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A new Keynesian model with delay: Monetary policy lag and determinacy of equilibrium

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ABSTRACT

We investigate the effects of a monetary policy lag on equilibrium determinacy by using a New Keynesian (NK) continuous-time framework. If the lag is not very large, the result obtained will not be different from the standard one: an active monetary policy attains local equilibrium determinacy, which is a policy norm known as the Taylor principle. However, if the lag is sufficiently large, then no equilibrium will exist.

1. Introduction

The dynamic stochastic general equilibrium (DSGE) model comprising factors of imperfect competition and nominal rigidities is referred to as the New Keynesian (NK) model. The simplest version of this model provides the following policy norm: for equilibrium determinacy, the central bank must increase (decrease) the nominal interest rate by more than one unit when a one-unit increase (decrease) in the inflation rate occurs. This norm is well known as the Taylor principle.[1]

Bernanke and Woodford (1997) and Carlstrom and Fuerst (2000) consider the situation of forward-looking interest-rate rule where the nominal interest rate responds to future inflation rates and the backward-looking interest-rate rule where the nominal interest rate responds to past inflation rates. Further, they demonstrate that the forward-looking interest-rate rule increases the possibility of equilibrium indeterminacy, whereas the backward-looking interest-rate rule is effective for avoiding equilibrium indeterminacy.

These studies are developed by considering the assumption of money in the utility function (MIUF) and adopt the descriptive method of difference equations; both the models are expressed in a discrete-time system of equations. In contrast, Benhabib et al. (2003) adopt the assumption of money in the production function (MIPF) and the descriptive method of differential equations; the model is expressed in a continuous-time system of equations.[2] Benhabib et al. (2003) demonstrate that a backward-looking interest-rate rule can generate a supercritical Hopf bifurcation and, therefore, limit cycles, even when the Taylor principle holds. This implies that the equilibrium can be globally indeterminate even if it is locally determinate.

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1 See Taylor (1993). For details of monetary policy analysis using the NK model, see Woodford (2003), Galí (2008), and Walsh (2010).

2 Benhabib et al. (2001) also proposed a continuous-time MIUF model and showed that forward-looking interest-rate rules are inappropriate for equilibrium determinacy, whereas backward-looking interest-rate rules are beneficial to determinacy.

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The crucial element to Benhabib et al.'s (2003) model is the assumption of MIPF. Actually, Feenstra (1986) demonstrates that a Hopf bifurcation can be ruled out in the MIUF model in which a strong cross-partial between consumption and money does not exist in the utility function, although he assumes flexible prices. Further, Carlstrom and Fuerst (2003) suggest that Feenstra's (1986) consequence can also be justified in the sticky-price model.

Moreover, Bilbiie (2008) incorporates limited asset market participation in a standard cashless DSGE model and demonstrates that, even if the Taylor principle does not hold, equilibrium can be determinate. However, Buffie (2013) shows that Bilbiie's (2008) result is strongly dependent on the assumption that the real wage is highly flexible, and that by relaxing this assumption, the Taylor principle reasserts itself as a necessary and sufficient condition for determinacy.

Thus, much studies have been conducted on monetary policy analysis with a specific focus on economic stability in NK models.[3] So far, however, there has been little research on the effects of a policy lag on equilibrium determinacy from a theoretical standpoint, especially in the context of the NK model.[4] This study examines the effects of delay in monetary policy response (i.e., recognition or implementation lags) on local equilibrium determinacy by using the MIPF model. An interest-rate rule with a policy lag is represented as a special case (a case in which the variance of the weighted function of past inflation rates is zero) of a backward-looking interest-rate rule.

This paper proceeds as follows: Section 2 presents a standard NK model. Section 3 analyzes the local equilibrium determinacy around the steady state. Section 4 presents our conclusion.

2. The model

We present the continuous-time version of a typical NK model. The model consists of a continuum of household–firm units indexed by i ($i \in [0, 1]$) and the central bank. Firm i produces differentiated good i by utilizing the labor supplied by household i. Households aggregate various types of differentiated goods and consume them.

2.1. Intratemporal optimization

Households aggregate differentiated goods via the Dixit–Stiglitz function[5]:

$$y = \left[\int_0^1 y_i^{\frac{\phi-1}{\phi}} di\right]^{\frac{\phi}{\phi-1}},$$

where y is the volume of the composite good; y_i is the volume of good i, and ϕ (>1) is the elasticity of substitution among the differentiated goods.

Given the price of good i, p_i; the price of composite goods p; the volume of composite goods y, then households determine what level of y_i that will minimize the total cost $\int_0^1 p_i y_i di$. The first-order condition for cost minimization is given as follows:

$$y_i = \left(\frac{p_i}{p}\right)^{-\phi} y, \tag{1}$$

where

$$p = \left[\int_0^1 p_i^{1-\phi} di\right]^{\frac{1}{1-\phi}}.$$

2.2. Intertemporal optimization

We formulate the production function of the firm i as follows:

$$y_i = l_i^{\alpha},$$

where l_i is the volume of labor force supplied by household i and $0 < \alpha < 1$.

A household–firm unit i obtains utility from consumption c_i and real money balances m_i, and disutility from labor l_i and price revisions $\pi_i = \dot{p}_i/p_i$ in every period. We formulate the utility function of the household–firm unit i as

[3] Carlstrom and Fuerst (2007), and Tsuzuki and Inoue (2011) consider a rule wherein the nominal interest rate is changed not in response to the inflation rate but to asset prices. Such a rule represents asset-price targeting. Carlstrom and Fuerst (2007) show that asset-price targeting increases the possibility of indeterminacy; however, it is shown by Tsuzuki and Inoue (2011) that Carlstrom and Fuerst's (2007) result can be overturned by introducing the technological change induced by the investment of profits.

[4] Asada and Yoshida (2001) and Yoshida and Asada (2007) theoretically investigate the impacts of a fiscal policy lag on an economy's stability using a descriptive framework, one that does not have a micro-foundation.

[5] See Dixit and Stiglitz (1977) and Blanchard and Kiyotaki (1987).