Monetary Policy Rules and Zero Lower Bound on Nominal Interest Rates in a Cost Channel Economy

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Abstract

The zero lower bound on nominal interest rates (ZLB) is no longer just of theoretical interest. This study examined the behavior of critical macroeconomic variables under some interest rate rules and a forward guidance rule in a cost channel economy in the presence of the ZLB. A cost channel is said to be present in an economy if changes in nominal interest rates affect the supply-side of the economy. The ZLB is considered as an occasionally binding constraint in a New Keynesian setting. The novel Forward Guidance (FG) rule considered in this study is an endogenous, threshold-based and anticipated rule, while interest rate rules are represented by Taylor-type Truncated Rules (TTR). The results suggest that irrespective of the existence of a cost channel, first, the FG rule reduces the frequency of liquidity-trapped recessions compared to the TTR. Second, the depth of the recession under the FG rule is lower. Third, an appropriate FG rule can avoid the deflation bias, while strict FG leads to an inflation bias. The existence of the cost channel amplifies the inflation bias under the FG rule. Under TTRs, the cost channel economy is more likely to fall into a liquidity trap and remain longer than the no-cost channel economy. The welfare loss is higher when uncertainty is high and appreciably higher in cost channel economies. The findings of this study suggest that the endogenous FG rule improves welfare compared to the interest rules considered, irrespective of the existence of a cost channel. If a cost channel was present in an economy, the transmission of monetary policy might be different from that in a no-cost channel economy in the presence of the ZLB. Additionally, if agents expected future recessions, achieving the inflation target is more challenging in cost channel economies. The results imply that the central banks should pay careful attention to the cost channel of monetary policy when they set policies under such economic conditions, while the FG rule discussed in this study appears to be welfare increasing.

Keywords: *cost channel, zero rates on interest rates, interest rate rules, forward guidance, inflation bias*

1. Introduction

The zero lower bound on nominal interest rates (ZLB)[1] is no longer just of theoretical interest. Short-term nominal interest rates were reduced to the ZLB recently in many economies around the globe amidst the COIVD-19 pandemic and a decade ago due to the global financial crisis. Generally, normal central banking activities and economic activities are affected by the existence of the ZLB. This is no different concerning monetary policy rules.[2] Studies of monetary policy rules with occasionally binding ZLB constraint have shown that the ZLB aggravates recessions and affects deterministic steady-state values. However, the impact of the supply-side effects of monetary policy on economic conditions under monetary policy rules at the ZLB has not been examined thus far. The main aim of the present study is to begin filling this gap in the literature by analyzing interest rate rules at the ZLB when monetary policy has supply-side effects. This is important because the supply-side effects of monetary policy involve direct feedback on nominal interest rates and inflation through monetary policy rules, primarily interest rate rules.[3] This direct feedback mechanism of supply-side effects may affect previous results under monetary policy rules with the ZLB constraint. The supply-side effects of monetary policy are incorporated by considering the cost channel of monetary policy. This study proposes an endogenous threshold-based forward guidance (FG) policy rule.[4] According to this FG rule, the central bank announces forward guidance well before a recession and activates the rule endogenously during a recession.

To this end, a reduced-form rational expectations New Keynesian model with the cost channel was considered assuming that the ZLB constraint is occasionally binding. The model is log-linearized; the only non-linearity comes from the monetary policy reaction function. Since the non-linear model is stochastic and

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1   In this study, I consider the short-term nominal interest rate is constrained by the zero lower bound. However, on a few occasions, as specified in those sections, I relax that assumption.

2   Monetary policy rules, in the context of this study, can be defined as follows: The central bank follows a monetary policy rule to set current nominal interest rates. The rule is directly expressed by economic variables such as the inflation rate, price level, output gap, lags and leads of those variables and nominal interest rates.

3   For example, a negative demand shock contracts output and creates deflationary pressure. The central bank cuts nominal interest rates as prescribed by the interest rate rule. This expansionary monetary policy reduces the cost of production and thereby inflation through the cost channel mechanism and this feeds back to a larger interest rate cut in the next period, and so on.

4   In general, forward guidance is considered as the central bank's public announcement of its near future policy plan. The literature identifies two major categories of forward guidance, namely, Odyssean and Delphic (see Campbell et al., 2012). Odyssean forward guidance can further be categorized into two, namely, calendar-based forward guidance and threshold-based forward guidance. In calendar-based forward guidance, the central bank commits to maintaining zero interest rate policy for a fixed duration. In threshold-based forward guidance, the monetary authority announces maintaining interest rates at the ZLB until a pre-announced variable breaches a pre-determined threshold. The present study analyses a variance of threshold-based forward guidance.

the ZLB binds occasionally, no analytical solution exists. Therefore, the numerical approximation method called *the collocation method* was used to solve the model.

2. Literature Review

Monetary policy strategies in the presence of the ZLB have been studied extensively in the economics literature. In general, the literature suggests that a purely forward-looking approach to policy can lead to bad outcomes in a liquidity-trapped recession following a negative demand shock (for example, see Eggertsson and Woodford, 2003). However, many studies, including the study cited above, assume perfect foresight. Perfect foresight is a fair benchmark. However, in that setting, it is assumed that agents never expect the ZLB to be reached in the future. Adam and Billi (2006, 2007), Nakov (2008) and Hills et al. (2016), among others, have considered both optimal monetary policy and monetary policy rules in a stochastic setting with uncertainty. In the stochastic setting, the ZLB is considered as an occasionally binding constraint. Surprisingly, when the ZLB is considered an occasionally binding constraint, the previous results about the recession change, but importantly, the steady-state is different from the deterministic steady state. This steady-state under uncertainty is called *the risky steady state.* The main result found in this literature, which incorporates uncertainty by way of occasionally binding ZLB constraint, is the existence of *a deflation bias* in the risky steady state (for example, see Adam and Billi, 2006, 2007 and Nakov, 2008). A deflation bias at the steady-state is observed because the expected cost of production is distributed asymmetrically in the steady-state as agents expect the ZLB occurrences in the future. When the expected marginal cost is less due to the ZLB, the pricing decisions of firms today are affected, resulting in the deflation bias steady state.

Taylor and Williams (2010) identified four important implications of interest rate rules at the ZLB. First, the interest rate rule should be modified to incorporate the ZLB. This modification typically termed *the truncated interest rate rule,* introduces an additional non-linearity to the model. Second, the ZLB can imply multiple steady states. Third, the ZLB may have implications for the parametrization of the monetary policy reaction function. For example, increasing the response to the output gap helps reduce the effects of the ZLB. Fourth, the ZLB provides a case for higher target inflation.

The impact of the cost channel under monetary policy rules at the ZLB has not been exclusively studied. However, the impact of the cost channel on monetary policy rules under normal conditions, i.e., without the ZLB constraint, has been studied. Llosa and Tuesta (2009), Surico (2008) and Brückner and Schabert (2003) have shown that in the existence of the cost channel, Taylor-type instrument rules may induce indeterminacy. Llosa and Tuesta (2009) have mainly considered two

variations of the Taylor rule, i.e., contemporaneous and forward-looking rules. They have shown that determinacy may only be attainable if the central bank reacts modestly to both the output gap and inflation expectations in a cost channel model.

In practice, forward guidance has been instrumental in stimulating the economy at the ZLB, especially in the recent global financial crisis (see Smith and Becker, 2015). In monetary policy modeling, forward guidance is generally incorporated into the models in a few different ways. For example, it can be incorporated as an optimal commitment policy, an external news shock to nominal interest rates (see Laséen and Svensson, 2011), an exogenous extension to the zero interest rate regime (see Chattopadhyay and Daniel, 2015), incorporating forward guidance endogenously by augmenting the monetary policy rule, the Taylor rule (see Reifschneider and Williams, 2000 and Katagiri, 2016) and finally assuming that the central bank announces a transitory endogenous rule (see Boneva et al., 2015).

3. The Model

The economy is represented by three blocks, as is standard in the New Keynesian literature. They are an aggregate demand block represented by the Dynamic IS equation (DIS), an aggregate supply block represented by the New Keynesian Phillips Curve (NKPC) and the monetary policy block. It is assumed that a portion of the cost of the working capital must be financed by firms externally at the beginning of the period to incorporate the cost channel.

Two types of monetary policy rules are considered in this study. One is truncated Taylor-type rules (TTRs), and the other one is a forward guidance (FG) rule. The baseline model assumes that monetary policy is conducted using a truncated Taylor rule with contemporaneous inflation and contemporaneous output gap variables (i.e., contemporaneous truncated Taylor rule, CTTR for short). Accordingly, the CTTR constrained by the ZLB is given by:

$$R_t = max[1, r^* + \pi^* + \phi_\pi(\pi_t - \pi^*) + \phi_x x_t],$$

Where R_t is the nominal interest rate, r^* the equilibrium gross interest rate, π^* is the target inflation rate, ϕ_π is the inflation response coefficient, π_t is the rate of inflation, ϕ_x is the output gap response coefficient and x_t is the output gap.

An endogenous threshold-based (or data-based) FG rule was considered in the baseline model. Instead of an exogenous shock, a state-contingent rule-based forward guidance that activates endogenously was considered here according to economic conditions. In normal economic conditions, the central bank conducts monetary policy following a TTR. However, the central bank promises to maintain

a fixed policy rate (for example, zero nominal interest rates) until a specific event occurs whenever the economy moves to a liquidity trap. For example, the central bank may promise to hold interest rates at zero level until the unemployment rate reaches a certain threshold following a recession. This forward guidance announcement is made at time zero. Therefore, it is permanent and anticipated by the general public. This is different from the normal forward guidance policy experiments found in the literature. In the literature, in general, the forward guidance policy announcement is entirely unanticipated and transitory.

Specifically, under the present FG rule, the central bank credibly announces that it will keep interest rates at zero level until the lagged output gap recovers to a certain level following the liquidity trap. At the exit of the zero interest rate policy, following a recession, the central bank promises to follow the TTR as before. More formally, the FG rule can be stated as follows.

$$R_t = 1 \;\; if \;\; \left[R_t^{Taylor} \leq 1\right] \;\; or \;\; [R_{t-1} = 1 \;\; and \;\; x_{t-1} < a],$$

$$R_t = R_t^{Taylor} \;\; \text{otherwise},$$

where $a < 0$ is a value chosen by the central bank and R_t^{Taylor} is the value of the nominal interest rate prescribed by the truncated Taylor Rule. If the central bank chooses a large value for a, that is considered strict forward guidance, while if the central bank chooses a small value for a, that is considered *weak forward guidance*.

4. Solution Method and Calibration

Since the proposed non-linear rational expectations model is stochastic and the ZLB binds occasionally, no analytical solution is possible. Therefore, a numerical approximation method called *the collocation method* is used to solve the model. This methodology has been widely used in past studies, including Nakov (2008), Adam and Billi (2006, 2007), Gavin et al. (2013), Boneva et al. (2015) and Joo (2010) to solve models with occasionally binding ZLB constraint. Any numerical method has its own advantages and disadvantages. The main advantage of collocation is that it is a global method appropriate for analyzing the proposed stochastic model with an occasionally binding constraint.

Further, the collocation method is flexible, accurate and numerically efficient compared to the more commonly used linear-quadratic approximation method (see Miranda and Fackler, 2004, Chapter 9). There are two main disadvantages of collocation. In the context of the ZLB constraint, it is known that there can be multiple equilibria. However, the collocation method would solve only for one of them. Second, this methodology may not compute an equilibrium for a specific

region in the parameter space. For example, Richter and Throckmorton (2015), with a fully non-linear model, report that when the persistence of the shock process increases, the standard deviation of the innovation should decline to avoid a non-convergence region.[5] However, the latter issue is not exclusively relevant to the collocation method. For an explanation of the collocation method, readers may refer to Miranda and Fackler (2004, Chapter 9) or McGrattan (2001) for a general description of the collocation method or Nakov (2008) for more specific details relevant to the context of this study.

The model is calibrated using standard parameter values for the US economy.

5. Results, Conclusion and Policy Implications

The novel forward guidance (FG) rule considered in this study was an endogenous, threshold-based and anticipated rule, while interest rate rules were represented by Taylor-type truncated rules (TTR). According to the FG rule, the monetary authority promises to keep interest rates at the ZLB following a liquidity trap until the lag of the output gap recovers up to a pre-determined and pre-announced value. The monetary authority announces the FG rule at time zero. Under the FG rule, the following results hold, irrespective of a cost channel: Frist, forward guidance reduces the probability of hitting the ZLB compared to the TTR policy. Second, the depth of the recession under the FG rule is less painful and welfare maximizing. Third, by announcing an appropriate FG rule, the deflation bias observed under the TTR policy can be avoided. In addition, strict forward guidance leads to an inflation bias in the risky steady state.

Under TTR, first, the probability of hitting the ZLB is larger in cost channel economies under uncertainty compared to that of no-cost channel economies. This is because, during the shock period when the central bank cuts interest rates, the marginal cost of production drops more in cost channel economies than in no-cost channel economies, resulting in a considerable drop in inflation. This result shows that the cost channel economy is more likely to fall into a liquidity-trapped recession. Further, cost channel economies remain longer in the liquidity trap than no-cost channel economies. Second, the risky steady state of a cost channel economy is different (more deflation bias) from the risky steady state of a no-cost channel economy. The reason for that is the amplified asymmetry of the expected cost of production created by the ZLB constraint in cost channel economies. The study also revealed that the welfare loss is higher when uncertainty is high, and the welfare loss is significantly higher in cost channel economies than in no-cost channel economies. The above results suggest that achieving the inflation target in cost channel economies is more challenging than in no-cost channel economies if

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5   Same non-convergence behavior was experienced in the present analysis.

agents expect future liquidity traps.

The findings of this study suggest that the endogenous FG rule improves welfare compared to interest rules considered, irrespective of the existence of a cost channel. If a cost channel is present in an economy, the transmission of monetary policy may be different from that in a no-cost channel economy in the presence of the ZLB. Additionally, if agents expect future recessions, achieving the inflation target is more challenging in cost channel economies.

Accordingly, central banks should pay careful attention to the cost channel of monetary policy when they set policies under such economic conditions, while the FG rule discussed in this study appears to be welfare increasing.

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