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Monetary policy regime shifts under the zero lower bound: An application of a stochastic rational expectations equilibrium to a Markov switching DSGE model

Hirokuni Iiboshi [1]

Tokyo Metropolitan University, Economic and Social Research Institute, Cabinet Office, Japan

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ABSTRACT

I extend a simple new Keynesian model with the Markov switching type Taylor rule introduced by Davig and Leeper (2007) by incorporating the constraint of the zero lower bound (ZLB), using the concept and algorithms of the stochastic rational expectations equilibrium proposed by Billi (2013). According to the calibration, when an economy does not face the ZLB constraint, there is no gap in the fluctuation of output and inflation between stochastic expectations and perfect foresight because of the linear policy functions. In contrast, once-negative aggregate demand shocks make the nominal interest rate hit the ZLB under stochastic expectations, unlike perfect foresight, intensifying uncertainty plays an important role in further declines of the output and price level even in response to the same shock, regardless of the monetary policy regime adopted. The calibration also indicates the possibility that the steady states of a model, in the absence of the ZLB, are underestimated in periods of deflation, since the means often used as estimates of the steady states are biased downward from these. The analysis sheds light on an exit strategy from the zero interest rate policy, since a passive policy regime reduces the expected interest rate and induces both the expected output and the inflation to increase under the ZLB.

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1. Introduction

The effectiveness of monetary policy in stabilizing inflation and business cycles has been extensively studied both theoretically and empirically; the literature discussing these topics is too extensive to mention at present. However, the important issues of monetary policy have continuously surfaced as new problems in the global real economy, and some of these issues have not yet been resolved. One problem concerns how to manage monetary policy subject to the zero lower bound (ZLB) constraint, and another involves the consideration of the dynamics of business cycles under monetary policy regime changes. These matters have frequently been observed in the real economy. These topics are related to the indeterminacy of equilibrium, which is known to induce instability of inflation and real activities.

After the Great Recession developed between 2007 and 2009, the economies of the US and the EU countries encountered the ZLB on the nominal interest rate in a similar fashion to the economy of Japan. The central banks of these countries also had no choice but to implement an unconventional monetary policy, such as the quantitative easing (QE) policy, to stimulate their economies and to withstand deflation. An exit strategy from the zero interest rate policy became not only a big issue within macroeconomic theory but also an actual problem that monetary authorities faced, as the next stage for reverting to the standard monetary policy emerged, along with their economic recovery. In the recent literature, a number of authors have begun to conduct a systematic investigation into the monetary policy implications arising from the ZLB in a rational expectations (RE) model, including a dynamic stochastic general equilibrium (DSGE) model. Research by initiators in this field has been undertaken by Eggertsson and Woodford (2003), Jung et al. (2005) and Kato and Nishiyama (2005). In particular, a serial study by Adam and Billi (2006, 2007) and Billi (2011, 2012, 2013) has attracted attention because of its numerical approach, since the authors focused on a form of stochastic rational expectations, while most other studies have adopted more deterministic approaches, such as perfect foresight. The above studies have mainly dealt with optimal policy, including commitment and discretionary policy subject to the ZLB constraint. The latest work, such as the study by Billi (2013), has, however, struggled with the Taylor rule as well as the optimal policy constrained by the lower bound on the nominal interest rate. According to Adam and Billi (2006, 2007) and Billi (2011, 2012, 2013), the form of expectations,

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such as perfect foresight or stochastic rational expectations, is an important factor in the determination of equilibrium in the case of a non-linear DSGE model caused by the ZLB. This paper follows their study.

On the other hand, monetary policy regime changes could often be observed in an actual economy before the Great Recession. For example, the replacement of a chairman of the Federal Reserve or a governor of the Bank of Japan, etc., indicates the shaping of monetary policy regime shifts. In fact, some empirical studies, including Lubik and Schorfheide (2004), have reported that the US inflation of the 1970s was due to the Federal Reserve' s failure to obey the Taylor principle, before Paul Volker, the chairman of the Federal Reserve between 1979 and 1987, steered monetary policy based on the Taylor principle and cleaned up the hyper-inflation caused by his predecessors. The analysis of policy regime change using an RE model can be undertaken by adopting a Markov switching (MS) linear RE (MSLRE) model. The literature on the MSLRE model has recently been an active field in empirical macroeconomics. For example, the research by Davig and Leeper (2007) and Farmer et al. (2009, 2011) is representative of this field. Davig and Doh (2008), Liu et al. (2011) and Schorfheide (2005) estimated the presence of monetary policy change for the US economy using MSLRE models. However, these models could not deal with the constraint of the ZLB.[2]

The purpose of this study is to combine these two theses; accordingly, I extend an MSLRE model to the model subject to the ZLB on the nominal interest rate. In addition, this task indicates the combination of two different types of regime-switching monetary policies. This is because the model subject to the ZLB is regarded as a kind of state-dependent regime-switching one, in which, if an economy belongs to a regime with a positive interest rate, then the interest rate can operate based on the Taylor rule, but if the economy hits the other regime, in which the interest rate is fixed at zero, then the Taylor rule cannot work, regardless of the status of its economic activities. This type of regime-switching model must be a non-linear model, unlike the MSLRE model. The combination of the two kinds of regime-switching policies is, however, likely to occur as explained above. Accordingly, the challenge in my study could contribute to the consideration of the operation of actual monetary policy in the future. In addition, I consider the difference in the effects on the economy with different expectations, since the lack of equilibrium between perfect foresight and stochastic expectations must be non-negligible under the ZLB, as pointed out by Adam and Billi (2007). In contrast, the gap does not exist in the MSLRE models without the ZLB. To this end, I deal with a simple new Keynesian model with the MS-type Taylor rule introduced by Davig and Leeper (2007) and incorporate the ZLB constraint into the model, using the concept and the algorithm of the stochastic rational expectation equilibrium (SREE) proposed by Billi (2013). Furthermore, I calibrate and evaluate the effects of monetary policy regime shifts under the ZLB constraint.

According to the calibration result, there are two findings. First, there is no gap in the fluctuations of output and inflation between stochastic expectations and perfect foresight due to the linear policy functions, when an economy does not face the ZLB constraint. In contrast, this calibration shows that once-negative aggregate demand shocks make the nominal interest rate hit the ZLB under stochastic expectations, unlike perfect foresight; intensifying uncertainty measured by the volatilities of shocks would further deepen the declines of the endogenous variables even in response to the same shock, regardless of the monetary policy regime adopted. These results suggest that perfect foresight is biased upward, so that the possibility exists that the steady states of a model in the absence of the ZLB are underestimated in periods of deflation, since the means often used as estimates of the steady states are biased downward from those. Second, the calibration shows the validity of a passive monetary policy under the ZLB, unlike one without the ZLB, in which Davig and Leeper (2007), dealing with the MS Taylor rule, showed that the passive policy always makes the output and inflation fluctuate more than the active policy. Since the passive policy regime reduces the expected interest rate and induces both expected output and inflation to increase under the ZLB, it is suggested that the passive policy might be a candidate for an exit strategy from a zero interest rate policy. It is also suggested that a guidance policy to form expectations would play an important role in recovering an economy by contributing to mitigating the uncertainty of an aggregate demand shock, rather than retaining an active monetary policy regime, since the reduction in the volatility of the shock raises the means of the output and inflation.

The rest of the paper is organized as follows. Section 2 explains motivation why stochastic rational expectations should be considered for nonlinear DSGE models including MS-DSGE models. Section 3 presents the model studied in this paper, the concept of equilibrium and an approach to solving the equilibrium. Section 4 explains the calibration method and parameter values used in this study. Section 5 discusses the calibration results of the effects of monetary policy regime changes under the ZLB. Also this section provides the policy evaluation. Section 6 presents our conclusions.

2. Motivation

In this section, I describe the reasons why stochastic rational expectations should be considered and why the expectations are introduced into a regime-switching DSGE model in order gain more insights for the remainder of the paper. First of all, I start by offering brief definitions of stochastic rational expectations and their counterpart: perfect foresight. The perfect foresight of endogenous variables is derived using a policy function with the expected value of the exogenous variables, structural shocks, as the domain of the function, as shown below:

$$E_t y_{t+1} = f\left(E_t \varepsilon_{t+1}\right),$$

where $y_t + 1$ is an endogenous variable and ε_{t+1} is an exogenous variable. E_t denotes the expectations in period t. On the other hand, the stochastic rational expectations are derived from the integration of the policy function with respect to the exogenous variables as below:

$$E_t y_{t+1} = \int f\left(\varepsilon_{t+1}\right) dp\left(\varepsilon_{t+1}\right),$$

where $dp(\varepsilon_{t+1})$ is the density function of the exogenous shocks. As above, the concept of stochastic rational expectations is more realistic than that of perfect foresight, since the size of the uncertainty of the future endogenous variables is taken into account in terms of the given information on the exogenous variables. Fig. 1(a) intuitively illustrates these two concepts. There is no discrepancy in the expected values of the endogenous variables between the two expectations in the case of a linear DSGE model without restrictions such as the ZLB. In the long run, their unconditional expected value and steady states are equivalent in this case, since the distribution of the endogenous variables is symmetrical. Accordingly, we do not need to select the stochastic rational expectations as a means of calculating the expectations with an effort.

[2] Recently, Aruoba et al. (2014) and Mertens and Ravn (2014) have considered Markov Switching DSGE models which incorporate the ZLB on the nominal interest rate. These two studies embed a sunspot shock with two-state discrete Markov process in the models, and the two-state shock generates two equilibria. In Aruoba et al. (2014), the sunspot shock triggers moves from a targeted-inflation regime to a deflation regime and vice versa, by switching inflation targeted value of the Taylor rule. In Mertens and Ravn (2014), the two-state discrete sunspot shock determines one out of two regimes such as “optimistic expectation” and “ pessimistic expectation”, and an equilibrium under the pessimistic expectation regime converges to the one under liquidity trap. However, these two studies fix coefficients of the Taylor rule. On the other hand, my study considers the two-state Taylor rule driven by Markov process under the ZLB.

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