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24 April 2020

Online at <https://mpra.ub.uni-muenchen.de/99842/>
MPRA Paper No. 99842, posted 29 Apr 2020 07:21 UTC

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April 2020

* We are indebted to Juin-jen Chang, Mei-ying Hu, Chun-hung Kuo, Yi-ting Li and Po-yang Yu, who provided us with helpful suggestions in relation to earlier versions of this article. Any shortcomings are, however, the authors' responsibility.

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Abstract

This paper sets up a New Keynesian model in which the monetary authority implements a zero lower bound interest rate policy, and uses it to explore whether the supportive fiscal instruments (including expansionary government spending, a payroll tax cut, and a financial assets tax cut) are effective in overcoming a deep recession. The salient feature of this study is that it provides a new dynamic viewpoint of regime switching by evaluating each of several supportive fiscal policies in terms of their performance in alleviating a deep recession. Two main findings emerge from the analysis. First, when the monetary authority implements the zero lower bound interest rate policy to dampen the negative natural rate shock, the economy will sink into a deep recession with deflation. Second, to overcome the deep recession, of the three supportive fiscal tools (i.e., expansionary government spending, a payroll tax cut, and a financial assets tax cut), only expansionary government spending is effective in alleviating the deep recession. More specifically, the implementation of fiscal policy in the form of either the payroll tax cut or the financial assets tax cut will only further deepen the recession.

Keywords: Zero lower bound, New Keynesian model, fiscal stimulus, regime switching

JEL Classification: E62, E63, H20

1. Introduction

During the financial crisis in 2008-2009, the monetary and fiscal authority in the U.S. implemented various monetary and fiscal measures in an attempt to dampen the adverse macroeconomic effects of the crisis. The monetary policy took the form of lowering the interest rate. However, in spite of the Fed funds rate being lowered to a sufficiently low level (between 0-0.25%), this measure was found to be insufficient to pull the economy out of the deep recession in the face of such a catastrophic crisis. Thus, various fiscal policies involving expansionary government spending and tax cuts were quickly and repeatedly implemented to support the monetary policy during the crisis period.

When the Fed funds rate had been lowered to close to zero during the financial crisis period, various fiscal policies (including expansionary government spending, a payroll tax cut, and a financial assets tax cut) were proposed by economists to dampen the adverse effects. A question naturally arose: When the economy experiences a serious adverse shock, are these supportive fiscal instruments able to effectively alleviate the negative effect on the economy when the monetary authority implements a zero lower bound (henceforth ZLB) interest rate policy? To answer this question, this paper builds up a New Keynesian framework to evaluate the performance of each of the proposed supportive fiscal policies from the viewpoint of transitional dynamics. To be more precise, this paper sets up a perfect foresight dynamic general equilibrium model that is able to describe the dynamic adjustment of relevant macroeconomic

variables during the financial crisis period when the monetary authority implemented the ZLB interest rate policy. It is worth mentioning that, to make our analysis of the transitional dynamics more clear, this paper will provide not only a complete analytical solution but also a simple graphical exposition when we examine whether the supportive fiscal policies are effective in overcoming a deep recession.

In essence, the time interval of the financial crisis embodies a *temporary* characteristic since it will only last for a specific period. As a consequence, even though the monetary authority implements an interest rate peg policy at the ZLB during the time interval of the financial crisis, the forward-looking public fully recognizes that the financial crisis will come to an end at a specific date in the future. At that time, the monetary authority will once again implement the original interest rate adjustment rule (the Taylor rule). With this understanding, our analysis involves regime switching between the interest rate peg regime and the interest rate adjustment regime.¹ Compared to the existing literature on the financial crisis, the dynamic analysis of this paper has the following three distinctive traits. First, this paper provides a complete analytical solution of the dynamic analysis to explain whether each of the supportive fiscal instruments is helpful in alleviating the negative impact of the financial crisis. Second, this paper develops a simple graphical exposition, and uses it to provide an intuitive explanation for the analytical solution. Third, this paper proposes a new dynamic viewpoint of regime switching to evaluate the stabilizing effect of fiscal policies.

This paper is related to three strands of the existing literature on monetary policy with the binding of the ZLB. Firstly, in their recent articles, Carlstrom et al. (2015) and Cochrane (2017) also set up a New Keynesian model in which the economy will sink into a deep recession with deflation when the monetary authority implements the ZLB interest rate policy. However, their analysis focuses on whether forward guidance regarding the central bank's action is helpful in dampening the recession. This paper instead discusses which kinds of fiscal policies (rather than the forward guidance announcement implemented by the central bank) would be able to alleviate the economy's deep recession when the nominal interest rate is constrained at the ZLB.

Secondly, by building up a Markov switching model, some studies, such as Eggertsson (2011) and Woodford (2011), pay special attention to the fiscal multiplier when the monetary authority implements the ZLB interest rate policy. However, these studies do not explore the transitional dynamics of policy implementation, and only

¹ For the traditional analysis on regime switching (or regime change), see, e.g., Sargent and Wallace (1981), Krugman (1979), Drazen (1985), Obstfeld and Stockman (1985), Agénor and Flood (1992), and Lai and Chang (1994).

focus on whether a fiscal stimulus would generate a large multiplier at the ZLB constraint.² This paper instead provides the transitional analysis with a graphical illustration and highlights that, if the fiscal authority does not adopt any supportive policies and the monetary authority is forced to implement the ZLB interest rate policy, the economy will tend to fall into a deep recession throughout the entire period in which a temporary negative shock is present. Moreover, this paper comprehensively depicts the transitional dynamics and shows that certain kinds of supportive fiscal policies can serve as an effective tool in helping to pull the economy out of a deep recession.

Thirdly, some recent studies including Eusepi (2010), Davig and Leeper (2011), Werning (2012), Schmidt (2016), and Shen and Yang (2018) set up New Keynesian models, and discuss how the coordination of monetary and fiscal policies will govern the transitional adjustment of relevant macroeconomic variables by resorting to *numerical* analysis.³ In departing from these studies, this paper provides a detailed analytical solution, coupled with a simple diagrammatic exposition, to explain whether the fiscal instruments are helpful in alleviating the negative impact of the financial crisis when the monetary authority implements the ZLB interest rate policy.

The remainder of this paper is organized as follows. Section 2 builds up a standard continuous-time New Keynesian model. Section 3 examines the dynamic properties under two distinct regimes, and then shows that, faced with the negative natural rate shock, the economy would sink into a deep recession if the government were to implement the ZLB interest rate policy without any supportive fiscal policies. Section 4 discusses whether there exist feasible fiscal policies that will enable the economy to escape from the deep recession at the ZLB interest rate. Finally, the main findings of our analysis are presented in Section 5.

² In a celebrated article by Eggertsson (2011), the short run is defined as the period in which the economy is subject to temporary disturbance, and the long run is defined as the period in which the shock reverts to the steady-state value with the probability $1-\mu$ in each period. Based on the feature of the Markov process, Eggertsson (2011) cannot discuss the transition dynamics of policy implementation, and instead focuses attention on the kind of fiscal policy that would generate a larger multiplier in association with *two points in time* (i.e., the short run and the long run). This paper instead highlights the economy's dynamic adjustment *during the whole time period* in association with the implementation of different kinds of supportive fiscal policies.

³ It should be noted that Werning (2012) focuses on the normative analysis from the viewpoint of social loss minimization (our analysis instead engages in a positive analysis). More specifically, Werning (2012) shows that, under the liquidity trap scenario, a monetary policy without commitment would lead the economy into a depression coupled with deflation, while a monetary policy with commitment (i.e., the monetary authority commits to implementing the ZLB policy over a period longer than the liquidity trap) could lead the economy out of the depression accompanied by deflation. However, due to the difficulty in determining the optimal ZLB lagged period so as to minimize the social loss, Werning (2012) depicts the dynamic path in association with the optimal ZLB lagged period by resorting to numerical analysis (see Werning (2012, Fig. 2) for a more detailed discussion). Moreover, among the available supportive fiscal policies, Werning (2012) only deals with expansionary government spending.

2. The New Keynesian model

In this section, we first develop is a continuous-time version of a standard New Keynesian model, which can be treated as an integration of Eggertsson (2011) and Farhi and Werning (2016).⁴ Similar to Farhi and Werning (2016), the New Keynesian model, summarized by the New Keynesian Phillips Curve (NKPC) and the IS curve, can be represented by the following linearized differential equations:⁵

$$\dot{\pi}_t = \rho\pi_t - \kappa c_t - \delta_g g_t - \delta_w \tilde{\tau}_t^w, \quad (1)$$

$$\dot{c}_t = \hat{\sigma}^{-1} \left((1 - \tau_0^a) i_t - i_0 \tilde{\tau}_t^a - r_t^n - \pi_t \right). \quad (2)$$

To make the notation more compact, the variable with the subscript “0” refers to its initial steady-state value. In Eqs. (1) and (2), π_t is the inflation rate, $c_t = (C_t - C_0)/Y_0$ is the ratio between the deviation of consumption C_t from its steady-state C_0 and the steady-state output Y_0 , $g_t = (G_t - G_0)/Y_0$ is the ratio between the deviation of government spending G_t from its steady-state G_0 and the steady-state output Y_0 , i_t is the nominal interest rate set by the monetary authority, and r_t^n denotes the natural (interest) rate, which is treated as an exogenous variable. In addition, τ_t^a denotes financial assets taxes and τ_t^w denotes payroll taxes, $\tilde{\tau}_t^a$ and $\tilde{\tau}_t^w$ are respectively defined as $\tilde{\tau}_t^a \equiv \tau_t^a - \tau_0^a$ and $\tilde{\tau}_t^w \equiv \tau_t^w - \tau_0^w$, and i_0 is the steady-state nominal interest rate. The coefficients σ , φ , ρ and θ are the inverse of the intertemporal consumption substitution elasticity, the inverse of the labor supply elasticity, the subjective discount rate, and the probability of resetting prices. In addition, $\hat{\sigma} = \sigma / (1 - \alpha_g)$, $\kappa = \theta(\rho + \theta)(\hat{\sigma} + \varphi)$, $\delta_g = \theta(\rho + \theta)\varphi$ and $\delta_w = \theta(\rho + \theta) / (1 - \tau_0^w)$, where α_g is the ratio between the steady-state government spending and the steady-state GDP, i.e., $\alpha_g = G_0 / Y_0$.

In addition, the economy’s resource constraint is given by:⁶

$$y_t = c_t + g_t. \quad (3)$$

⁴ To be more precise, the model we develop can be treated as an integration of the Farhi and Werning (2016) perfect-foresight model and a variety of fiscal policies proposed by Eggertsson (2011).

⁵ See Appendix A for a detailed mathematical derivation.

⁶ See Appendix A for a detailed derivation of the economy’s resource constraint.