The Neo-Fisherianism to Escape Zero Lower Bound

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Abstract

Sufficiently persistent rise in nominal interest increases inflation rate in short-run. This short-run comovement of nominal interest rate and inflation rate is known as Neo-Fisherianism. This paper proposes a policy based on Neo-Fisherianism to escape Zero Lower Bound (ZLB) using a textbook forward looking New Keynesian model. I have shown that proposed policy with properly chosen inflation target and persistence can stimulate economy and escape ZLB by raising nominal interest rate. I have also shown that the proposed policy is robust to varying degrees of price stickiness.

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1 Introduction

Conventional wisdom says rise in nominal interest rate is contractionary; it reduces inflation and depresses economic activity in the short-run. On the other hand, Fischer Effect suggests a positive relationship between inflation and nominal interest rate in the long-run. However, recent data of low inflation rate with near zero nominal interest rate of US, Europe and Japan indicates a positive relationship of nominal interest rate and inflation even in short-run. This short-run comovement of nominal interest rate and inflation is known as Neo-Fisherianism (see, Garín, et. al, 2018, Cochrane, 2016, 2017, Schmitt-Grohé and Uribe, 2014, 2017 for detail). This paper proposes a policy based on Neo-Fisherianism to escape Zero Lower Bound (ZLB) or liquidity trap.[1]

Large adverse demand shock sends nominal interest rate to ZLB, where conventional monetary policy looses its ability to stimulate economy by reducing it further. After worldwide financial crisis started from 2007-08 and economic slum of Japan during last two decades, ZLB is no longer a mere theoretical curiosity. A large body of literature devoted to analyze monetary policy suggest a major role to expected inflation to stimulate economy activity when nominal interest rate is near zero. While Krugman (1998) suggests to increase expected inflation through a permanent rise in money growth,[2] Svensson (2003) argues for currency depreciation to achieve a higher price level target for stimulating economic activity at ZLB.[3]

Beside these, a large body of literature have also been devoted to analyze optimal conduct of monetary policy at ZLB. Papers analyzing the optimal monetary policy at ZLB include Eggertsson and Woodford (2003), Jung, et. al. (2005), Adam and Billi (2006, 2007), Nakov (2008), Werning (2012) and Cochrane (2017). Using a textbook forward looking New Keynesian model, these papers suggest a "forward guidance" policy where monetary authority retains its ability to stimulate economy by promising a path of future interest rates which can stimulate expected inflation. The optimal policy at ZLB is divided into two parts, e.g., optimal discretionary policy and optimal policy under commitment.

[1] ZLB and liquidity trap are used synonymously in this paper.

[2] See, Schmitt-Grohé and Uribe (2014) for a discussion on the advantage of interest based policy over money based policy to combat ZLB.

[3] Much of the literature on monetary policy in a liquidity trap expands policy to unconventional methods, which are effective to the extent that financial-market arbitrage is imperfect and/or the quantity of money has an effect on the economy independent of its effect on the real interest rate. These policies are interesting and potentially useful, but the simple New Keynesian model is not complex enough to provide a role for them. Examples of unconventional monetary policy include Auerbach and Obstfeld (2004), Blinder (2000, 2010), Bernanke (2002), Bernanke and Reinhart (2004), Bernanke, Reinhart and Sack (2004), Clouse *et.al.* (2003) and Gurkaynak, Sack and Swanson (2004,2005).

Since monetary authority cannot influence individual expectations, nominal interest rate under discretion remains zero as long as adverse demand shock is strong enough to keep natural rate of interest negative. However, economy exits ZLB under discretion as soon as natural rate of interest becomes positive.

While optimal discretionary policy is credible, it involves higher welfare loss than policy under optimal commitment. Optimal policy under commitment can influence individual expectations optimally and produces lower welfare loss than discretion by delaying exit from ZLB. Such promises even if non-credible, allows optimal commitment to generate extra stimulus to produce lower welfare loss than discretion. Moreover, the extent of recession and deflation under commitment is also lower than discretion. Note, optimal policies both under discretion and commitment discussed above do not escape ZLB and associated recession. In fact, they allow economy to fall into recession initially and choose the date of exit according to the requirement of stimulus needed by optimal monetary policy.

This paper on the other hand stands at another extreme. Unlike optimal policy at ZLB, this paper proposes policy to escape ZLB when economy gets hit by a large adverse demand shock. The proposed policy is based on the textbook forward looking New Keynesian model and its property of Neo-Fisherianism. The textbook New Keynesian model produces short-run comovement between nominal interest rate and inflation rate when change in inflation target is sufficiently persistent. Garín, et. al. (2018) shows a persistent rise in inflation target increases both output and expected inflation through New Keynesian Phillips curve (NKPC) and the rise in output is consequently matched by a sufficient reduction in real interest rate through expectational IS equation. Note, when expected inflation rises sufficiently due to a persistent increase in inflation target, real interest rate may fall and nominal interest rate can rise, yielding a comovement between nominal interest rate and inflation rate in short-run, known as Neo-Fisherianism in the literature.[4] Garín, et. al. (2018) further shows that the textbook New Keynesian model follows Neo-Fisherianism due to its forward looking nature and the same model may ceases to follow Neo-Fisherianism under hybrid Phillips curve with both forward and backward looking inflation rate) due to the presence "rule of thumb" price setters in Phillips curve (see, Gali and Gertler, 1999).[5]

The theory of Neo-Fisherianism as noted by Garín, et. al. (2018), is advanced in

[4]See, Schmitt-Grohé and Uribe (2014) for a nice discussion on conventinal wisdom, Fisher effect and Neo-Fisherianism.

[5]Moreover, both Cochrane (2016) and Garín, et. al. (2018) shows that the textbook New Keynesian model is more likely to be Neo-Fisherian when prices are less sticky.

several theoretical writings of John Cochrane and Steven Williamson.[6] Uribe (2018) is the first to find empirical evidence of Neo-Fisherianism while estimating a Bayesian SVAR model for postwar US and Japan. He shows while a rise in nominal interest rate, expected to be transitory is both contractionary and deflationary, it is inflationary when expected to be permanent. Moreover, the paper also shows that the rise in nominal interest rate, which is expected to be permanent is expansionary too as it keeps real interest rate remains low through out the transition. Uribe (2018) also argues that proper identification of permanent and temporary shock can provide answer to the issue of price puzzle (see, Eichenbaum, 1992). While, Uribe (2018) provides the empirical evidence, Cochrane (2017) have provided theoretical explanation of Neo-Fisherianism using the text New Keynesian model with a permanent rise in nominal interest rate.

Schmitt-Grohé and Uribe (2014) has proposed a policy to avoid liquidity trap using a model of endowment economy. They have used a Taylor rule for their analysis that depends only on inflation rate (not on output) with an exit strategy (from liquidity trap) where monetary authority promptly switches to set a deterministic nominal interest rate as soon as inflation rate goes below a pre-determined threshold level. Authors show that, such a truncated Taylor rule is able to avoid liquidity trap by raising inflationary expectation. However, the model used by them is not only based on endowment economy but also assumes complete price flexibility. The counterfactual assumption of complete price flexibility held deflation costless, which is not true in reality as correctly identified by the author themselves.

Schmitt-Grohé and Uribe (2017) on the other hand uses the full blown DSGE model with downward nominal wage rigidity to show (i) standard dynamic optimization model can produce jobless growth recovery observed in US, Japan and Europe in recent times and (ii) an appropriate policy prescription to avoid liquidity trap entails proper identification of the characteristics of the shock pushing economy into liquidity trap. They show if economy falls into liquidity trap due to negative confidence shock, raising nominal interest rate to its intended target for an extended period of time boosts inflationary expectations and foster employment. The paper also argues that a proper policy to combat liquidity trap in this context should of Neo-Fisher in nature.

Using the property of Neo-Fisherianism of the textbook forward looking New Keynesian model, this paper proposes policy that can escape ZLB through a persistent rise in inflation target when economy gets hit by adverse demand shock, large enough to send

[6] See, Williamson (2016) also has a nice discussion on the role of Neo-Fisherianism in the context of low inflation rate.

the economy to ZLB. I have shown that, the policy proposed by me where inflation target follows a first order autoregressive process with half-life 2.40 quarters not only escapes ZLB but also robust to various degrees of price stickiness. I have also shown that my proposed policy is characterized completely by the persistence and value of inflation target at initial period, chosen by the monetary authority so that economy gets enough stimulus to escape ZLB with positive nominal interest rate.

It is worth remembering here that, the effectiveness of a policy depends heavily on its communication and credible implementation. Therefore, it is important to discuss these properties for the policy based on Neo-Fisherianism too. Note, while analyzing the communication of optimal forward guidance policy using standard Taylor rule with time varying inflation target, Chattopadhyay and Daniel (2018) shows, (i) we can replicate discretionary policy by choosing zero inflation target and (ii) we can replicate optimal policy under commitment by choosing appropriate non-zero inflation target whose persistence is determined by the stable root of the system post-exit. As a result, the optimal policy under discretion and commitment can be communicated successfully using inflation target and its persistence as it can be described using the time path of nominal interest rate. Now, since policy based on Neo-Fisherianism is also characterized by inflation target and its persistence, it can similarly be communicated completely by them. Nevertheless, in sharp contrast with the standard forward guidance policy that keeps nominal interest rate low longer, the policy based on Neo-Fisherianism can be communicated as a policy that increases nominal interest rate instantaneously and allows it to converge to its long-run value gradually through an appropriate choice of a sufficiently persistent inflation target.

Note, policy based on Neo-Fisherianism requires increasing nominal interest rate at ZLB to stimulate economy, contradicting the conventional wisdom. Moreover, the policy based on Neo-Fisherianism is dynamically inconsistent and hence non-credible too as it requires to keep inflation target positive even if ZLB on nominal interest rate is no longer binding. Therefore, implementation and effectiveness of such policies requires re-education of general public through effective, transparent and periodic communication of the monetary authority about their policy stance and future course of action.[7] Nonetheless, following the discussion on effectiveness of Fisher effect by Schmitt-Grohé and Uribe (2014), we can say that the policy based on Neo-Fisherianism can be implemented credibly as general public, having observed low inflation rate with near zero nominal interest rate will gradually internalize the possibility raising inflation expectations by increasing

[7]See, Blinder (2008) for a nice survey of literature on the importance and strategies of central bank communication to influence financial market and achieve macroeconomic stability.

nominal interest rate at ZLB.

However, the policy based on Neo-Fisherianism has its own cost and benefit. In this paper, I have shown that the welfare loss of the proposed policy is close but higher than optimal discretionary policy and hence higher than policy under optimal commitment too. On the other hand, policy based on Neo-Fisherianism can escape ZLB and associated recession and deflation completely. We know recession is "bad" and it has negative impact on the economy both in short-run and long-run. Moreover, recession has its own dynamics which is generally very persistent and often goes out of control once sets in. Along with this, Schmitt-Grohé and Uribe (2017) shows that, due to the presence of financial frictions and downward nominal wage rigidity, macroeconomic adjustment in the context of deflation becomes costly as it yields more distressed financial market condition. Beside this, I also feel that communicating policy based on Neo-Fisherianism which is associated output expansion at the cost of a bit more welfare loss than optimal forward guidance policies is far more easier to communicate than the optimal forward guidance policy producing temporary recession but smaller overall welfare loss. This is because general people can observe recession and feel the pain of unemployment easily but cannot observe the implicit welfare loss incurred by the monetary authority. Given this backdrop, policy that escapes ZLB and associated recession and deflation seems more desirable to me even if it comes with a little more welfare loss.[8]

2 Monetary Policy in the Simple New Keynesian DSGE Model

2.1 Simple New Keynesian Model

Following Walsh (2017) and Woodford (2003), I represent the textbook forward looking New Keynesian model through an IS curve derived from the log-linearized Euler Equation of the representative agent and representing the aggregate demand of the economy (equation (1)) and a New Keynesian Phillips Curve (NKPC) derived from a model of Calvo pricing (Calvo, 1983) and log-linearized around zero long-run inflation rate (equation

[8]Note, in the context of the New Keynesian macroeconomic model with a Taylor Rule for the nominal interest rate, there is another reason to escape ZLB. The Taylor Rule requires the nominal interest rate to rise in response to an increase in inflation and/or the output gap. When these responses are large enough, the model has two unstable roots, yielding a unique determinate equilibrium. However, at ZLB with the interest rate fixed at zero, there is a single unstable root, creating indeterminacy and leaving a role for sunspot equilibria. Certainly, calculating the policy rate given such indeterminacy is not desirable to the monetary authority.

(2)).[9]NKPC represents the aggregate supply of the economy.

$$y_t = E_t\left(y_{t+1}\right) - \sigma\left[i_t - r_t^n - E_t\pi_{t+1}\right] \tag{1}$$

$$\pi_t = \beta E_t\left(\pi_{t+1}\right) + \kappa y_t. \tag{2}$$

In these equations y_t denotes the output gap; inflation (π_t) is the deviation about a long-run value of zero; i_t denotes the nominal interest rate, σ represents the intertemporal elasticity of substitution with $\sigma \geq 0$; κ represents the degree of price stickiness;[10] $\beta \in (0,1)$ denotes the discount factor. The natural rate of interest embodies the combination of the long-run natural rate together with demand shocks associated with preferences, technology, fiscal policy, etc. Note, following Schmitt-Grohé and Uribe (2017), the demand shock, u_t also captures the shock in confidence in the simple New Keynesian model discussed here. I assume demand shock follows an AR(1) process as given below,

$$u_t = \rho_u u_{t-1} + \epsilon_t, 0 < \rho_u < 1 \tag{3}$$

and natural rate of interest is defined as,

$$r_t^n = r^n - \sigma^{-1} u_t \tag{4}$$

where, $r^n = \beta^{-1} - 1$ is the long-run natural rate of interest. Following Woodford (2003, Chapter 4), we do not add an independent shock to inflation in the Phillips Curve.[11] This restricts the analysis to the case where monetary policy faces no trade-off between inflation and the output gap.

2.2 Taylor Rule

The method, typically employed in New Keynesian models for determining the nominal interest rate is to assume that the monetary authority follows a Taylor rule (Taylor, 1983). In Taylor's original rule, the nominal interest rate is set to equal a fixed real rate plus a

[9]This does not require that the inflation rate be zero in the long run, only that it not be so far from zero to make the linearization inappropriate (Woodford 2003, p. 79).

[10]$\kappa = \frac{(1-s)(1-\beta s)}{s}\frac{\sigma^{-1}+\omega}{1+\omega\varepsilon}$, where $s \in (0,1)$ represents the fraction of randomly selected firms that cannot adjust their price optimally in a given period. Therefore, $s = 0 \Rightarrow \kappa \to \infty \Rightarrow$ complete flexibility and $s = 1 \Rightarrow \kappa = 0 \Rightarrow$ complete stickiness. Hence, $\kappa \in (0,\infty) \Rightarrow$ incomplete flexibility. $\omega > 0$ is the elasticity of firm's real marginal cost with respect to its own output, $\varepsilon > 0$ is the price elasticity of demand of the goods produced by monopolistic firms. See, Adam and Billi (2006) and Woodford (2003) for details.

[11]Adam and Billi (2006) demonstrate that calibrated supply shocks are not large enough to send the economy to the zero lower bound.

fixed inflation target and to respond positively to deviations of inflation and output from fixed target values. The Taylor Rule, log linearized about long-run equilibrium values of zero, can be expressed as

$$i_t = r_t^n + E_t\left(\pi_{t+1}^*\right) + \phi_\pi\left(\pi_t - \pi_t^*\right) + \phi_y\left(y_t - y_t^*\right),\ \phi_\pi > 1,\ 0 < \phi_y < 1, \tag{5}$$

Liquidity trap is defined as a situation of a big enough demand shock causing $r_t^n < 0$. I assume inflation target to follow a deterministic AR(1) process as given below.

$$\pi_t^* = \xi\pi_{t-1}^*, 0 < \xi < 1 \tag{6}$$

I allow the monetary authority to choose a target value for inflation (π_t^*) greater than the long-run value of zero with persistence ξ.[12] Both inflation target and its persistence is determined by monetary authority.

When the inflation target is positive, solution of equation (2) implies that the output gap target is given by $y_t^* = \frac{1-\beta\xi}{\kappa}\pi_t^*$. Substituting the value of output gap target to equation (5) and collecting terms gives,

$$i_t = r_t^n + \phi_\pi\pi_t + \phi_y y_t - z\pi_t^* \tag{7}$$

where,

$$z = \phi_\pi + \phi_y\left(\frac{1-\xi\beta}{\kappa}\right) - \xi$$

Taylor rule given in equation (5) follows Taylor principle where nominal interest rate responds strongly enough to endogenous variables that solves the problem of indeterminacy. Specifically, Bullard and Mitra (2002) demonstrate that if ϕ_π and ϕ_y are large enough such that equations (1) and (2), with equation (5) substituted for the interest rate, yields a dynamic system with two unstable roots, corresponding to the two forward-looking variables, then the equilibrium is unique. Note, we get, $z > 0$ when Taylor Principle is satisfied with, $\phi_\pi > 1$, $0 < \phi_y < 1$.

Using equations (1), (2), and (7), and denoting the unstable roots of the system as λ_1 and λ_2,[13] the rational expectations solutions for the output gap and inflation are given

[12] There are empirical evidences of time varying inflation target in the literature. Ireland (2007) argues that US inflation can be explained by a New Keynesian model with a Taylor Rule only if the inflation target is allowed to vary over time. Additionally, Kozicki and Tinsley (2001), Rudebusch and Wu (2004), Gurkaynak, Sack and Swanson (2005) and Dewachter and Lyrio (2006) provide evidence of a time-varying short-run inflation target for the US.

[13] Taylor principle implies $z > 0$, implies $\lambda_i > 1, i = 1, 2$, yielding sunspot free determinant equilibrium

by[14]

$$y_t = \frac{1-\xi\beta}{\beta\left(\lambda_1-\xi\right)\left(\lambda_2-\xi\right)}\sigma z\pi_t^*, \tag{8}$$

and

$$\pi_t = \frac{\kappa}{\beta\left(\lambda_1-\xi\right)\left(\lambda_2-\xi\right)}\sigma z\pi_t^*. \tag{9}$$

Both the output gap and inflation respond positively to the inflation target. This is because an increase in the inflation target raises inflationary expectations, reducing the real interest rate, stimulating current spending. Note that the Taylor Rule, with a time-varying intercept dependent on the natural rate of interest, eliminates any effect of u_t, which does not operate through π_t^*. Substituting equilibrium values for π_t and y_t from equations (8) and (9) into equation (5) yields an equilibrium value for the nominal interest rate as,

$$i_t = r_t^n + qz\pi_t^* \qquad \text{where } q = \left[\frac{\phi_\pi\kappa + \phi_y\left(1-\xi\beta\right)}{\beta\left(\lambda_1-\xi\right)\left(\lambda_2-\xi\right)}\sigma - 1\right] \tag{10}$$

Note, q captures both direct and indirect effect of inflation target on nominal interest rate. The indirect effect of inflation target on nominal interest rate, captured by the first term of the square bract in the expression of q above rises with the persistence of inflation target, ξ. For ξ high enough the indirect effect dominates the direct effect and we observe the short-run comovement of nominal interest rate and inflation rate and our model would follow the Neo-Fisherianism.

2.3 The Loss Function

The model is completed with determination of the nominal interest rate. We consider two alternative methods to specify the nominal interest rate. The first follows Woodford (2003), and chooses values for the time paths of inflation and the output gap to minimize the loss function,

$$L_1 = \frac{1}{2}E_1\sum_{t=1}^{\infty}\beta^{t-1}\left(\pi_t^2 + \lambda y_t^2\right),\ \lambda \in [0,\infty). \tag{11}$$

Woodford derives equation (11) as a linear approximation to the utility function of the representative agent when equilibrium inflation is zero and the flexible-price value for output is efficient.[15]

given in equation (8) and (9)

[14] These are the rational expectations solutions, ignoring the lower bound on the nominal interest rate. If we are able to manipulate π_t^* to avoid the lower bound, then these are the equilibrium solutions.

[15] The government can subsidize firms to increase production to the perfectly competitive level.

To explain first optimal policy, define a threshold value for u_t as $\hat{u} = \sigma\bar{\imath}$. Note, when demand shock is small ($u_t < \hat{u}$) so that $r_t^n > 0$, the optimal policy is, $i_t = r_t^n$ with $\pi_t^* = \pi_t = y_t = 0$, yielding $L_1 = 0$. However, if demand shock is large ($u_t \geq \hat{u}$) so that $r_t^n < 0$, optimal policy is no longer $\pi_t^* = 0$. This is because $\pi_t^* = 0$ yields $i_t = r_t^n < 0$ which is not possible since nominal interest has ZLB.

A large body of literature have analyzed the optimal policy under ZLB and its implementation as discussed above. Chattopadhyay and Daniel (2018) have analyzed optimal policy at ZLB with uncertainty in the persistence of the shock. To keep their analysis analytically tractable, the paper assumes that individuals are uncertain about the persistence of adverse demand shock initially, which can take three different values, e.g., 0.85, 0.9 and 0.95 with probability 0.25, 0.50 and 0.25 respectively. As a result, there can be three different time paths of natural rate of interest depending on the realized persistence of the shock, which individuals get to know after an year. Note, such a specification of natural rate of interest yields three different time paths for optimal output gap, inflation and nominal interest rate both under discretion and commitment. I have used the algorithm of Chattopadhyay and Daniel (2018) to calculate welfare loss under discretion and commitment when the realized persistence of the shock is 0.9. In the analysis of Chattopadhyay and Daniel (2018), economy never reverts back to ZLB once exits. Note, this is true for my analysis as well. The policy based on Neo-Fisherianism proposed by me is based on a model which assumes nonoccurrence of ZLB once economy exits out of it. Hence, I have used welfare losses obtained by Chattopadhyay and Daniel (2008) as benchmark to compare the same produced by the policy based on Neo-Fisherianism.

3 The Policy Based on Neo-Fischerianism

The issue in a liquidity trap is how to stimulate output and inflation without reducing the nominal interest rate. The Neo-Fisherianism does the same. To understand the intuition of Neo-Fisherianism and how it escapes ZLB, note that equations (8) and (9) reveal that stimulating output and inflation requires raising the inflation target. Also note that the coefficient on π_t^* in equation (10) is increasing in the degree of persistence of the short-run inflation target, given by ξ. In the New Keynesian model, the direct effect of an increase in the inflation target is a reduction in the nominal interest rate, and this stimulates demand and inflation. However, the increase in the inflation target also raises expectations of inflation, further stimulating demand, and through the Taylor Rule responses to inflation and the output gap, leads to an increase in the interest rate. For

large enough persistence of the short-run inflation target, this indirect effect dominates, implying that an increase in the inflation target raises the nominal interest rate, inflation and output.[16] To assure that the monetary authority can escape ZLB by stimulating the economy with an increase in the short-run inflation target, the monetary authority must set ξ high enough such that q in equation (10) is positive, allowing the indirect effect of the increase in the inflation target to dominate. Given this let me propose two policies that can escape ZLB and the associated recession.

3.1 Policy A: Escape ZLB with Fixed Nominal Interest Rate

Suppose, economy is hit by a large adverse demand shock in period 1 such that, $u_t \geq \hat{u}$ and $\pi_t^* = 0$ is no longer a feasible policy since $i_t < 0$. I propose, once $u_t \geq \hat{u}$, the short-run inflation target switches to a positive inflation-target rule with the target given by equation (12) below that keeps nominal interest rate fixed at, $i_t = r^n$, for all t obtained from equation (10)

$$\pi_t^* = \frac{\sigma^{-1} u_t}{zq} \tag{12}$$

To maintain equation (12) going forward, it is necessary that the autoregressive coefficient on the inflation target, given by ξ, equals ρ_u. We have seen episode of ZLB persists for a long period time for Japan and US, yielding large ρ_u.[17]Therefore, setting $\xi = \rho_u$ satisfies the restriction on q in equation (10).[18] Additionally, the monetary authority must continue to follow this policy until $\pi_t^* \leq 0$. Once $\pi_t^* = 0$, the monetary authority can switch back to the zero target inflation rule until the demand shock again exceeds the threshold value. Note. the policy with a positive inflation target cannot switch back to that with a zero inflation target once the demand shock falls below the threshold value ($\hat{u}$) because this would violate the promise of strong persistence in the inflation target, as implied by a high value of ξ. The strong persistence is needed for an increase in the inflation target to imply an equilibrium increase in the interest rate instead of a decrease. An interest rate reduction in a liquidity trap is not feasible.

We illustrate the quantitative effects of our proposal using the RBC parameterization

[16]This is why calibrated models fail to find a liquidity effect of a negative interest rate shock when persistence is high.

[17]Ireland (2004) provides an estimate of persistence of 0.95, Adam and Billi (2006) estimate persistence at 0.8.

[18]If not, the restriction on q must be satisfied, and the inflation target must disappear more slowly than the demand shock, implying that it will not be possible to follow equation (12) going forward. The next policy we propose deals explicitly with this case.

from Chattopadhyay and Daniel (2018),

$$\sigma = 1,\ \beta = 0.99,\ \kappa = 0.057,\ \lambda = 0.0074, \phi_\pi = 1.5,\ \phi_y = 0.5, \rho_u = 0.9.$$

All values are expressed at quarterly rates. The values for the elasticity of substitution and the discount factor are standard. The value of κ is consistent with 44% of firms adjusting their price each period. We set the persistence of the monetary policy response $\xi = \rho_u$, yielding $q > 0$. We let the adverse demand shock be large enough to imply a negative interest rate under optimal policy, were such a value possible, $u_1 = 0.02253508$.[19]

Impulse responses to the demand shock, with a Taylor Rule given by equation (10), and a time-varying inflation target, given by equation (12), are shown in Figure 1.

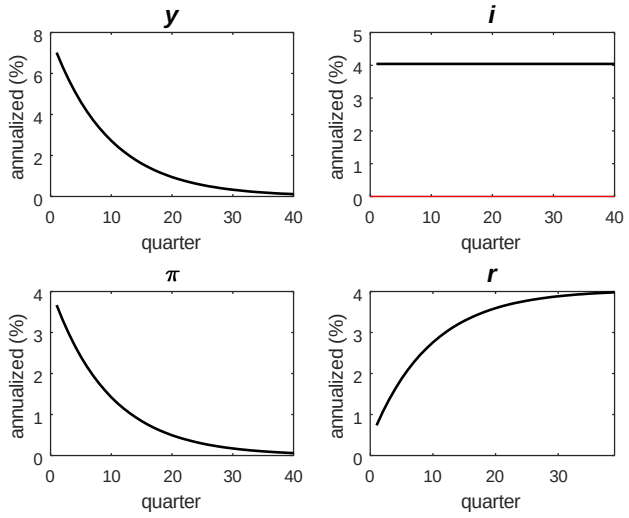

Figure 1: Impulse Response under Policy A

The demand shock itself has a negative effect on output and inflation. The monetary authority needs to stimulate by reducing the real interest rate. However, when the demand shock is sufficiently adverse, the Taylor Rule with a fixed long-run inflation target requires the nominal interest rate to fall below zero, implying that monetary policy looses its

[19]Note, time period takes integer values only in discrete time. Therefore, optimality in discrete time is achieved only at few initial values of demand shock. Chattopadhyay and Daniel (2018) shows that a solution in discrete time might be far away from optimal solution if the exit time from ZLB is non-integer for some initial value of demand shock. As a result, extra care needs to be taken while choosing the value of initial demand shock for analyzing optimal policy at ZLB under discrete time. See, Chattopadhyay and Daniel (2018) for detail.

traditional nominal interest rate instrument.

Our policy provides an alternative way of manipulating the real interest rate. In response to the strong adverse demand shock, the monetary authority increases inflationary expectations by raising the time-varying inflation target and promising to keep it high for a long period of time by promising strong persistence. With sufficient persistence, the increase in inflationary expectations reduces the real interest rate, stimulating demand and inflation, even if the nominal interest rate does not actually fall. This is known as Neo-Fisherianism in the literature. In the impulse response output, inflation, and the inflation target all rise initially, and subsequently fall as the shock vanishes. Since persistence in the short-run inflation target and in the demand shock are both high and since the policy with a positive short-run inflation target must persist until the demand disturbance has vanished, inflation and the output gap remain above their long-run target values of zero for a long period of time.

This policy keeps the nominal interest rate at its long-run equilibrium value of r^n. However, this is not a fixed interest rate policy. The nominal interest rate is allowed to respond to deviations of inflation and the output gap from their time-varying, short-run target values by ϕ_π and ϕ_y. Should sunspot shocks arise, the promise to offset them is credible, assuring that they do not arise in equilibrium. Since the nominal interest rate does not fall, this policy generates very large increases in output and inflation with initial increases of 7.01% and 3.67%, respectively, at annual rates. As a result Policy A causes a welfare loss almost 12 times higher that optimal under discretion and 128 times higher than optimal forward guidance policy.

However, there is no reason the monetary authority must keep the nominal interest rate this high. Under our policy proposal, the nominal interest rate must be above zero and it must retain the ability to respond, using the Taylor Principle, to deviations in inflation and output. Following this principle, I propose the next policy which escapes ZLB with reasonable welfare loss.

3.2 Policy B: Escape ZLB with Variable Nominal Interest Rate

Suppose, economy is hit by a large adverse demand shock in period 1that can push the economy into liquidity trap with zero inflation target policy. However, now I allow $0 < i_t \leq r^n$, for all t. Therefore, using equation (10), I propose a switching policy which

increases inflation target as follows,

$$\begin{aligned} \pi_1^* &= \frac{\sigma^{-1}u_1 - \eta}{zq}, \\ \pi_t^* &= \xi^{t-1}\pi_1^* \end{aligned} \tag{13}$$

where, η and ξ are chosen by the monetary authority to minimize welfare loss subject to $i_t > 0$, for all t. Note, this policy is not unique since feasible values for η are not unique. When $\eta = 0$, and $\xi = \rho_u$, this policy is identical with Policy A. The impulse responses based on equation (13) with $\xi = 0.75$ and $\eta = 0.0075375968$ are given in Figure 2. Figure 2 shows that Policy B can escape ZLB by stimulating inflationary expectations. Rise in inflationary expectations, fall in nominal interest rate and high persistence of inflation target keeps real interest rate low for a long period of time and provides the required stimulus to escape ZLB and associated recession. Comparing Figure 1 with Figure 2 we see that Policy B yields smaller deviation in inflation with initial values at annual rates of 1.60% but slightly higher fluctuations in output with initial values at annual rates of 7.21% than Policy A. However, even if there is higher fluctuations in output, Policy B with a half-life of inflation target, output and inflation rate approximately 2.4 quarters yields lower welfare loss than Policy A as inflation has higher weight than output in the loss function.[20] I have seen while welfare loss under Policy B is 12 times higher than optimal forward guidance policy it is only 1.13 times higher than optimal discretionary policy.

[20] Half life of inflation target which follows an AR(1) process is calculated as, $\frac{\log(0.5)}{\log(\xi)}$

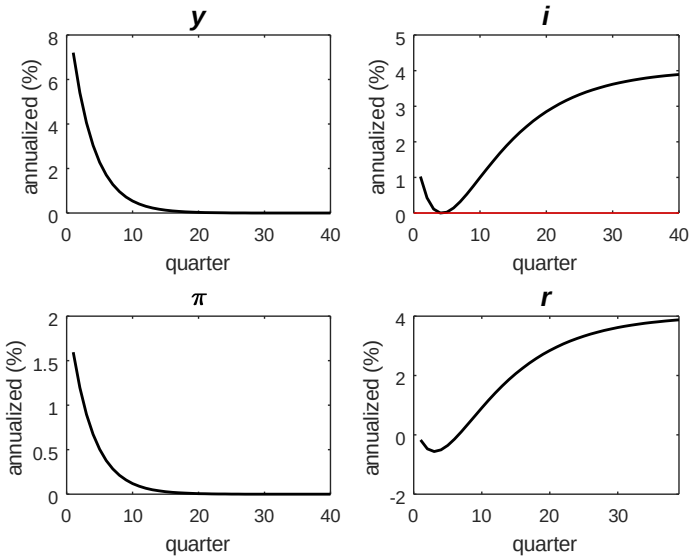

Figure 2: Impulse Response under Policy B

3.3 Robustness of the Policy

Countries do differ according to their degree of price stickiness and textbook New Keynesian model predicts severe recession at ZLB when prices are less sticky (Cochrane, 2017). However, since the textbook New Keynesian model is more likely to be Neo-Fisherian when prices are less sticky (Cochrane, 2016 and Garín, et. al., 2018), it provide a better scope to the policy based on Neo-Fisherianism to combat liquidity trap effectively successfully .Therefore, analyzing policy to escape ZLB and examining its robustness under different degrees of price stickiness is important. Here, I check the robustness of my proposed policy under varying degree of price stickiness. Note, the policy based on Neo-Fisherianism proposed above is completely characterized by the combination of η and ξ.[21] I call a policy robust when the combination of η and ξ survives relevant parametric changes. Also note that a robust policy is desirable to the monetary authority for its easy communication to the public.

To check the robustness of our proposed policy, I have allowed fraction firms who choose their price optimally each period to increase from 44% to 99% (implying reduction

[21] η (determines the magnitude of initial inflation target) tand ξ (persistence of inflation target) determines the time path of inflation target which characterizes the time path of output, inflation, inflation expectation, nominal interest rate and real interest rate.

of s from 66% to 1%) keeping other parameters unchanged. This produces a steeper aggregate supply curve with κ increasing from 0.057 to 31.32. Since identical demand shock with steeper supply curve yields higher fluctuation to inflation than output, it produces higher welfare loss too as inflation has higher weight in loss function than output. Here, my objective here is to find a combination of η and ξ which keep nominal interest rate positive and produces welfare loss as little as possible. Note, at least lower η and/or ξ would serve my purpose. A lower value of η would lower inflation target and reduce fluctuations of inflation and output and a lower ξ on the other hand would bring inflation target and hence output and inflation quickly to zero after an initial increase. Hence, a lower η and/or ξ can offset the impact of higher κ and produce lower welfare loss. I find that the policy based on Neo-Fisherianism with combination of $\xi = 0.75$,(half-life of inflation target, output and inflation rate approximately 2.4 quarters) and initial period rise in inflation target, $\eta = 0.0075375968$ is robust as it produces the best outcome for any $\kappa \in [0.057, 31.32]$.

Figure 3 shows the impulse response with $\kappa = 31.32$. Three important characteristics of Figure 3 are worth mentioning here. First, steeper New Keynesian Phillips curve causes higher fluctuations in inflation (initial fluctuations rises from 1.60% to 3.99% at an annualized rate) and lower fluctuations in output (initial fluctuation falls from 7.21% to 3.28% at annualized rate) and produces almost 0.01 times lower welfare loss than the case when $\kappa = 0.057$. Second, rise in κ reduces z but increases q by allowing indirect effect of inflation target on nominal interest rate to dominate the direct effect.[22] However, though the opposite movement of z and q reduces their product, it keeps the time path of nominal interest rate almost unchanged (see, impulse response of nominal interest rate in Figure 2) by raising inflation target and keeping the product of z and q and π^* almost unchanged. Third, increasing expected inflation with unchanged nominal interest rate reduces real interest rate further to higher negative values. Note, output depends on the present value demand shock and negative of real interest rate (obtained from forward solution of equation (1)). The sufficiently negative real interest rate can stimulates output

[22]Rise of q with κ implies that the textbook New keynesian model is more likely to follow Neo-Fisherianism when prices are more flexible. Garín, et. al. (2018) obtained the same result too.

and escape recession even after offsetting the adverse demand shock completely.

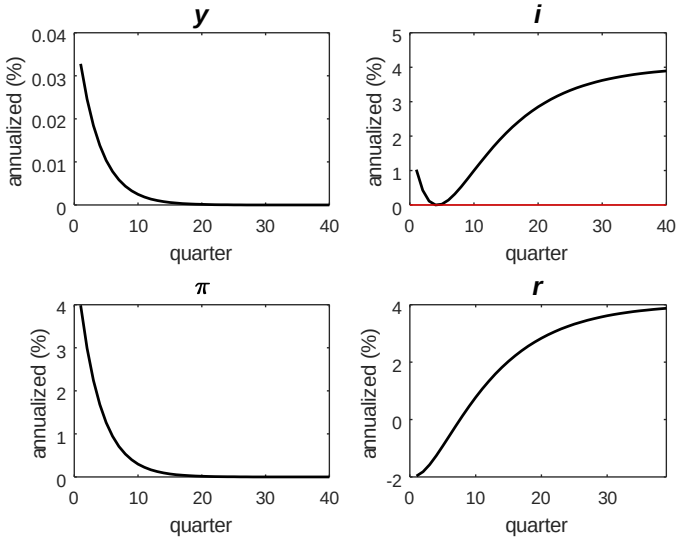

Figure 3: Impulse Response under Policy B with $\kappa = 31.32$

3.4 Implementation and Credibility

Under optimal forward guidance policy, monetary authority needs to commit to a path of nominal interest rate which remains at zero for some extra period of time even if nominal interest rate has already been exited ZLB by then. Although this delayed exit provides the extra stimulus to produce lower welfare loss, the optimal forward guidance policy is dynamically inconsistent and hence not credible. Based on same logic, the policy based Neo-Fisherianism discussed above is dynamically inconsistent too. To implement it, the monetary authority must have the ability to commit to the interest rate rule with a time-varying target and must be able to continue to keep the short-run inflation target above its long-run level as long as the inflation target exceeds zero. This requires that the inflation target remain higher than its long-run optimal value, even after the demand shock has fallen in value sufficiently that the nominal interest rate with a zero target inflation rate would be positive. This is necessary to generate the strong increase in inflationary expectations required to keep the economy out of a liquidity trap following a large adverse demand shock.

Additionally, for implementation, the monetary authority must be able to communi-

cate its policy to the public and its communication must have credibility. The public must know that the short-run inflation target has changed and that this change will be very persistent. An increase in the nominal interest rate, without this communication is insufficient to escape liquidity trap. A nominal interest rate increase together with low persistence would reduce inflationary expectations, raise the real interest rate and reduce in inflation and the output gap further. The public needs to know more about policy than is revealed by the nominal interest rate alone to make correct expectations about future inflation.

Failure to establish credibility dooms the policy. However, I feel that it should be no more difficult to establish credibility for this policy than for policies like the promise to "blow up the economy" (Cochrane 2011) in the event of off-equilibrium paths for prices and/or output, Woodford's (2003) timeless perspective policy, or optimal policy of Eggertson and Woodford (2003), Adam and Billi (2006). Since our policy requires commitment to a rule, it is arguably easier to communicate than commitment to optimal policy. Svensson's (2003) devaluation policy has a credibility advantage because the exchange rate is an observable piece of data, but most countries no longer peg exchange rates. Perhaps a larger problem than getting the public to believe that the central bank would follow a rule would be public outrage over a policy to increase inflation, following the long and successful battle to reduce it.[23] The public would require re-education, countering the prevailing wisdom that inflation is always a "bad."[24]

4 Conclusion

The worldwide recession started from 2007-08 and the economic slum of Japan from late nineties have forced policy makers to examine the conduct of monetary policy at ZLB. This paper uses the property of Neo-Fisherianism of the textbook forward looking New Keynesian model to prescribe policy that escapes ZLB. Garín, et. al. (2018) shows that the textbook New Keynesian model under standard parameterization yields short-run comovement of nominal interest rate and inflation rate when AR (1) inflation target is persistent enough with half-life 1.5 quarters or more. I have shown that my proposed policy is characterized completely by the persistence of inflation target and its value at the initial period. I have also shown that an initial period rise in inflation target of

[23] Krugman (1998) made this point.

[24] Schmitt-Grohé and Uribe (2014) argues that raising interest rate policy near ZLB would be credible as public, having observed low inflation rate and near zero nominal interest rate will gradually internalize the possibility of raising nominal interest rate by the monetary authority to combat deflationary pressure.

amount 0.007537596 with persistence 0.75 (half-life 2.4 quarters) not only escapes ZLB, it is robust to varying degrees of price stickiness and produces welfare loss very similar to optimal discretionary policy at ZLB.

Along with this I also have argued that, the policy based on Neo-Fisherianism has its own cost and benefit as well. I have shown that the welfare loss under the proposed policy is close but higher than optimal policy under discretion (hence under commitment). On the other hand, policy based on Neo-Fisherianism can escape ZLB and also the recession associated with it. We know recession is bad and has negative impact on the economy both in short-run and long-run. Moreover, it has its own dynamics which often goes out of control once sets in. Moreover, deflation becomes very costly especially due to the presence of financial frictions and downward wages rigidity (see, Schmitt-Grohé and Uribe, 2014). Along with this, textbook New Keynesian model predicts severe recessions when prices are less sticky (Cochrane, 2017). Given this backdrop, policy that escapes ZLB and associated recession and deflation is always desirable even if it comes with a little more welfare loss.

Moreover, even if my proposed policy is robust and communicable using inflation target and its persistence, it is dynamically inconsistent (like the optimal commitment policy under ZLB). The implementation of this policy requires monetary authority to commit into a forward guidance policy that keeps inflation target above its long-run level even after the demand shock has fallen in value sufficiently that the nominal interest rate with a zero target inflation rate would be positive. However, I also believe that it should be no more difficult to establish credibility for this policy than for policies like the promise to "blow up the economy" (Cochrane 2011) in the event of off-equilibrium paths for prices and/or output, Woodford's (2003) timeless perspective policy, or optimal policy of Eggertson and Woodford (2003), Adam and Billi (2006). I also feel that communicating policy based on Neo-Fisherianism which is associated output expansion at the cost of a bit more welfare loss than optimal forward guidance policies is far more easier to communicate than the optimal forward guidance policy producing temporary recession but smaller overall welfare loss. This is because general people can observe recession and feel the pain of unemployment easily but cannot observe the implicit welfare loss incurred by the monetary authority. Hence, policy that escapes ZLB and associated recession and deflation seems more desirable to me even if it comes with a little more welfare loss.

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