

Evaluating Monetary Policy at the Zero Lower Bound

By Craig S. Hakkio and George A. Kahn

Evaluating the stance of monetary policy has become very challenging. In the past, policymakers could simply compare the target federal funds rate to the prescriptions from simple policy rules to get a sense of whether the stance of policy was appropriate given economic conditions. However, as the economy fell deep into recession in 2008, the Federal Open Market Committee (FOMC) lowered its target for the federal funds rate to its effective lower bound. Since then, and until recently, many of the simple rules that have guided policy in the past have prescribed a negative federal funds rate target. However, with the federal funds rate constrained by the zero lower bound (ZLB) on nominal interest rates, the FOMC could not move the target federal funds rate below zero.

Instead, the FOMC turned to a number of unconventional policies to provide additional monetary accommodation. These other policies included several large-scale asset purchase programs and the use of “forward guidance.” Purchases of longer-term Treasury and agency mortgage-backed securities resulted in an expansion of the Federal Reserve’s balance sheet to more than \$4 trillion. Forward guidance provided

Craig S. Hakkio is a senior vice president and special advisor on economic policy with the Federal Reserve Bank of Kansas City. George A. Kahn is a vice president and economist at the bank. Lisa Taylor, a research associate at the bank, helped prepare the article. This article is on the bank’s website at www.KansasCityFed.org.

market participants information about how long the federal funds rate target might remain at its effective lower bound and how steep its trajectory might be after liftoff from zero. These policies are widely viewed as having put downward pressure on longer-term interest rates, providing additional monetary accommodation even though short-term rates remained constrained by the ZLB.

With the implementation of unconventional policies, there currently is no single, directly observable indicator that can summarize the stance of policy. Moreover, the economics literature provides no generally accepted rule for how unconventional policies should be adjusted in response to changing economic conditions. As a result, policymakers have had to use considerable judgment and discretion to calibrate the stance of policy in the aftermath of the Great Recession.

This article addresses these challenges by using a “shadow” federal funds rate to assess the overall stance of monetary policy. The shadow federal funds rate—based on research by Jing Cynthia Wu and Fan Dora Xia and by Leo Krippner—is a summary measure of the total accommodation provided by conventional and unconventional policies. It provides an estimate of what the federal funds rate would be, given asset purchases and forward guidance, if the federal funds rate could be negative. More precisely, it represents the policy rate that would generate the observed yield curve if the ZLB were not binding.

This shadow federal funds rate is then compared to the prescriptions from a policy rule estimated over a period of relative macroeconomic stability. The estimated rule shows how monetary policy responded in the past to economic conditions. The specification of the rule reflects the Federal Reserve’s dual mandate of price stability and maximum employment. It prescribes a setting for the federal funds rate that depends on the deviation of inflation from the FOMC’s medium to long-term objective of 2 percent and on two indicators of labor market activity that summarize a wide range of variables. The labor market indicators replace the unemployment or output gaps traditionally used in policy rules based on the concern that, currently, the unemployment rate may not be a reliable indicator of economic slack and that the output gap is difficult to measure in real time.

Based on deviations of the shadow federal funds rate from the prescriptions of the estimated policy rule, policy was not sufficiently

accommodative in the immediate aftermath of the Great Recession but became considerably more accommodative over time. While the unconventional policies adopted by the FOMC were effective in pushing the shadow federal funds rate well below zero, they did not initially lower it sufficiently to reach the level prescribed by the estimated rule. Over time, however, the shadow federal funds rate fell below the rate prescribed by the rule, suggesting that monetary policy became more accommodative. On a cumulative basis, the under-accommodative stance of policy is roughly offset by the more recent highly accommodative stance.

I. THE SHADOW FEDERAL FUNDS RATE

The conventional tool of Federal Reserve monetary policy is the federal funds rate. Traditionally, an increase in the funds rate would be associated with a tightening of policy while a lowering of the rate would be associated with an easing of policy. However, once the federal funds rate reached the ZLB in December 2008 and the FOMC turned to unconventional monetary policies, the funds rate could no longer fully characterize the stance of policy.

One unconventional tool was the use of explicit forward guidance about the likely future path of the federal funds rate target. For example, in August 2011, the FOMC introduced date-based forward guidance by saying low interest rates were likely to continue “at least through mid-2013.” The FOMC later began describing economic conditions that would warrant consideration of a change in the federal funds rate, going so far as to specify numerical thresholds for the unemployment and inflation rates.

Another unconventional tool was large-scale asset purchases, also known as quantitative easing (QE). The FOMC introduced three separate programs to purchase long-term Treasury and agency mortgage-backed securities starting in late 2008. In addition, in September 2011, the FOMC implemented a maturity extension program (MEP) to extend the average maturity of its securities holdings by purchasing longer-term Treasury securities and selling an equal amount of shorter-term Treasuries. Both QE and MEP were designed to lower longer-term interest rates. Together with forward guidance, these programs were widely viewed as adding accommodation beyond that provided by the

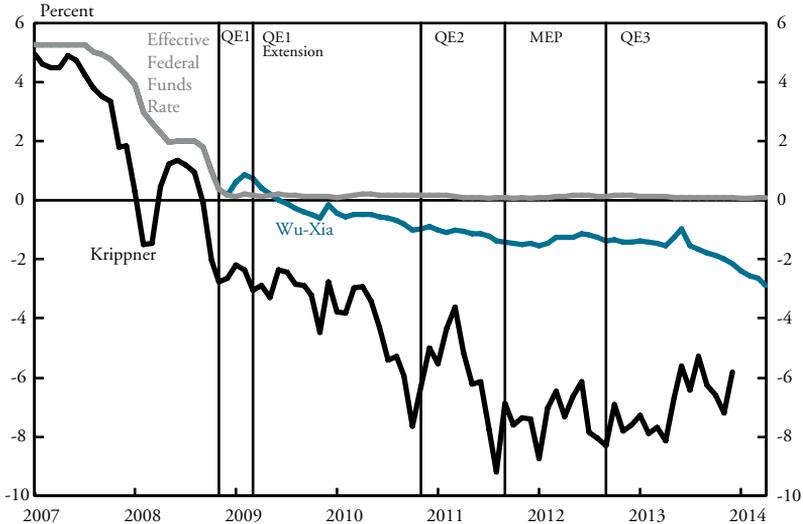
near-zero level of the federal funds rate. But the policies were untested, and their effect on economic conditions is difficult to determine.

In response, economists have used information from asset pricing models and the term structure of interest rates to estimate a “shadow” federal funds rate that is not constrained by the ZLB. The estimates address the following question: “What policy rate would generate the observed yield curve if the policy rate could be taken negative?” (Krippner 2012, p. 2). The intuition is simple, but the implementation is complex.¹ Consider the interest rate yield curve, with maturities from very short (overnight) to very long (10 years to 30 years). The ZLB constrains interest rates of short maturity because cash, which pays zero interest rate, is available and preferable to holding an asset that pays a negative interest rate. Thus, the ability to hold cash provides significant protection against negative interest rates that would otherwise prevail if cash were not available. Subtracting the value of the call option to hold cash at the ZLB from the actual yield curve produces a shadow yield curve.

The idea that the stance of monetary policy can be measured by a shadow interest rate when the federal funds rate is constrained by the ZLB is controversial (Kim and Priebsch; Krippner, 2012 and 2014). After all, the shadow rate is not directly observed and is model specific. As a result, different models may yield different estimates of a shadow federal funds rate. In addition, while borrowers and lenders may face longer-term interest rates that incorporate expectations of remaining at the ZLB for a period of time, they do not directly face the negative federal funds rates implied by the shadow rate.

Despite these reservations, economists have used estimates of the shadow federal funds rate as an indicator of the overall stance of monetary policy (see, for example, Bullard and Hamilton). Two such estimates are shown in Chart 1. One is provided by Wu and Xia, and the other is provided by Krippner (2014). The two rates differ considerably, however. Krippner’s shadow rate is much more negative and volatile than the shadow rate calculated by Wu and Xia. These differences reflect different estimation techniques, different models, and different maturities used in constructing yield curves.

Chart 1
SHADOW FEDERAL FUNDS RATES



Sources: Federal Reserve Board, Haver Analytics, Krippner (2014), Wu and Xia (2014).

Nevertheless, both shadow rates suggest unconventional policies provided additional monetary accommodation beyond the accommodation from the zero-constrained effective federal funds rate. Both shadow measures fall below zero, with the Wu-Xia shadow rate reaching almost minus 3 percent in 2014 and the Krippner measure falling as low as minus 9 percent. In addition, movements in the two measures are highly correlated (with a correlation coefficient of 0.82 from January 2009 to December 2013). Importantly, both measures generally declined either in anticipation of, or in response to, the various large-scale asset purchase programs, commonly known as QE1, the QE1 extension (which increased the total assets purchased under QE1), QE2, and QE3.² The only exception is the Krippner shadow rate, which rose after QE3. In contrast, the shadow funds rates showed little movement around the date of the MEP announcement.

The analysis in this article focuses on the Wu-Xia shadow federal funds rate for several reasons. First, the Krippner shadow rate is volatile. This volatility seems inconsistent with the idea that the stance of monetary policy changes gradually over time and not on a month-to-month basis. Second, the Krippner shadow rate arguably declines too far and too fast to be a credible indicator of the monetary policy stimulus

provided by forward guidance and asset purchases. Third, the Krippner index differs from the actual effective federal funds rate even when that rate is above zero. In contrast, by construction, the Wu-Xia index is exactly equal to the actual effective federal funds rate when that rate is above 0.25 percent. Finally, the Krippner rate is not updated on a regular basis, and currently, the data series ends in December 2013. In contrast, the Wu-Xia shadow rate is regularly updated and available on the Federal Reserve Bank of Atlanta's web site at http://www.frbatlanta.org/cqer/researchcq/shadow_rate.cfm.

II. THE ESTIMATED POLICY RULE

Policymakers often use simple rules to guide monetary policy decisions (Kahn 2012). The most famous such rule was introduced by John Taylor (1993). It relates the setting of the federal funds rate to the deviation of inflation, p_t , from a target rate of 2 percent and the deviation of real GDP from a measure of potential, or full-employment, real GDP—which is referred to as the output gap:³

$$\text{Federal funds rate}_t - p_t = \alpha + \beta[p_t - 2] + \gamma[\text{output gap}_t].$$

Taylor specified the parameters of the rule based on earlier research on interest-rate reaction functions, setting the coefficients on the inflation and output gaps equal to 0.5 and the intercept equal to 2. In contrast, this article *estimates* a simple rule over a period of relative macroeconomic stability (from the late 1980s to the early 2000s) when the ZLB was not a binding constraint. The estimated rule is intended to capture how policymakers actually responded to economic conditions over a time period when policy decisions were associated with good macroeconomic performance.

The estimated rule is then used to describe how policymakers might have responded to economic conditions after 2008 had they not been constrained by the ZLB, assuming their responses were similar to those in the earlier period of macroeconomic stability. Prescriptions from the rule, which are not constrained by the ZLB, provide a normative reference for the federal funds rate. These prescriptions can then

be compared to the shadow federal funds rate, which is assumed to represent the actual stance of policy.

Specification

The specification of the estimated rule differs from the one proposed by Taylor in several important ways. First, one lag of the federal funds rate is included on the right side of the equation to capture the effects of policy inertia, which many analysts consider to be desirable in theory and consistent with monetary policy in practice.⁴ Second, the inflation rate is measured by the personal consumption expenditure price index excluding food and energy prices as opposed to the GDP price index. And third, labor market slack is used as the measure of economic activity rather than the output gap.

The use of labor market indicators in the policy rule is consistent with the Federal Reserve's dual mandate from Congress. Moreover, the FOMC has recently emphasized the importance of labor market conditions in its monetary policy decisions.⁵ While maximum employment has long been a goal of Federal Reserve monetary policy, the FOMC's "mandate to promote maximum employment and price stability" was explicitly mentioned in a post-meeting FOMC press release after the FOMC's meeting of September 21, 2010. Later, in its press release on September 13, 2012, the FOMC introduced labor market conditions as part of its forward guidance, saying, "If the outlook for the labor market does not improve substantially, the Committee will continue its purchases of agency mortgage-backed securities, undertake additional asset purchases, and employ its other policy tools as appropriate until such improvement is achieved in a context of price stability." Then, in its press release of December 12, 2012, the FOMC indicated that it would be appropriate to maintain an "exceptionally low range for the federal funds rate ... at least as long as the unemployment rate remains above 6½ percent" Finally, in its press release of March 19, 2014, the FOMC replaced its 6½ percent unemployment threshold with a statement that it "will assess progress—both realized and expected—toward its objectives of maximum employment and 2 percent inflation. This assessment will take into account a wide range of information, including measures of labor market conditions"

Unfortunately, simply substituting the unemployment rate gap for the output gap may not be an adequate proxy for labor market conditions in today's economy. In particular, the decline in the unemployment rate from 10.0 percent in October 2009 to 6.3 percent in April 2014 may overstate the improvement in labor market conditions. This is because the decline occurred while the labor force participation rate was falling and the employment-population ratio was stable at a historically low level, developments generally not associated with improving labor markets.

This discrepancy between the unemployment rate and the state of labor markets was also noted by then-Vice Chair Yellen who said:

“Federal Reserve research concludes that the unemployment rate is probably the best single indicator of current labor market conditions. ... That said, the unemployment rate also has its limitations. As I noted before, the unemployment rate may decline for reasons other than improved labor demand, such as when workers become discouraged and drop out of the labor force. ... To judge whether there has been a substantial improvement in the outlook for the labor market, I therefore expect to consider additional labor market indicators along with the overall outlook for economic growth” (March 4, 2013).

More recently, Chair Yellen said in her March 2014 post-FOMC meeting press conference:

“Now, the Committee has never felt that the unemployment rate is a sufficient statistic for the labor market. I think if I had to choose one indicator of the labor market, the unemployment rate is probably as good a one as I could find. But in assessing the real state of slack in the labor market and ultimately of inflationary pressures that might—or deflationary pressures that could result from that—it's appropriate to look at many more things. And that's why the Committee now states we will look at a broad range of information.”

For these reasons, this article measures labor market conditions not only with the unemployment rate gap but also with two broad indicators

calculated by the Federal Reserve Bank of Kansas City. The Kansas City Labor Market Conditions Indicators (LMCI) are based on 24 labor market variables, including various measures of unemployment, labor force participation, the growth rate of employment, and surveys of economists, businesses, and consumers. Rather than trying to assess the current state of labor market conditions by monitoring all 24 variables, two indicators of labor market conditions are calculated using principal components (see Hakkio and Willis). This statistical technique reduces the 24 labor market variables to two easily monitored indicators. The first indicator is “level of activity” and the second is “momentum.”⁶ These two indicators jointly explain 81 percent of the variability of the 24 labor market variables, with the activity indicator and momentum indicator explaining 58 percent and 23 percent, respectively. The Appendix provides additional details about the index.

The momentum indicator captures additional variables relevant to assessing labor market conditions. For example, in making such an assessment, then-Vice Chair Yellen said she would “expect to consider additional labor market indicators along with the overall outlook for economic growth. For example, the pace of payroll employment growth is highly correlated with a diverse set of labor market indicators, and a decline in unemployment is more likely to signal genuine improvement in the labor market when it is combined with a healthy pace of job gains” (2013). Consistent with Yellen’s statement, the momentum indicator is in fact highly correlated with growth in private payroll employment, with a correlation coefficient of 0.85.

Estimation period

The estimation period is based on the view that policy was “rule based” or systematically and predictably related to economic conditions from the mid-1980s to early 2001 and then became more discretionary and less predictable. The underlying assumption is that good monetary policy contributed to the favorable macroeconomic performance of the period, which was marked by reduced volatility of inflation and economic activity.⁷ This view has been advanced by Taylor, who argues that in 2003 policy deviated from the rule-based approach (2012). He further argues the adoption of a more discretionary policy contributed to a subsequent deterioration

in financial and macroeconomic stability. Nikolsko-Rzhevskyy, Pappell, and Prodan statistically test this hypothesis and find that policy was rule based from the second quarter of 1985 to the first quarter of 2001 and discretionary from the second quarter of 2001 to the fourth quarter of 2008. Thus, the policy rule is estimated over the earlier period when policy was estimated to have been rule based and macroeconomic performance was widely viewed as favorable.

Of course, after reaching the ZLB in December 2008, there was essentially no variation in the federal funds rate, making the estimation of a policy rule over that period impossible. Moreover, with the ZLB constraining further downward movement in short-term interest rates, the federal funds rate could no longer be used as a tool for providing additional policy accommodation. After all, the federal funds rate cannot fall materially below zero since holding cash (which pays a zero interest rate) would be preferable to holding an asset that pays a negative interest rate. Finally, the Federal Reserve—and other central banks—introduced unconventional tools for providing additional accommodation during this period. Specifically, the FOMC used forward guidance—telling the market it intended to keep the funds rate low for an extended period of time—and purchases of longer-term assets to provide additional accommodation through lower longer-term interest rates. As a result, the federal funds rate is no longer a complete measure of the stance of monetary policy.

Estimated rules

Two simple policy rules are estimated in which the real federal funds rate depends on the deviation of inflation from its desired level (assumed to be 2 percent) and either the unemployment rate gap or the two labor market indicators from the LMCI:

$$\begin{aligned} \text{ffr}_{t-2} &= \rho(\text{ffr}_{t-1} - 2) + (1 - \rho)[r + \beta(p_t - 2) + \gamma(\text{ugap}_t)] + e_t, \text{ and} \\ \text{ffr}_{t-2} &= \rho(\text{ffr}_{t-1} - 2) + (1 - \rho)[r + \beta(p_t - 2) + \theta \text{Level}_t + \mu \text{Momentum}_t] + e_t, \end{aligned}$$

where ffr_t is the federal funds rate in period t , r is the constant term, p_t is the inflation rate as measured by the core personal consumption expenditure (PCE) price index over 12 months, ugap_t is the Congressional Budget Office (CBO) measure of the unemploy-

Table 1
ESTIMATED POLICY RULES

Dependent variable: Federal funds rate	(1)	(2)
Lagged federal funds rate (ρ)	0.90*** (0.021)	0.92*** (0.015)
Constant(r)	3.24*** (0.26)	0.74 (0.45)
Core PCE inflation gap (β)	1.27*** (0.23)	2.20*** (0.22)
Unemployment rate gap (γ)	-1.78*** (0.26)	
LMCI level of activity (θ)		2.28*** (0.34)
LMCI momentum (μ)		2.38*** (0.57)
Observations	192	192
R-squared	0.985	0.989
Adjusted R-squared	0.985	0.988
RMSE	0.205	0.181
Log-likelihood	34.026	58.281
AIC	-60.052	-106.561

* Significant at 10 percent level

** Significant at 5 percent level

*** Significant at 1 percent level

Notes: Newey-West standard errors (using 12 lags) are given in parentheses. Each model was estimated over the period from April 1985 to March 2001. The models are given by:

$$(1) \text{ffr}_t = \rho(\text{ffr}_{t-1}) + (1-\rho)[r + \beta(p_{t-2}) + \gamma(\text{ugap}_t)] + e_t$$

$$(2) \text{ffr}_t = \rho(\text{ffr}_{t-1}) + (1-\rho)[r + \beta(p_{t-2}) + \theta \text{Level}_t + \mu \text{Momentum}_t] + e_t$$

Sources: Bureau of Economic Analysis, Bureau of Labor Statistics, Congressional Budget Office, Federal Reserve Bank of Kansas City, Federal Reserve Board, Haver Analytics, and authors' calculations.

ment gap, and Level_t and Momentum_t come from the LMCI.⁸ The coefficient ρ measures the degree of policy inertia—the dependence of the current federal funds rate on its level from the previous month. The sample period is April 1985 to March 2001, to match the period identified by Nikolsko-Rzhevskyy, Papell, and Prodan as rule-based.⁹

Table 1 shows the results of estimating the policy rule using the unemployment rate gap and the two labor market conditions indicators. Since the labor market indicators are generated, robust standard errors are calculated.¹⁰ The overall fit of the two equations is similar.¹¹ Importantly, the results satisfy the Taylor principle, which says central

banks should adjust their policy interest rate more than one-for-one with inflation so the *real* policy rate increases when inflation increases. The coefficient on the inflation rate gap suggests that if inflation rises 1 percentage point above its target, the nominal federal funds rate rises between 1.3 and 2.2 percentage points, depending on which labor market variables are used.

The labor market indicators are also highly significant. In particular, a 1-unit increase in the unemployment gap leads to a 1.8-percentage-point decline in the federal funds rate.¹² In the equation with the labor market indicators, a 1-unit increase in the indicator measuring the level of activity (which historically has been associated with a 1.6-percentage-point decline in the unemployment rate) leads to a 2.3-percentage-point increase in the federal funds rate. The new twist is that the indicator measuring momentum is also significant in describing monetary policy prior to the ZLB. Specifically, a 1-unit increase in momentum leads to a 2.4-percentage-point increase in the funds rate. This suggests the FOMC tends to tighten policy when labor market conditions are improving faster than normal.

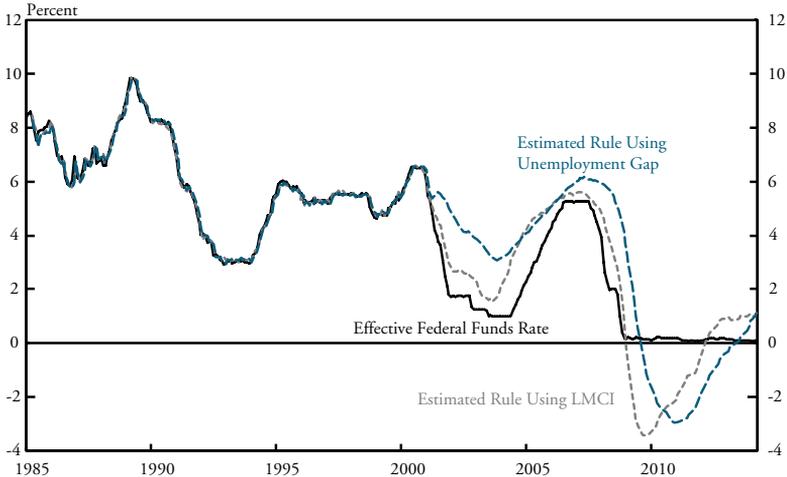
III. POLICY PRESCRIPTIONS BEFORE AND DURING THE ZLB PERIOD

The actual path of the federal funds rate has deviated considerably since 2001 from the path prescribed by the estimated policy rule. Chart 2 shows the actual and predicted federal funds rate over the in-sample period from April 1985 to March 2001 and the out-of-sample period from April 2001 to April 2014. The fit of the estimated rule over the in-sample period partly reflects the effect of the lagged federal funds rate pulling the policy rule prescription back toward the actual funds rate in the previous month. Over the out-of-sample period, the predicted value of the federal funds rate is calculated recursively: actual values of inflation and the labor market indicators are plugged into the estimated rule, while the predicted value for the federal funds rate from previous month is used for the lagged federal funds rate.¹³ As a result, in the out-of-sample period, deviations from the prescribed rule have greater persistence.¹⁴

From 2001 to December 2008 when the federal funds rate fell to its effective lower bound, both versions of the estimated policy rule

Chart 2

FEDERAL FUNDS RATE VERSUS PRESCRIPTIONS FROM ESTIMATED RULES



Sources: Bureau of Economic Analysis, Bureau of Labor Statistics, Congressional Budget Office, Federal Reserve Bank of Kansas City, Federal Reserve Board, Haver Analytics, and authors' calculations.

prescribed a less accommodative policy than shown by the actual path of the federal funds rate. Notably, though, the rule with the LMCI came considerably closer to the actual path than the rule with the unemployment gap, especially from September 2007 to December 2008 as the FOMC lowered the federal funds rate target from 5¼ percent to its effective lower bound. This finding suggests the FOMC may have been reacting to a broader set of labor market indicators in this period than just the unemployment rate.

After reaching the ZLB, both policy rules prescribed a highly accommodative policy. According to the rule with the LMCI, the funds rate prescription fell quickly, reaching a low of minus 3.5 percent in November 2009. According to the rule with the unemployment gap, the funds rate prescription turned down somewhat later, reaching a low of minus 3.0 percent in December 2010. Of course, setting the federal funds rate more than, perhaps, a very small amount below zero is not possible. But the extent to which the prescribed federal funds rate fell below zero is a clear indication of the need for additional monetary policy accommodation. Ultimately, the FOMC added further accommodation through its asset purchase programs and forward

guidance. A key question (discussed in the next section) is whether this additional accommodation was sufficient to provide the stimulus that a significantly negative federal funds rate would have provided had that been possible to achieve.

Interestingly, both estimated rule prescriptions have policy becoming less accommodative by late 2010. The funds rate prescriptions start rising in late 2009 for the rule with the LMCI and in late 2010 for the rule with the unemployment gap. This turnaround occurred as the unemployment rate and the level of labor market activity slowly improved, momentum turned positive, and inflation increased. In addition, the funds rate prescribed by the estimated rule using the LMCI reaches the actual funds rate target range of zero to 25 basis points in March 2012, while the funds rate prescribed by the estimated rule using the unemployment gap reaches its actual level in June 2013.

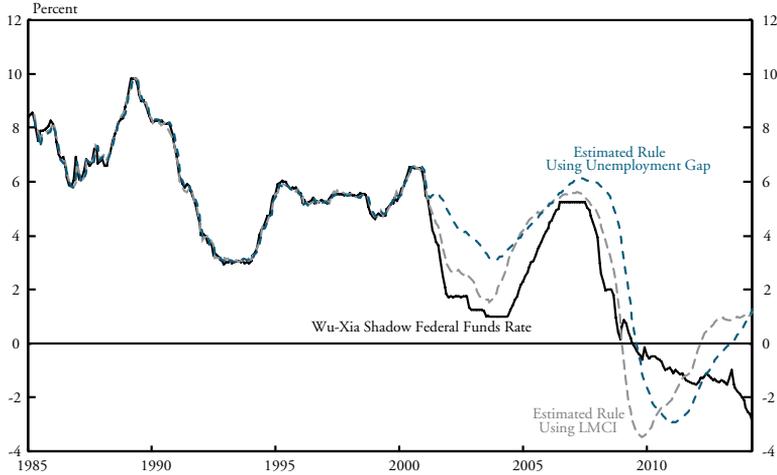
At least two factors explain the different prescriptions from the two rules. One is that the estimated rule using the LMCI puts greater weight on the level of activity (a coefficient of 2.3) than the rule using unemployment puts on the unemployment gap (coefficient of minus 1.8). In addition, the estimated rule including the LMCI puts considerable weight on the momentum indicator (coefficient of 2.4) which was also improving, but not included in the other rule. Thus, even though the improvement in the unemployment rate since 2010 was less than the improvement in broad labor market conditions as measured by the level of activity indicator, the rule using the LMCI called for somewhat less accommodative policy. This effect also outweighed the greater weight the estimated rule with the LMCI puts on the inflation gap (a coefficient of 2.2 as opposed to 1.3 in the rule with the unemployment gap).

IV. EVALUATING MONETARY POLICY DURING THE ZLB PERIOD

Comparing the prescriptions from the estimated rules with the shadow federal funds rate provides insight into whether unconventional policies provided sufficient accommodation to overcome the ZLB constraint on the federal funds rate. In other words, were these policies sufficient to provide the same accommodation that the FOMC might have provided had the federal funds rate not been constrained by the ZLB? To answer this question, Chart 3 combines elements of Charts 1 and 2. It shows the stance of monetary policy as measured by the

Chart 3

WU-XIA SHADOW FEDERAL FUNDS RATE VERSUS PRESCRIPTIONS FROM ESTIMATED RULES



Sources: Bureau of Economic Analysis, Bureau of Labor Statistics, Congressional Budget Office, Federal Reserve Bank of Kansas City, Federal Reserve Board, Haver Analytics, Wu and Xia (2014), and authors' calculations.

Wu-Xia shadow federal funds rate (solid black line) and the prescriptions of the two estimated rules (the gray dashed line for the estimated rule with the LMCI and the blue dashed line for the rule with the unemployment gap).

Even with unconventional policies, the stance of monetary policy was less accommodative than prescribed by either estimated rule for a considerable period starting in 2009. Specifically, the estimated rule prescriptions were well below the shadow federal funds rate, which measures the stance of monetary policy. Prescriptions from the estimated rule using the LMCI remained below the shadow funds rate until July 2011, while prescriptions from the rule using the unemployment gap remained below the shadow rate until June 2012.

These results suggest that even with the deployment of unconventional tools, monetary policy was “constrained” from providing enough accommodation. This may be because there are practical limits to how much accommodation can be provided through forward guidance and asset purchases. For example, markets simply may not believe a promise to keep interest rates low for an unusually long time. And while the Fed could have purchased larger amounts of long-term assets, their effi-

cacy in further easing financial conditions may be limited, and at some point, the costs of larger purchases may exceed the benefits. Regardless, for whatever reason, it appears monetary policy was unable to provide as much accommodation as prescribed by the estimated rules.

The results also suggest the stance of monetary policy was *more* accommodative than prescribed by the two estimated rules from mid-2011 or mid-2012 to April 2014. Specifically, starting in the second half of 2011, the stance of monetary policy as measured by the Wu-Xia shadow rate fell below the funds rate prescribed by the estimated rule using the LMCI, and starting in the second half of 2012, the stance of monetary policy fell below the funds rate prescribed by the rule using the unemployment gap. In fact, by the end of the sample period in April 2014, both estimated rules prescribed a federal funds rate of about 1 percent, whereas the stance of policy as measured by the Wu-Xia shadow rate suggested a rate of about minus 3 percent.

While the stance of monetary policy may have become more accommodative than prescribed by the two estimated rules, whether monetary policy was “overly” accommodative is not clear. Answering this question requires a benchmark appropriate for periods when the overall stance of monetary policy is constrained—either by the ZLB constraint on the federal funds rate or by the ZLB and other constraints on unconventional monetary policy such as limits on the effectiveness of asset purchases and forward guidance and on the available supply of Treasury securities.

Several economists have argued that, when the federal funds rate is constrained by the ZLB, policy should be “history dependent.” History dependence essentially means “history matters” and that, when it comes to monetary policy at the ZLB, bygones *may not* be bygones.¹⁵ For example, Woodford says that “following a period in which the interest-rate lower bound has required policy to be tighter than would otherwise have been desired, policy will be looser than it would otherwise have been ... ” and “the central bank’s policy will be *history-dependent* in a particular way—it will behave differently than it usually would, under the conditions prevailing later, simply because of the binding constraint *in the past*” (2012, pp. 190-191).

In addition, then-Vice Chair Yellen described monetary policy when constrained by the ZLB:

“I’ve previously argued that ... optimal policy prescriptions for the federal funds rate’s path diverge notably from those of standard rules. For example, David Reifschneider and John Williams have shown that when policy is constrained by the effective lower bound, policymakers can achieve superior economic outcomes by committing to keep the federal funds rate lower for longer than would be called for by the interest rate rules that serve as reasonably reliable guides for monetary policy in more normal times. Committing to keep the federal funds rate lower for longer helps bring down longer-term interest rates immediately and thereby helps compensate for the inability of policymakers to lower short-term rates as much as simple rules would call for” (2013, p. 7).

Reifschneider and Williams consider a simple example in which the prescription of a policy rule falls below zero for a period of time. They argue that a possible response to the ZLB would be to keep the funds rate at zero for a period of time *after* the policy rule began to prescribe a positive funds rate target. In fact, they suggest keeping the funds rate target at zero until the cumulative deviation of the prescribed funds rate as it rises above zero roughly offsets the cumulative deviation of the prescribed funds rate when it was below zero.

Applying this logic to deviations of the estimated rules from the Wu-Xia shadow rate suggests the actual funds rate should possibly remain at zero until the cumulative overshooting of the prescribed funds rate above the shadow rate roughly offsets the cumulative undershooting. For example, the prescription from the estimated rule based on the unemployment gap (Chart 3, dashed blue line) fell below the shadow rate (solid black line) in September 2009 and remained below the shadow rate until June 2012. The cumulative deviation of the prescribed rate from the shadow rate over those 34 months was 41.2 percentage points. From July 2012 to April 2014, the prescribed federal funds rate was above the shadow federal funds rate for a cumulative deviation of 38.3 percentage points. Thus, by this criterion, it is currently appropriate for the funds rate to remain at zero.¹⁶ However, if the positive deviation of the prescribed rate from the shadow rate persists, the simple analysis here, based on history dependence, would soon prescribe raising the funds rate above zero.

The conclusion differs somewhat when using the rule estimated with the LMCI. In this case, the shadow rate (solid black line) was above the prescription from the estimated rule (dashed gray line) from January 2009 to July 2011, with a cumulative deviation of 58.5 percentage points. Since then, the shadow rate has been below the prescribed federal funds rate, with a cumulative deviation of 67.7 percentage points. As a result, in this case, the earlier period in which policy was insufficiently accommodative has been more than fully offset, suggesting that the funds rate should rise.

V. CONCLUSIONS

Understanding the stance of monetary policy in recent years has become very challenging. With the global recession, a significant increase in the unemployment rate, and the federal funds rate constrained by the ZLB, the FOMC has deployed the unconventional tools of forward guidance and asset purchases. As a result, the federal funds rate no longer serves as a summary indicator of the stance of policy. Moreover, the prescriptions of many simple policy rules—based on inflation and output gaps—have, until recently, called for a negative federal funds rate, which, of course, could not be implemented.

To address these issues, this article measures the overall stance of monetary policy with a shadow federal funds rate. This shadow rate—which is not constrained by the ZLB—incorporates both conventional and unconventional tools in its assessment of the overall stance of policy. The shadow rate is then compared to the prescriptions of two estimated rules. The estimated rules describe how policymakers responded to economic conditions in an earlier period of relatively good macroeconomic performance when the ZLB was not a binding constraint. Given the FOMC's increased focus on labor market conditions, the estimated rules alternatively use the unemployment gap and the Federal Reserve Bank of Kansas City's Labor Market Conditions Indicators as the measure of real economic activity.

The article concludes that the use of unconventional tools—forward guidance and asset purchases—was not sufficient to fully offset the early constraint on accommodation coming from the ZLB. The shadow federal funds rate did not fall nearly as far as the estimated policy rules prescribed. However, at some point between mid-2011 and

mid-2012, the prescribed federal funds rate rose above the shadow federal funds rate, with the prescribed rate eventually reaching 1 percent in April 2014.

In assessing the overall accommodation provided by monetary policy during this period, the analysis draws on the view that monetary policy should be history dependent, especially when policy has been constrained by the ZLB. In other words, once the constraint on policy is no longer binding, the overall stance of monetary policy should remain more accommodative than a conventional policy rule would suggest, thereby offsetting the tighter-than-prescribed policy during the period when the ZLB was binding. According to the estimated policy rule with the two labor market indicators, the prescribed federal funds rate has remained sufficiently above the shadow rate since mid-2011 that it has now fully offset the prior period during which the shadow rate exceeded the prescribed rate. However, based on the estimated policy rule with the unemployment gap, the period in which the prescribed federal funds rate has been above the shadow rate has not yet fully offset the prior period during which the shadow rate exceeded the prescribed rate. This suggests monetary policy should continue to remain more accommodative than prescribed by the rule. More generally, though, both policy rules suggest the time is near for returning to a more conventional approach to monetary policy.

APPENDIX

LABOR MARKET CONDITIONS INDEX

Table A1 describes the variables used in the construction of the two labor market indicators.

Table A1

VARIABLES USED IN LABOR MARKET CONDITIONS INDEX

Variable	Measure	Source	Notes
Unemployment rate	Percent	BLS	
U6 unemployment rate	Percent	BLS	1
Work part time for economic reasons	Percent of total employment	BLS	8
Initial claims for unemployment insurance, state programs	Percent of total employment	DOL, BLS	11
Unemployment for 27 weeks and over	Percent of unemployed	BLS	
Civilian employment-population ratio	Percent	BLS	
Blue Chip forecast of unemployment four quarters ahead	Percent	Blue Chip	10
Private nonfarm payroll employment	Percent change over past three months	BLS	
Temporary help services employment	Percent change over past three months	BLS	
Aggregate weekly hours of production and nonsupervisory employees	Percent change over past three months	BLS	
Average weekly earnings of production and nonsupervisory employees	Percent change over past three months	BLS	
Job flows from unemployed to employed	Percent of unemployed	BLS	7
Total private hires rate, JOLTS	Percent	BLS	2,3
ISM manufacturing employment index	Index	ISM	
Job losers	Percent of unemployed	BLS	
Job leavers	Percent of unemployed	BLS	
Total private quits rate, JOLTS	Percent	BLS	2,3
Challenger, Gray, & Christmas announced job cuts	Percent of labor force	CGC, BLS	6
NFIB: percent planning to increase employment	Percent	NFIB	
NFIB: percent of firms with positions not able to fill right now	Percent	NFIB	
Thomson-Reuters/University of Michigan, expected job availability	Index	University of Michigan	9
Conference Board, present situation, job availability	Index	CB	4
Conference Board, expected job availability	Index	CB	5
Labor force participation rate	Percent	BLS	

Notes to Table A1

1. The U6 unemployment rate is available starting in 1994. The data was backcast to 1992 using the unemployment rate, work part time for economic reasons, and unemployment for 27 weeks and over (measured as listed in table above).

2. JOLTS data is available starting in December 2000. For data prior to December 2000, synthetic quarterly JOLTS data from the second quarter of 1990 to the second quarter of 2010 is obtained from Davis, Faberman, and Haltiwanger. The quarterly data are converted to a monthly series using a cubic spline interpolation and then spliced to the actual JOLTS series in December 2000.

3. JOLTS data are generally delayed by one month relative to the regular employment reports. A simple model is estimated to forecast JOLTS one-month ahead where each JOLTS series is a function of four lags of both JOLTS variables along with current values of job leavers, job losers, and job flows. This model is used to predict period t values of the JOLTS series using lags ($t-1$, ..., $t-4$) of JOLTS and period t values of the other series.

4. CB, present situation, job availability = present situation, jobs plentiful – present situation, jobs hard to get + 100.

5. CB, expected job availability = expected in six months, more jobs – expected in six months, fewer jobs.

6. CGC data are available monthly starting in January 1993. For 1992, they are available for March and June. A cubic spline is used to interpolate data for 1992. This series is then divided by the labor force.

7. Job flows from U to E = flows from unemployed to employed/lagged level of unemployment.

8. Work part time for economic reasons = $100 \times (\text{work part time for economic reasons, all industry, seasonally adjusted, thousands}) / \text{level of household employment}$.

9. Thomson-Reuters/University of Michigan, expected job availability = Expected change in unemployment is less – expected change in unemployment is more.

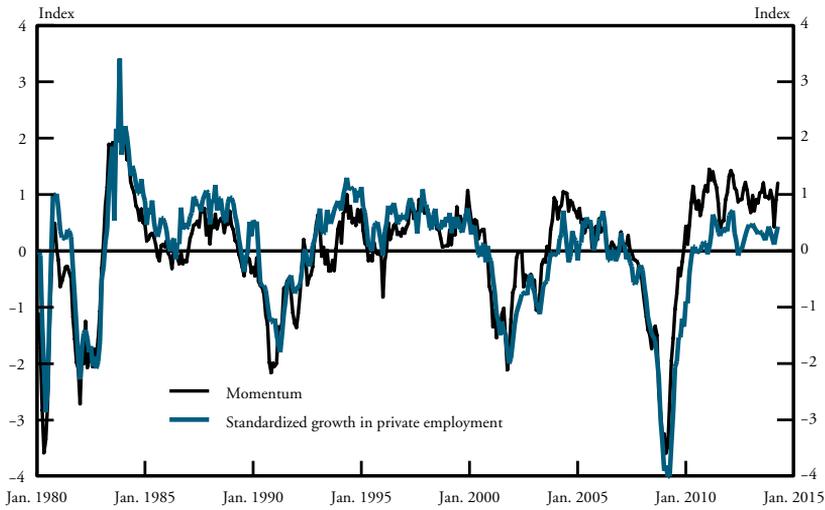
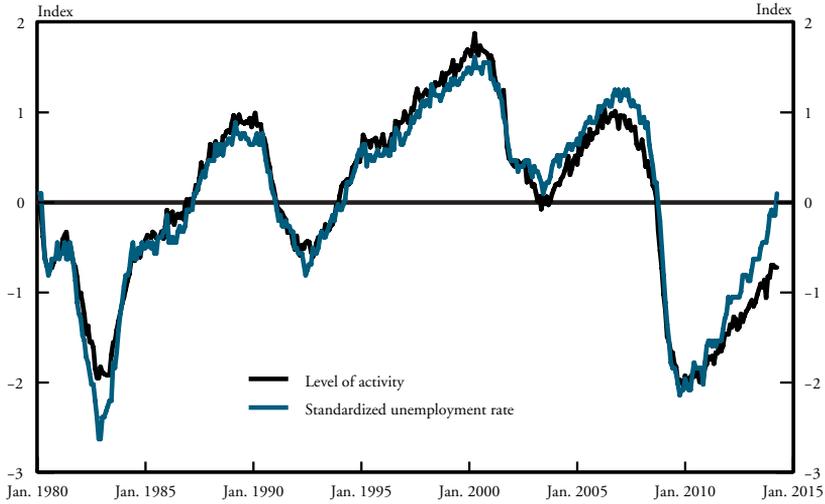
10. BC, EU in four quarters = unemployment rate expected in four quarters. Since Blue Chip provides monthly estimates of the unemployment, the following scheme is used:

- If the Blue Chip month is part of the first quarter, the unemployment rate is for the fourth quarter (of the current year).
- If the Blue Chip month is part of the second quarter, the unemployment rate is for the first quarter (of the next year).
- If the Blue Chip month is part of the third quarter, the unemployment rate is for the second quarter (of the next year).
- If the Blue Chip month is part of the fourth quarter, the unemployment rate is for the third quarter (of the next year).

11. For initial claims, the monthly values are monthly averages of prorated seasonally adjusted weeks. This series was obtained from Haver Analytics.

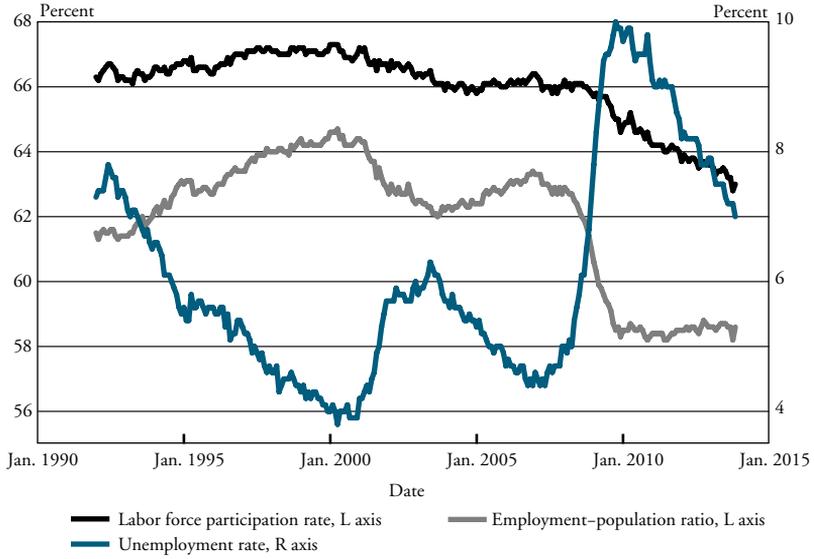
Chart A1

LABOR MARKET CONDITIONS INDICATORS



Sources: Bureau of Labor Statistics, Haver Analytics, and authors' calculations.

Chart A2
LABOR MARKET VARIABLES



Sources: Bureau of Labor Statistics and Haver Analytics.

ENDNOTES

¹This discussion follows closely the argument in Krippner (2012). The estimation of the shadow funds rate builds on the shadow rate term structure model proposed by Black.

²See Foerster and Cao for evidence on the extent to which markets anticipated the various asset purchase programs.

³Taylor assumed the inflation target was 2 percent. In January 2012, the FOMC formalized a medium to long-term inflation objective of 2 percent in its “Statement on Longer-Run Goals and Monetary Policy Strategy.”

⁴See Woodford (2003); Rudebusch; and Coibion and Gorodnichenko.

⁵Kahn and Taylor (2014) discuss how policymakers’ interpretation, and financial markets’ perception, of the Federal Reserve’s dual mandate has evolved since it was incorporated into the Federal Reserve Act in 1977.

⁶See Hakkio and Willis. In their article, the second indicator was called “rate of change.” Since then, construction of the index has changed. In particular, the labor force participation rate was included as one of the variables, thereby increasing the number of labor market variables from 23 to 24. In addition, two variables were redefined. In particular, rather than including the level of monthly claims, the index now divides claims by the labor force. Similarly, rather than simply including the level of Challenger, Gray, & Christmas job cuts, the index now divides this by the labor force. The Appendix includes a detailed discussion of the variables used, any transformations used, and the sources of the data.

⁷See Kahn (2012) for a discussion of estimated rules during the Great Moderation.

⁸The LMCI used in this paper differs slightly from the LMCI constructed in Hakkio and Willis. To construct LMCIs starting in 1985, six variables had to be deleted: the Challenger, Gray, & Christmas announced job cuts, job flows from unemployment to employment, temporary employment, JOLTS quit and hire rates, and the U6 unemployment rate. By deleting these observations, the LMCI was constructed starting in February 1980. Even without the six deleted variables, the LMCIs constructed with data starting in 1992 and constructed with data starting in 1980 are highly correlated. The correlation for the two measures of the level of activity is 0.999 and the correlation for the two measures of momentum is 0.985. In the regression with the unemployment gap, the constant term can be viewed as an estimate of the equilibrium real federal funds rate. In the other regression, plugging in sample period averages of *level* and *momentum* multiplied by their estimated coefficients and adding their sum to the constant provides an estimate of the equilibrium real federal funds rate. These estimates assume the inflation target over the period was 2 percent.

⁹All rules are estimated using current vintage data as opposed to “real-time” data; that is, data available to policymakers at the time decisions were made. While the unemployment rate is typically not revised, some of the other labor market indicators and the PCE price index are. As a result, the estimated rules provide a guide for policymakers based on today’s understanding of the historical data as revised and do not necessarily reflect how policymakers responded to economic conditions as they knew them in real time.

¹⁰Specifically, heteroskedasticity and autocorrelation-consistent (HAC) standard errors are calculated.

¹¹The fit is similar based on adjusted R squares and root mean square errors. However, according to the Akaike Information Criterion (AIC), the model with the two labor market indicators has better overall fit (see Table 1).

¹²This response is in between the coefficient on the unemployment gap implied by the original 1993 Taylor rule and the coefficient implied by a modified Taylor rule that raises the coefficient on the output gap from 0.5 to 1.0. Using an Okun’s law coefficient of 2.3 to convert the unemployment gap to an output gap, the 1993 Taylor rule would set the coefficient on the unemployment gap at 1.15 while the modified Taylor rule would set it at 2.3. The modified Taylor rule was examined in Taylor (1999).

¹³Of course, the realized values of inflation and labor market variables may not have been realized if the federal funds rate was actually set according to one of the estimated policy rules. In other words, the analysis is static in that it evaluates policy at each point in time without allowing an alternative setting of the policy rate to affect future employment and inflation. A dynamic analysis would require a complete macroeconomic model and could yield different results.

¹⁴Starting the recursive predictions for the federal funds rate in 2009 rather than 2001 has little effect on the prescriptions from the estimated rule using the two labor market indicators. In contrast, the prescriptions from the rule with the unemployment gap are shifted down from 3.6 percent to 0.1 percent in January 2009, from -1.6 percent to -2.6 percent in January 2010, from -3.0 percent to -3.3 percent in January 2011, and from -1.9 percent to -2.0 percent in January 2012. From that point on, the prescriptions from the rule with the labor market indicators are very similar regardless of whether the projections are started in 2001 or 2009.

¹⁵The estimated policy rules already incorporate some history dependence through the influence of the lagged federal funds rate on the right hand side.

¹⁶The results differ somewhat if the projections are started in 2009 rather than 2001. In this case, the prescription from the estimated rule based on the unemployment gap fell below the shadow rate in January rather than September 2009. The cumulative deviation of the prescribed rate from the shadow rate over the period was 64.8 percentage points rather than 41.2 percentage points. After crossing the shadow rate in July 2012, the prescribed federal funds rate rose

above the shadow rate for a cumulative 37.9 percentage points. This suggests a somewhat longer period will be needed for the federal funds rate to remain at its effective lower bound before the cumulative deviation of the prescribed rate above the shadow rate fully offsets the prior cumulative deviation of the prescribed rate below the shadow rate.

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