

The Zero Lower Bound and the Dual Mandate

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Abstract

This article uses a DSGE framework to evaluate the effect of alternative policy rules on the likelihood of encountering the zero lower bound. We find that the probability of experiencing episodes of being at zero lower bound depends primarily on the monetary policy rule. A policy rule, such as the one proposed by Taylor (1993) which is based on the dual mandate is highly likely to lead to episodes of zero short-term interest rates if the central bank is not committed to its inflation target. Our results on nominal interest rate and inflation dynamics do not depend on the mechanism that makes monetary policy have real effects. Any of the existing general equilibrium models will deliver our results. The key and necessary assumption is that expectations are forward looking. The bottom line in models in which monetary policy can influence the real economy is that a central bank must be committed to a long-run average-inflation objective if it wishes to achieve a dual mandate while avoiding the zero lower bound.

Key Words: Zero Lower Bound, Taylor-Type Rules, Dual Mandate

JEL Codes: E31, E42, E58, E61

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Introduction

In over 300 years of central banking history, there are few extended episodes with the market interest rate at zero. Two well-known examples are in the United States during the Great Depression in the 1930s and in Japan since 1995. Japan appears to have settled into a regime with steady state inflation rate near or slightly below zero, the money market rate effectively at zero, and long-term government bonds around two percent. According to many economic models this may be the optimal monetary policy because it promotes an optimal level of real cash balances. But that is not the case examined in this paper. We investigate the factors that determine the probability of having extended periods of a zero money market interest rate when the inflation target is positive. Except when explicitly noted otherwise, we assume that the central bank's inflation target (and the steady state inflation rate) is two percent.

Why did the federal funds rate go to zero in 2008:Q4? The obvious answer is that the Federal Reserve injected several hundred billion dollars of excess reserves into the banking system which had been operating with less than \$10 billion. But a main point of this paper is that the Federal Reserve has stumbled into a policy regime in which zero lower bound episodes are likely to occur. Figure 1 shows a history of two interest rates: the yield on 10-year U.S. Treasury bonds and the overnight interest rate on bank reserves—the federal funds rate. Consider first the period before October 1979.² The 10-year yield was between 2 and 2½ percent in 1955. It rose in fits and starts to over 10 percent in 1979. In this early period, the federal funds rate was often above the 10-year rate. The Fed was regularly ‘fighting inflation.’ As inflation became a problem the Fed would have to raise rates very high to discourage borrowing and spending. Aggregate demand and inflation would fall for a time, but the inflation trend kept rising. There were two periods before October 1979 in which the Fed kept the federal funds rate relatively low as the expansion proceeded, in 1971 to 1973 and again in 1976 to 1978. In both of these episodes the Fed kept the rate low in an attempt to speed up the recovery. In both instances, the economy did not grow faster, but inflation did. The lesson learned then was that the Fed could not conduct output stabilization policy using low interest rates because doing so would quickly lead to accelerating inflation. As we will see, that lesson was not quite correct.

Between October 1979 and October 1982, the Federal Reserve implemented monetary policy by focusing open market operations on a short-run target for bank reserves. This led to high and volatile interest rates, but it also caused people to change their views about future monetary policy and the inflation objective. From 1982, interest rates and inflation followed a fluctuating but downward trend. In contrast to the earlier period, the federal funds rarely traded at a rate higher than the 10-year bond yield. In the period from 1992 to 1994, the Fed held the federal

² See Lindsey, Orphanides and Rasche (2005) for a detailed analysis of the policy reform that was implemented in October 1979.

funds rate well below the 10-year bond yield well into the recovery from the 1991 recession. But there was no subsequent acceleration in inflation. Again, following the 2001 recession, the Fed held the overnight rate well below the 10-year yield and there was little acceleration in inflation or inflation expectations. Both episodes were characterized as “jobless recoveries” and the federal funds rate was held down in an attempt to stimulate faster real growth. During this period, speeches by Federal Reserve officials indicated that, although the Federal Reserve did not have an explicit inflation target, they wanted inflation to be low and would do whatever was necessary to prevent a 1970s rerun of high and rising inflation. Interest rates remained relatively low, and inflation appeared to remain under control. The lesson from modern dynamic stochastic general equilibrium models is more sophisticated--inflation depends on what monetary policy regime is in place and the confidence that people have that it will remain in place.

The purpose of this paper is to characterize the regime that is in place, to show why this regime is likely to produce episodes with the monetary market rate at zero, and to show how policy can be modified to achieve the Fed’s dual mandate without hitting the zero lower bound on a regular basis.

In Section 2, we briefly describe the model framework(s) that we use. We begin with a typical New Keynesian model with nominal rigidities. Here, the monetary transmission mechanism works through a combination of sticky wages and prices. In Section 3, we describe the computational experiments in which we calculate the probability of zero lower bound episodes occurring under alternative policy regimes. We also present sensitivity analysis of models that rely on different monetary transmission mechanisms including versions of cash-in-advance constraints on purchases of consumption, investment, and/or labor and a version that relies on an imperfectly indexed tax system. As far as we can determine, these specifications span the set of monetary models in which money matters. Note that research on the microfoundations of money provides an economic rationale for the cash-in-advance specifications, but does not offer a fundamentally different transmission mechanism that can be featured in dynamic stochastic general equilibrium (DSGE) models—see Aruoba and Schorfheide (2009). In Section 4, we discuss the policy implications and other conclusions.

The Model

Our baseline DSGE framework is a typical New Keynesian sticky price model. Agents are infinitely-lived; households get utility from consumption and leisure but need to spend time shopping for consumption goods. Higher money balances reduce shopping time for a given level of consumption. The interest elasticity of money demand is a key parameter determining the

nature of inflation dynamics. Households consume a composite good that is a combination of outputs from monopolistically competitive firms. Sticky prices are introduced using a Calvo (1983) specification that allows for the possibility of perfect price flexibility as a nested special case. Monetary policy is conducted through lump sum monetary transfers that are determined by the central bank's monetary policy rule. Our focus is on the differences implied by policy rules that place more or less weight on output stabilization and are more or less committed to a long-term inflation objective.

Households: Each period, households maximize the discounted present value of the expected utility they get from consumption and leisure:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, l_t), \quad (1)$$

where β is the household's discount factor, c_t is the consumption bundle, and l_t is leisure time. The momentary utility function takes the form

$$u(c_t, l_t) = \ln(c_t) + \chi \frac{l_t^{1-\sigma_1}}{1-\sigma_1},$$

where the preference parameters σ_1 and χ are positive.

The household maximizes (1) subject to a budget constraint

$$P_t c_t + P_t i_t + M_t + B_t = P_t w_t n_t + P_t q_t k_t + D_t + M_{t-1} + R_{t-1} B_{t-1} + T_t \quad (2)$$

where P_t is the nominal goods price, i_t is investment, k_t is the capital stock which evolves following the capital accumulation process, $k_{t+1} = i_t + (1-\delta)k_t$ and depreciates at rate δ . M_t and B_t are stocks of money and bonds, w_t is the real wage rate, q_t is the real rental price of capital, and R_{t-1} is the gross nominal interest rate on bonds purchased at time $t-1$. The household also receives monetary transfers T_t and distributed profits from the goods-producing sector, D_t .

The household also faces a time constraint. Total time available to the household (normalized to unity) can be allocated to leisure, labor, and shopping time, s_t ,

$$l_t + n_t + s_t = 1 \quad (3)$$

The amount of time households spend shopping, s_t , can be reduced by holding larger money balances relative to nominal consumption expenditures,

$$s_t = \zeta \left(\frac{P_t c_t}{M_t} \right)^\gamma, \quad (4)$$

Money demand elasticities are determined by the curvature parameter $\gamma > 0$, while $\zeta > 0$ is a scale parameter that is calibrated to match estimates of shopping time.

Firms: The composite consumption good is a combination of outputs, $y_{j,t}$, produced in period t by monopolistically competitive firms. Each firm's output comes from a production function:

$$y_{j,t} = Z_t f(k_{j,t}, n_{j,t}), \quad (5)$$

where j indicates the number of periods since the firm last adjusted its price, $n_{j,t}$ is the firm's demand for labor, $k_{j,t}$ is the firm's demand for capital, and Z_t is an economy-wide productivity factor. The productivity factor is assumed to follow a stationary autoregressive process:

$$\ln(Z_t) = \rho_Z \ln Z_{t-1} + (1 - \rho_Z) \ln(Z) + \varepsilon_{Zt}, \quad (6)$$

where Z is the steady state value of Z_t and ε_{Zt} is a mean zero, independently and identically distributed (i.i.d.) shock. Every period, each firm must determine: (1) the cost minimizing combination of $n_{j,t}$ and $k_{j,t}$ given its output level, the real wage rate, w_t , and the real rental rate of capital, q_t and (2) whether or not it can adjust its price. Sticky prices are introduced using Calvo's (1983) model of random price adjustment. Specifically, the probability that a firm can set a new price, P_t^* , is η and the probability that a firm must keep the price that it set j periods ago is $(1 - \eta)$.

Each period, firms seek to minimize their costs:

$$w_t n_{j,t} + q_t k_{j,t}, \quad (7)$$

subject to the production function (6). Market clearing conditions require that an individual firm's labor and capital demand must sum to the economy aggregates, n_t and k_t . Our goal here is merely to understand the workings of a simple model, so we have omitted capital adjustment and other frictions that are often included in this type of model.

Cost minimization by households yields the following demand equation facing each firm:

$$y_{j,t} = \left(\frac{P_{t-j}^*}{P_t} \right)^{-\varepsilon} y_t, \quad (8)$$

where $-\varepsilon$ is the price elasticity of demand. Aggregate output, y_t , is given by:

$$y_t = \left[\sum_{j=0}^{\infty} \eta(1-\eta)^j y_{j,t}^{(\varepsilon-1)/\varepsilon} \right]^{\varepsilon/(\varepsilon-1)}, \quad (9)$$

and the aggregate price level is a nonlinear combination of current and past prices:

$$P_t = \left[\sum_{j=0}^{\infty} \eta(1-\eta)^j P_{t-j}^{*(1-\varepsilon)} \right]^{1/(1-\varepsilon)}. \quad (10)$$

The appendix describes in more detail the implications of this pricing structure for the evolution of the aggregate price level.

Our general policy rule is a modified version of the Taylor rule.

$$R_{t+1} - R_{t+1}^* = \theta_{\pi}(\pi_t - \pi_t^*) + \theta_y(y_t - y_t^*) + \theta_p(p_t - p_t^*) + u_t, \quad (11)$$

where p is the logarithm of the price level; $\pi_t = p_t - p_{t-1}$ and $p_t^* = p_{t-1}^* + \pi^*$;

R is the federal funds rate; the inflation target follows a stochastic AR1 process,

$\hat{\pi}_t^* = \rho_{\pi} \hat{\pi}_{t-1}^* + \varepsilon_{\pi t}$, and the transitory policy shock, u_t , follows an AR1 process $u_t = \rho_u u_{t-1} + \varepsilon_{u t}$.

Both error processes, $\varepsilon_{\pi t}$ and $\varepsilon_{u t}$, are mean zero, i.i.d. shocks. We use y to represent the logarithmic level of GDP. The starred terms represent the equilibrium levels of the federal funds rate, the inflation target, and the level of GDP that is expected when the economy is operating at full employment. The equation represents a policy rule in which the central bank reacts to both deviations of inflation from target (inflation gap) and output from potential (output gap). The third term is the gap between the current price level and the price level path target.

The inflation target has a time subscript because the Federal Reserve does not have an explicit inflation target. Consequently, the inflation target has evolved over time and with shifts in the economy (although here the shifts are treated as exogenous shocks). In equation (2) the inflation target is a constant. When we consider regimes in which θ_p is nonzero, we will drop the time subscript on the inflation target and treat the target as a constant. The price path is a reference line that loses much of its operational content as an indicator policy if the inflation target is allowed to shift from period to period.

Calibration

The model is calibrated using empirical estimates of steady-state relations among the model's variables and parameters. Most of the estimates come from long-run or average values. Measurements from panel data also are used. In the utility function, the value of σ_1 is set at 7/9. The steady state labor share is 0.3 and shopping time is 1 percent of that value. That calibration implies a labor supply elasticity of real wages equal to $((1 - \bar{n} - \bar{h}) / \bar{n})(1 / \sigma_1)$, approximately 3 in this case. The household discount factor is 0.99, so that the annual real interest rate is 4 percent. We calibrate the money-time trade-off so that the implied money demand function is consistent with the empirical evidence summarized by Lucas (2000) and Mulligan and Sala-i-Martin (1997). The money demand relationship in the model has a unitary elasticity of the scale variable (consumption). When we set η (the curvature parameter in the money-time trade-off) equal to -1, the interest rate elasticity equals -0.5. The scale parameter, ξ , is calibrated to target the average ratio the price level to an index of real money balances. In our model this is equivalent to targeting velocity.

The capital share of output is set to 0.33 and the capital stock is assumed to depreciate at 2 percent per quarter. The price elasticity of demand is set equal to 6, implying a steady state markup of 20 percent. We set the probability of price adjustment equal to 1 for the flexible price case and equal to 0.25 for the sticky price case. For the sticky price case, this implies that firms change prices on average once a year. The model is calibrated so that the steady state inflation rate is zero.³

The baseline policy rule is calibrated to match Taylor's (1993) values. The coefficient on the deviation of inflation from target is set at 0.5 and the response of the interest rate—specified as a quarterly return—to the output gap is evaluated at several values to capture the idea that the Fed has begun to put more weight on that term. Taylor suggested 0.5, which is equivalent to 0.125 in our model where rates are scaled to reflect quarterly returns. We also examine the effect of adding more weight, choosing 2.0 (or 0.5 for quarterly rates), to describe aggressive output stabilization policies.

In this preliminary document, we have calibrated the shock processes to match the behavior of inflation and output in the data. In the next version, we plan to estimate these shock processes jointly with a reduced form policy function conditional on the calibrated structure of

³ This is necessary to prevent the nonadjusting firms' prices from becoming too far out of line with the flexible price benchmark. The same model dynamics result if there is a positive steady state inflation and the non-adjusting firms can index prices to rise each period by the steady state inflation rate.

the model. For this versions, shocks to the nominal growth trend are assumed to be highly persistent, $\rho_\pi = 0.95$, while the transitory policy shocks are less persistent., $\rho_u = 0.3$. The shocks to technology are calibrated to be highly persistent, $\rho_a = 0.9$ and $\rho_z = 0.95$.⁴

The Computational Experiments.

(This section is incomplete, does not include the estimated shock processes or the sensitivity tests for alternative specifications of the monetary transmission mechanism.)

In each of these experiments, we assume that the government has an inflation target of 2 percent. Some policies do better than others in achieving the target, those that do worse have wider swings in interest rates, so are more likely to hit the zero lower bound. In each case we run the experiments for 2500 years or 10,000 quarters. We then record the number of times that the model predicts zero interest rates. We also record the number and length of episodes in which the interest rate stays at zero for more than one quarter. Results are displayed in histograms, which report the number of episodes on the vertical axis and the length of the episodes on the horizontal axis. Note that the current episode, which began in December 2008, is already 2 years old. Japan has been at the zero lower bound for about 15 years.

In our first set of experiments shown in Figure 2, we look at how putting more or less weight on the output gap—or in other words, trying to fulfill the full employment part of the mandate more or less aggressively—affects the likelihood of hitting the zero lower bound. Given the Taylor rule with $\theta_\pi = 0.5$, the best we can do to avoid the zero lower bound is to put no weight on output. Using the Taylor rule with no weight on the output gap results in hitting the zero lower bound about 4 percent of the time. Using John Taylor’s suggestion, which puts equal weight on both output and inflation, does almost as well. It results in hitting the zero lower bound 6 percent of the time, with a few more long episodes lasting as long as five years. Business economists usually estimate that the Fed’s weight on the output gap is larger than recommended by Taylor, perhaps as large as 1 or 2: With $\theta_y = 2$ the model predicts that the interest rate is at the zero lower bound 16 percent of the time. As Figure 2 shows, putting more weight on the output gap causes wider swings in the federal funds rate and greatly increases the chances of hitting the zero lower bound. If the weight is as large as 2 with an inflation target of 2 percent, the interest rate is quite likely to hit the zero lower bound in every recession.

The problem with the Taylor rule is that it targets the short-run inflation rate. When the Fed misses the target for any reason, the target miss is forgiven and the future target is kept at the

⁴ See the appendix for details about the nonlinear model, the equilibrium, the steady state, and the linear approximation around the steady state that are used to calculate the model dynamics. The solution method is based on King and Watson (1998, 2002).

target rate. The reason the dual mandate causes such wide swings in the interest rate and the inflation rate is because output and employment are much more volatile than inflation. By putting more weight on output, the policy transmits the fluctuations in output and employment into wide swings in the inflation rate and interest rates. The Taylor rule offers no remedy for these fluctuations. The solution is for the central bank to find a way to commit to offsetting the swings in inflation that are induced by its mandate to promote full employment.

The Price Path as a Commitment Mechanism for an Inflation Target. Kydland and Prescott (1977) showed that it can be difficult, if not impossible, for governments to commit to following good long-run policies if the optimal short-run policy runs counter to it. As long as people believe that there is a tradeoff between full employment and inflation, they will always want more inflation when there is some unemployment. Without an explicit target, it is easy to let the inflation objective move up and down with shocks to the economy. If these shifts are not offset, then they induce uncertainty about inflation and interest rates at all horizons. Svensson (1999) shows that the discretion solution to a model with a price path target is isomorphic to the commitment solution when the central bank targets inflation.

In equation (11) there is a time subscript on the inflation target because the Federal Reserve does not have an explicit inflation target. Consequently, the inflation target has evolved over time and with shifts in the economy. When we allow a positive value for θ_p , we drop the time subscript on the inflation target. The price path is a reference line that loses much of its operational content as an indicator if the inflation target is allowed to shift from period to period.

In the experiments reported in Figure 3, the policymaker is aggressively pursuing the full employment mandate—the weight on the output gap is 2. Results from the Taylor rule from Figure 2 are repeated here as a benchmark to show how much policy improves when we add a price level path target with a weight of 0.1 on a price gap. Doing so almost eliminates the likelihood of hitting the zero lower bound. Choosing a weight of 0.2 resulted in no occurrences—in 10,000 quarters, there was not a single instance of hitting the zero lower bound.

To summarize the key results from our computational experiments, we find that one can avoid the zero lower bound by giving up the dual mandate, something that is not considered politically feasible, or one can commit to an inflation target. In fact, committing to an inflation target is the only way that we can avoid the zero lower bound and achieve the dual mandate in forward-looking macroeconomic models. So why hasn't the Fed adopted a price level path target (or equivalently, a long-run average inflation target)? One reason is a widespread myth about price path targeting that it would increase the chances of having episodes of deflation (See Fisher 1994). This is just not true. In all our experiments, we also saved the results for inflation. As we did with the zero lower bound on interest rates, we recorded episodes of negative inflation—deflation. Figure 4 shows two cases of the Taylor rule with the aggressive output gap policy and alternative weights on a price path. The Taylor rule in its original form (but with a higher weight

on output) has more incidences of deflation, especially long periods of deflation for up to a decade. Putting weight on the price gap reduces the incidence of deflation.

Conclusion

A key result in this paper is that the monetary policy regime is the primary factor creating zero lower bound episodes. This paper exploits an insight about price level path targeting by Lars Svensson (1999) who demonstrated that the discretion solution to a forward-looking model with a price level path target is equivalent to a commitment solution to the same model with an inflation target. Our results hold generally in all dynamic stochastic general equilibrium models with forward-looking agents. Different models will have different implications for real variables, but implications for inflation and the nominal interest rate are quite robust across a wide range of New Keynesian and New Classical specifications.

We argue that the current economic and policy situation is the direct result of policy aimed at dual objectives for price stability and full employment in an environment with an uncertain inflation objective. Once the interest rate hits zero, a policymaker using the Taylor rule has a problem managing expectations about future inflation. The problem is that there is a stable outcome with zero interest rates and a mild deflation trend. An example of this outcome can be seen in Japan (1995 to 2010). This is not necessarily a bad outcome as long as people expect the inflation rate to be zero or less. There is also a concern that attempting to expand the supply of bank reserves with very large purchases of Treasury securities may lead to a replay of the 1970s, during which the Federal Reserve and other government officials appeared to ignore the inflationary consequences of excessive money growth. Both sets of beliefs appear to co-exist in today's market as surveys of inflation expectations show more dispersion in beliefs about future inflation.

The only way to achieve the dual mandate in the forward-looking models used at central banks is to commit to a clear inflation objective. Managing expectations is the key to successful monetary policy. But the key is to manage expectations about the long-run average inflation rate, not the short-term interest rate. We show that trying to pursue a dual mandate for price stability and full employment will likely lead an economy to the zero lower bound if the central bank is not committed to an inflation objective.

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Figure 1. US Interest Rates: 1955 to 2010

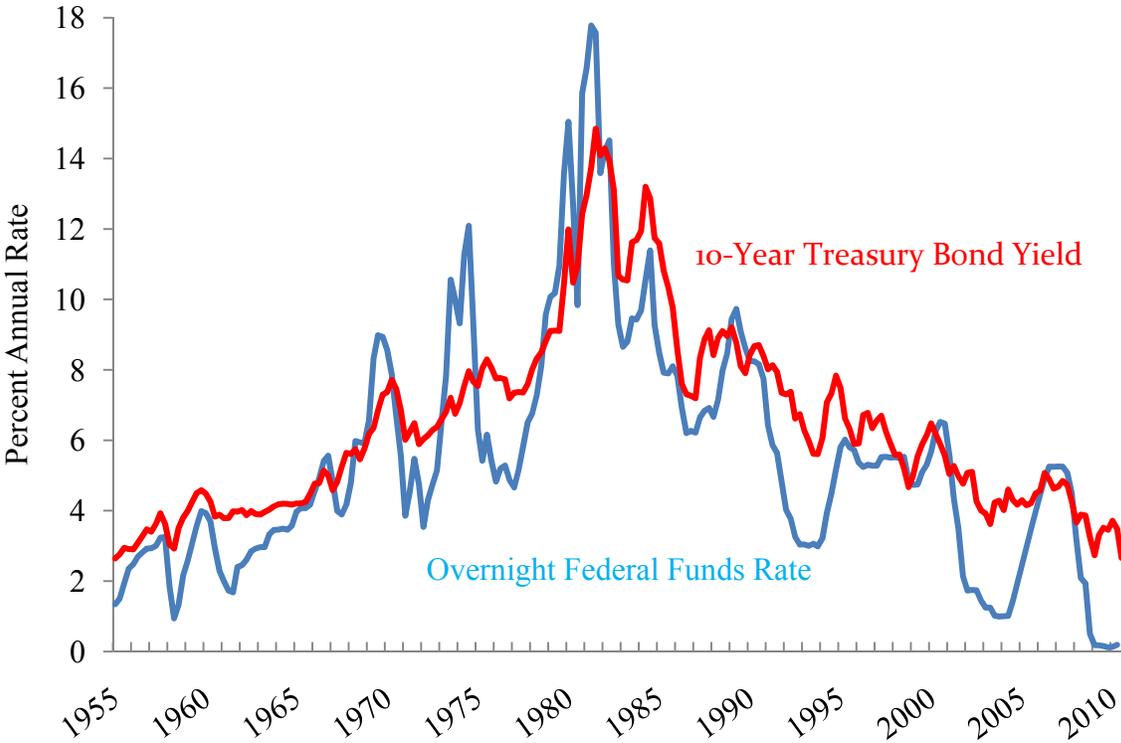


Figure 2. Histogram of Zero Lower Bound Episodes and Weight on the Output Gap

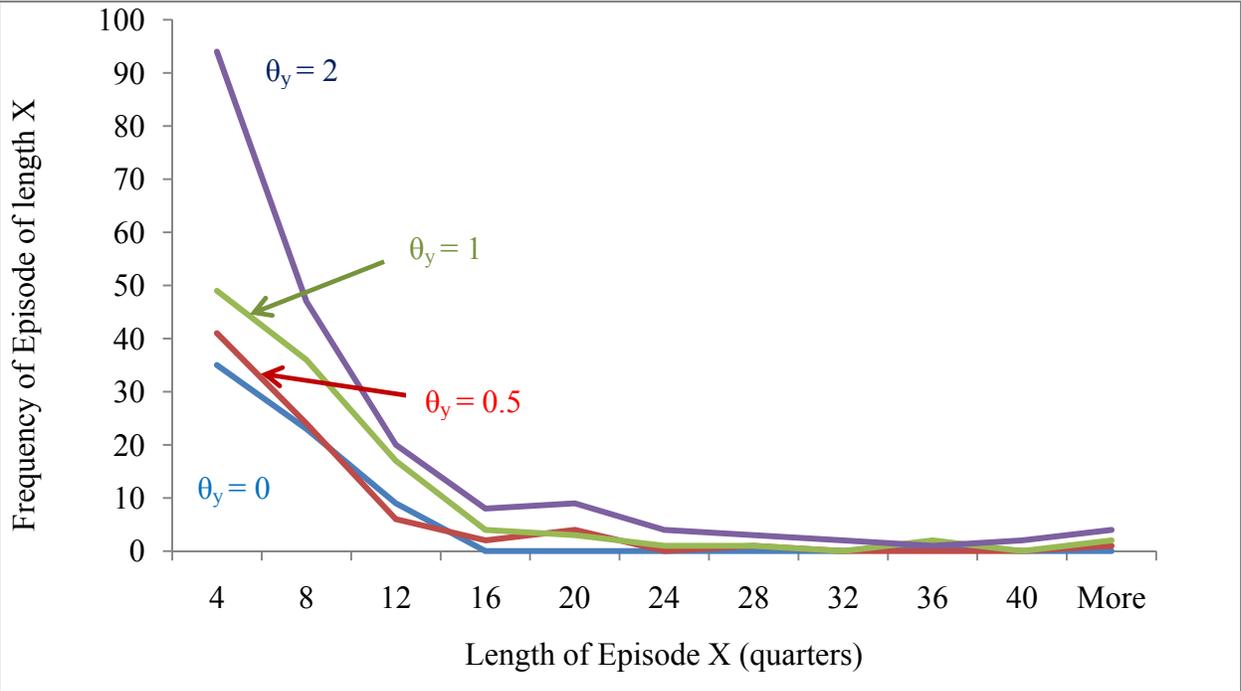


Figure 3. Histogram of Zero Lower Bound Episodes with Some Weight on the Price Gap

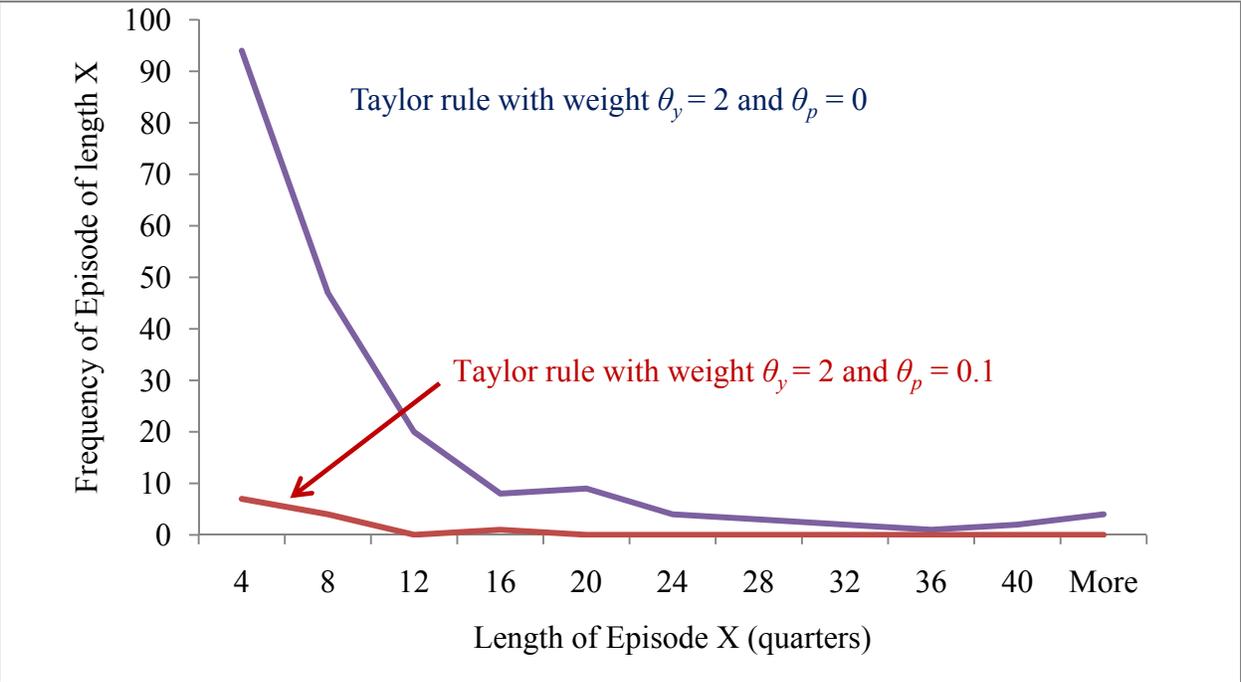


Figure 4. Histogram of Deflation Episodes and Price Level Path Targeting

