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Three Scenarios for Interest Rates in the Transition to Normalcy

By Diana A. Cooke and William T. Gavin[1]

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Abstract

This article develops time-series models to represent three alternative, potential monetary policy regimes as monetary policy returns to normal. The first regime is a return to the high and volatile inflation rate of the 1970s. The second regime, the one that most Federal Reserve officials and business economists expect, is a return to the credible low inflation policy that characterized the U.S. economy from 1983 to 2007, a period that has come to be known as the Great Moderation. The third regime is one in which policymakers decide to keep policy interest rates at or near zero for the foreseeable future. Japanese data are used to estimate this regime. These time-series models include four variables, per capita GDP growth, CPI inflation, the policy rate and the 10-year bond rate. These models are used to forecast the U.S. economy from 2008 through 2013 and represent the possible outcomes for interest rates that may follow the return of monetary policy to normal. Here, normal depends on the policy regime that follows the liftoff of the federal funds rate target that is expected in mid-2015.

Key Words: Exit strategy, Credibility, Interest rate policy
JEL codes: E43, E47, E52, E58, E65

Introduction

During the fourth quarter of 2008, in the process of rescuing a few large financial firms following the Lehman Brothers bankruptcy, the Federal Reserve (Fed) added about $600 billion in excess reserves to the banking system. This system operated with fewer than $5 billion throughout 2007. This action drove the interest rate on bank reserves (aka the federal funds rate) to zero. On December 16, 2008, the Federal Open Market Committee (FOMC) followed the market down by setting the official federal funds rate target at a range of 0 to 0.25 percent, where it remains to this day. With the policy rate effectively at zero, the FOMC has tried to ease monetary conditions through two related policies: 1) forward guidance promises of keeping the policy rate unchanged for even further into the future and 2) large-scales purchases of long-term Treasury debt and Agency

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[1]Thanks to Kevin Kliesen and Yi Wen for helpful comments.

mortgage backed securities, which effectively places a downward pressure on long-term interest rates. As of June 2014, this latter policy has increased the total of excess reserves to $2.6 trillion.

Within the Federal Reserve System, this situation is considered temporary and the FOMC is now debating strategies that would return the balance sheet and the policy rate to normal. When the economy and monetary policy eventually return to normal, it is expected that excess reserves would return to levels observed before the financial crisis. The effects of reducing excess reserves will depend on what happens to interest rates during the transition to normalcy. The level and volatility of interest rates will depend on the public's beliefs about future monetary policy. Carpenter et al. (2013) provide an excellent overview of the Fed's balance sheet and describe three exit strategies based on FOMC policy statements. They develop projections of the Fed's balance sheet as well as its net income that are conditioned on assumptions about future interest rates.

There is a well-known econometric problem, the "Lucas Critique," associated with simulating an economy under alternative policy assumptions (See Lucas, 1976). The Carpenter et al. (2013) simulations are done under the implicit assumption that the U.S. economy has had one stable policy regime from about 1983 to the present and that the transition period will be just an extension of this same policy regime. In this paper, we drop that assumption and allow the period with a zero policy rate to be a different regime with different econometric properties.

Distinguishing between regimes is important because the major concerns surrounding the exit strategy for monetary policy arise from the interest rate implications of moving to a different policy regime. For example, our judgment is that the "taper tantrum" of 2013 was a typical interest rate response that would naturally be associated with moving from a zero interest rate policy back to the credible monetary policy regime that was in place between 1983 and 2007, a period that has come to be known as "The Great Moderation." There are also economists and policymakers who worry that the zero interest rate policy regime will eventually lead to a loss of credibility for the Fed and a return to the high inflation regime that existed in the United States from about 1965 through 1979.[2]

Predicting interest rates during the transition to normalcy is complicated because it requires predicting which regime will be in place at the end of the transition. How high interest rates are likely to rise and how likely the yield curve is to become inverted depends on what people believe about the policy regime. To shed light on such questions we develop three scenarios involving alternative assumptions about Federal Reserve policy.

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[2] See, for example, the arguments made by Calomiris (2012) in his comments on Campbell et al. (2012). More recently, Meltzer (2014) explains the high-inflation risk posed by the Fed's balance sheet policy.

We use a data-based scheme to identify time series models for interest rates that are associated with each regime. Data from unique episodes before 2008 are used to estimate the models, which are then simulated to forecast the U.S. economy during the period from 2008 through 2013 from the point of view of 2007:Q4. The purpose of these forecasts is simply to illustrate how well the alternative regimes can explain interest rates during the past six years, and, perhaps, what we should think about interest rates during the next few years.

The time series model for each scenario generates interest rates that are assumed to be typical of the relevant policy regime. We ask, for example, what will happen to interest rates if the Fed loses credibility for price stability, as it did in the period following the breakdown of the dollar standard agreed to at Bretton Woods after World War II. Our results show that inflation and interest rates become unacceptably high and volatile as they did in the 1970s. We consider this scenario and two others; one based on policy during the Great Moderation (the United States economy from 1983 to 2007) and the other based on the zero interest rate policy (ZIRP) in Japan where the monetary policy rate was held at or below ½ percent from 1995 through 2007.

Three Scenarios for Monetary Policy

We consider three scenarios representing three different policy regimes.

- The first scenario imagines that the Fed loses credibility for its inflation objective. Inflation accelerates as it did in the 1970s when the Fed did not have credibility for its inflation objective. We use data from the United States from 1965:Q1 to 1979:Q3 to estimate the *No Credibility* model.
- The second scenario assumes that the Fed has credibility and operates policy to achieve price stability (low inflation). We use data from 1983:Q1 to 2007:Q4 to estimate the *Credibility* model.
- In the third scenario the Fed keeps the money market rate at or near zero permanently. The credibility for the 2 percent inflation objective is dominated by credibility for its zero interest rate policy (ZIRP). We use data from Japan for the period from 1995:Q1 to 2007:Q4 to estimate the *ZIRP* model.

The statistical relationships determining per capita output, inflation and interest rates are assumed to depend on the monetary policy regime, which is characterized by the time series models developed below. We recognize that monetary policy is not the only reason that there are differences in the time series properties of the data among our alternative sample periods. There are structural differences between the U.S. economy and the Japanese economy, as well as between the early U.S. period and the later one. For this reason, we do not emphasize results for the real economy. The key

assumption we make is that monetary policy, through its determination of the inflation trend, is the dominant factor driving nominal interest rates.[3]

We examine three periods corresponding to three distinctly different monetary policies. We review the historical experience to clarify how credibility matters for interest rates and inflation. Then we use our models to forecast inflation and interest rates over the financial crisis period to evaluate the range of uncertainty that may arise during a transition to normalcy.

Three Regimes (The same time series model estimated over different episodes)

Our basic model in all three of the policy scenarios is a vector autoregression (VAR) including four quarterly time series: per capita GDP growth, Consumer Price Index (CPI) inflation, a short-term policy rate, and the 10-year government bond rate. For the United States the policy rate is the overnight federal funds rate. In Japan, it is the call money rate.

Our model produces a 4-quarter-ahead forecast. It is written as

$$Y_{t+3} = A(L)Y_{t-1} + e_{t+3},$$

where

$$Y_t = \begin{pmatrix} GDP_t \\ CPI_t \\ RS_t \\ RL_t \end{pmatrix} \; and \;\; e_t = \begin{pmatrix} e_{gdp,t} \\ e_{cpi,t} \\ e_{rs,t} \\ e_{rl,t} \end{pmatrix},$$

where GDP_t is real GDP growth minus population growth, CPI_t is the 4-quarter change in the CPI, RS_t is the policy rate and RL_t is the 10-year government bond rate. We assume that the error process is multivariate normal $e_t \sim N(0, \Sigma)$. We include the 4-quarter forecast horizon rather than a one-quarter horizon because we are mainly interested in medium-term forecasts and the 4-quarter specification produces better forecasts at longer horizons. Our models have identical structures, but the estimated parameters differ across the three scenarios (*No Credibility, Credibility,* and *ZIRP*) because the data used to estimate the models come from three episodes with very different monetary policy environments.

1965 to 1979: No Credibility

[3] See Gavin and Kydland (1999) for evidence comparing the properties of nominal and real time-series data before and after the Volcker monetary policy reform. They show that the change in monetary policy regime had a statistically significant impact on the time-series properties of the nominal data (prices, money and velocity), but not on the real quantities (output, consumption, investment and hours worked).

During the 1970s, the United States experienced a period of accelerating inflation that came to be known as the Great Inflation.[4] The top panel of Figure 1 shows that inflation rose in fits and starts from just under 2 percent in 1965 to 14.4 percent in June 1980. This period was often characterized as an era of stop-go monetary policy. When inflation accelerated, the FOMC would raise the policy rate high enough to slow inflation. The relatively high policy rate would lower aggregate spending, reduce the demand for labor and lead to a recession. The FOMC would then switch gears, lowering the policy rate sharply to stimulate spending and job growth. The stop-go nature of this policy is evident in the bottom panel of Figure 1, which shows the policy rate and the bond rate from 1965 through 1979.

The relationship between the policy rate and the bond rate during the period before 1980 displays three distinct features. First, both interest rates display rising trends and, on average, are roughly equal; the policy rate averaged just 0.6 percent less than the bond rate. Second, the policy rate was sometimes as much as 2 percentage points higher than the bond rate. Third, periods of a relatively low policy rate were followed by higher inflation and inflation expectations, reflected in rising bond rates.

The lack of credibility made setting the policy rate above the bond rate necessary in order to reduce inflation expectations. When the FOMC raised the policy rate too slowly, inflation expectations would rise to match the rise in the interest rate, and there was no dampening effect on either the economy or inflation. The lack of credibility meant that to succeed in lowering inflation, the FOMC had to raise the policy rate high enough to slow the economy. This led to a belief that stabilizing inflation would likely lead to high unemployment. A corollary to this idea was that low interest rates would raise inflation, and, at the same time, lower the unemployment rate. What has not been generally recognized is that these dynamic relationships came to be part of conventional wisdom in macroeconomics during a time when the Fed had no credibility for its inflation objective.

For this *No Credibility* model we use U.S. data from 1965:Q1 through 1979:Q3. For this and the other models, we find that the best lag length was just one quarter based on the Schwartz Bayesian Information Criterion. The estimates of the model and summary statistics are shown in Table 1a. The standard errors in the per capita GDP growth, inflation, policy rate and bond rate equations are 1.46, 1.45, 1.79 and 0.62 percent, respectively. These standard errors are important because they influence the inherent uncertainty in the forecasts.

The other major factor influencing the uncertainty in the forecast is the implication for the long-run trend. Table 2 presents the long-run mean forecasts for each model starting from initial conditions in 2007 and 2013. These are dynamic forecasts under the assumption that there are no

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[4] See Nelson (2004), who explains why, during this period, many economists and policymakers did not feel that it was important for the Fed to focus sharply on price stability.

further shocks over the forecast period. The number of years to convergence depends on how far initial conditions are from the long-run trends and how quickly the model equations converge when we start away from the long-run values[5]. In the *No Credibility* model, starting from 2007 (2013) initial conditions, per capita GDP growth converges to -6.7 percent in 222 (224) years. The inflation rate converges to 34.5 percent in 283 (286) years, the federal funds rate converges to 22.0 percent in 238 (240) years and the bond rate converges to 23.7 percent in 335 (338) years. When we start with initial conditions in 2013, the long-run values are the same but the years to convergence are a bit longer because we start further from the long run values.

These long-run values suggest that this policy regime is headed toward a hyperinflation of the type that has occurred in third-world countries. Such a policy regime is politically unsustainable. Either the government changes the policy or the people change the government. In the United States, this policy regime spanned less than two decades. Political pressure from home and abroad led the Federal Reserve to abandon this regime and adopt one with a credible inflation policy (See Lindsey, Rasche and Orphanides, 2013).

1983 to 2007: Credibility

In October 1979, the Federal Reserve, under Chairman Paul Volcker, adopted a new policy procedure based on direct money supply targeting to restore price stability. This new procedure lasted for 3 years during which interest rates were very high and volatile. At the end of the three years the inflation rate had fallen from double digits in 1980 to somewhere around 3 percent at the end of 1982. The Fed then switched away from direct money supply targeting back to an indirect form of interest rate targeting**.** By the time that Alan Greenspan became Fed chairman in June 1987 the Fed had gained credibility for its inflation policy. The period of low inflation and credible monetary policy was accompanied by dramatic changes in the relationship between the policy rate and the bond rate. Notice the contrast from the earlier period, as evident in both panels of Figure 2. The CPI inflation trend stabilized at about 3 percent rather quickly, but the trend in interest rates fell only gradually as inflation expectations lagged behind the actual decline in the inflation rate.

An interesting event occurred after Sept. 2, 1992, when, worried about low job growth in a slow recovery, the FOMC decided to set the policy rate at 3 percent, a rate approximately equal to the perceived trend in inflation. It was felt that such a low interest rate would cause higher inflation and, in October 1993, the bond rate began to rise from a low of 5.3 percent. The FOMC began to raise the policy rate in February 1994, but did not have to raise it above the bond rate to end this

[5] The model has converged when it is less than one-tenth of a percentage point from the long-run value.

brief inflation scare.[6] The policy rate was raised to 6 percent in early 1995, but, by then, the bond rate had already begun to retreat from its peak at just under 8 percent in November 1994. On a 12-month moving average basis, the CPI inflation rate peaked at 2.9 percent in August 1994. During this entire episode, there are only a few instances in which the policy rate was as high as the bond rate. On average, over the 1983 to 2007 sample period, the policy rate was 1.6 percentage points below the bond rate.

Table 1b presents the estimates of our *Credibility* model. For this period, the best lag structure in the VAR is also one quarter. The standard errors in the per capita GDP growth, inflation, policy rate and bond rate equations are 1.36, 0.98, 1.37 and 1.07 percent, respectively. Notice that the standard errors are slightly smaller than the values in the *No Credibility* model for the per capita GDP growth, inflation and the policy rate equations, but actually larger for the bond rate equation. The reduction in uncertainty associated with the *Credibility* model stems largely from the much improved properties of the long-run trends. The middle panel in Table 2 presents the long-run mean forecasts for the *credibility* model starting from initial conditions in 2007 and 2013. In the model starting from 2007 (2013) initial conditions, we find that the per capita GDP growth rate converges to 1.5 percent in 8 (19) years, the inflation rate converges to 2.9 percent in 12 (24) years, the policy rate converges to 3.4 percent in 21 (24) years, and the bond rate converges to 4.8 percent in 15 (26) years. The key difference for interest rates and inflation in the *Credibility* model versus the *No Credibility* model is not in the short-run volatility but, rather, in the long-run trends. Inflation and interest rates converge toward much lower values when policy is credible than when it is not.

2008 to 2014: The Zero Interest Rate Policy (ZIRP)

Our third scenario is an environment in which the policy rate is held at or near zero for an extended period. From the point of view of the public, monetary policy goes from having credibility for a 2 percent inflation target to also having credibility for promising to keep the policy rate near zero. A problem can arise if this promise spans time in which the economy recovers. The problem is that we expect real returns to be positive if the economy recovers. In any equilibrium, the Fisher equation must hold; that is, the nominal interest rate equals the real return plus the expected inflation rate. If the central bank holds the nominal interest rate at zero while the economy is recovering, equilibrium dynamics will put downward pressure on inflation. Over extended periods, a zero interest rate policy is not consistent with a positive inflation target. The two policy objectives can only persist if real returns continue to be negative.[7]

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[6] See Goodfriend (1993) for an essay on inflation scares.

[7] See Bullard (2010) for a survey of economic theories which show how an economy can become "trapped" at the zero lower bound. See page 8-9 in Cooke and Gavin (2014) for an introductory discussion of the Fisher Equation.

This zero interest rate policy can be a trap if inflation is below target, the economy is recovering and policymakers believe that promising to keep interest rates low in the future will raise inflation. The 2 percent inflation target is not consistent with the zero interest rate (Japan's -0.1 inflation trend appears to be compatible with the *ZIRP* regime). The *ZIRP* regime will lead to negative inflation in a growing economy. Policymakers will not want to raise interest rates because many believe that even small increases can have large negative impacts on the real economy. For a good example of this belief applied to this Japanese experience, see Ito and Mishkin (2006) who describe the interest rate hike from 2 basis points to 25 basis points in August 2000 as a "clear mistake." This occurred in a time when many of the Japanese policymakers wanted to return to normal. Economic news had been positive, but not conclusive, leading to a typical hawks versus doves debate. Ito and Mishkin write

> "Almost as soon as the interest rate was raised in August 2000, the Japanese economy entered into a recession. It was not known at the time, but the official date for the peak of the business cycle turned out to be October 2000. The growth rate of 2000:III turned negative, which was offset to some extent by a brief recovery in 2000:IV. But, as the economy turned into a recession, the criticism of the BOJ's actions became stronger." (Ito and Mishkin, page 146)

This sort of narrative, which is common in the financial press, has a chilling effect on any attempt to raise interest rates before the central bank is certain that the economy has reached full employment. In fact, there is no empirical evidence that such small changes in the money market rate have any measurable or sustainable effect on the real economy.[8] Moreover, every recovery is associated with uncertainty and fluctuations in news that drive observers from pillar to post. One news-day economic reports are optimistic about the recovery, and the next news-day, they are worried that the economy will slide back into a recession. Such worries keep the policy rate at zero.

Since the United States does not have an earlier period with such a *ZIRP* regime, we use data from the Japanese economy for the period from 1995:Q1 through 2007:Q4 to estimate the *ZIRP* model.[9] The Japanese experience with CPI inflation and interest rates is shown in Figure 3. The inflation rate, although slightly negative on average, appears to fluctuate around zero. In the beginning of 1995, the Treasury bond rate was 4.5 percent, but fell quickly to 2 percent and continued to drift even lower after 2000. The policy rate had been set low, at 2.25 percent, to try to stimulate the economy in 1995. However, further economic weakness led the Bank of Japan to lower the rate to ½ percent by the end of the year and to nearly zero in 1999 (the beginning of the official

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[8] For evidence of the contrary, showing weak empirical links among interest rates, inflation and the real economy, see Staiger, Stock and Watson (1997) and Stock and Watson (2003). For a good explanation about how beliefs about such relationships may drive shifts in the policy regime, see Cho, Williams and Sargent (2002).

[9] We did not investigate the possibility that U.S. data from the 1930s may fit this definition of a ZIRP regime.

ZIRP policy). Although there have been periods when the rate was raised slightly, bad incoming news about the economy and slightly negative inflation eventually led the Japanese policymakers to lower the rate back near zero.

The *ZIRP* model estimates are shown in Table 1c. For this period in Japan from 1995:Q1 through 2007:Q4, the best lag structure is, again, just one quarter. The standard errors in the per capita GDP growth, inflation, policy rate and bond rate equations are 1.37, 0.73, 0.14 and 0.34 percent, respectively. The standard error in the per capita GDP growth equation is approximately the same across all three regimes. It is slightly higher in the *No Credibility* regime. The standard error of the inflation equation is lower when the central bank follows the *Credibility* regime and lowest in the *ZIRP* regime. The biggest differences are in the interest rate equations. The standard error in the policy rate equation falls from 1.79 to 1.37 going from the *No Credibility* to the *Credibility* regime and then to nearly zero, 0.14, in the *ZIRP* regime. The standard error in the bond rate equation actually rises from 0.62 in the *No Credibility* to 1.07 in the *Credibility* regime, but then falls to 0.34 in the *ZIRP* regime.

The bottom panel in Table 2 presents the long-run mean forecasts for the *ZIRP* model starting from initial conditions in 2007 and 2013. In the model starting from 2007 (2013) initial conditions, we find that the per capita GDP growth rate converges to 1.5 percent in 9 (7) years, the inflation rate converges to -0.1 percent in 5 (5) years. The policy rate converges to 0.1 percent in 7 (2) years, and the bond rate converges to 1.5 percent in 6 (3) years.

Projecting Interest Rates in the Post-Crisis Economy: 2008 to 2013

We use the long-run properties of our three times series models to show what the alternative policy regimes imply for per capita GDP growth, inflation and interest rates during the period following the financial crisis. We start at the beginning of 2008 because the housing crisis was already underway. The FOMC officially adopted the *ZIRP* on December 16, 2008 when it set the range for policy rate target at 0 to 0.25 percent.

We calculate dynamic stochastic forecasts using 10,000 draws of random shocks for the period from 2008:Q1 to 2013:Q4. We calculate the median forecast and the standard error for each quarter. In Figure 4, the median forecast is displayed as a solid red line and confidence bands of plus and minus one standard deviation are shown as dotted blue lines. The actual values of the predicted variables are shown as purple dashed lines. Each column represents a policy regime with four rows representing per capita GDP growth, CPI inflation, the policy rate, and the bond rate.

The top row shows that none of the models could predict the deep recession that occurred in 2008 and 2009. The *No Credibility* model fails miserably for per capita GDP growth. One reason for this failure is that the trend in per capita output growth was declining throughout the period of *No Credibility* and that downward trend continues into negative territory in the long run. The *ZIRP* does the best job of predicting the downturn, but still misses the negative growth in 2009. Both the

Credibility and *ZIRP* models predict that per capita GDP growth will converge to 1.5 percent in the long run. The ZIRP model has the smallest confidence bands.

In the second row, we see that none of the models predicted the decline of inflation that occurred during the recession. The *No Credibility* model predicts rising and increasingly volatile inflation. The *Credibility* model converges to a 2.9 percent long-run inflation trend and predicts too much inflation during this period. The *ZIRP* model, on the other hand, predicts that CPI inflation will converge toward zero and predicts too little inflation.

The third row shows the forecasts for the policy rate. The *No Credibility* model predicts a high, rising and volatile policy rate. The *Credibility* model shows the policy rate converging to a 3.4 percent trend with widening confidence bands. The *ZIRP* model, as expected, is spot on with a nearly perfect forecast over the past five years. All the 'miss' is in 2008 as the rate converges toward zero at the end of the year.

In the fourth row, the *No Credibility* model predicts a high, rising and volatile bond rate, just as it does for inflation and the policy rate. The *Credibility* model predicts that the bond rate will converge to 4.8 percent, but the confidence bands continue to widen with the length of the forecast horizon. The actual bond rate stays below the median forecast, but generally within one or 2 percentage points. The biggest surprise to us in this figure was the result for the bond rate forecast from the *ZIRP* model. Here the bond rate forecast is on average below the actual rate, but the mean error is small relative to the other forecasts and the model correctly predicts the falling trend.

The average of the quarterly median and RMSE statistics are shown in Table 3. Although the *Credibility* model appears to provide a reasonable outlook for per capita GDP growth and the best forecast for inflation, it loses dramatically to the *ZIRP* model in a comparison of interest rate forecasts. Historically, uncertainty in bond markets has been driven mainly by uncertainty about inflation expectations.[10] We had expected the results from the inflation forecast to be more strongly reflected in performance of the bond rate forecast. The *ZIRP* model appears to tie down the long rate as well as the short rate. The visual evidence can be seen clearly in Figure 5 where we compare the Blue Chip long range forecast of the U.S. 10-year Treasury rate with the 6 year out-of-sample forecast from the *ZIRP* model. The Blue Chip long-range forecast for the bond rate is consistent with the 4.8 percent trend predicted by the *Credibility* model. The *ZIRP* model was always within one standard deviation of the actual rate and the long-run implication is that the bond rate will converge to a record low 1.5 percent if the Fed does not exit the *ZIRP* regime.

[10] See Gallmeyer, Hollifield, Palomino and Zin (2007).

Forecasting interest rates in the transition to normalcy: 2014 to 2019

The market and Fed policymakers expect to begin exiting the *ZIRP* regime in the middle of 2015. They plan to return to the *Credibility* regime that characterized policy from 1983 to 2007. For our purpose, we begin the simulations at the end of 2013. The forecasts will look very much like those in Figure 4 with slightly different initial conditions. The important comparison is between the *ZIRP* regime and *Credibility* regime. Nevertheless, we also report statistics for the *No Credibility* regime.

The path of interest rates during the transition to normalcy matter for many reasons, but one important concern for the Fed is the effect that interest rates will have on the Fed's interest income and expenses during the transition back to normal. Carpenter et al. (2013) provide the institutional details and simulations of the transition under alternative interest rate assumptions. Their baseline path for interest rates is based on the consensus Blue Chip forecast reported in the December 2012 release. Under their high interest rate scenario, they assume that paths for the federal funds rate and the 10-year rate are 1 percentage point above the Blue Chip consensus forecast.[11] In Figure 6, we show an updated version of the Blue Chip interest rate forecasts used by Carpenter et al. (2013) in their simulations. We define the Blue Chip Benchmark (BCB) as this forecast plus one percentage point. In this section we ask the following questions, "How likely is it that the policy and bond rates will exceed their respective BCB paths in each quarter of our 6-year simulation period?" and "How often does the policy rate exceeds the bond rate in in each quarter of the 10,000 simulations for our three models?"

Our forecasts will start with actual conditions at the end of 2013. The answers to our questions are shown in Figure 7. The top panel shows the percentage of times that the policy rate was above the BCB. In both the *Credibility* and the *No Credibility* models there is a significant likelihood of exceeding this Blue Chip benchmark in the first two years after the transition begins. By 2019, the likelihood of the federal funds rate exceeding the BCB in the *No Credibility* model reaches a maximum of about 90 percent after three years then declines to about 57 percent by 2019. In the *Credibility* model, with its lower trend, the likelihood is more than 50 percent in the first two years, but stabilizes around 30 percent by 2019. In the *ZIRP* model, the policy rate never exceeds the Blue Chip benchmark.

Results for the bond rate are shown in the middle panel of Figure 7. The likelihood that the bond rate forecast from the *No Credibility* model exceeds the BCB for the bond rate is quite low in the first year, below 10 percent. The likelihood rises gradually to 50 percent by the end of 2017. The

[11] See Figure 6. This is the high interest benchmark used by Carpenter et al. (2013) when simulating alternative exit strategies. On page 28, they write that this "…is an unlikely outcome, we present it to show the interest rate sensitivity of the outcome."

pattern for the *Credibility* model is similar. The likelihood remains below 20 percent in 2014 and rises gradually to 30 percent by 2019. The bond rate forecasted by the ZIRP model never exceeds the Blue Chip benchmark.

In the bottom panel of Figure 7 we plot the likelihood that the policy rate will be higher than the bond rate. In the *No Credibility* model, we find that the yield curve is inverted (the policy rate exceeds the bond rate) much of the time in the second through the fourth years of the transition to normalcy. In the *Credibility* model, the likelihood is much lower, especially in the first year when it is at or below 10 percent. After the second year, the probability of an inverted yield curve rises to a range of 20 to 25 percent. The policy rate is almost never above the bond rate in the *ZIRP* simulations. During the last three years of the simulations, the number is positive, rising only as high as 19 out of 10,000 in the final year.

Forecast Uncertainty

Our three policy regimes, *No Credibility*, *Credibility*, and *ZIRP*, were chosen to reflect the different concerns that policymakers have had about the transition to normalcy. The biggest source of uncertainty involves predicting which model will be the right one. A risk-averse decision maker will consider the risks involved in a variety of likely outcomes.

We are using VAR models to forecast inflation and interest rates. Analysis of forecasts including the 1970s and early 1980s data found the VAR forecasts were generally less accurate than more sophisticated forecasts that combined the forecaster's judgment with a large econometric model forecasts. But these forecasts typically involved periods less than two years into the future. For these short horizons, McNees (1986, 1990) found that, while VAR models performed relatively well on some variables, they did not do so well on inflation. He reports that the root mean squared error of forecasts was almost twice as large for the VAR forecasts as for the professional forecasters. The VAR interest rate forecasts for the 3 month T-bill were about 33 percent larger than the large model alternatives.

Reifschneider and Tulip (2008) report that the RMSEs of CPI inflation forecast errors for the period of 1986 to 2006 were clustered around 1 percent for horizons of 2 to 4 years. These forecasts are tethered to the official forecasts—implicit objectives—of the Fed and the Government. This is less than the uncertainty we estimate for the *Credibility* models at a 2 year horizon and much less than the uncertainty associated with the *No Credibility* models. Even in the *Credibility* regime, we are not constraining the time series forecast to the official inflation objective. Although we know that the VAR forecasts are more disperse than typical economic forecasts, they have the advantage that they are simple to construct and easy to replicate. Furthermore, we are mainly interested in characterizing the alternative regimes and in comparing the relative uncertainty across them.

Conclusions

The first conclusion we draw is that the *ZIRP* should be treated as a separate regime with different statistical processes than we see in the United States during the period known as the Great Moderation. We assume that the *ZIRP* could be adequately modeled using Japanese data from 1995 through 2007. The most startling result of the paper is that the *ZIRP* model, estimated using Japanese data, does the best job forecasting the U.S. data from 2008 through 2013.

A second finding of this paper is that the *ZIRP* regime leads to low and stable long-term bond rates and lower than expected inflation. The *ZIRP* model under predicts inflation, which we attribute to the fact that policymakers and markets expect the FOMC to return to the *Credibility* model with a 2 percent inflation target. As we noted, the 2 percent inflation target is not consistent with the *ZIRP* and the longer the FOMC stays in the *ZIRP* regime, the further the trend inflation rate will fall below the target.

A third finding is that the *No Credibility* model has terrible implications for the post crisis period. The time-series properties of this regime strongly recommend against it as a policy choice. Nevertheless, the bad properties of this regime make it imperative for policymakers to take special care to avoid it. Worldwide, this policy regime has been seen in countries that lose control of their federal government budget process. Losing the ability to curb spending or raise taxes, such governments print money to pay for spending.

The fourth, and perhaps less obvious, conclusion we draw is that any attempt to return to the *Credibility* regime will likely involve higher and more volatile interest rates, reminiscent of the volatility that occurred during the "Taper Tantrum" of May-June 2013 when then Fed Chairman, Ben Bernanke, announced that the Fed would gradually slow its large scale purchases of long-term securities. Our analysis suggests that lifting off the zero lower bound will involve a period of heightened uncertainty about interest rates at both short- and long-term horizons.

We do not draw any firm conclusions from these experiments about the effects of the *ZIRP* on the real economy. In our models, the per capita GDP growth rate converges to 1.5 percent at an annual rate in both the *Credibility* and the *ZIRP* models. Our main concern is that uncertainty about which regime the economy will converge to creates a headwind that keeps the economy operating below its efficient level. A decision to adopt the *ZIRP* model should be accompanied by an explicit decision to allow inflation to run at or below zero percent, as the Japanese have done. Our analysis suggests that their recent decision to adopt a 2 percent inflation target is doomed to fail if they are not willing to raise interest rates to some normal level that is approximately equal to the sum of the inflation target and per capita real GDP growth. The problem is that over time, if the central bank fixes the nominal interest rate and allows real factors to determine the real interest rate, then the Fisher equation says that inflation will adjust to clear the bond market.

From the point of view of money and bond markets, the FOMC has been replicating the *ZIRP* regime of Japan. The only circumstance in which future interest rates are not likely to be a problem is if the *ZIRP* policy is the new normal. In our simulations, the policy rate exceeded the bond rate about 20 to 25 percent of the time in the *Credibility* regime. In the *ZIRP* model, the yield curve was almost never inverted. If normalization is, as planned, a return to the *Credibility* model with a historically 'normal' sized balance sheet for the Fed, then one should plan for a scenario in which higher interest rates will complicate the normalization process.

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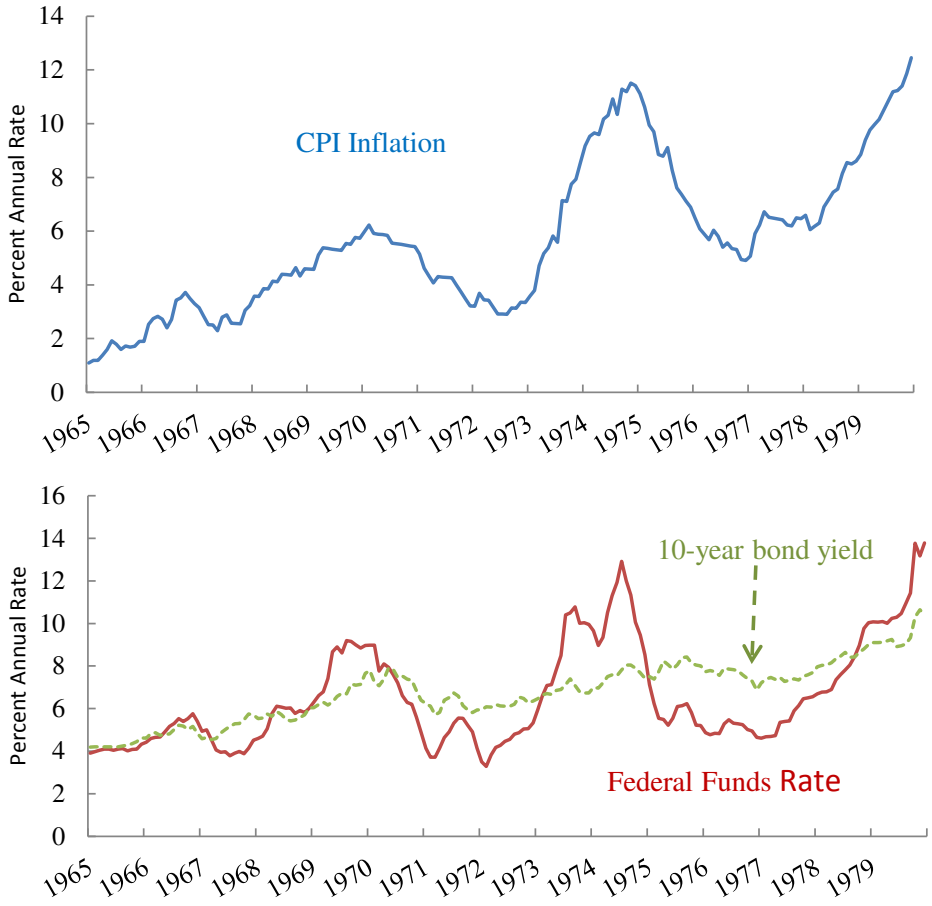
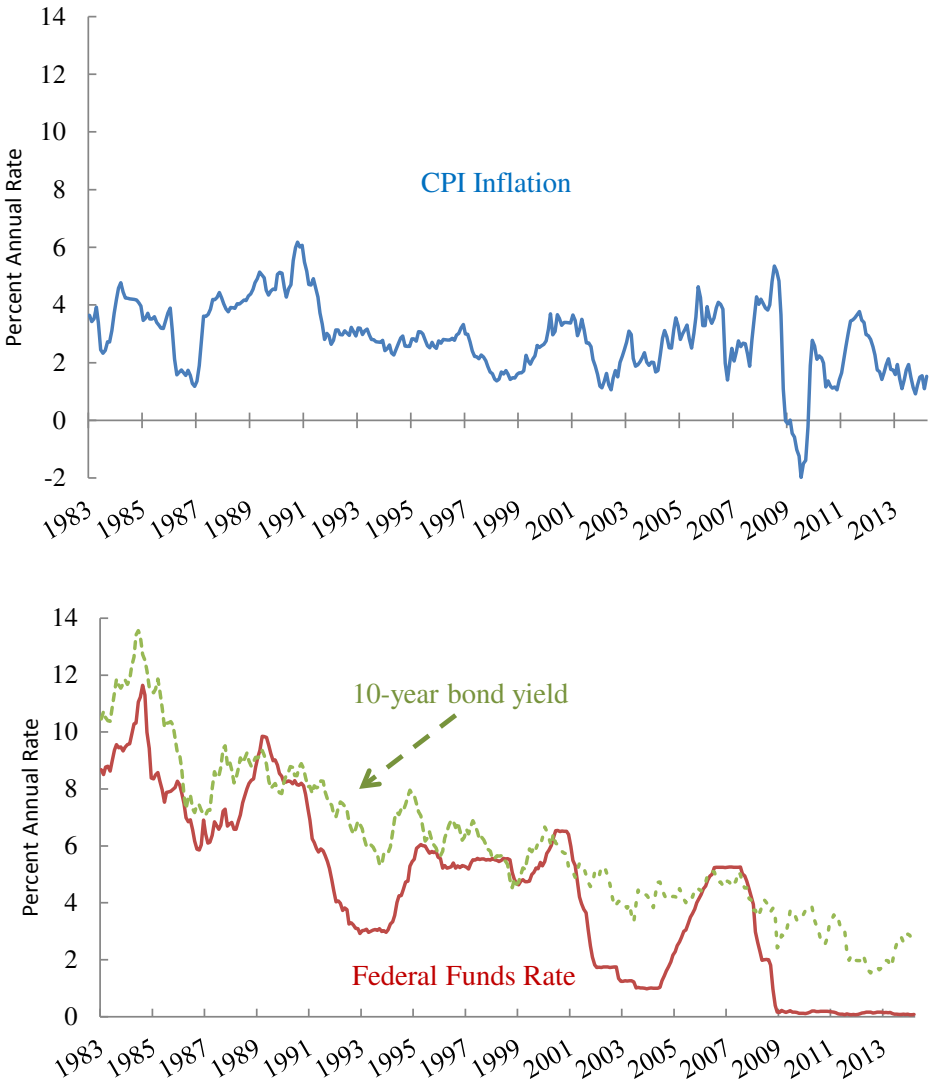
Figure 1. United States without Fed Credibility: 1965 to 1979
(Note that inflation is measured as the change over the previous year.)



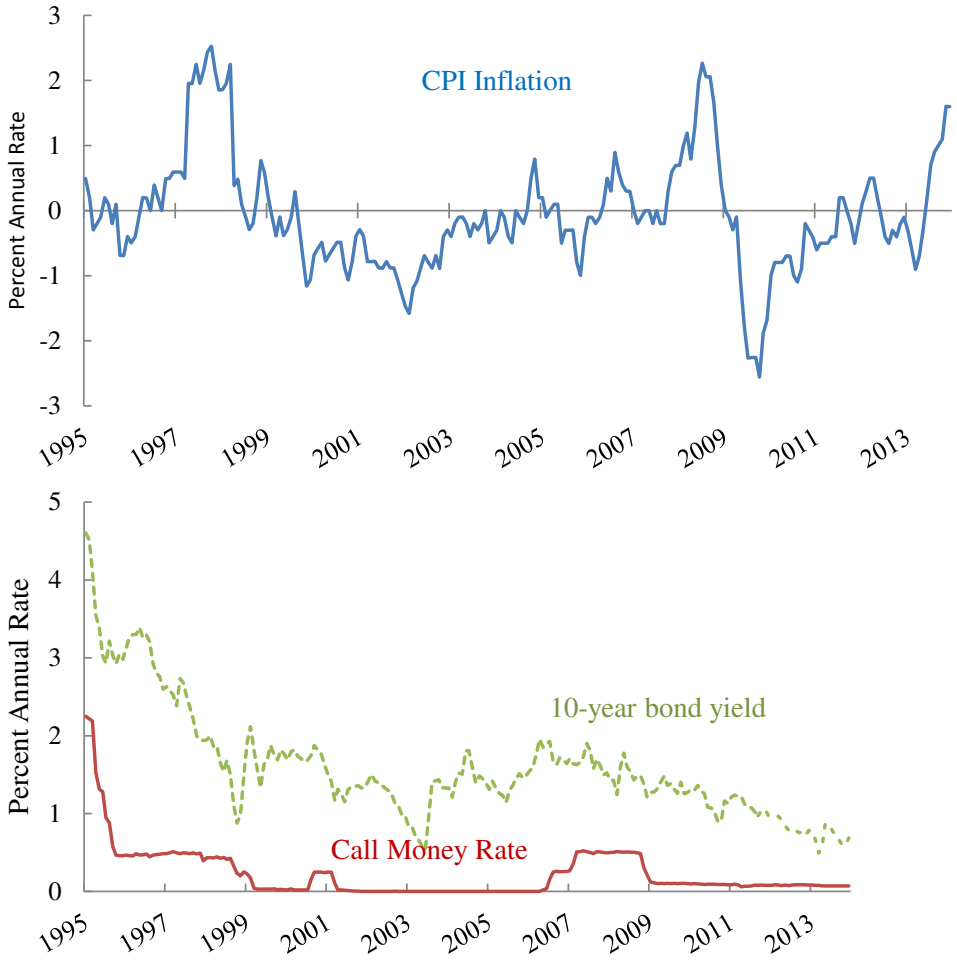
Source: Federal Reserve Bank of St. Louis FRED®.

Figure 2. United States with Fed Credibility: 1983 to 2013
(Note that inflation is measured as the change over the previous year.)



Source: Federal Reserve Bank of St. Louis FRED®.

Figure 3. Japan with the Zero Interest Rate Policy, 1995 to 2013
(Note that inflation is measured as the change over the previous year.)



Source: Federal Reserve Bank of St. Louis FRED®.

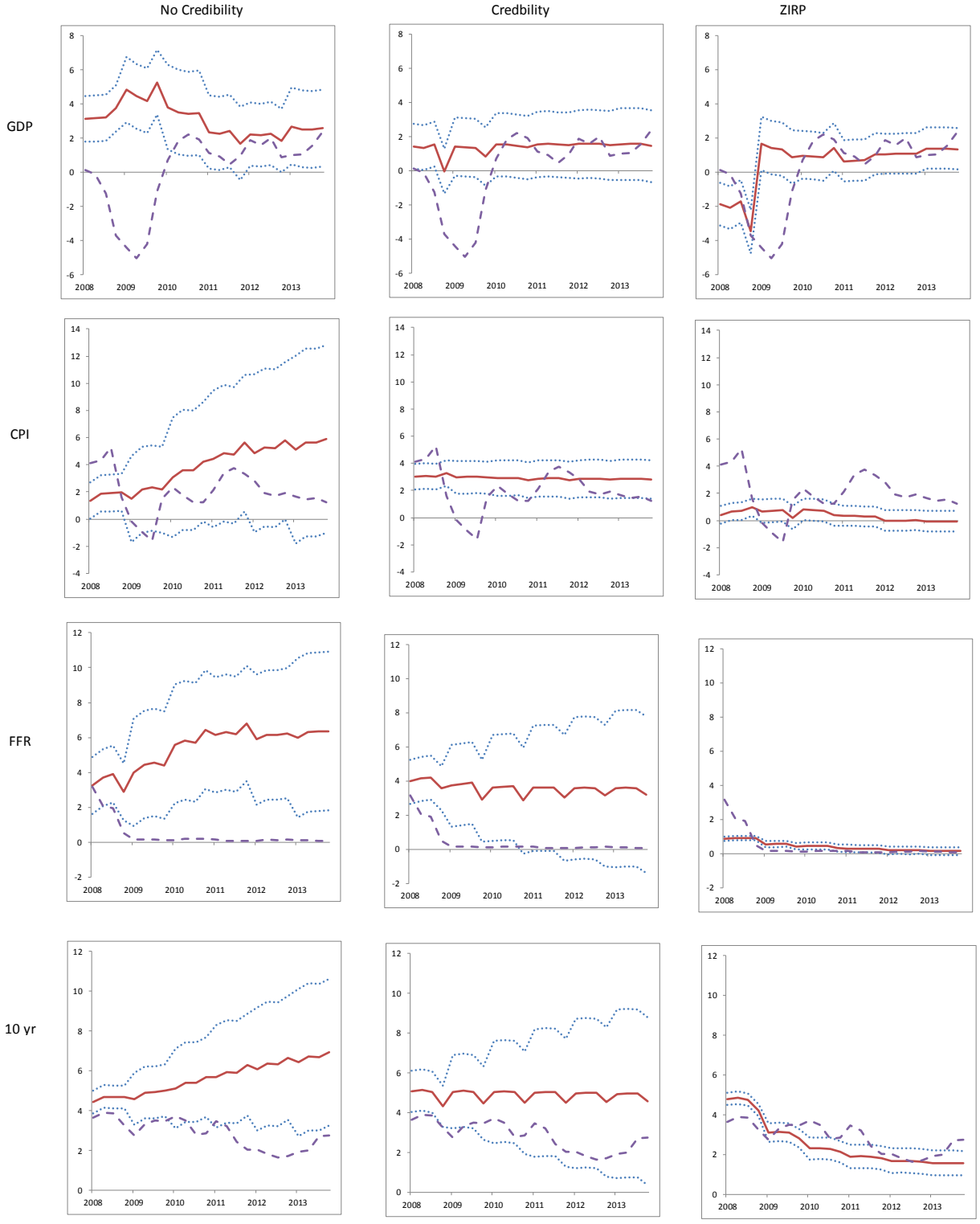
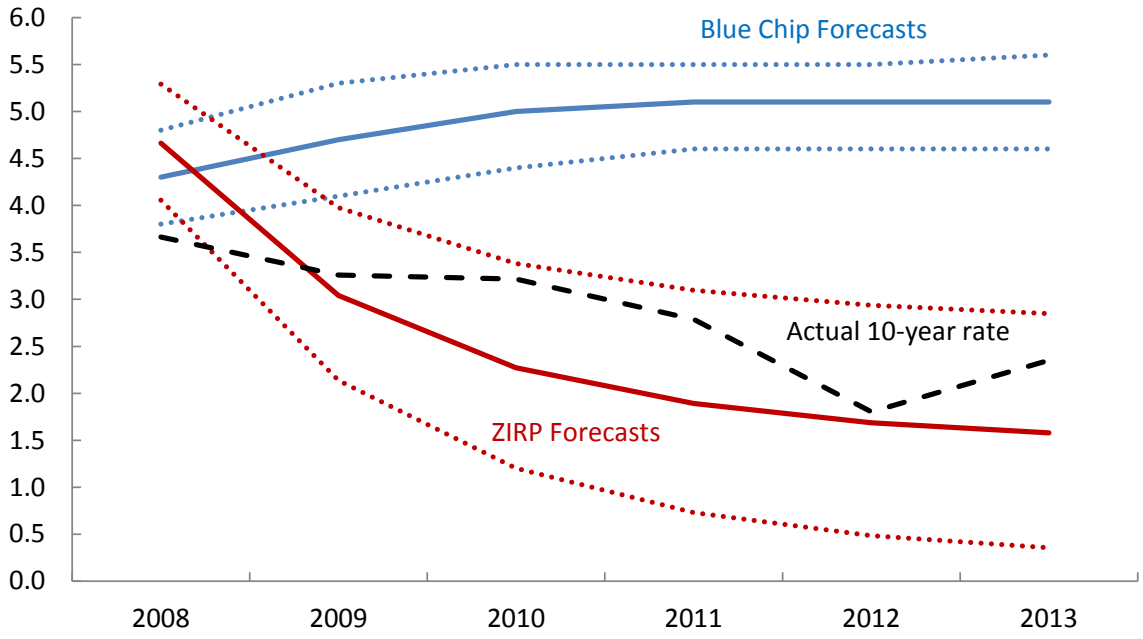


Figure 4. Out of Sample Forecasts 2008 through 2013: Three Scenarios
Red solid line is the median forecast in 10,000 simulations, the dotted blue lines are the median plus and minus one standard deviation, the dashed purple line is the actual value.

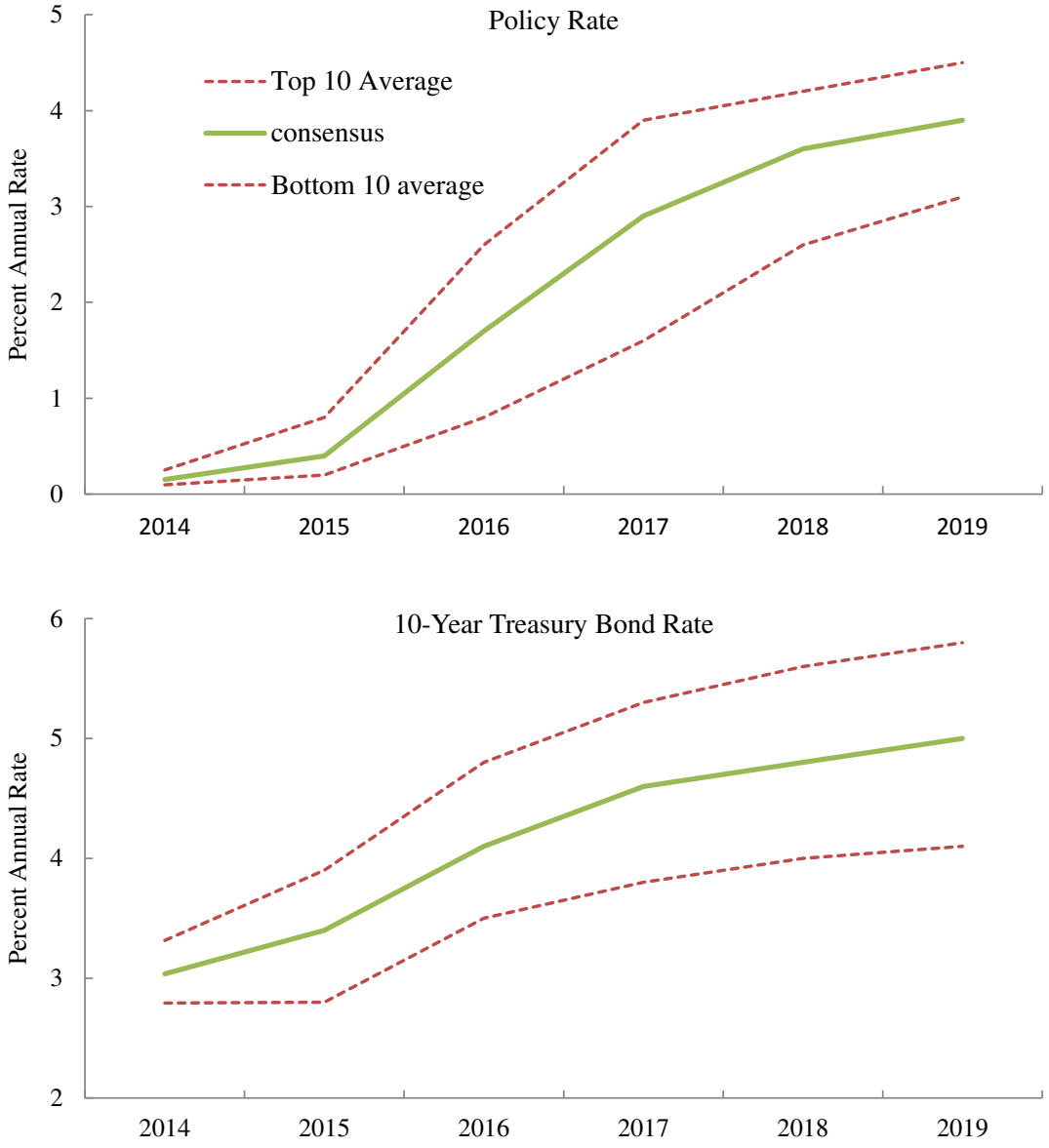
Figure 5. Blue Chip Consensus vs. ZIRP forecasts of the U.S. 10-year Treasury rate



Blue Chip: Solid line is the consensus, dotted lines are top 10 and bottom ten forecasts, ZIRP: Solid line is the median forecast, dotted lines are plus and minus one standard deviation. The actual data are shown in the dashed black line. The ZIRP model is estimated using Japanese data from 1995:Q1 through 2007:4. All forecasts are out-of-sample . Blue Chip forecasts are reported on December 1, 2007. We thank Yi Wen for suggesting this figure.

Source: Blue Chip Financial Forecasts published on December 1, 2007 and authors' calculations.

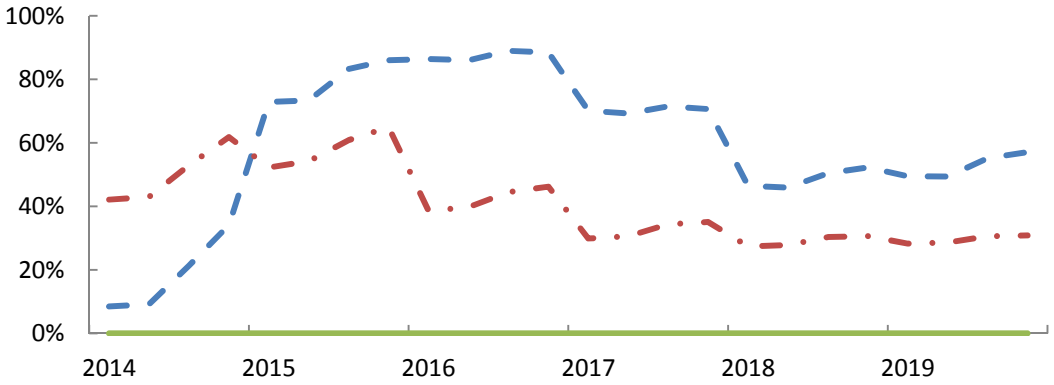
Figure 6. Blue Chip Interest Rate Forecasts



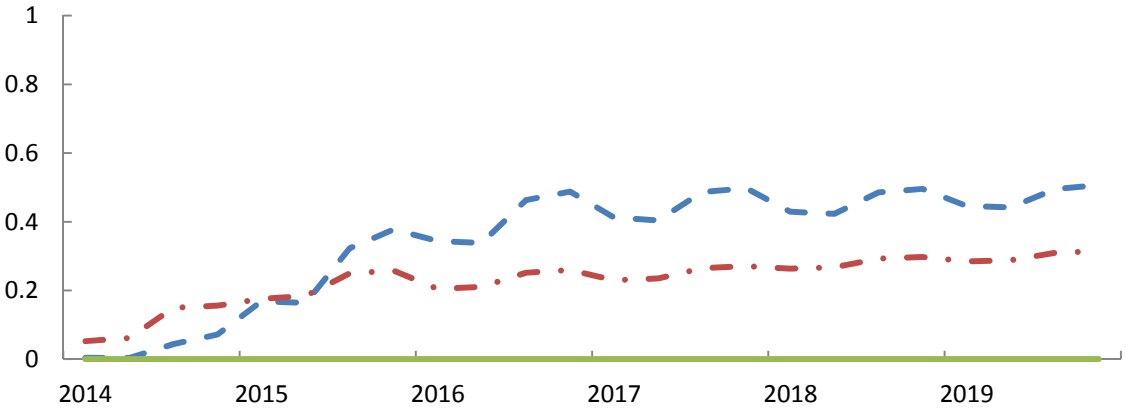
Source: Blue Chip Financial Forecasts published on December 1, 2013.

Figure 7. The Likelihood of High Interest Rates

What is the likelihood: policy rate > Blue Chip policy rate forecast plus 1 percent?



What is the likelihood: bond rate rate > Blue Chip bond rate forecast plus 1 percent?



What is the likelihood: policy rate > bond rate?

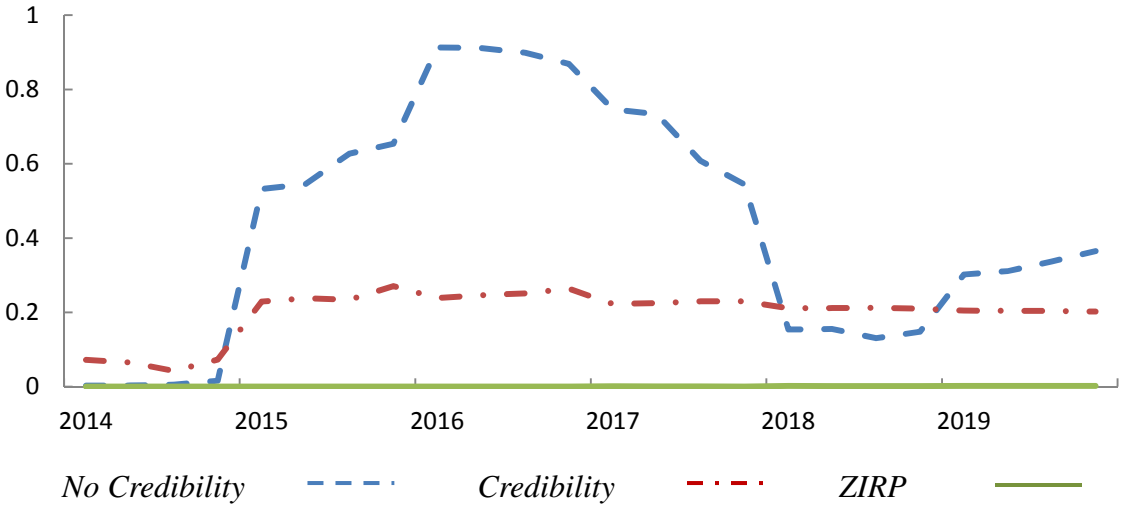


Table 1a. *No Credibility* Model*

	GDP_{t+3}	CPI_{t+3}	RS_{t+3}	RL_{t+3}
GDP_{t-1}	-0.16	0.65	0.66	0.23
CPI_{t-1}	0.01	0.54	-0.03	0.25
RS_{t-1}	-1.15	0.51	0.51	0.04
RL_{t-1}	0.42	0.63	0.84	0.64
Constant	7.23	-5.74	-3.43	0.57
Adj. R-squared	0.67	0.79	0.56	0.83
S.E. equation	1.46	1.45	1.79	0.62
Mean dependent	2.39	6.37	6.93	7.05
S.D. dependent	2.54	3.15	2.70	1.52
Included Observations	59			
Sample	1965Q1 1979Q3			

*Dark (light) shading indicates significance at the 5% (10%) level.

Residual Correlation Matrix (Standard Error on Diagonal)

	GDP	CPI	RS	RL
GDP	1.28	-	-	-
CPI	0.25	0.36	-	-
RS	-0.05	0.31	1.34	-
RL	0.34	0.32	1.28	1.05

Table 1b. *Credibility* Model *

	GDP_{t+3}	CPI_{t+3}	RS_{t+3}	RL_{t+3}
GDP_{t-1}	-0.03	0.04	0.31	-0.06
CPI_{t-1}	-0.85	0.21	-0.05	-0.17
RS_{t-1}	-0.20	0.17	0.52	0.13
RL_{t-1}	0.63	-0.06	0.25	0.79
Constant	1.66	1.94	0.12	1.17
Adj. R-squared	0.32	0.16	0.68	0.76
S.E. equation	1.36	0.98	1.37	1.07
Mean dependent	2.18	3.15	5.27	6.66
S.D. dependent	1.64	1.07	2.42	2.20
Included Observations	100			
Sample	1983Q1 2007Q4			

*Dark (light) shading indicates significance at the 5% (10%) level.

Residual Correlation Matrix (Standard Error on Diagonal)

	GDP	CPI	RS	RL
GDP	0.90	-	-	-
CPI	0.47	0.75	-	-
RS	-0.09	0.44	0.94	-
RL	0.80	0.54	0.52	1.20

Table 1c. *ZIRP* model*

	GDP_{t+3}	CPI_{t+3}	RS_{t+3}	RL_{t+3}
GDP_{t-1}	0.01	0.22	0.05	0.02
CPI_{t-1}	-1.07	0.27	0.06	-0.05
RS_{t-1}	-0.31	-0.28	0.02	0.41
RL_{t-1}	0.29	0.47	0.16	0.42
Constant	0.96	-1.05	-0.18	0.77
Adj. R-squared	0.22	0.31	0.60	0.63
S.E. equation	1.37	0.73	0.14	0.34
Mean dependent	1.49	0.06	0.20	1.68
S.D. dependent	1.55	0.87	0.22	0.56
Included Observations	51			
Sample	1995Q2 2007Q4			

*Dark (light) shading indicates significance at the 5% (10%) level.

Residual Correlation Matrix (Standard Error on Diagonal)

	GDP	CPI	RS	RL
GDP	1.10	-	-	-
CPI	0.49	0.31	-	-
RS	-0.14	-0.01	0.66	-
RL	0.34	0.04	0.05	0.11

Table 2. Long-Run Properties of Forecasting Models (Long-run values are shown in percent annual rates)

No Credibility	GDP	CPI	RS	RL
Long Run Value	-6.7	34.5	22.0	23.7
Years to convergence from 2007 initial conditions	222	283	238	335
years to convergence from 2013 initial conditions	224	286	240	338
Credibility	GDP	CPI	RS	RL
Long Run Value	1.5	2.9	3.4	4.8
Years to convergence from 2007 initial conditions	8	12	21	15
years to convergence from 2013 initial conditions	19	24	24	26
Zero Lower Bound	GDP	CPI	RS	RL
Long Run Value	1.5	-0.1	0.1	1.5
Years to convergence from 2007 initial conditions	9	5	7	6
years to convergence from 2013 initial conditions	7	5	2	3

Table 3. Accuracy of Forecasts

Regime	Mean Error			RMSE		
	Not Credible	*Credible*	*ZIRP*	*Not Credible*	*Credible*	*ZIRP*
GDP	-2.95	-1.30	-0.44	3.93	2.70	2.11
Inflation	-1.90	-0.95	1.61	5.29	2.05	2.19
Policy Rate	-4.96	-3.16	0.01	6.00	4.54	0.46
Bond Rate	-2.80	-2.06	0.32	3.58	3.48	0.93