

# Federal Reserve Policy in a World of Low Interest Rates\*

Eric R. Sims  
University of Notre Dame  
& NBER

Jing Cynthia Wu  
University of Notre Dame  
& NBER

October 24, 2019

The Federal Reserve (Fed) is tasked with maintaining price stability and achieving maximum employment. In practice, over the last decades the Fed has sought to achieve its objectives primarily through the manipulation of a short-term inter-bank interest rate, the federal funds rate (FFR).

At the height of the Great Recession of 2007-2009, the Fed pushed its benchmark policy rate to zero. With its principal tool unavailable, the Fed resorted to a sequence of unconventional policy actions in attempt to provide further stimulus to the economy. These actions included large-scale asset purchases (more commonly referred to as quantitative easing, or QE) and forward guidance. These programs were viewed by most as solutions to the temporary problem of the zero lower bound (ZLB) on the short-term policy rate. Market participants never expected the ZLB to last more than a couple of years (Bauer and Rudebusch 2016; Wu and Xia 2016), but in actuality the FFR was at zero for seven years. And though the Fed began raising the FFR at the end of 2015, it has since cut it twice, and at present the FFR sits less than two hundred basis points above zero. Markets are expecting further rate cuts in the near future.

A substantial body of research finds that the so-called natural rate of interest, or sometimes “r-star,” is on a continuing secular downward trend. Figure 1 plots the estimate of the natural rate from Laubach and Williams (2003), updated to the present. The dashed lined is a best-fitting trend line, and shaded gray regions are recessions as dated by the National Bureau of Economic Research (NBER). While the Laubach-Williams estimate of r-star declined substantially in the wake of the Great Recession, this decline is part of a longer-run downward trend. In standard models, optimal

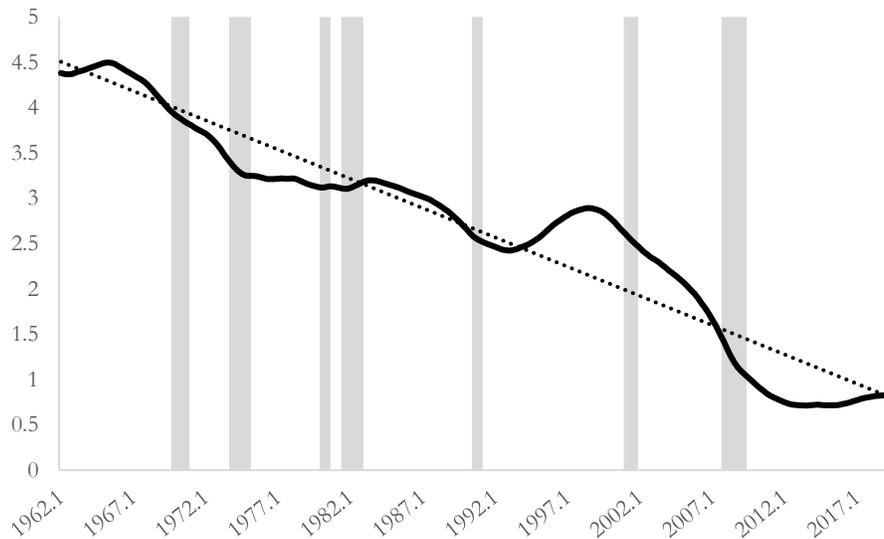
---

\* This paper was prepared for the Cato Institute’s 37<sup>th</sup> Annual Monetary Conference, “Fed Policy: A Shadow Review.”  
Correspondence: [esims1@nd.edu](mailto:esims1@nd.edu) and [cynthia.wu@nd.edu](mailto:cynthia.wu@nd.edu).

policy entails adjusting the policy rate to track movements in the natural rate. With the natural rate hovering so close to zero, there is little room for conventional policy rate cuts should the need arise.

All signs therefore point towards an extended period in which interest rates are significantly lower than their average levels from the 1980s to 2000s. This means that the problem of the ZLB and the inability to push the FFR down in response to deteriorating economic conditions is likely to arise again. As a consequence, the Fed must move away from its conventional operating framework – for example, by significantly raising its inflation target, experimenting with negative rates, or more regularly using unconventional tools like QE as a substitute for conventional rate cuts at the ZLB. Which of these options should the Fed and other central banks choose?

**Figure 1: Laubach-Williams (2003) r-star**



Source: Laubach and Williams (2003) and the [New York Fed](#). Shaded gray areas are recessions as defined by the NBER.

### **The Problem of the ZLB and Policy Proposals to Avoid It**

The macroeconomic models popular prior to the Great Depression – chiefly, New Keynesian dynamic stochastic general equilibrium (DSGE) models – were developed in the context of the Fed’s pre-crisis operating framework.<sup>1</sup> These models feature one short-term interest rate (the policy rate) and abstract from the myriad debt instruments that are ubiquitous in modern economies. Decision rules for consumption and investment are derived from microeconomic decision problems. Nominal rigidities in the form of price and/or wage stickiness are introduced, giving rise

---

<sup>1</sup> See Woodford (2003) or Galí (2008) for textbook treatments of New Keynesian models.

to a Phillips curve-type relation between inflation and resource utilization. Monetary policy is characterized via some sort of rule, such as the famed Taylor (1993) rule, for the short-term policy interest rate.

The ZLB poses a substantial constraint for stabilization policy in these models – after all, there is only one policy instrument, and at the ZLB this instrument is unavailable. Kiley and Roberts (2017) survey the costs of the ZLB in standard New Keynesian DSGE models and conclude that they are sizeable. At the ZLB, the economy is much more susceptible to adverse demand shocks, and supply shocks can have non-intuitive effects on output and other aggregates (Cochrane 2017 and Wieland 2019). Furthermore, at the ZLB the economy can get stuck in a self-fulfilling trap of deflation and negative output gaps (Benhabib, Schmit-Grohe, and Uribe 2001).

Based on the prevailing view that the ZLB imposes substantial costs, many economists have pushed for policy changes meant to reduce both the likelihood and length of ZLB episodes. One popular proposal is to raise the Fed's long-term inflation target. The logic behind such proposals is the celebrated Fisher relationship, which says that the nominal interest rate equals the real rate plus the rate of expected inflation. For a given real rate, higher expected inflation raises the nominal rate one-for-one. An inflation target of say, four percent instead of two, would therefore give the Fed and other central banks an average of two more percentage points of room for rate cuts before hitting the ZLB. See, for example, Ball (2014) or Eberly, Stock, and Wright (2019) for economists who have called for a higher inflation target.

A number of other economists have argued for wider implementation of negative interest rates as a policy tool. See, for example, Kimball (2017), Rogoff (2017), or Agarwal and Kimball (2019). Conventional wisdom holds that the existence of currency paying a zero nominal return places a floor of zero on interest rates on other assets. Contrary to this wisdom, a number of central banks – with the Fed being a notable exception – have successfully implemented negative policy rates without much trouble, and at present a large amount of sovereign debt is trading at mildly negative yields. Nevertheless, rates have not gone substantially negative anywhere in the world, and the existence of a zero yielding substitute like cash, as well as other features of financial markets and institutions, likely puts a cap on just how far into negative territory rates can fall. For this reason, some economists have called for the (near) abolition of paper currency (Rogoff 2016).

The elimination of barriers on how negative nominal interest rates can fall might entail significant changes in central bank operating procedures, but if successfully implemented would render the problem of low rates moot – the Fed and other central banks could adjust policy by

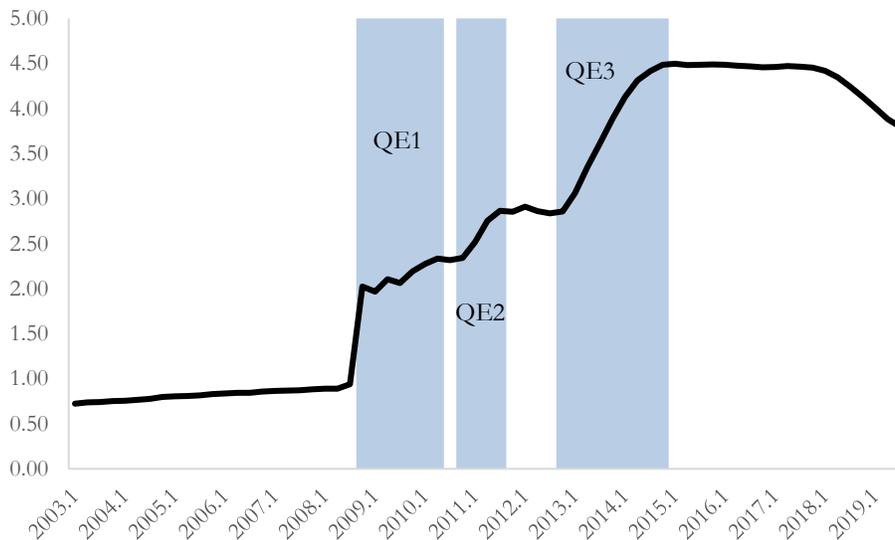
moving rates up or down as needed without regard for a binding floor, zero or otherwise. Increasing the inflation target by a few percentage points would give the Fed significantly more room to cut rates in the face of deteriorating economic conditions without having to worry about pushing rates into negative territory. Enabling deeply negative rates or increasing the inflation target would both represent a significant departure from Fed practice and would both certainly entail some potentially large costs. But if the ZLB poses a substantial threat, perhaps those costs are worth incurring.

### The Fed’s Unconventional Policy Actions

The large costs of a binding ZLB presuppose that central banks cannot do anything once policy rates have hit their floor. In actuality, neither the Fed nor the world’s other leading central banks sat idly by when short-term policy rates approached zero in the wake of the recent financial crisis and ensuing Great Recession. Rather, central banks engaged in a series of unprecedented policy actions meant to circumvent the ZLB. Taken together, these policy actions have been referred to as “unconventional” monetary policy.

In the middle of 2008, the total value of assets held by the Federal Reserve totaled less than \$1 trillion. The majority of these assets were Treasury bills, notes, and bonds, and most of these assets were held to maturity.

**Figure 2: The Fed’s Balance Sheet, 2003-2019**



Source: St. Louis Fed [FRED](https://fred.stlouisfed.org/). Shaded blue areas denote periods of active QE programs.

The Fed’s first round of quantitative easing (or QE1) began in November of 2008. The Fed initially began to buy \$600 billion of agency mortgage backed securities (MBS). The program was

extended in early March of 2009. The purchase of these securities was financed with the creation of bank reserves, on which the Fed had begun to pay interest in the fall of 2008.<sup>2</sup> A second round of quantitative easing, or QE2, was announced in November of 2010. It entailed purchasing another \$600 billion of assets through the creation of reserves, though this time involved purchases of longer maturity Treasury securities rather than agency mortgage backed securities. A third round of QE began in September of 2012. This was announced as an open-ended program with a target volume of agency mortgage backed securities purchases each month. Active balance sheet expansion ceased at the end of 2014. In between QE2 and QE3, the Fed engaged in the Maturity Extension Program (or “Operation Twist”), in which it sold short maturity Treasury securities and used the proceeds to buy up longer maturity Treasuries, in effect extending the maturity of its asset holdings without impacting the size of its balance sheet.

Figure 1 plots the magnitude of assets held on the Fed’s balance sheet dating back to 2003. Regions shaded light blue denote periods of active QE purchases (QE1, QE2, and QE3). As noted above, prior to the Great Recession, the balance sheet was under \$1 trillion. QE1, which was announced in the immediate wake of the Fed opening a number of emergency lending facilities, resulted in the Fed’s balance sheet being well over \$2 trillion by mid-2010. QE2 brought the balance sheet to nearly \$3 trillion and QE3 pushed the balance sheet to a peak of \$4.5 trillion. This represented a nearly five-fold increase in the size of the Fed’s balance sheet in the span of six years.

The other principal unconventional tool deployed by the Fed was forward guidance. Forward guidance involves telegraphing the intended path of policy rates after a period of low or zero rates. For an excellent overview of forward guidance and different types of forward guidance (e.g. Delphic versus Odyssean) see Campbell, Evans, Fisher, and Justiniano (2012). By credibly signaling the intended path of future policy rates, forward guidance is meant to push down current long-term interest rates via the logic of the expectations hypothesis.

Less explicit forms of forward guidance had been employed by the Fed and other leading central banks prior to the Great Recession, but forward guidance became an even more important and explicit policy tool when the FFR hit its lower bound. Table 1 presents a selection of quotes characteristic of different types of forward guidance. As soon as the FFR hit the ZLB in December 2008, the Fed included in its minutes wording that indicated it anticipated that economic conditions would warrant a low FFR for some time into the future. It later adopted a more calendar-based type

---

<sup>2</sup> See Ireland (2019) and Williamson (2019) for a discussion of the Fed’s paying interest on reserves.

of forward guidance, being explicit about when it anticipated pushing policy rates back above zero. Finally, the Fed moved to target-based forward guidance, announcing explicit targets for the unemployment and inflation rates that would need to be hit before increasing the policy rate.

**Table 1: Forward Guidance Announcements**

Date	Quote
Dec-08	"... weak economic conditions are likely to warrant exceptionally low levels of the FFR for some time."
Mar-09	"... weak economic conditions are likely to warrant exceptionally low levels of the FFR for an extended period."
Aug-11	"... economic conditions ... are likely to warrant exceptionally low levels of the FFR at least through mid-2013."
Sep-12	"... exceptionally low levels of the FFR are likely to be warranted at least through mid-2015"
Dec-13	"... will be appropriate to maintain the current target range for the FFR well past the time that the unemployment rate declines below 6-1/2%."

Source: Wu and Xia (2016)

### The Macroeconomic Effects of Unconventional Policies

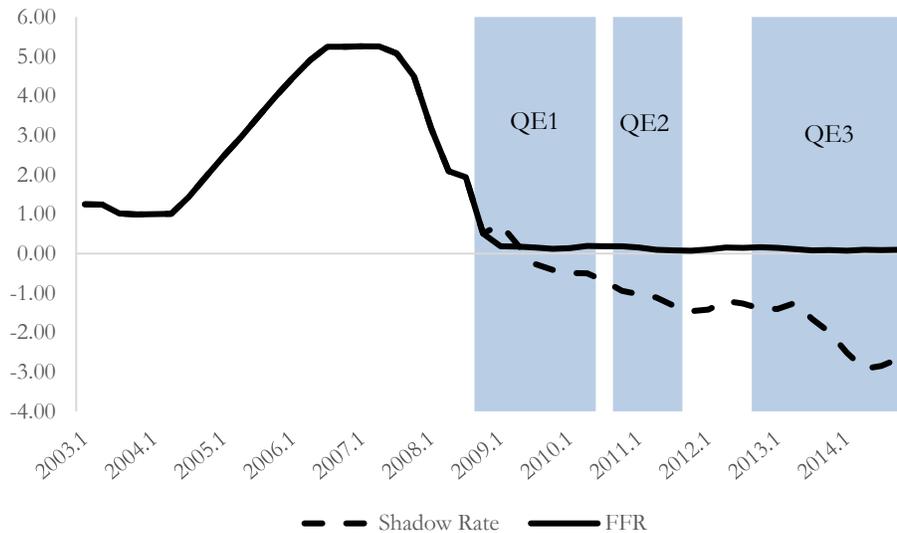
There is a large literature that empirically studies the macroeconomic effects of QE. See Gagnon, Raskin, Remache, and Sack (2011) and Krishnamurthy and Vissing-Jorgensen (2011) for high frequency event studies, Krishnamurthy and Vissing-Jorgensen (2012) for work based on a longer-run analysis of the effects of the supply of Treasuries on bond yields, or Hamilton and Wu (2012) for an analysis based on affine term structure models. The majority of papers in this area find stimulative effects of QE, though findings differ somewhat concerning the magnitude and persistence of effects. Swanson and Williams (2014) and Gagnon and Sack (2018) provide overviews of these literatures. Some authors, notably Greenlaw, Hamilton, Harris, and West (2018), have questioned the persistence of QE, highlighting that the stimulative effects found in many event studies are quiet transient. Swanson (2018a) argues instead that QE effects are both strong and persistent, and points to the special QE extension announcement from March of 2009 as driving some of the transience results in the literature.

There is a similarly large literature on the effects of forward guidance, some of which actually predates the Great Recession (Gürkaynak, Sack, and Swanson 2005). For more recent work, see, for example, Campbell, Evans, Fisher, and Justiniano (2012), Carvalho, Hsu, and Nechio (2016), or Campbell, Fisher, Justiniano, and Melosi (2017). These papers all find that forward guidance in particular, and central bank communication more generally, has important economic effects.

On balance, the literatures on QE and forward guidance find that unconventional policies had measurable economic effects that very likely lessened the severity of the Great Recession. See also the conclusion in Swanson (2018b). This coincides with several other empirical papers that show that the economy’s reaction to structural shocks during the ZLB period was not consistent with the predictions of standard New Keynesian macroeconomic models at the ZLB – see, e.g., Garín, Lester, and Sims (2019), Debortoli, Galí, and Gambetti (2019), Wieland (2019), and Wu and Zhang (2019).

A useful way to summarize the effects of unconventional policy actions is the so-called shadow rate. The shadow rate makes use of models of the term structure to infer a hypothetical value of short-term interest rates from the behavior of long-term rates as if there were no ZLB. A very popular shadow rate series is the one produced by Wu and Xia (2016). It is plotted in Figure 2 (dashed line) along with the effective FFR (solid line). The frequency of observation is quarterly and shaded blue regions denote periods of active QE purchases. The shadow rate reaches a nadir of nearly three percentage points below zero. This is suggestive that unconventional policy actions provided economic stimulus the equivalent of pushing the FFR significantly into negative territory.

**Figure 3: Wu-Xia (2016) Shadow Rate and Effective FFR**



Source: Cynthia Wu’s [website](#). Shaded blue areas denote periods of active QE programs.

## **Modeling Unconventional Policy as a Substitute for the Policy Rate**

The work cited above generally relies on reduced-form empirical techniques. In recent years, a number of researchers have worked to modify pre-crisis models to allow scope for unconventional monetary policy.

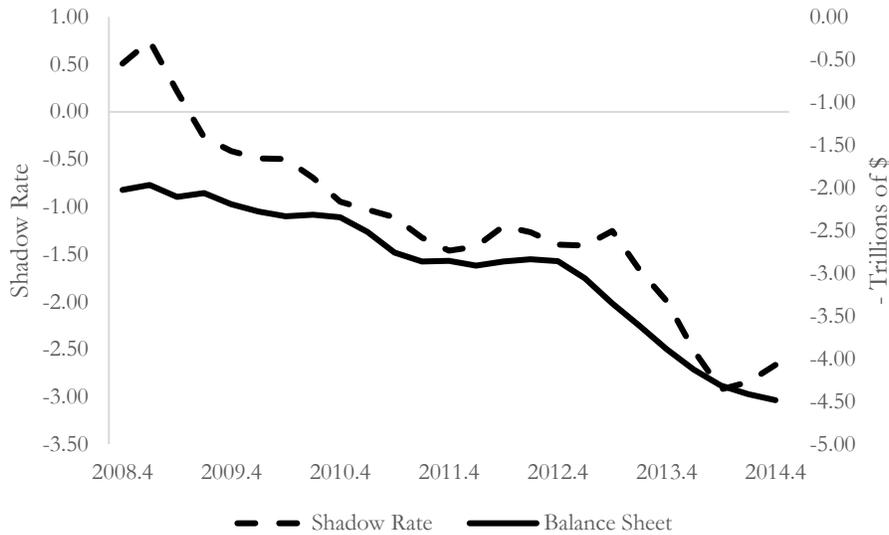
The efficacy of forward guidance in standard New Keynesian models has never been in doubt; indeed, the earliest work on the problem of the ZLB (e.g. Krugman 1998 and Eggertsson and Woodford 2003) called for the expansive use of forward guidance during such periods so as to mitigate the economic costs of policy being constrained. More recently, other researchers have concluded that standard models predict that forward guidance is too powerful relative to what is observed in the data (see, e.g. Del Negro, Giannoni, and Patterson 2013 and McKay, Nakamura, and Steinsson 2016).

Quantitative easing, in contrast, has no effects in standard macroeconomic models, where a form of “Wallace Neutrality” holds (Wallace 1981). To provide scope for QE to matter, several recent papers explicitly model constrained financial intermediaries – for example, see Gertler and Karadi (2011, 2013), Carlstrom, Fuerst, and Paustian (2016), and Sims and Wu (2019a). In these models, endogenous leverage constraints arise, and central bank purchases or sales of assets can impact these constraints so as to endogenously affect credit spreads. Sims and Wu (2019a) show that exogenous shocks to QE can have impacts similar to a conventional policy rate change, and in a counterfactual Great Recession simulation further show that a simple endogenous feedback rule for QE can largely mitigate the consequences of the ZLB.

The papers cited above employ medium-scale models with a number of different nominal and real frictions. Sims and Wu (2019b) instead develop a four equation version of the Sims and Wu (2019a) model that stays as close as possible to the benchmark three equation New Keynesian model of Galí (2008) while still allowing scope for QE. In a follow-up paper, Sims and Wu (2019c) ask how much of the decline in the Wu-Xia shadow rate can be accounted for by the Fed’s QE purchases.

The starting point of their analysis is depicted in Figure 3, which plots the Wu-Xia shadow rate on the left axis along with the negative of the Fed’s balance sheet over the course of its QE operations on the right axis (measured in trillions of dollars). The frequency of observation is quarterly. The association between the shadow rate and the balance sheet is obvious and is suggestive, though of course not dispositive, of a causal link between the two.

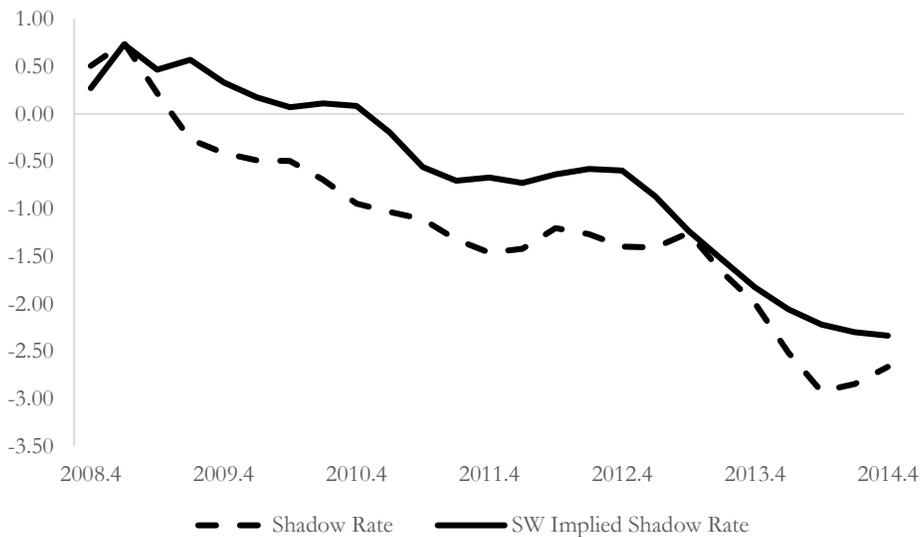
**Figure 4: Wu-Xia (2016) Shadow Rate and Fed Balance Sheet**



Source: Cynthia Wu's [website](#) and St. Louis Fed [FRED](#).

Sims and Wu (2019c) use the four equation model of Sims and Wu (2019b) to develop a model-implied shadow rate given the observed magnitudes of the Fed's balance sheet expansion. Calibrated to US data, they show that the observed increase in the Fed's balance sheet over the course of its QE operations can account for more than two-thirds of the decline in the Wu-Xia shadow rate. This is shown in Figure 4, which plots their model-implied shadow rate (solid line) along with the observed shadow rate (dashed line).

**Figure 5: Wu-Xia (2016) Shadow Rate and Sims-Wu (2019c) Model-Implied Shadow Rate**



Source: Sims and Wu (2019c).

The model-implied shadow rate of Sims and Wu (2019c) lies above the actual shadow rate in almost all periods.<sup>3</sup> This suggests, quite naturally, that QE alone cannot account for all of the observed stimulus from the Fed’s unconventional actions. After all, as noted above in Table 1 and elsewhere in the text, at the same time that it was engaging in active bond purchases, the Fed was also using forward guidance. These results are in-line with complementary work by Gagnon and Sack (2018), who argue that at peak the Fed’s QE operations provided economic stimulus the equivalent of moving the FFR nearly three percentage points below zero.

### **Higher Inflation, Negative Rates, or Unconventional Policy?**

Faced with a low and declining natural rate of interest, the Fed and other central banks must confront the reality that the pre-crisis operating framework of changing short-term policy rates needs some adjustment if monetary policy is to provide adequate stimulus in response to adverse economic shocks. Central banks must either significantly increase inflation targets so as to provide more room for traditional rate cuts, experiment with deeply negative rates and the requisite changes to the operating framework to make such actions feasible, or must regularly adopt unconventional actions such as QE and forward guidance whenever policy rates hit their lower bound.

We believe that the Fed and other central banks should opt for the latter of these options – unconventional policies, and in particular QE, ought to become a conventional part of central banks’ toolkits. Reduced form empirical studies, term structure models, and appropriately modified DSGE models all suggest that QE (and forward guidance) can provide adequate stimulus similar to conventional policy rate cuts. This conclusion aligns with work by Swanson (2018b) and Gagnon (2019). Even though there were serious concerns about potential side effects from QE at the time of its implementation (such as high inflation), few, if any, of these side effects have materialized. The massive run up and slow but steady decline in the Fed’s balance sheet in the last year or two seem to have gone off without a hitch. We therefore see no practical political economy concerns with continuing to deploy QE in the future.

Absent some sort of behavioral bias, policymakers should be weakly better off with more tools at their disposal. It should therefore be the case that the ZLB nevertheless imposes some costs on policymakers in particular and on the economy more generally. Indeed, Sims and Wu (2019b)

---

<sup>3</sup> Two exceptions are at the very beginning of the sample in late 2008 and early 2009, and in 2013 during the so-called “Taper Tantrum” where the shadow rate series increased while the Fed was still actively increasing the size of its balance sheet.

stress that QE is a good, albeit imperfect, substitute for conventional policy at the ZLB. Should, then, policymakers adopt one of the other two recommendations discussed in this paper to reduce the likelihood of the ZLB binding again in the future?

We are skeptical that raising the inflation target or experimenting more heavily with negative rates would do much good, and in fact could bring about other unintended consequences. The conquest of the high inflation of the 1970s and the credibility of the two percent inflation target were hard fought victories that took years to achieve. Abandoning the two percent target in light of the recent ZLB episode therefore strikes us as short-sighted. There are myriad potential costs of higher trend inflation. Coibion, Gorodnichenko, and Wieland (2012) find that the optimal inflation rate in New Keynesian models when taking the ZLB into account is quite small and remarkably close to the Fed's two percent target. Ascari, Phaneuf, and Sims (2018) argue that increasing the trend inflation rate from two to four percent could be quite costly. Diercks (2019) provides a meta-study of papers examining the optimal long run inflation target; the vast majority of these studies suggest that low or even negative inflation is optimal.

Negative rates have been implemented in a number of countries, although in no case have rates been pushed deep into negative territory. Eggertsson, Juelsrud, Summers, and Wold (2019) document in Swedish data that the transmission from policy to deposit rates breaks down once policy rates turn negative, and even show that policy rate cuts further into negative territory can lead to increases in lending rates. Similarly, Ulate (2019) theoretically emphasizes how negative policy rates can squeeze bank profitability, causing a partial breakdown of the usual monetary transmission mechanism. Similar forces are at work in Sims and Wu (2019a), whose model allows the interest rate on reserves to turn negative but imposes a ZLB on deposit rates. Negative rates can provide stimulus as a form of credible forward guidance, but also work to erode the net worth of intermediaries, which has a contractionary effect. In their model, when central banks carry very large balance sheets financed via bank reserves, negative rates can even become contractionary, similarly to the empirical findings in Eggertsson, Juelsrud, Summers, and Wold (2019).

## **Summary and Conclusions**

The recent experiences in the US and other developed economies of policy rates being pushed to their lower bound are likely not one-off events. A low and declining natural rate of interest means that the Fed and other central banks will likely have to confront again the challenges of combatting recessions with little or no room to cut short-term rates.

We argue, on the basis of a number of empirical studies as well as a literature based on quantitative macro models, that unconventional policies like quantitative easing and forward guidance may serve as effective substitutes for conventional rate cuts at the zero lower bound. Policy changes to reduce the incidence and severity of ZLB episodes, such as raising inflation targets or experimenting with deep negative rates, would impose additional costs and are therefore not desirable given the efficacy of policies such as QE.

## References

- Agarwal, Ruchir and Miles S. Kimball (2019) “Enabling Deep Negative Rates to Fight Recessions: A Guide.” IMF Working Papers 19/84.
- Ascari, Guido, Louis Phaneuf, and Eric Sims (2018) “On the Welfare and Cyclical Implications of Moderate Trend Inflation.” *Journal of Monetary Economics* 99: 56-71.
- Ball, Laurence M. (2014) “The Case for a Long-Run Inflation Target of Four Percent.” IMF Working Papers 14/92.
- Bauer, Michael D. and Glenn D. Rudebusch (2016) “Monetary Policy Expectations at the Zero Lower Bound.” *Journal of Monetary Economics* 48(7): 1439-1465.
- Benhabib, Jess. Stephanie Schmitt-Grohe, and Martin Uribe (2001) “The Perils of Taylor Rules.” *Journal of Economic Theory* 96(1-2): 40-69.
- Campbell, Jeffrey R., Charles L. Evans, Jonas D.M. Fisher, and Alejandro Justiniano (2012) “Macroeconomic Effects of Forward Guidance.” *Brookings Papers on Economic Activity* 1: 1-80.
- Campbell, Jeffrey R., Jonas D.M. Fisher, Alejandro Justiniano, and Leonardo Melosi (2017) “Forward Guidance and Macroeconomic Outcomes Since the Financial Crisis.” *NBER Macroeconomics Annual* 31: 283-357.
- Carlstrom, Charles T., Timothy S. Fuerst, and Mathias Paustian (2017) “Targeting Long Rates in a Model with Segmented Markets.” *American Economic Journal: Macroeconomics* 9(1): 205-242.
- Carvalho, Carlos, Eric Hsu, and Fernanda Nechio (2016) “Measuring the Effect of the Zero Lower Bound on Monetary Policy.” Federal Reserve Bank of San Francisco Working Paper 2016-06.
- Cochrane, John H. (2017) “The New-Keynesian Liquidity Trap.” *Journal of Monetary Economics* 92: 47-63.
- Coibion, Olivier, Gorodnichenko, Yuriy, and Johannes Wieland (2012) “The Optimal Inflation Rate in New Keynesian Models: Should Central Banks Raise Their Inflation Targets in Light of the ZLB?” *Review of Economic Studies* 79(4): 1371-1406.

- Del Negro, Marco, Marc Giannoni, and Christina Patterson (2013) “The Forward Guidance Puzzle.” Federal Reserve Bank of New York Staff Report 574.
- Debortoli, Davide, Jordi Galí, and Luca Gambetti (2019) “On the Empirical (Ir)Relevance of the Zero Lower Bound Constraint.” *NBER Macroeconomics Annual 2019*, forthcoming.
- Diercks, Anthony (2019) “The Reader’s Guide to Optimal Monetary Policy.” Available at [SSRN](#).
- Eberly, Janice C., James H. Stock, and Jonathan H. Wright (2019) “The Federal Reserve’s Current Framework for Monetary Policy: A Review and Assessment.” NBER Working Paper 26002.
- Eggertsson, Gauti, Ragner E. Juelsrud, Lawrence H. Summers, and Ella Getz Wold (2019) “Negative Nominal Interest Rates and the Bank Lending Channel.” NBER Working Paper 25416.
- Eggertsson, Gauti and Michael Woodford (2003) “The Zero Interest-Rate Bound and Optimal Monetary Policy.” *Brookings Papers on Economic Activity* 1: 139-235.
- Gagnon, Joseph (2019) “What Have We Learned About Central Bank Balance Sheets and Monetary Policy?” *Cato Journal* 39(2): 407-417.
- Gagnon, Joseph, Matthew Raskin, Julie Remache, and Brian Sack (2011) “The Financial Market Effects of the Federal Reserve’s Large-Scale Asset Purchases.” *International Journal of Central Banking* 7(1): 3-43.
- Gagnon, Joseph and Brian Sack (2018) “QE: A User’s Guide.” Peterson Institute for International Economics Policy Brief.
- Galí, Jordi (2015). *Monetary Policy, Inflation, and the Business Cycle*. Princeton, NJ: Princeton University Press.
- Garín, Julio, Robert Lester, and Eric Sims (2019) “Are Supply Shocks Contractionary at the Zero Lower Bound? Evidence from Utilization-Adjusted TFP Data.” *Review of Economics and Statistics* 101(1): 160-175.
- Gertler, Mark and Peter Karadi (2011) “A Model of Unconventional Monetary Policy.” *Journal of Monetary Economics* 58(1): 17-34.
- Gertler, Mark and Peter Karadi (2013) “QE1 vs. 2 vs. 3 . . . : A Framework for Analyzing Large-Scale Asset Purchases as a Policy Tool.” *International Journal of Central Banking* 9(1): 5-53.
- Greenlaw, David, James D. Hamilton, Ethan Harris, and Kenneth D. West (2018) “A Skeptical View of the Impact of the Fed’s Balance Sheet.” NBER Working Paper 24687.
- Gürkaynak, Refet, Brian Sack, and Eric Swanson (2007) “Market-Based Measures of Monetary Policy Expectations.” *Journal of Business and Economic Statistics* 25: 201-212.
- Ireland, Peter N. (2019) “Interest on Reserves: History and Rationale, Complications and Risks.” *Cato Journal* 39(2): 327-337.

- Hamilton, James D. and Jing Cynthia Wu (2012) “The Effectiveness of Alternative Monetary Policy Tools in a Zero Lower Bound Environment.” *Journal of Money, Credit and Banking* 44(s1): 3-46.
- Kiley, Michael T. and John M. Roberts (2017) “Monetary Policy in a Low Interest Rate World.” *Brookings Papers on Economic Activity* 48(1): 317-396.
- Kimball, Miles S. (2017). “Next Generation Monetary Policy.” *Journal of Macroeconomics* 54(A): 100-109.
- Krishnamurthy, Arvind and Annette Vissing-Jorgensen (2011) “The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy.” *Brookings Papers on Economic Activity* 2: 215-265.
- Krishnamurthy, Arvind and Annette Vissing-Jorgensen (2012). “The Aggregate Demand for Treasury Debt.” *Journal of Political Economy* 120(2): 233-267.
- Krugman, Paul (1998) “It’s Back! Japan’s Slump and the Return of the Liquidity Trap.” *Brookings Papers on Economic Activity* 2: 137-187.
- Laubach, Thomas and John C. Williams (2003) “Measuring the Natural Rate of Interest.” *Review of Economics and Statistics* 4: 1063-1070.
- McKay, Alisdair, Emi Nakamura, and Jon Steinsson (2016) “The Power of Forward Guidance Revisited.” *American Economic Review* 106(10): 3133-3158.
- Rogoff, Kenneth (2016). *The Curse of Cash*. Princeton, NJ: Princeton University Press.
- Rogoff, Kenneth (2017): “Dealing with Monetary Paralysis at the Zero Bound.” *Journal of Economic Perspectives* 31(3): 47-66.
- Sims, Eric and Jing Cynthia Wu (2019a) “Evaluating Central Banks’ Tool Kit: Past, Present, and Future.” NBER Working Paper 26040.
- Sims, Eric and Jing Cynthia Wu (2019b) “The Four Equation New Keynesian Model.” NBER Working Paper 26067.
- Sims, Eric and Jing Cynthia Wu (2019c) “Are QE and Conventional Monetary Policy Substitutable?” University of Notre Dame Working Paper.
- Swanson, Eric T. (2018a) “Measuring the Effects of Federal Reserve Forward Guidance and Asset Purchases on Financial Markets.” NBER Working Paper 23311.
- Swanson, Eric T. (2018b) “The Federal Reserve is not Very Constrained by the Lower Bound on Nominal Rates.” *Brookings Papers on Economic Activity* 2: 555-572.
- Swanson, Eric T. and John D. Williams (2014) “Measuring the Effect of the Zero Lower Bound on Medium- and Longer-Term Interest Rates.” *American Economic Review* 104(10): 3154-3185.

Taylor, John B. (1993) “Discretion versus Policy Rules in Practice.” *Carnegie-Rochester Conference Series on Public Policy* 39: 195-214.

Ulate, Mauricio (2019) “Going Negative at the Zero Lower Bound: The Effects of Negative Nominal Interest Rates.” Online working paper available [here](#).

Wallace, Neil (1981) “A Modigliani-Miller Theorem for Open Market Operations.” *American Economic Review* 71(3): 267-274.

Wieland, Johannes F. (2019) “Are Negative Supply Shocks Expansionary at the Zero Lower Bound?” *Journal of Political Economy* 127(2): 973-1007.

Williamson, Stephen D. (2019) “The Fed’s Operating Framework: How Does it Work and How Will it Change?” *Cato Journal* 39(2): 303-316.

Woodford, Michael (2003) *Interest and Prices: Foundations of a Theory of Monetary Policy*. Princeton, NJ: Princeton University Press.

Wu, Jing Cynthia and Fan Dora Xia (2016) “Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound.” *Journal of Money, Credit and Banking* 48(2-3): 253-291.

Wu, Jing Cynthia and Ji Zhang (2019) “Global Effective Lower Bound and Unconventional Monetary Policy.” *Journal of International Economics* 118: 200-216.