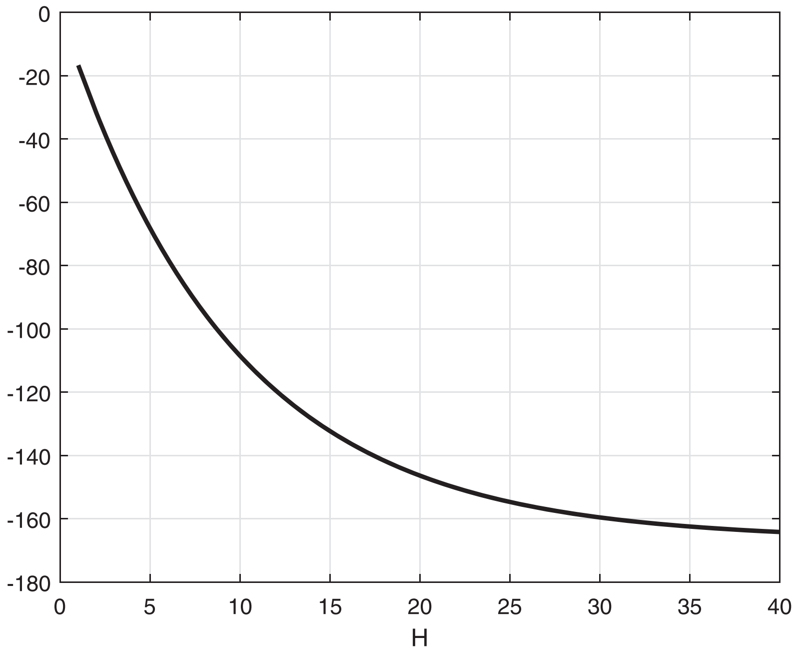
In practice, given their latent nature, identifying structural shocks remains a challenge. With the simple and plausible assumption that $\rho_f = \rho_\theta = \rho$, (15) and (16) collapse to the same expression:

$$\frac{qe_t}{r_t} = -\frac{(1-z)\zeta}{\sigma z \bar{b}^{cb}\chi}\frac{1-\rho^H}{1-\rho}. \tag{17}$$

Equation (17) provides an exact mapping between the requisite policy rate movement and QE purchase necessary to stabilize inflation about target. This ratio is nonpositive for all parameter values, meaning that QE purchases must move opposite of the policy rate.

Our model makes a novel yet intuitive prediction about the amount of QE required to stabilize prices as a function of the duration of an interest rate peg. To our knowledge, we are the first to note this interesting relationship. Figure 6 plots the required QE response to stabilize inflation relative to the necessary policy rate response (17) as a function of H. The QE response always has an opposite

Figure 6. Substitution Factor as a Function of *H*



Notes: This figure plots the substitution factor between QE and conventional policy, (17), as a function of the duration of the ZLB, H. Parameter values are set as described in table 1.

sign of the policy rate response and is decreasing in the duration of the ZLB, H. Rather naturally, for a longer expected duration of a ZLB episode, QE must move by *more* in order to attain price stability. The units are as follows. When $H = 8$, a 4 percentage point cut in the annualized policy rate is roughly equivalent to increasing the size of the balance sheet by about 160 percent.[7]

[7]The unit of time in our model is one quarter, so a 4 percentage point cut in the annualized policy rate is a 1 percent cut at a quarterly frequency. When $H = 8$, for our parameterization we have $\frac{qe_t}{r_t} = -94.92$. Thus, cutting r_t by 0.01 is equivalent to raising by qe_t by 0.9492. $\exp(0.9492) = 2.58$, so this corresponds to about a 160 percent increase in the size of the balance sheet.

5.2 QE and the Empirical Shadow Rate

In this subsection, we apply the conversion factor from above and use actual data on the expansion in the Fed's balance sheet to quantify its effect on the empirical shadow rate. Using the relationship in (17), we can estimate the model implied shadow rate as follows:

$$\widehat{s}_t = -\frac{qe_t}{\frac{(1-z)\zeta}{\sigma z \bar{b}^{cb}\chi}\frac{1-\rho^H}{1-\rho}}. \tag{18}$$

We use the baseline parameterization described in table 1. We assume an expected duration of the ZLB of $H = 8$, or two years. While the ZLB episode in the United States in fact lasted seven years, what is relevant is how long agents expect the ZLB to last ex ante. A two-year duration is roughly consistent with the estimated durations in Bauer and Rudebusch (2016) and Wu and Xia (2016). Using this parameterization, we then take actual data on the size of the Fed's balance sheet over the course of its QE operations to measure qe_t in (18) at each month from November of 2008 to October of 2014, which in turn allows us to calculate an implied time series of the hypothetical shadow rate series, $\widehat{s}_t$.[8]

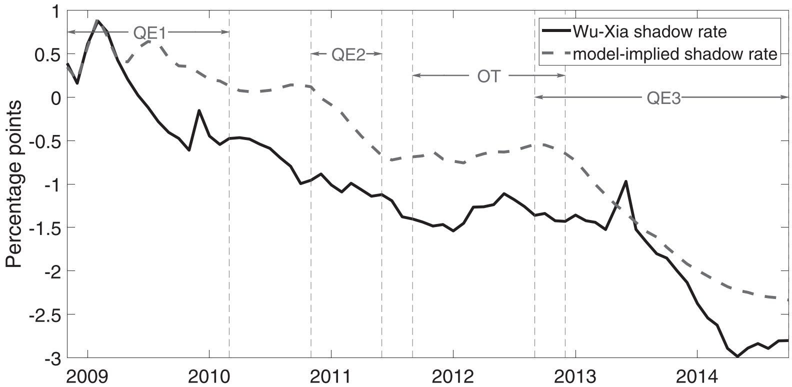
5.2.1 Results

We plot the relationship between the actual shadow rate and the shadow rate implied by the level of the Fed's balance sheet in figure 7. The solid line is the Wu and Xia (2016) shadow rate, and the dashed line plots the implied shadow rate calculated with the Fed's balance sheet using (18). The two lines appear very similar, implying that the theoretical relationship developed in subsection 5.1 works well in practice.

Figure 7 appears similar to figure 1. However, the crucial difference lies in how they are produced. This highlights the main

[8]For each period from November 2008 to October 2014, we measure $qe_t = \ln BS_t - \ln$ BS2007m12, where BS refers to total assets held by the Federal Reserve and we take December of 2007 as the reference point. We then multiply this by 400 (to translate into annualized units from our model), divide by the conversion factor, and add 4, the latter of which is necessary because $\widehat{s}_t$ is an absolute deviation relative to steady state, and in our model the steady-state policy rate is 4 percentage points annualized.

Figure 7. Wu and Xia (2016) Shadow Rate and Model-Implied Shadow Rate



Data Sources: Wu-Xia/Federal Reserve Bank of Atlanta and Federal Reserve Economic Data.
Notes: Solid line: the Wu-Xia shadow rate; dashed line: implied shadow rate calculated with the Fed's balance sheet using (18). Scale: interest rates in percentage points. QE1: the first round of QE from November 2008 to March 2010; QE2: the second round of QE from November 2010 to June 2011. OT: Operation Twist from September 2011 to December 2012. QE3: the third round of QE from September 2012 to October 2014.

contribution of our paper. In figure 1, the two lines use different scales (the Wu and Xia 2016 shadow rate on the left, and the actual Fed's balance sheet on the right). In figure 7, we are plotting the implied shadow rate from (18) using data on the size of the Fed's balance sheet, and both series are on the same scale.

Qualitatively, movements in the model-implied shadow rate series closely track those in the empirical series. The model-implied shadow rate series mostly lies above the actual Wu and Xia (2016) shadow rate. This suggests, quite naturally, that our model—which focuses solely on quantitative easing—does not capture all of the observed movements in the shadow rate that might arise from other types of unconventional policies (such as forward guidance). Moreover, there are other channels by which QE might provide stimulus to the economy that are not captured in our model—for example, the scarcity of safe assets (see Krishnamurthy and Vissing-Jorgensen 2011) or signaling the future path of the policy rate (see Bauer and Rudebusch 2014). After a minor upward blip, the model predicts a modest reduction of the shadow rate into negative territory during the QE1 period. The model predicts the largest decline in the shadow rate during QE3. These declines correspond with significant movements in the estimated Wu and Xia (2016) shadow rate. During the so-called Operation Twist episode, in which the Fed bought long-maturity securities financed through the sale of short-maturity bonds so as to maintain the size of its balance sheet, our model predicts little change in the shadow rate. This is precisely what one observes in the empirical Wu and Xia (2016) series. In May 2013, then Federal Reserve Board Chair Bernanke communicated a plan for winding down QE, an event which led to the so-called taper tantrum in financial markets. The taper tantrum coincides with a large temporary upward spike in the empirical shadow rate, but does not appear in the model implied shadow rate because this communication did not materialize in practice.

6. Conclusion

We use the four-equation linear New Keynesian model of Sims and Wu (2019b) to assess the substitutability between conventional monetary policy and QE at the ZLB. When short-term interest rates are fixed, QE can be utilized to achieve price stability, albeit with different implications for the output gap compared with conventional policy. Moreover, we show that the amount of QE required to implement an inflation target depends on the expected duration of the ZLB.

We use the model to derive an analytical substitution factor between conventional monetary policy and QE. We find that a doubling of the central bank's balance sheet provides stimulus roughly equivalent to a 3 percentage point cut in the policy interest rate. Taking the observed time series of the Fed's balance sheet over its QE operations as given, we use our substitution factor to assess how much of the decline in the Wu and Xia (2016) shadow rate series can be accounted for by QE. We find that QE1 through QE3 is equivalent to moving the policy rate a little more than 2 percentage points into negative territory. This lines up very closely with the empirical results in Wu and Xia (2016).

The results of our paper have a number of potentially important implications for the conduct of monetary policy going forward.

First, our finding that QE can serve as an effective substitute for conventional interest rate policy suggests that ZLB is not as costly as once thought. Therefore, implementing policy to reduce the likelihood of the ZLB binding again in the future—such as raising the inflation target (Ball 2014)—may not be desirable. Second, our conclusion that QE can serve as an effective substitute for conventional policy hinges on the ability of long-term interest rates to fall. This suggests that balance sheet normalization (i.e., quantitative tightening) after periods of substantial QE is likely desirable so as to provide more space for QE to be effective in subsequent episodes. Third, our results have implications for the desirability of negative interest rate policy. Studied in more depth in Sims and Wu (2019a), we urge caution in deploying negative short-term policy rates in the current environment. While doing so may lower long-term rates, negative short-term rates would likely leave less scope for QE to be effective by restricting the amount by which longer-term rates could decline. Finally, our analysis calls for heightened attention to monetary-fiscal interactions. In our model, increased issuance of long-term debt by the Treasury could undermine bond-purchasing programs by the central bank. This suggests that greater cooperation between fiscal and monetary authorities, particularly during strained times, is likely warranted.

Appendix A. No QE

Inflation targeting and no QE implies $\pi_t = 0$ and $qe_t = 0$. Plug these into the Phillips curve. We get (8). The IS equation becomes

$$r_t - r_t^f = \frac{\sigma}{1-z}(E_t x_{t+1} - x_t) - \frac{\sigma z \bar{b}^{FI}}{1-z}(E_t \theta_{t+1} - \theta_t). \tag{A.1}$$

Using (8), we can write this as

$$r_t - r_t^f = \frac{\sigma}{1-z}\frac{\sigma z \bar{b}^{FI}}{(1-z)\zeta}(E_t \theta_{t+1} - \theta_t) - \frac{\sigma z \bar{b}^{FI}}{1-z}(E_t \theta_{t+1} - \theta_t). \tag{A.2}$$

Since $E_t \theta_{t+1} = \rho_\theta \theta_t$, we can simplify this further to

$$r_t - r_t^f = \frac{\sigma z \bar{b}^{FI}(\rho_\theta - 1)}{1-z}\left[\frac{\sigma}{(1-z)\zeta} - 1\right]\theta_t. \tag{A.3}$$

Note $\zeta = \frac{\chi(1-z)+\sigma}{1-z}$, therefore $\frac{\sigma}{(1-z)\zeta} - 1 = -\frac{\chi}{\zeta}$. Hence (A.3) gives us (7). To derive (8), simply impose $\pi_t = qe_t = 0$ in (4) and rearrange so as to isolate x_t on the left-hand side.

Appendix B. Interest Rate Pegs

The short rate is constrained for H periods, after which time we revert to the conventional monetary policy described in (7). We derive the QE policy during the peg that generates the same zero inflation response. To do so, we solve backwards from $t+H-1$ (the last period the interest rate is pegged) to t.

B.1 Period $t + H - 1$

In period $t+H$, the interest rate peg ends, and we have r_{t+H} obeying (7), which means x_{t+H} obeys (8), $\pi_{t+H} = 0$, and $qe_{t+H} = 0$. In the last period of the peg, $t + H - 1$, $r_{t+H-1} = 0$, hence the IS curve is

$$\begin{aligned} x_{t+H-1} = {} & \frac{\sigma z \bar{b}^{FI}}{(1-z)\zeta} E_{t+H-1}\theta_{t+H} + \frac{1-z}{\sigma} r^f_{t+H-1} \\ & - z\bar{b}^{FI}(E_{t+H-1}\theta_{t+H} - \theta_{t+H-1}) + z\bar{b}^{cb} qe_{t+H-1}. \end{aligned} \quad \text{(B.1)}$$

From the Phillips curve, x_{t+H-1} satisfies

$$x_{t+H-1} = \frac{\sigma z}{(1-z)\zeta} \left[\bar{b}^{FI}\theta_{t+H-1} + \bar{b}^{cb} qe_{t+H-1}\right]. \quad \text{(B.2)}$$

Combine (B.2) with (B.1) to eliminate x_{t+H-1}:

$$\begin{aligned} & \frac{\sigma z}{(1-z)\zeta} \left[\bar{b}^{FI}\theta_{t+H-1} + \bar{b}^{cb} qe_{t+H-1}\right] \\ & = \frac{\sigma z \bar{b}^{FI}}{(1-z)\zeta} E_{t+H-1}\theta_{t+H} + \frac{1-z}{\sigma} r^f_{t+H-1} \\ & \quad - z\bar{b}^{FI}(E_{t+H-1}\theta_{t+H} - \theta_{t+H-1}) + z\bar{b}^{cb} qe_{t+H-1}. \end{aligned} \quad \text{(B.3)}$$

Eliminate fractions:

$$\bar{b}^{FI}\theta_{t+H-1} + \bar{b}^{cb}qe_{t+H-1} = \bar{b}^{FI}E_{t+H-1}\theta_{t+H} + \frac{(1-z)^2\zeta}{\sigma^2 z}r^f_{t+H-1} - \frac{(1-z)\zeta\bar{b}^{FI}}{\sigma}(E_{t+H-1}\theta_{t+H} - \theta_{t+H-1}) + \frac{(1-z)\zeta\bar{b}^{cb}}{\sigma}qe_{t+H-1}. \tag{B.4}$$

Write $E_{t+H-1}\theta_{t+H} = \rho_\theta\theta_{t+H-1}$ and simplify:

$$\bar{b}^{cb}\left[1 - \frac{(1-z)\zeta}{\sigma}\right]qe_{t+H-1} = \frac{(1-z)^2\zeta}{\sigma^2 z}r^f_{t+H-1} + (\rho_\theta - 1)\bar{b}^{FI}\left[1 - \frac{(1-z)\zeta}{\sigma}\right]\theta_{t+H-1}, \tag{B.5}$$

or

$$\bar{b}^{cb}\left[\frac{\sigma - (1-z)\zeta}{\sigma}\right]qe_{t+H-1} = \frac{(1-z)^2\zeta}{\sigma^2 z}r^f_{t+H-1} + (\rho_\theta - 1)\bar{b}^{FI}\left[\frac{\sigma - (1-z)\zeta}{\sigma}\right]\theta_{t+H-1}. \tag{B.6}$$

Simplifying further, we obtain

$$qe_{t+H-1} = (\rho_\theta - 1)\frac{\bar{b}^{FI}}{\bar{b}^{cb}}\theta_{t+H-1} + \frac{(1-z)^2\zeta}{\sigma z\bar{b}^{cb}(\sigma - (1-z)\zeta)}r^f_{t+H-1}. \tag{B.7}$$

B.2 Period $t+H-2$

Next, we go back to $t+H-2$, taking (B.7) as given. Writing out the IS curve, we have

$$x_{t+H-2} = E_{t+H-2}x_{t+H-1} + \frac{1-z}{\sigma}r^f_{t+H-2} - z\bar{b}^{FI}(E_{t+H-2}\theta_{t+H-1} - \theta_{t+H-2}) - z\bar{b}^{cb}(E_{t+H-2}qe_{t+H-1} - qe_{t+H-2}). \tag{B.8}$$

Plug in for x_{t+H-1} in terms of qe_{t+H-1} from (B.2):

$$x_{t+H-2} = \frac{\sigma z}{(1-z)\zeta}\left[\bar{b}^{FI}E_{t+H-2}\theta_{t+H-1} + \bar{b}^{cb}E_{t+H-2}qe_{t+H-1}\right] + \frac{1-z}{\sigma}r^f_{t+H-2} - z\bar{b}^{FI}(E_{t+H-2}\theta_{t+H-1} - \theta_{t+H-2}) - z\bar{b}^{cb}(E_{t+H-2}qe_{t+H-1} - qe_{t+H-2}). \tag{B.9}$$

From the Phillips curve, x_{t+H-2} also satisfies

$$x_{t+H-2} = \frac{\sigma z}{(1-z)\zeta}\left[\bar{b}^{FI}\theta_{t+H-2} + \bar{b}^{cb}qe_{t+H-2}\right]. \tag{B.10}$$

Plug this into (B.9):

$$\frac{\sigma z}{(1-z)\zeta}\left[\bar{b}^{FI}\theta_{t+H-2} + \bar{b}^{cb}qe_{t+H-2}\right] = \frac{\sigma z}{(1-z)\zeta}\left[\bar{b}^{FI}E_{t+H-2}\theta_{t+H-1} + \bar{b}^{cb}E_{t+H-2}qe_{t+H-1}\right] + \frac{1-z}{\sigma}r^f_{t+H-2} - z\bar{b}^{FI}(E_{t+H-2}\theta_{t+H-1} - \theta_{t+H-2}) - z\bar{b}^{cb}(E_{t+H-2}qe_{t+H-1} - qe_{t+H-2}). \tag{B.11}$$

Eliminate the fraction on the left-hand side:

$$\bar{b}^{FI}\theta_{t+H-2} + \bar{b}^{cb}qe_{t+H-2} = \bar{b}^{FI}E_{t+H-2}\theta_{t+H-1} + \bar{b}^{cb}E_{t+H-2}qe_{t+H-1} + \frac{(1-z)^2\zeta}{\sigma^2 z}r^f_{t+H-2} - \frac{(1-z)\zeta\bar{b}^{FI}}{\sigma}(E_{t+H-2}\theta_{t+H-1} - \theta_{t+H-2}) - \frac{(1-z)\zeta\bar{b}^{cb}}{\sigma}(E_{t+H-2}qe_{t+H-1} - qe_{t+H-2}). \tag{B.12}$$

Write $E_{t+H-2}\theta_{t+H-1} = \rho_\theta\theta_{t+H-2}$ and rearrange terms:

$$\bar{b}^{cb}\left[1 - \frac{(1-z)\zeta}{\sigma}\right]qe_{t+H-2} = \bar{b}^{cb}\left[1 - \frac{(1-z)\zeta}{\sigma}\right]E_{t+H-2}qe_{t+H-1} + \frac{(1-z)^2\zeta}{\sigma^2 z}r^f_{t+H-2} + (\rho_\theta - 1)\bar{b}^{FI}\left[1 - \frac{(1-z)\zeta}{\sigma}\right]\theta_{t+H-2}. \tag{B.13}$$

This implies

$$qe_{t+H-2} = E_{t+H-2}qe_{t+H-1} + \frac{(1-z)^2\zeta}{\sigma z\bar{b}^{cb}(\sigma-(1-z)\zeta)}r^f_{t+H-2} + (\rho_\theta - 1)\frac{\bar{b}^{FI}}{\bar{b}^{cb}}\theta_{t+H-2}. \tag{B.14}$$

Next, plug in for qe_{t+H-1} from (B.7):

$$qe_{t+H-2} = (\rho_\theta - 1)\frac{\bar{b}^{FI}}{\bar{b}^{cb}}E_{t+H-2}\theta_{t+H-1} + (\rho_\theta - 1)\frac{\bar{b}^{FI}}{\bar{b}^{cb}}\theta_{t+H-2} + \frac{(1-z)^2\zeta}{\sigma z\bar{b}^{cb}(\sigma-(1-z)\zeta)}E_{t+H-2}r^f_{t+H-1} + \frac{(1-z)^2\zeta}{\sigma z\bar{b}^{cb}(\sigma-(1-z)\zeta)}r^f_{t+H-2}. \tag{B.15}$$

Noting that $E_{t+H-2}\theta_{t+H-1} = \rho_\theta\theta_{t+H-2}$ and $E_{t+H-2}r^f_{t+H-1} = \rho_f r^f_{t+H-2}$, we have

$$qe_{t+H-2} = (1+\rho_\theta)(\rho_\theta - 1)\frac{\bar{b}^{FI}}{\bar{b}^{cb}}\theta_{t+H-2} + \frac{(1-z)^2\zeta(1+\rho_f)}{\sigma z\bar{b}^{cb}(\sigma-(1-z)\zeta)}r^f_{t+H-2}. \tag{B.16}$$

B.3 Period $t + H - 3$

Next, we go back to $t + H - 3$. Writing out the IS curve, we have

$$x_{t+H-3} = E_{t+H-3}x_{t+H-2} + \frac{1-z}{\sigma}r^f_{t+H-3} - z\bar{b}^{FI}(E_{t+H-3}\theta_{t+H-2} - \theta_{t+H-3}) - z\bar{b}^{cb}(E_{t+H-3}qe_{t+H-2} - qe_{t+H-3}). \tag{B.17}$$

Plug in for x_{t+H-2} in terms of qe_{t+H-2} from (B.10):

$$x_{t+H-3} = \frac{\sigma z}{(1-z)\zeta}\left[\bar{b}^{FI}E_{t+H-3}\theta_{t+H-2} + \bar{b}^{cb}E_{t+H-3}qe_{t+H-2}\right] + \frac{1-z}{\sigma}r^f_{t+H-3} - z\bar{b}^{FI}(E_{t+H-3}\theta_{t+H-2} - \theta_{t+H-3}) - z\bar{b}^{cb}(E_{t+H-3}qe_{t+H-2} - qe_{t+H-3}). \tag{B.18}$$

From the Phillips curve, x_{t+H-3} also satisfies

$$x_{t+H-3} = \frac{\sigma z}{(1-z)\zeta}\left[\bar{b}^{FI}\theta_{t+H-3} + \bar{b}^{cb} qe_{t+H-3}\right]. \tag{B.19}$$

Plug this into (B.18):

$$\begin{aligned}
&\frac{\sigma z}{(1-z)\zeta}\left[\bar{b}^{FI}\theta_{t+H-3} + \bar{b}^{cb} qe_{t+H-3}\right] \\
&\quad = \frac{\sigma z}{(1-z)\zeta}\left[\bar{b}^{FI} E_{t+H-3}\theta_{t+H-2} + \bar{b}^{cb} E_{t+H-3} qe_{t+H-2}\right] \\
&\qquad + \frac{1-z}{\sigma} r^{f}_{t+H-3} - z\bar{b}^{FI}(E_{t+H-3}\theta_{t+H-2} - \theta_{t+H-3}) \\
&\qquad - z\bar{b}^{cb}(E_{t+H-3} qe_{t+H-2} - qe_{t+H-3}).
\end{aligned} \tag{B.20}$$

Eliminate the fraction on the left-hand side:

$$\begin{aligned}
&\bar{b}^{FI}\theta_{t+H-3} + \bar{b}^{cb} qe_{t+H-3} \\
&\quad = \bar{b}^{FI} E_{t+H-3}\theta_{t+H-2} + \bar{b}^{cb} E_{t+H-3} qe_{t+H-2} \\
&\qquad + \frac{(1-z)^2\zeta}{\sigma^2 z} r^{f}_{t+H-3} - \frac{(1-z)\zeta\bar{b}^{FI}}{\sigma}(E_{t+H-3}\theta_{t+H-2} - \theta_{t+H-3}) \\
&\qquad - \frac{(1-z)\zeta\bar{b}^{cb}}{\sigma}(E_{t+H-3} qe_{t+H-2} - qe_{t+H-3}).
\end{aligned} \tag{B.21}$$

Write $E_{t+H-3}\theta_{t+H-2} = \rho_\theta \theta_{t+H-3}$ and rearrange terms:

$$\begin{aligned}
&\bar{b}^{cb}\left[1 - \frac{(1-z)\zeta}{\sigma}\right] qe_{t+H-3} = \bar{b}^{cb}\left[1 - \frac{(1-z)\zeta}{\sigma}\right] E_{t+H-3} qe_{t+H-2} \\
&\quad + \frac{(1-z)^2\zeta}{\sigma^2 z} r^{f}_{t+H-3} + (\rho_\theta - 1)\bar{b}^{FI}\left[1 - \frac{(1-z)\zeta}{\sigma}\right]\theta_{t+H-3}.
\end{aligned} \tag{B.22}$$

This implies

$$\begin{aligned}
qe_{t+H-3} = E_{t+H-3} qe_{t+H-2} + \frac{(1-z)^2\zeta}{\sigma z \bar{b}^{cb}(\sigma - (1-z)\zeta)} r^{f}_{t+H-3} \\
+ (\rho_\theta - 1)\frac{\bar{b}^{FI}}{\bar{b}^{cb}}\theta_{t+H-3}.
\end{aligned} \tag{B.23}$$

Next, plug in for qe_{t+H-2} from (B.16):

$$qe_{t+H-3} = (\rho_\theta+1)(\rho_\theta-1)\frac{\bar{b}^{FI}}{\bar{b}^{cb}}E_{t+H-3}\theta_{t+H-2}+(\rho_\theta-1)\frac{\bar{b}^{FI}}{\bar{b}^{cb}}\theta_{t+H-3}$$
$$+\frac{(1-z)^2\zeta(1+\rho_f)}{\sigma z\bar{b}^{cb}(\sigma-(1-z)\zeta)}E_{t+H-3}r^f_{t+H-2}$$
$$+\frac{(1-z)^2\zeta}{\sigma z\bar{b}^{cb}(\sigma-(1-z)\zeta)}r^f_{t+H-3}. \quad \text{(B.24)}$$

Noting that $E_{t+H-3}\theta_{t+H-2} = \rho_\theta\theta_{t+H-3}$ and $E_{t+H-3}r^f_{t+H-2} = \rho_f r^f_{t+H-3}$, we have

$$qe_{t+H-3} = (1+\rho_\theta+\rho_\theta^2)(\rho_\theta-1)\frac{\bar{b}^{FI}}{\bar{b}^{cb}}\theta_{t+H-3}$$
$$+\frac{(1-z)^2\zeta(1+\rho_f+\rho_f^2)}{\sigma z\bar{b}^{cb}(\sigma-(1-z)\zeta)}r^f_{t+H-3}. \quad \text{(B.25)}$$

B.4 Period $t+j$

Comparing (B.7), (B.16), and (B.25), we can generalize to period $t+j$

$$qe_{t+j} = \frac{\bar{b}^{FI}}{\bar{b}^{cb}}(\rho_\theta-1)\sum_{i=0}^{H-j-1}\rho_\theta^i\theta_{t+j}+\frac{(1-z)^2\zeta}{\sigma z\bar{b}^{cb}(\sigma-(1-z)\zeta)}\sum_{i=0}^{H-j-1}\rho_f^i r^f_{t+j}$$
$$= -\frac{\bar{b}^{FI}}{\bar{b}^{cb}}(1-\rho_\theta^{H-j})\theta_{t+j}+\frac{(1-z)^2\zeta}{\sigma z\bar{b}^{cb}(\sigma-(1-z)\zeta)}\frac{1-\rho_f^{H-j}}{1-\rho_f}r^f_{t+j}. \quad \text{(B.26)}$$

Using $\sigma-(1-z)\zeta = -\chi(1-z)$ yields (10).

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Financial Stability Considerations and Monetary Policy*

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The Federal Reserve faces a dilemma with respect to financial stability. On the one hand, the simplest interpretation of its mandate gives the Federal Reserve a limited role in addressing financial stability risks. On the other hand, monetary policy can interact with financial stability considerations. Hence, the Federal Reserve cannot ignore financial stability and has strong incentives to ensure that risks are not only identified but also addressed. Given that no part of the U.S. government can mitigate all of the threats identified by the Fed, we argue that Congress should evaluate the effectiveness of the post-crisis regulatory reforms.

JEL Codes: G01, G21, G23, G28, E02, E43, E58.

1. Introduction

"The Board of Governors of the Federal Reserve System and the Federal Open Market Committee shall maintain long run growth of the monetary and credit aggregates commensurate with the economy's long run potential to increase production,

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> so as to promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates."
>
> Monetary Policy Objectives, Federal Reserve Act

A plain reading of the Federal Reserve Act's instructions regarding monetary policy objectives makes no reference to financial stability considerations. So it might seem odd that these days, the Federal Reserve (Fed) pays significant attention to financial stability risks. We suspect the reason for doing so is twofold. First, financial instability was a central feature of the last recession. That recession was very costly and, in the course of battling it, the Fed and other central banks were forced to resort to unconventional and at the time untested monetary policy tools. Second, it is widely believed that some of these policies will become part of the standard toolkit and that, unless accompanied by appropriate macroprudential safeguards, they could have the potential to contribute to instability. Both of these factors suggest that there are important interdependencies between monetary policy and financial stability.

Echoing Dudley (2015) and Fischer (2015), we argue that the United States does not currently have a fully effective framework for managing financial stability risk. The Financial Stability Oversight Council (FSOC), which is formally tasked with responding to emerging threats to the stability of the United States, has a limited set of tools and powers that would not be sufficient to prevent a replay of the last crisis. It also has a limited ability to attend to financial stability risks that the Fed currently is concerned about.

These considerations put the Fed in a difficult position. The most natural interpretation of its mandate might be for the Fed to ignore financial stability risks and focus on a literal interpretation of its mandate. However, given the important interactions between monetary policy and financial stability risks, this option does not seem credible. This leaves three options. The Fed could hope that Congress will review and redesign the FSOC to expand its toolkit and powers. A second option is that Congress amends the Federal Reserve Act to give the Fed's Board of Governors an explicit financial stability objective and the additional powers necessary to achieve that objective. This would build on the Federal Reserve Board's separate regulatory and supervisory powers. A third possibility is the Fed could conclude that financial stability is a necessary condition for maximum sustainable employment and stable prices, and could ask the Fed's Federal Open Market Committee (FOMC), which is exclusively tasked with setting monetary policy to achieve the dual monetary policy mandate of stable prices and full employment, to incorporate financial stability considerations into its deliberations over monetary policy.

The remainder of the paper has four parts. First, we discuss the Federal Reserve Board's approach to identifying financial stability risks as laid out in its recently launched Financial Stability Report. By publishing a high-quality analytical Financial Stability Report, the Federal Reserve Board demonstrates that it takes financial stability risks seriously and sees them to be an important risk to the economic outlook.

Next, we consider two sets of financial stability risks that authorities might need to address at some point in the future. Drawing heavily on Aikman, Bridges, Kashyap, and Siegert (2019), we review the events leading up to the last crisis and explain what types of policy interventions would be necessary if we found ourselves faced with similar vulnerabilities. To consider a timelier example, we also consider which interventions might be necessary if the vulnerabilities identified in the Federal Reserve Board's recent Financial Stability Reports were to persist and intensify. In both cases, we find that the FSOC and its members would not have all of the necessary powers to mitigate these threats.

In a third section we argue that the Fed should take this regulatory underlap seriously: a future financial crisis would make it difficult for the Fed to achieve its dual mandate of price stability and full employment, given low equilibrium interest rates and potentially more limited monetary policy space. In addition, the regulatory underlap means that the Fed cannot rely on other authorities to offset any unintended consequences that its monetary policy stance might have for financial stability.

The final section considers the options mentioned above for reviewing the institutional framework. Each of these options has costs and benefits, so we do not see one dominant option. However, we think our analysis suggests that doing nothing and accepting the status quo arrangements bears significant risks. There is a strong case for Congress convening a commission to review the effectiveness of the post-crisis regulatory reforms, including whether authorities have sufficient flexibility to react to new vulnerabilities. The fact that financial stability policy and monetary policy are not always separable from each other means that it should also be in the Fed's interest to make sure that financial stability risks are not only identified but also effectively addressed.

2. The Federal Reserve Board's Financial Stability Report and Its Role in Identifying Financial Stability Risks

Despite lacking an explicit financial stability objective that extends beyond its supervisory responsibilities, in November 2018 the Federal Reserve Board launched a biannual Financial Stability Report, or FSR (Board of Governors of the Federal Reserve System 2018). In May 2019 it published the second edition of this report. The FSRs begin by stating that the report "summarizes the Federal Reserve Board's framework for assessing the resilience of the U.S. financial system and presents the Board's current assessment." The decision to publish an FSR despite not being explicitly responsible for financial stability suggests that the Federal Reserve Board considers financial stability risks to be of critical importance for the country's overall economic outlook. The fact that the Federal Reserve System takes financial stability risks very seriously is further evidenced by the fact that it has conducted two high-level "war games" that evaluated potential policy responses to financial stability risks (see below).

The FSR is a high-quality, analytic document that is filled with detailed commentary about the financial vulnerabilities facing the United States. It groups vulnerabilities into four categories: elevated asset valuations, excessive borrowing by businesses and households, excessive leverage within the financial system, and short-term funding risks. For each of these categories the FSR includes a wide range of data and useful charts that help the reader form a top-down view on current financial stability risks. The grouping itself, especially if we recognize that some of these factors are connected and interact, encompasses almost every plausible channel through which financial instability could arise. So the FSR casts a wide net in assessing risks that the Federal Reserve Board considers most important.

However, there are aspects of the way the FSR analysis is organized, and issues that are omitted, that are striking. First, while the FSR contains an overview section that describes the Federal Reserve Board's view on each of the various risk categories, it offers no summary measure of financial vulnerabilities. Even within each of the four categories that the FSR considers, it presents multiple indicators and leaves it to the reader to reconcile various pieces of countervailing information with the overall assessment of the risks.

Absent any agreed-upon summary indicators, different policymakers are free to cherry-pick their own preferred indicators of vulnerabilities, which makes reaching a consensus on the size of the vulnerabilities difficult; and having a consensus position on the risks the system is facing is presumably a necessary precursor to agreeing on any actions to address these risks. Imagine trying to achieve a dual mandate of stable prices and maximum employment without having agreed on any price or labor market statistics to discipline the discussion.

A second, related issue is that the FSR stops short of discussing potential policy interventions or recommending that relevant authorities take action. This may simply reflect the Federal Reserve Board's assessment that the current risk environment does not require any policy action, but it may also reflect the fact that the Federal Reserve Board is not explicitly tasked with addressing financial stability risks and may prefer to leave it to other authorities to draw the necessary conclusions.

A third issue is the way in which debt vulnerabilities are analyzed. The experience in the global financial crisis suggests that *who* ends up owing the debt can be much more important than the aggregate level of household debt. Most theories of "household deleveraging risk," i.e., the risk that highly indebted borrowers amplify a downturn by cutting back on consumption in order to continue servicing their debts, also point to the importance of focusing on the condition of the most highly indebted borrowers. Kashyap (2019) explains why, for households, the distribution of the debt service to income ratio (DSR) merits special attention. Essentially, he argues that the right-hand tail of that distribution is likely to be a good proxy of the number of at-risk households and deleveraging risk. Yet, the FSR shows no data on the distribution of debt service ratios for households. The analysis of corporate indebtedness is more granular but is largely restricted to large, listed companies.

Analyzing the distribution of debt servicing ratios can be challenging, as it requires detailed loan-level data. The Fed would appear to be in a good position to look at some of these issues. It already runs a detailed Survey of Consumer Finance that provides insights into the debt burdens of the most highly indebted borrowers. And the Home Mortgage Disclosure Act requires the vast majority of mortgage lenders to report their mortgage origination activity to the Federal Financial Institutions Examination Council. However, the data are subject to limitations, which makes it difficult to get a complete picture of household DSRs.[1]

For corporate borrowers, the Fed can rely on the financial statements of publicly listed firms or data on leveraged loan markets to provide some breakdown of debt levels by borrower types. But data availability can still be an issue when assessing the distribution of debt amongst smaller, privately held companies. In a “war game” that evaluated the policy response to any increase in U.S. financial stability risks, senior Fed officials also voiced concerns regarding the insufficient granularity of data on leveraged loans (Duffy et al. 2019).

3. Addressing Financial Stability Risks

Having argued that by publishing a comprehensive Financial Stability Report, the Fed acknowledges that financial stability is an important determinant of economic performance, we next consider whether the Fed can rely on others to address any risks that it might identify in its FSR. In particular, we will focus on whether the FSOC as the authority formally responsible for U.S. financial stability could be reasonably expected to address all identified vulnerabilities.

We take two perspectives on this question. First, we will draw on the analysis in Aikman, Bridges, Kashyap, and Siegert (2019)

[1]For instance, the data reported as part of the Home Mortgage Disclosure Act include second-lien mortgages separately, which makes it difficult to look at households’ combined DSRs. It also does not include other debts, such as auto loans and student loans. And while it contains data on borrowers’ income and the size and interest rate of the loan, it does not include data on the term of the loan. This means that amortization cost and DSRs have to be estimated based on average mortgage terms (see Butta, Popper, and Ringo 2015).

to identify the vulnerabilities that led to the global financial crisis, and consider the actions that authorities would have had to take to address these vulnerabilities. Second, we consider the main vulnerabilities identified in the Federal Reserve Board's November 2018 and May 2019 FSRs and consider the types of interventions that might be necessary if these vulnerabilities were judged to require policy action.

3.1 Addressing Vulnerabilities that Developed in the Run-up to the Financial Crisis

Aikman, Bridges, Kashyap, and Siegert (2019) argue that the financial system prior to the global financial crisis was vulnerable because of three factors. First, in the run-up to the financial crisis, the overall U.S. financial system was undercapitalized relative to the risks it was exposed to. While leverage in the traditional commercial banking system had remained largely the same, certain nonbank financial institutions that were outside of the regulatory perimeter had grown substantially. For example, between 2001 and 2007, nonbank financials accounted for more than 70 percent of the total growth in U.S. home mortgage credit. Broker-dealers in particular had always relied on high leverage, and largely funded their significant growth by issuing more debt. They were hence much less able to absorb losses than commercial banks. Table 1 shows leverage across different parts of the U.S. financial system.

The table also shows clearly the second important vulnerability: U.S. nonbanks were particularly reliant on short-term debt funding that could be withdrawn quickly in the event of stress. For example, the repo liabilities of broker-dealers increased from \$1.4 trillion in 2001 to \$3.0 trillion in 2007 (see figure 1).

The third important risk was the unprecedented surge in U.S. household debt (table 2). Mortgage debt doubled in the six years before the crisis, and by 2007 it had reached 72 percent of GDP. That boom was accompanied and reinforced by soaring property prices, which rose by two-thirds in the five years to their peak in early 2006.

The aggregate loan-to-value ratio on the stock of U.S. housing remained broadly flat during this period, meaning that for each 1 percent increase in house values, homeowners also increased their

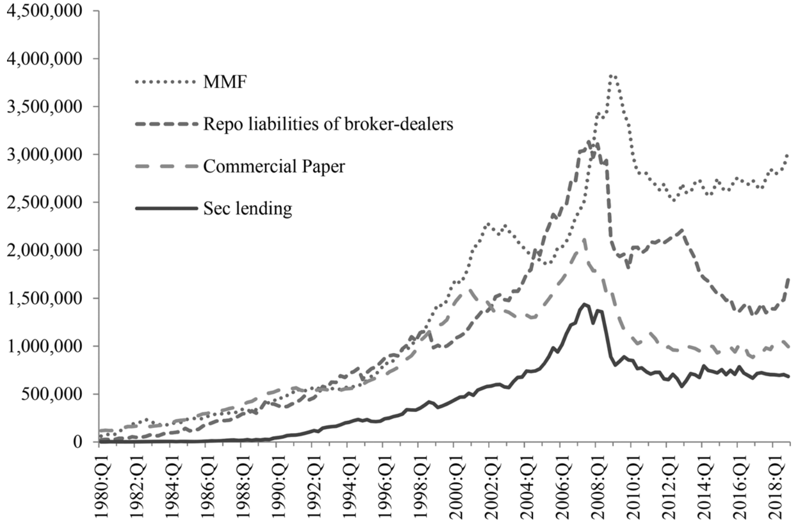
Table 1. Size and Structure of the U.S. Leveraged Financial System

	Size, Leverage, and Liquidity Risk of Leveraged Financial Institutions							
	2001:Q4				2007:Q4			
	Assets ($bn)	Leverage	Liquid Assets	Short-Term Funding	Assets ($bn)	Leverage	Liquid Assets	Short-Term Funding
Commercial Banks	6,552	11.0	6.6%	26.5%	11,182	9.8	4.6%	33.2%
Savings Inst.	1,317	11.6	3.0%	18.2%	1,852	9.1	2.3%	22.6%
Broker-Dealers	2,376	28	2.4%	57.3%	4,686	45	0.4%	63.4%
Gov.-Sponsored Enterprises	1,417	42.3	0.2%		1,677	23.7	0.7%	
Total	12,657				19,397			

Source: Financial Accounts of the United States; Federal Deposit Insurance Corporation; Adrian, Fleming, et al. (2017); and Annual Reports of Fannie Mae (Federal National Mortgage Association) and Freddie Mac (Federal Home Loan Mortgage Association).

Notes: Based on Aikman, Bridges, Kashyap, and Siegert (2019). “Leverage” is defined as total assets divided by (book) equity. “Liquid assets” refers to the ratio of cash and Treasury securities to total assets. For brokers, “short-term funding” refers to repo funding relative to total assets. For deposit takers, it refers to (estimated) uninsured domestic deposits and foreign deposits relative to total assets. While deposits are typically short-term liabilities, many types of deposits, including insured deposits in particular, are “behaviorally stable” and were not withdrawn during the crisis (see Martin, Puri, and Ufier 2018). Government-sponsored enterprises include Fannie Mae and Freddie Mac.

Figure 1. Increase in Short-Term Liabilities in the U.S. Financial System in $Million



Source: Financial Accounts of the United States, based on Adrian, de Fontnouvelle, et al. (2017).
Notes: The size of money market funds is measured as outstanding money market fund shares (liabilities) in table L.121 of the Financial Accounts of the United States. Commercial paper refers to commercial paper (liabilities) issued by any sector (table L.2019), which includes asset-backed commercial paper. Repo liabilities of broker-dealers are based on security repurchase agreements (liabilities) in table L.130. Securities lending captures net securities loaned by funding corporations in table L.132.

mortgage debt by around 1 percent. In part, this reflected the fact that existing homeowners extracted housing equity by taking out additional debt. More importantly, new homeowners took out larger mortgages in order to purchase more expensive homes.

As a result, affordability metrics for households become increasingly stretched. The share of the stock of mortgagors with debt of more than four times their income more than doubled between 2001 and 2007 from 6 percent to 13 percent.[2] The number of new subprime

[2] Above we have argued that debt servicing ratios (DSRs) are a good proxy for deleveraging risk. The variation in debt-to-income ratios that we consider here is closely related to variation in DSRs, but strips out variation in interest rates (which affects the cost of servicing a loan of a given size).

Table 2. U.S. Household Debt and Its Characteristics

	A. Household Debt and House Price Boom				
	2001:Q4	2004:Q4	2007:Q4	2017:Q4	
Level of Indebtedness: $trn; (% GDP in Parentheses)					
Household Debt	$7.9 (73.4%)	$10.9 (86.4%)	$14.3 (97.1%)	$15.1 (76.6%)	
of which: Mortgage Debt	$5.3 (49.7%)	$7.9 (62.5%)	$10.6 (72.4%)	$10.1 (51%)	
House Prices					
Annual Growth	6.7%	13.7%	−5.3%	6.2%	
Loan-to-Value Ratio (Mortgage Debt/Housing Assets)					
Household Sector	35.8%	37.6%	45.7%	36.1%	
	B. The Heavily Indebted Tail and Marginal Borrowers				
	2001:Q4	**2004:Q4**	**2006:Q4**	**2007:Q4**	**2017:Q4**
Heavily Indebted Tail	2001	2004	—	2007	2016
LTV > 90%	9.5%	9.4%	—	9.4%	10.6%
Debt to Income > 4x	6%	11%	—	13.2%	10.7%
DSR > 40%	16.9%	17.3%	—	20.2%	13.9%
Marginal Borrowers	2003	2004	2005	2006	2007:H1
Subprime					
Originations (# million)	1.1	1.7	1.9	1.4	0.2
Combined LTV (%)	90%	95%	100%	100%	100%
Proportion on "Teaser" Rates (%)	68%	77%	81%	77%	68%
"Near-Prime": Alt-A Pools					
Originations (# million)	0.3	0.7	1.1	0.9	0.3
Median Combined LTV (%)	90%	90%	90%	95%	95%
Proportion Interest Only (%)	16%	37%	40%	44%	52%

Sources: Financial Accounts of the United States; S&P/Case-Shiller; Federal Reserve Board's "Household Debt Service and Financial Obligations Ratios" release; Survey of Consumer Finance; Mayer, Pence, and Sherlund (2009).
Note: Based on Aikman, Bridges, Kashyap, and Siegert (2019).

mortgages nearly doubled between 2003 and 2005, and 80 percent of these mortgages were made with short-term “teaser” interest rates (Mayer, Pence, and Sherlund 2009).

Financial fragility and household debt affected the depth of the subsequent downturn in two separate but related ways. The fragilities in the financial system meant that lenders had to cut back lending as they struggled to absorb losses and saw funding withdrawn, which led to a credit crunch that reduced investment and employment. As households also struggled to deal with excessive debt, they cut spending, amplifying the downturn further. This effect is typically referred to as “household deleveraging risk” or the “aggregate demand externality.”[3]

3.1.1 Possible Interventions

Based on a range of studies, Aikman et al. (2019b) find that each of these two channels can explain between one-third and one-half of the depth of the crisis. So in order to make a meaningful difference to the severity of the crisis, authorities would have had to address both financial-sector fragility and household indebtedness. Aikman, Bridges, Kashyap, and Siegert (2019) estimate that policy interventions to significantly reduce both of these vulnerabilities would not have been prohibitively expensive, but they would have required an activist approach to macroprudential regulation.

However, the authority nominally in charge of financial stability, the FSOC, lacks the powers that would have been necessary to fully address the vulnerabilities that developed in the run-up to the crisis. In particular, the FSOC has no authority that would allow it to limit household debt buildups itself. It could have issued a “comply or explain” recommendation to the predecessor of the Federal Housing Finance Agency or relevant banking regulators to restrict the availability of mortgage financing. But it is not clear that these agencies would have had the authority to intervene on the grounds

[3] See Kashyap and Lorenzoni (2019) for a model that captures stability risks from both borrower and lender vulnerabilities and can be used to study when separate tools are needed for attending to both.

of financial stability concerns.[4] And while many of the macroprudential authorities that have been set up in other countries rely on issuing similar nonbinding recommendations, there are some indications that the FSOC's ability to influence other regulators is limited.[5] Attempts to issue recommendations have in the past received pushback from the relevant primary regulators. And in the context of money market mutual funds, the FSOC never finalized the draft recommendation that it had consulted on, even as the Securities and Exchange Commission decided to implement reforms that were more limited in scope.

The FSOC's ability to move unregulated entities into the regulatory perimeter is also limited. The FSOC's primary tool is the ability to designate nonbanks for higher capital requirements and enhanced supervision by the Federal Reserve Board. However, this process is limited to designating a small number of systemically important institutions, and some designations have been challenged and overturned by the courts. The FSOC can also issue "comply or explain" recommendations to impose new or heightened standards for all firms conducting certain activities to relevant primary regulators. But this relies on activities already being regulated. There is no clear process (such as a regular public review) for asking Congress to expand the regulatory perimeter to other, currently unregulated, activities.[6]

[4]Problems might not have been limited to the formal mandate of the primary regulators. In addition, there may have been issues in relation to regulators' resourcing and expertise. The predecessor agency to the Federal Home Financing Agency, the Office of Federal Housing Enterprise Oversight (OFHEO), ran a stress test in the first quarter of 2008 and concluded that Fannie Mae (Federal National Mortgage Association) and Freddie Mac (Federal Home Loan Mortgage Corporation) were capitalized sufficiently to withstand a 10-year period of housing market stress. Both Fannie Mae and Freddie Mac were deemed insolvent by September 2008. Based on this track record, it seems doubtful to us that the OFHEO would have been inclined to follow any guidance in this area.

[5]Edge and Liang (2019) document that out of 47 financial stability committees they survey, only 4 have powers to take direct actions themselves. In this sense the FSOC may be the rule rather than the exception internationally.

[6]In principle, the FSOC could recommend changes in the scope of regulation to Congress as part of the annual testimony on the FSOC's risk assessment. But we are skeptical if this would catalyze action unless it was part of a regular statutory process, such as an annual review of the regulatory perimeter.

The Federal Reserve Board's new post-crisis toolkit would likely have allowed it to address some of the vulnerabilities in the financial system. For example, it could have uncovered and addressed leverage and maturity mismatches in nonbank affiliates of bank holding companies (which would have included a number of large broker-dealers) via its annual stress tests, increased countercyclical capital buffers for bank holding companies, and set minimum margin requirements. But the Fed's powers are also limited. The Fed also lacks a clear, well-defined process for asking Congress to expand the scope of its supervisory powers to apply to new types of financial companies that might pose risks. And it has no tools that can be used to tackle household debt vulnerabilities. A June 2015 "war game" exercise conducted by four Reserve Bank presidents concluded that instead, the Fed's FOMC might have had to use monetary policy to lean against a buildup of risks outside of the core financial system (Adrian, de Fontnouvelle, et al. 2017).

Of course, post-crisis reforms have significantly changed the structure of the financial system, so the initial conditions we would be starting from would be very different. The banking system is better capitalized, and broker-dealers have either disappeared or been brought into the scope of prudential regulation. This means that an exact rerun of the developments that led to the last crisis would be much less damaging. So perhaps a more relevant consideration is whether the financial stability concerns that are currently being raised by the Federal Reserve Board could be well managed by the FSOC. This mirrors the focus of a more recent "war game" that Federal Reserve officials conducted in 2018 (Duffy et al. 2019).

3.2 Addressing Vulnerabilities Identified in the Last Two FSRs

The commentary in the Federal Reserve Board's first two FSRs suggests that currently the Federal Reserve's concerns focus on vulnerabilities in the area of asset valuations and corporate debt. Conversely, it strikes a more sanguine tone with respect to financial system leverage, funding risks, and household debt.

3.2.1 Asset Valuations

Within the broad area of asset valuations, the November 2018 FSR opens by discussing risks related to the high valuation of long-term Treasuries. It suggests that high valuations are in part driven by historically low term premiums—the difference between the yield investors require for holding longer-term Treasuries and the expected yield from rolling over shorter-dated ones. The May 2019 FSR provides evidence that low Treasury yields appear to be reflected in elevated prices of a range of other assets, such as corporate bonds or commercial real estate. This should not come as a surprise, as investors tend to use Treasury yields as a proxy for the risk-free rate that is used to discount the future payoffs of a wide range of financial assets.

Stretched asset valuations matter for financial stability because any sharp downward adjustment in prices can expose investors to losses and may threaten their solvency or liquidity.[7] However, not all sharp falls in asset prices are the same. For instance, the $20 trillion S&P 500 equity market briefly fell by 20 percent toward the end of 2018, and yet the real economy has continued to perform well. Similarly, while sharp falls in equity prices at the end of the "dot-com bubble" coincided with a recession, this recession was short and was generally considered benign by historical standards. Conversely, the 20 percent falls in house prices, and the resulting sharp fall in value of $1 trillion of U.S. subprime mortgage-backed securities in 2007 triggered a global financial crisis. Jordà, Schularick, and Taylor (2015) provide evidence that, more generally, equity bubbles are less likely to give rise to financial stability concerns than other types of asset price reversals, and price drops are more likely to pose risks to financial stability if the boom was fueled by debt. This difference may be driven by the fact that credit-driven bubbles can result in a debt overhang on the side of borrowers. It may also reflect the fact that equity funding tends to be provided by less high-leveraged real money investors who find it easier to absorb losses, while "safe" debt is more likely to be held by highly leveraged lenders.

[7]Losses on certain derivative positions can trigger significant margin calls, which can expose some nonbanks to liquidity risk even if there are no concerns regarding their solvency (see, e.g., Bank of England 2018).

One specific asset class that the FSR focuses on is corporate debt, and leveraged loans in particular. The November 2018 FSR presented evidence that high valuations in this sector are not fully explained by the low level of risk-free rates, and that the valuations appear particularly stretched for more risky assets (e.g., leveraged loans rated BB or lower). As part of a detailed discussion of ways in which leveraged loans could pose risks to financial stability, the May 2019 FSR shows that traditional financial institutions appear to be resilient to any sharp fall in asset prices, and that risks are more likely to be driven by the behavior of highly indebted borrowers (see below). However, sharp falls in asset prices may also pose risks to nonbanks that are important investors in leveraged loans and the collateralized loan obligations (CLOs) that are used to securitize around one-quarter of the global leveraged loan market. This includes structured credit funds, CLO managers, and hedge funds. Indeed, Bank of England (2019) shows that the majority of CLOs are held by nonbanks.

3.2.2 Borrowing by Businesses

High valuations of corporate debt tend to translate into accommodative conditions for new corporate borrowing, and into a buildup in corporate leverage. The FSR provides evidence that the current environment is no exception, and shows that the business credit-to-GDP ratio has grown significantly in the past five years. By May 2019 it had reached a historical high level. The ratio of debt to assets for publicly traded nonfinancial firms is also at one of the highest levels in recent history. Detailed analysis of balance sheet data suggests that within that, the most highly leveraged firms have increased their debt load the most. However, total debt service costs for these risky firms are being held down by low interest rates and are still at the low end of their historical range.

While the May FSR argues that losses on corporate loans are unlikely to pose risks to leveraged financial institutions that hold these loans, it does highlight risks related to the behavior of borrowers. In particular, any reassessment of risks in the corporate sector and the resulting tightening in financial conditions could have an effect on investment and employment by highly indebted corporates. This could have significant macroeconomic consequences and make any future downturn worse, including due to aggregate demand externalities similar to the ones discussed above.

3.2.3 Possible Interventions

Given the lack of summary indicators, it is unclear whether the Federal Reserve Board believes the vulnerabilities identified in its FSRs warrant policy actions. Instead, we focus on discussing potential policy options *assuming the risks warranted a meaningful policy response.*

The ability to mitigate threats from misaligned asset prices depends in part on the perceived reasons for any mispricing and the asset classes that are affected. Part of the elevated asset valuations appear to be driven by compressed term premiums, which affect a wide range of asset classes. This makes it difficult to use macroprudential measures to target asset valuations at source, e.g., by reducing the amount of new money flowing into a specific asset class. Instead, it may be appropriate to build resilience to potential price corrections by strengthening capital and liquidity requirements across the entire financial system. However, doing so is difficult, not least because large parts of the financial system are not currently subject to prudential requirements, and the FSOC and its member organizations have limited powers to impose such requirements.

In addition to compressed term premiums, there appear to be sector-specific factors that result in high valuations of corporate debt. An effective way of tackling risks specific to corporate debt valuation might be to subject the entities that are most exposed to risky corporate debt, such as structured credit funds, CLO managers, and hedge funds, to appropriate prudential requirements. However, these entities do not currently tend to be within the regulatory perimeter.

Instead, the appropriate policy response may involve limiting the amount of additional debt flowing into the corporate sector. Regulators could, for example, impose limits on banks' ability to originate loans that would result in the borrower's total debt exceeding a multiple of its earnings. Such an intervention would be similar to the nonbinding 2013 "Interagency Guidance on Leveraged Lending" published by U.S. banking regulators. Applying such rules at the origination stage would mean that they are effective even if the loans are not retained on banks' balance sheets.

Limiting the amount of new capital that can be made available to fund corporate debt would also address the vulnerabilities associated with corporate indebtedness by reducing borrowers' ability to take on additional debt and making them less likely to contribute to aggregate demand externalities in a downturn. However, the FSOC does not have any binding powers in this area. And while the Fed and other FSOC members might be able to take action, banking regulators have recently clarified that their existing nonbinding guidance in this area should be read as ensuring the resilience of banks rather than leaning against a buildup in corporate indebtedness. The head of the Office of the Comptroller of the Currency, for example, noted in February 2018 that "institutions should have the right to do the leveraged lending they want, as long as they have the capital and personnel to manage that and it doesn't impact their safety and soundness."[8] This statement suggests that banking regulators may feel they are not authorized to act based on concerns around borrower deleveraging risk.

These observations lead us to three important conclusions. First, both in the run-up to the global financial crises and in a hypothetical scenario in which the vulnerabilities identified in the current FSR intensify, effective policy interventions would involve changes to the regulatory perimeter as well as actions targeted at borrower indebtedness. Second, both historically and currently, the Federal Reserve Board is not well positioned to manage all of these vulnerabilities using its supervisory tools. Third, the FSOC also lacks the authority and tools to fully attend to these risks. This assessment is consistent with concerns voiced by Dudley (2015) and Fischer (2015) that the migration of activities outside of the regulatory perimeter, the lack of policy tools that can be flexibly recalibrated over time to match evolving risks, and the fragmentation of the regulatory landscape leave the United States without a fully effective macroprudential framework.

[8]See https://www.forbes.com/sites/debtwire/2018/02/28/new-occ-head-disowns-post-crisis-lending-guidelines-expects-leverage-to-increase/#30c27a3a54db.

4. Monetary Policy and Financial Stability Risks

The last section demonstrated that the Fed cannot reasonably expect other authorities to address all of the financial vulnerabilities that may develop. To the extent that the Fed's mandate of ensuring price stability and full employment was orthogonal to financial stability, this might not be an issue that the Fed needs to worry about. But below, we argue that there are a number of ways in which monetary policy and financial stability affect each other.

4.1 Effect of Financial Instability on Monetary Policy

Financial instability can have important implications for the FOMC's ability to achieve its monetary policy objectives of maximum employment and stable prices.

The most obvious way in which financial stability can affect the objectives of a monetary policymaker is by contributing to high unemployment, and by causing deflationary pressures that monetary policy may find difficult to offset. The latter is particularly relevant in a world characterized by low equilibrium interest rates ("r*"). The combination of a persistent slowdown in economic growth and shifting demographics means that the nominal rate of interest that we would expect the economy to operate at in equilibrium is currently estimated to be in the region of 2.5 percent, less than half its level in the late 1980s.[9]

The structural shifts that caused this decline in equilibrium interest rates are beyond the control of monetary policymakers. However, they are relevant for the conduct of monetary policy, as they may restrict the FOMC's ability to react to adverse shocks by lowering the federal funds rate below this equilibrium level. Historically, even standard recessions were typically associated with a roughly 5 to 6 percentage point reduction in the federal funds rate; and a modified Taylor rule suggests that if it hadn't been for the fact that interest rates cannot be reduced significantly below zero (the "effective lower bound"), it would have been appropriate to cut interest

[9]See, e.g., Holston, Laubach, and Williams (2017). This 2.5 percent is based on a predicted real rate of 0.5 percent and an assumed inflation rate of 2 percent.

rates by 9 percentage points during the last financial crisis.[10] So the FOMC may be stuck at the effective lower bound more frequently, and this would be especially likely following another severe financial crisis.

If low equilibrium interest rates restrict the FOMC's ability to react to future shocks in a way that allows the FOMC to "clean up" the consequences of the shock and continue meeting its inflation target, then the Fed should have an interest in ensuring that such shocks are as rare as possible.

4.2 Effect of Monetary Policy on Financial Stability

Importantly, the connections between monetary policy and financial stability run in both directions: while financial instability can affect the efficacy of monetary policy in "cleaning up" after a credit boom, loose monetary policy can also contribute to the buildup of a credit boom. This has led to a large body of literature that considers the merits of running monetary policy that is tighter than warranted by current macroeconomic conditions in order to "lean against the wind" (see below).

There are a number of ways in which discretionary monetary policy decisions could affect financial stability. We focus on the effect that monetary policy might have on the vulnerabilities described in the May 2019 FSR. This task is made more difficult by the fact that the FSR itself is largely silent on how monetary policy and financial stability risks may interact. Moreover, we focus on the effect of *unconventional* monetary policy tools on these vulnerabilities. Following the global financial crisis, the Fed has taken unprecedented actions to contribute to a slow but steady economic recovery, and has prevented much greater pain being inflicted on the economy.[11] These actions included reducing short-term interest rates to their effective lower bound, providing extensive liquidity support, providing forward guidance, and conducting large-scale asset purchase programs ("quantitative easing") that provided monetary stimulus while also helping to jump-start frozen asset markets. The decline in equilibrium interest rates that we have observed over the past

[10] See Bernanke (2015) and Rosengren (2019).
[11] See, e.g., International Monetary Fund (2013) or Chen et al. (2016).

decades creates challenges for traditional policy levers and may mean that policies like quantitative easing become a much more regular component of monetary policymakers' toolkit.

Below, we argue that unless accompanied by appropriate macroprudential measures, the more regular use of unconventional monetary policy tools could intensify the vulnerabilities identified in the FSR. If the Fed wants to be confident that it can always run a monetary policy stance that is appropriate in light of current macroeconomic conditions without worrying about contributing to a credit boom, then the Fed may want to ensure that any financial stability risks are being addressed effectively via other tools.[12]

4.3 Effect of Unconventional Monetary Policy on Asset Valuations

There is extensive evidence that the large-scale asset purchases that central banks conducted in the wake of the global financial crisis reduced Treasury yields not just by lowering future expected policy rates but also by compressing term premiums (see, e.g., Gagnon et al. 2011; Krishnamurthy and Vissing-Jorgensen 2011; D'Amico et al. 2012; Li and Wei 2013; Hanson and Stein 2015; Abrahams et al. 2016; and Kaminska and Zinna 2019). Moreover, a range of studies show that large-scale asset purchases also affected the prices of other assets such as corporate bonds (see, e.g., Krishnamurthy and Vissing-Jorgensen 2011; Joyce et al. 2012; and Swanson 2015).

The fact that unconventional monetary policy affects term premiums is hardly surprising. Asset purchases can not only contain a signal about future monetary policy, but they also have a mechanical effect on the balance between supply and demand for long-term bonds. Given that term premiums are defined as the yield *not explained* by future interest rate expectations, any increase

[12] A similar logic led the United Kingdom's Monetary Policy Committee to include a financial stability knockout criterion in its 2013 forward guidance. This criterion stated that the MPC would abandon its forward guidance if "the Financial Policy Committee (FPC) judges that the stance of monetary policy poses a significant threat to financial stability that cannot be contained by regulatory actions."

in bond prices that is driven by a greater scarcity of Treasuries will show up as a compression in term premiums. The effect of quantitative easing on term premiums is one of the key distinguishing features between quantitative easing and other monetary policy tools. Indeed, reducing term premiums was one of the key objectives of the Fed's large-scale asset purchases (see, e.g., Kohn 2009).

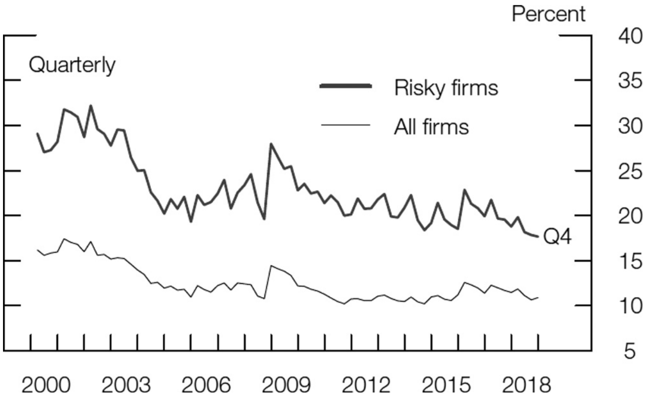
Low levels of term premiums are one of the key drivers of asset valuations highlighted in the May 2019 FSR. Stretched asset valuations are always a source of risk, but they may be of particular concern if they are driven by compressed term premiums. A compression in term premiums means that investors receive less compensation for the risk that inflation or short-term interest rates may surprise on the upside. This not only leaves the prices of long-term Treasuries, and the investors who hold them, vulnerable to a snap-back of interest rates to previous levels, but it also makes them more vulnerable to small deviations from their new expected path.

4.4 Effect of Unconventional Monetary Policy on Corporate Indebtedness

If monetary policy reduces the yield that investors expect to earn on corporate bonds, then this should also make it cheaper for corporates to roll over existing debt once it falls due. In the short term, this is good news from a financial stability perspective, as it reduces the burden of servicing an existing stock of debt. But in the longer term, financially constrained corporates may be tempted to use the additional breathing space that loose monetary policy affords them to increase the amount of debt funding. This is consistent with the fact that despite significant falls in interest rates, interest expense ratios for U.S. public nonfinancial corporates have remained broadly stable since 2005 (see figure 2).

The risks associated with such corporate "releveraging" may become apparent if interest rates rise again in the medium run, which might make some corporate borrowers' interest expense ratios unsustainable. Interest rates would appear to be most at risk of increasing if monetary policy rates are significantly below the long-term equilibrium rate of interest, or if unconventional

Figure 2. Interest Expense Ratio for Public Nonfinancial Corporations in the United States



Source: May 2019 Financial Stability Report.
Note: The interest expense ratio is defined as the ratio of total interest expenses to earnings before interest, depreciation, and taxes.

monetary policy has led to a temporary compression in term premiums.[13]

The risks associated with such releveraging are not confined to corporates. Internationally, policymakers tend to be at least as worried about the risks associated with household indebtedness, which might also be triggered by a snap-back in term premiums (or interest rates more generally). However, the average initial fixed interest rate period for mortgages in the United States (by far the biggest liability of U.S. households) is currently more than 25 years. More than four out of five new mortgages that have been taken out have had interest rates that are fixed for 30 years (Pradhan 2018). These choices mean that U.S. households are currently relatively insulated from rate movements so that any interest rate risk is likely to be borne by lenders.[14]

[13]This illustrates that a *tightening* in monetary policy can lead to the *crystallization* of vulnerabilities that have previously built up. However, our discussion focuses on the effect of monetary policy on the buildup of future vulnerabilities.

[14]A corollary of this is that lenders will need to hold enough capital to be able to absorb any interest rate risk without having to deleverage.

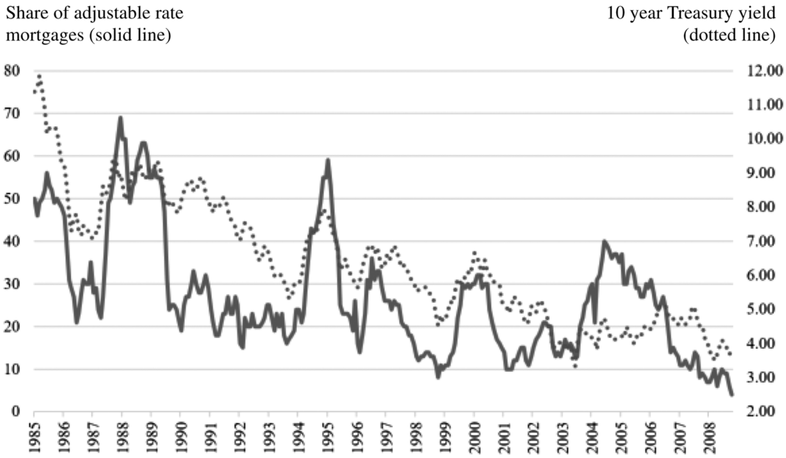
There are two important caveats to this relatively sanguine assessment of risks stemming from the interaction between monetary policy and household indebtedness in the United States. First, the shares of mortgages with long fixed terms vary regionally. In particular, more expensive areas tend to feature a larger share of adjustable-rate mortgages, which may appear more affordable. In particularly expensive areas such as Silicon Valley, the share of adjustable-rate mortgages is twice the national average. So there might be some regional variation in the effect of an interest rate snap-back. More importantly, the share of new mortgages that have adjustable rates tends to increase as interest rates rise and "locking in" low rates by taking out a fixed-rate mortgage seems less attractive.[15] For instance, when interest rates increased toward the end of 1994, the share of new mortgages that had adjustable rates reached more than 50 percent, with similar dynamics being observable in other tightening cycles (see figure 3). So the relatively benign current conditions for household exposure to interest rate movements are not guaranteed to persist.

4.5 Empirical Evidence for the Relationship between Term Premiums and Financial Stability

To explore the empirical significance of term premiums for financial stability, we can turn to the emerging literature on GDP-at-risk (see, e.g., Adrian et al. 2018; International Monetary Fund 2018; Adrian, Boyarchenko, and Giannone 2019; and Aikman, Bridges, Hoke, et al. 2019). Standard regression analysis seeks to explain the *mean* of the distribution of the variable of interest. The GDP-at-risk framework instead investigates the relationship between different indicators and the *left tail* of the future distribution of GDP. In our analysis we look at the determinants of the 10th percentile of the future GDP distribution. Roughly speaking, this allows us to check how financial stability risks affect the severity of a one-in-ten-year downturn at different time horizons. While not all downside risk to future GDP

[15] See Moench, Vickery, and Aragon (2010) for a more detailed analysis of how the share of adjustable-rate mortgages depends on (the term structure of) interest rates.

Figure 3. Correlation between the Share of Adjustable-Rate Mortgages and Interest Rates



Source: Federal Reserve and Federal Housing Finance Agency Monthly Interest Rate Survey.

is driven by financial conditions, we would certainly expect financial vulnerabilities to affect this downside risk.

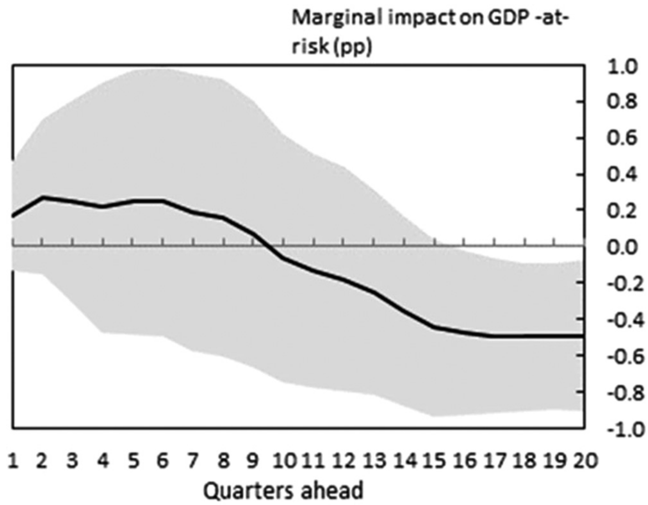
More specifically, our GDP-at-risk calculations summarize the relationship between the 10th percentile of the GDP distribution at various forecast horizons k as a function of vulnerabilities X and a set of control variables Z today (time t):

$$GDP^{10}_{t+k} = \beta X_t + \gamma Z_t.$$

Drawing on the methodology in Aikman, Bridges, Hoke, et al. (2019) and data on 16 advanced-economy countries running from 1995 to 2017, we find a subtle relationship between a compression in term premiums and the 10th percentile of future GDP. While a one-standard-deviation compression in term premiums seems to make relatively bad GDP outturns less bad in the short run, the net effect of a compression in term premiums turns significantly negative in the longer run (see figure 4).

While the evidence is only indicative and should not be interpreted as establishing a causal relationship, it is consistent with a

Figure 4. Effect of a One-Standard-Deviation Compression in Term Premiums on the 10th Percentile of GDP (in percentage points)

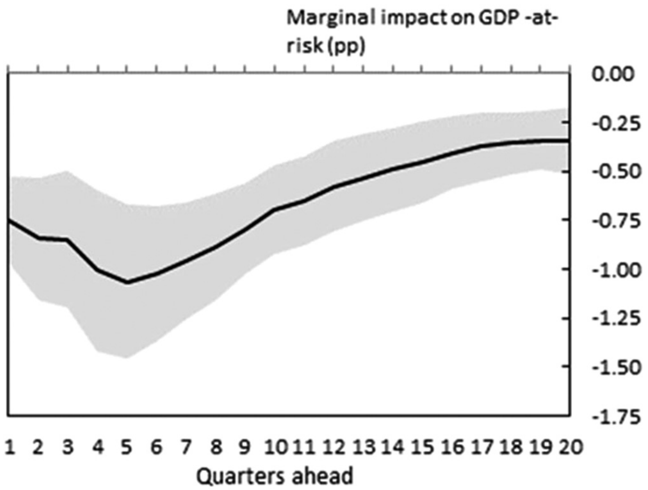


Notes: See Aikman, Bridges, Hoke, et al. (2019) for details on the methodology and data. Changes in GDP are measured as the change in the average annual rate of growth at each horizon. Shaded swaths indicate a two-standard-deviations range. All regressions control for lagged GDP growth to control for general macroeconomic conditions.

story where a compression in term premiums improves the short-term outlook for financial stability by supporting asset prices and reducing households' and corporates' debt servicing costs, but contributes to risks building up over time. Figure 5 provides some indicative evidence that this effect might operate through the influence of term premiums on debt servicing ratios and subsequent "releveraging" decisions. The chart demonstrates that GDP-at-risk is strongly correlated with the overall level of DSRs, and that higher DSRs are associated with larger downside risks to GDP growth over the entire horizon.[16]

[16]Hofmann and Peersman (2017) provide separate, confirming evidence on this effect by demonstrating that monetary tightening leads to an initial increase in DSRs, which is partially offset by lower debt levels in the long run. While this

Figure 5. Effect of a One-Standard-Deviation Increase in DSRs on the 10th Percentile of GDP (in percentage points)



Notes: See Aikman, Bridges, Hoke, et al. (2019) for details on the methodology and data. Changes in GDP are measured as the change in the average annual rate of growth at each horizon. Shaded swaths indicate a two-standard-deviations range. DSR data are taken from the BIS database for debt service ratios. The measure of DSRs that we use captures the debt service ratios of both households and nonfinancial corporations. Data on DSRs are only available from 1999, so figure 5 is based on a shorter sample than that used for figure 4. All regressions control for lagged GDP growth to control of general macroeconomic conditions.

5. Where Does This Leave Us?

The foregoing sections can be summarized as making two arguments. First, the Fed cannot reasonably expect the FSOC or any of its other member organizations to take action to address all of the vulnerabilities that may emerge in the future. Second, there are important interdependencies between its monetary policy objectives and financial stability that the Fed ought to take into account. If monetary policy can affect financial stability risks (and vice versa), then the

evidence looks at changes in the policy rate, we would expect to see similar effects for an increase in term premiums.

Fed should have an interest in ensuring that somebody is unambiguously responsible for addressing—and is empowered to address—these risks. That kind of separation in responsibilities would allow the FOMC to set aside financial stability risks when deciding on its monetary policy stance. However, given the remaining gaps in the regulatory architecture, that option does not currently exist. This leaves three alternatives to address the void.

5.1 Option 1: Revisit the FSOC

First, the Federal Reserve could encourage Congress to redesign the FSOC and expand its powers to effectively manage financial stability risk. In particular, the FSOC would need to have a more extensive and active role in publicly reviewing and—where necessary—recommending to expand the regulatory perimeter, and would need to have powers to address borrower indebtedness. This is important because the FSOC cannot rely on its members to be the front-line responders for dealing with these vulnerabilities. The member agencies do not have the relevant powers either, and, as Kohn (2014) has emphasized, not all the members even have an explicit financial stability objective.

Expanding the toolkit of the FSOC would appear to be the most natural approach, as it would build on the existing macroprudential framework that the United States has put in place following the crisis. It would also ensure that financial stability decisions are made by an authority that is used to focusing on tail risks rather than the central outlook of the economy (as, e.g., monetary policymakers are). Given that the Chairman of the Federal Reserve Board is a member of the FSOC, such an arrangement could also ensure effective coordination between monetary policy and macroprudential policy.[17]

[17]By "coordination" we do not mean that macroprudential policy and monetary policy should always be tightened or loosened at the same time. Our discussion above has illustrated that it can be optimal to tighten macroprudential policy precisely when monetary policy is optimally loose. Instead, we mean that the relevant policymakers are aware of each other's views and—where relevant—intended actions.

However, there is a widespread belief that the post-crisis overhaul of the regulatory framework has been completed, and whether an initiative to revisit the FSOC's powers would be successful is therefore doubtful. The experience of the Office of Financial Research (OFR) casts doubt on whether there is much appetite in either the Treasury or Congress for having a much more activist FSOC.[18] The OFR has been starved for resources and encountered various challenges when it tried to promote discussions of financial stability risks.

Moreover, this approach would double down on the current structure of the FSOC. This structure is centered on the Treasury Secretary, who chairs the Council and has numerous responsibilities, while the independent staffing available to support the FSOC is limited. The fact that the FSOC is chaired by a member of the administration can make it difficult for the committee to consistently abstract from short-term political considerations.

In practice, it seems that the committee's activities and actions have oscillated with the changes in the chairs. For example, in 2016 the chair appealed a ruling that MetLife was not to be designated as systemically important by the FSOC. Under a new chair, the FSOC supported dismissing this appeal in 2018, and published new designation guidelines that were publicly criticized by the two previous FSOC and Federal Reserve Chairs.[19]

One last consideration is that if the responsibilities of the FSOC were to be reopened, it seems inevitable that each of the member agencies would need to be consulted regarding changes. Given the different orientations and objectives of the different agencies, this sort of consultation is unlikely to result in the members speaking in unison.

[18] As a matter of disclosure, Kashyap was on the Federal Research Advisory Council to the OFR; however, these views are our own and we have not discussed this with any current or former members of the OFR leadership or the U.S. Treasury.

[19] The authors of the comment stated, "We caution against taking the steps outlined in the proposed guidance. We believe that these steps — in design and in practice — would neuter the designation authority. Though framed as procedural changes, these amendments amount to a substantial weakening of the post-crisis reforms. These changes would make it impossible to prevent the build-up of risk in financial institutions whose failure would threaten the stability of the system as a whole." See https://int.nyt.com/data/documenthelper/887-bernanke-geithner-lew-yellen-letter/a22621b202dfcb0fe06e/optimized/full.pdf#page=1.

5.2 Option 2: Expanding the Federal Reserve Board's Toolkit

As a second option, the Fed could ask Congress to amend the Federal Reserve Act to give the Federal Reserve Board an explicit financial stability objective, and to expand the Federal Reserve Board's toolkit beyond its existing supervisory powers to allow it to achieve this objective. Such an option might seem attractive, as it would be most likely to ensure the effective coordination of macroprudential policy and the FOMC's monetary policy decisions. The coordination benefits of having macroprudential policy and monetary policy committees sit within the same institution is one of the reasons why the United Kingdom decided to set up its macroprudential authority as a committee within the central bank. However, in order to address financial stability risks in a targeted and effective manner, the Federal Reserve Board would still require additional powers. Otherwise, the Federal Reserve Board may find itself in the same position that the FSOC is in today. Again, the powers that the Federal Reserve Board would require are likely to include powers to address excessive borrower indebtedness, as well as a process for publicly reviewing the regulatory perimeter and recommending any necessary changes to Congress.

Unless there is a broad consensus that the current arrangements for managing financial stability are inadequate, it is hard to imagine that Congress would make a surgical, targeted technocratic change to include explicit responsibilities and powers with respect to financial stability in the Federal Reserve's remit. But the risks associated with not having a fully effective financial stability framework suggest that there should be significant value in trying to build such a consensus. Hence, we include suggestions for an evidence-based review of the effectiveness of the current regulatory framework below.

5.3 Option 3: Use Monetary Policy to Address Financial Stability Concerns

A third approach could be for the Fed to conclude that financial stability is a necessary condition for achieving maximum sustainable employment and stable prices, and try to take actions to address financial stability risk even without Congress having made any changes to the Federal Reserve Act. However, unless the Federal

Reserve Act is being reopened to amend the Federal Reserve Board's objectives, it seems doubtful that the Federal Reserve Board would receive any of the additional powers that are necessary to address financial stability risks in a targeted way, as part of the Federal Reserve Board's supervisory responsibilities.

Instead, the Federal Reserve System might have to rely on the FOMC to incorporate financial stability considerations into its deliberations over the setting of monetary policy and use monetary policy to "lean against the wind." This would put a significant burden on the FOMC, which does not currently have any regulatory or supervisory objectives. A number of authors have argued that using monetary policy to lean against the wind may be optimal if the macroprudential toolkit is incomplete (see, e.g., Gourio, Kashyap, and Sim 2018; Caballero and Simsek 2019). However, monetary policy is a crude tool and is unlikely to be the most effective way of addressing financial stability risks (see, e.g., Farhi and Werning 2016 and Korinek and Simsek 2016). Convincing Congress to amend the Federal Reserve Board's objectives may hence be a price worth paying to be granted powers that allow the Federal Reserve Board to achieve those objectives.

6. Conclusion

Given that we have just passed the 10-year mark since the global financial crisis, there have been many conferences devoted to looking at the lessons from the crisis. In the course of these discussions, there have been many calls to reconsider whether the Dodd Frank Act went too far in regulating various aspects of the financial system. The current administration is in the process of rolling back some parts of Dodd Frank. This kind of reconsideration seems appropriate. Dodd Frank was enacted right after the crisis, and Congress has not yet undertaken a systematic review of this far-reaching piece of legislation in light of new research on the causes and consequences of the crisis, as well as in light of structural changes in the financial system.

However, it seems equally appropriate to step back and ask whether there are financial stability risks that Dodd Frank did not fully mitigate. As a first step, authorities would need to collect more granular data, including data on the distribution of debt across different borrowers, to identify financial stability risks. This could be achieved by enhancing the data-gathering abilities of the OFR. In addition, our analysis strongly suggests that there are two structural gaps in the current macroprudential landscape in the United States. One is the absence of any regulator having sufficient authority to extend the regulatory perimeter to account for risks that continue to appear outside the banking system. The fact that the Federal Reserve Board identifies leverage lending as a source for concern and that a large fraction of leveraged lending exposures are held by investors that reside outside of the regulatory perimeter is a timely reminder of why authorities need the flexibility to adjust the regulatory perimeter. A second gap is the absence of tools that regulators have for dealing with borrower indebtedness.

Our suggestion is for Congress to establish an expert commission to take a systematic look not only at whether there are areas in which post-crisis reforms have unnecessarily restricted the provision of financial services to the real economy, but also whether there are important regulatory gaps in the current architecture. This commission could survey international best practices for how financial stability risks have been addressed elsewhere and consider what might be suitable for the United States. It could also draw on detailed work that the Financial Stability Board has been doing at an international level to evaluate the effectiveness of post-crisis reforms and to identify new, emerging vulnerabilities. While the appetite to make any far-reaching changes to the U.S. framework may be limited, we believe our analysis suggests that there is a strong case for examining whether the current regulatory framework gives authorities enough flexibility to address emerging risks. And as a profession, we would struggle to explain why we have not done everything we can to reduce the risk of future crises.

The recent experience of the U.S. Commission on Evidence-Based Policymaking provides some insights into how such an expert commission might be designed. That commission was a bipartisan effort that was set up to address challenges that existed across multiple government agencies. It was sponsored by members of Congress who strongly believed in the mission of the commission and selected members based on technical expertise. The commission was given a clear deadline for when to issue a final report, and members worked hard on arriving at recommendations that had unanimous support. Many of their recommendations were included in the Foundations for Evidence-Based Policymaking Act of 2018 that was signed into law. For example, the act requires agencies to appoint a chief evaluation officer, and establishes a Chief Data Officer Council tasked with promoting data sharing among agencies. Upon completion of its work, some members of the commission continued to work through a think tank to support the implementation of the steps that had been agreed upon.

One advantage of starting with a commission to address these issues is that it allows experts to agree on a small set of tangible changes before putting its proposals to Congress. This would help focus the discussion on holes in the macroprudential toolkit that a group of experts identifies as most relevant, rather than debating a full rewrite of the FSOC's mandate or the Fed's responsibilities.

The Fed also has a key role to play in seeing that the issues we have raised are resolved: by publishing a comprehensive and insightful FSR, the Federal Reserve Board has already demonstrated that it takes financial stability very seriously. And the fact that financial stability policy and monetary policy are not always separable from each other means that it should be in the Fed's interest to make sure that financial stability risks are not only identified, but that there is also somebody minding the shop and ensuring that identified risks are being addressed.

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