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Taylor rules and equilibrium determinacy in a two-country model with non-traded goods☆

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ABSTRACT

We analyze a relation between interest rate controls and equilibrium determinacy using a two-country model featuring traded and non-traded goods. In addition, parameters of preference and production may differ between the two countries. We find that macroeconomic stability strongly depends on such heterogeneity including monetary policy, and that it is easier to generate determinate equilibrium under perfect liberalization of the economy, but to operate monetary policy in the economy with non-traded goods.

1. Introduction

In this paper, we analyze equilibrium determinacy of a two-country model with traded and non-traded goods in which the monetary authority in each country may adopt different interest rate control rules, and the countries can have asymmetric production technologies and preferences.

There are a considerable number of studies concerning the stabilization effect of interest rate control rules in open economy settings that utilize small country models. For example, Chang et al. (2008) examine an AK growth economy with a generalized Taylor rule in which the central bank controls nominal interest rate in response not only to inflation but also to the growth rate of income.[1] They show that the number of equilibrium paths is less than one, that is, equilibrium is determinate or source.[2] Carlstrom and Fuerst (1999), Kam (2004, 2007), and Zanna (2003, 2009) examine small-open economy models with Taylor-type monetary policy under sticky prices.

The role of interest rate controls in a world economy model with two-countries also has been extensively discussed in the literature. The New Keynesian models in Batini et al. (2004), Benigno and Benigno (2006), Bullard and Schaling (2009), De Fiore and Liu (2005), and Airaudo and Zanna (2012a) are based on Clarida et al. (2002) In these models with sticky price and monopolistic competition, preferences and production parameters are assumed to be identical in both countries, and the results are not analytically clear.

Moreover, non-traded goods are often ignored in open economy models. This is because the law of one price is plausible only for traded goods and thus the non-arbitrage condition is described simply as the equivalence of real interest rates. For instance, Ono (2006) considers a two-country economy in which all goods are tradable, the utilities of consumption and money are additively separable, production is linear in labor and involuntary unemployment can emerge. He focuses on monetary policy such that the growth rate of real money balances equals to the deflation rate, that is, nominal money holdings are constant. Fujisaki (2012) revises his model by using an interest-rate control rule, and the utility of money need not be additively separable from consumption. The results mainly depend on the heterogeneity of interest rate controls and preferences, whereas productivity plays a limited role.

However, in the real economy, we cannot live without non-traded goods represented by service like hair-cutting. The share of non-traded goods is empirically over 50% as in Cardi and Restout (2011) and Vega (2012). In addition, Lee and Shin (2010) and Monacelli and Perotti (2010) investigate the relation between the exchange rate and non-traded goods.

In order to check the robustness of the result in Fujisaki (2012) and to obtain its implications for the openness of the economy, we construct a two-country version of the model in Airaudo and Zanna (2012b). They

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[1] Such a monetary policy rule is also formalized in Fujisaki and Mino (2007).

[2] However, we should note that they assume sticky nominal interest rate.

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investigate small-country models with Taylor-type monetary policy[3] and they distinguish non-traded goods from tradable ones. If a continuous-time setting is used in their models, we only reconfirm the well-known results established in closed economy models: Taylor principle holds, which means that interest-rate control with an aggressive response to the rate of inflation generates equilibrium determinacy. They utilize discrete-time models for investigating the effect of timings of monetary dynamics[4] on equilibrium determinacy. In order to focus on heterogeneity between two countries, we assume a continuous-time model. That is, each country responds independently to its own inflation rate using interest rate controls, and parameters such as elasticities of labor used in production and intertemporal substitution may differ between the two countries. We suppose that production functions can be non-linear in labor by assuming a fixed productive factor as in Carlstrom and Fuerst (1999).

Using the Keynesian model with capital, McKnight (2011a) shows that real indeterminacy is considerably easier to obtain once trade liberalization is permitted. However, as his other papers McKnight (2011b) and McKnight and Mihailov (2007), they generally conclude that Taylor principle tends to hold regardless of the openness of the economy, and parameters about preferences and production in these models are assumed to be the same in both countries.

We show that heterogeneity has a significant effect on equilibrium determinacy and thus an appropriate combination of monetary policy is necessary to stabilize the world economic system. This does not necessarily mean that central banks in both countries should aggressively control nominal interest rates in response to inflation. Rather, passive monetary policy in one country may play a role for realizing the stable economy. Such results are similar to those in Fujisaki (2012), who assumes two kinds of tradable goods. In this paper, we consider the effect of non-traded goods that violates the law of one price. Then, the non-arbitrage condition may not imply the equivalence of real interest rates, and thus it becomes difficult to hold both the non-arbitrage condition and traded-goods equilibrium, which can be a source of indeterminacy. Liberalization might be effective for macroeconomic stability in that indeterminate equilibrium which can be determinate by being all goods tradable. On the other hand, central banks can operate monetary policy more easily when there are non-traded goods in the economy, because the results of stability are clearer.

2. The model

2.1. Households in Country 1

We assume that there are two countries, Country 1 and Country 2, in the world economy. They produce and consume tradable and non-traded goods. Additionally, the structure of the economy in the two countries is similar, although they differ in the values of some parameters for preferences, production, and monetary policy. Our purpose is to investigate the effect of such heterogeneity on equilibrium determinacy.

We examine the structure of Country 1's economy. The consumer price index (CPI) p, the CPI-inflation rate π, and the price of traded-goods relative to non-traded goods' $\widetilde{P}$ are

$$p \equiv \left(\frac{P^T}{\alpha}\right)^{\alpha}\left(\frac{P^N}{1-\alpha}\right)^{1-\alpha}, \quad \pi = \alpha\pi^T + (\pi 1-\alpha)\pi^N, \tag{1}$$

$$\widetilde{P} = \frac{P^T}{P^N}, \tag{2}$$

where $\pi^T \equiv \frac{\dot{P}^T}{P^T}$ $\left(\text{resp. } \pi^N \equiv \frac{\dot{P}^N}{P^N}\right)$ is the inflation rate of the price of traded goods P^T (resp. non-traded goods P^N) expressed in domestic currency, and $\alpha \in (0,1]$ is the proportion of tradable goods among all commodities consumed in the country.

The production functions of traded and non-traded goods are respectively

$$y^T = \left(l^T\right)^{\theta^T}\left(\mathcal{L}^T\right)^{1-\theta^T}, \quad y^N = \left(l^N\right)^{\theta^N}\left(\mathcal{L}^N\right)^{1-\theta^N}, \quad 0<\theta^N<1, \quad 0<\theta^T<1,$$

where l^T and l^N are labor, and $\mathcal{L}^T$ and $\mathcal{L}^N$ are fixed factors. This formulation follows Airaudo and Zanna (2012b) and Carlstrom and Fuerst (1999). In the following, we suppose that the rent from the fixed factor is distributed to household and that $\mathcal{L}^T = \mathcal{L}^N = 1$. Then, income distribution is described as follows:

$$y^T = w^T l^T + h^T, \quad y^N = w^N l^N + h^N,$$

where $w^T = \frac{\theta^T y^T}{l^T}$ is a wage of labor and $h^T = (1-\theta^T)y^T$ is the rent from fixed factor for traded goods. (Notation of non-traded goods is similar.)

The budget constraint of representative household in nominal terms is

$$\dot{B} + \dot{M} = RB + P^T\left(y^T - c^T\right) + P^N\left(y^N - c^N\right),$$

where B denotes bonds, M nominal money holdings, R the nominal interest rate, c^T and c^N (resp. y^T and y^N) consumption (resp. output) of the tradable and non-traded goods. (We assume zero lump-sum taxes.) Employing notation $z \equiv \frac{Z}{p}$ that evaluates a nominal variable Z in real terms and $a \equiv b + m$ as real financial assets, we can describe

$$\frac{\dot{B} + \dot{M} - RB}{P^N}\frac{p}{p} = \frac{p}{P^N}(\dot{a} + \pi a - R(a-m)),$$

because

$$\frac{\dot{B} + \dot{M}}{p} = \frac{\dot{A}}{p} = \dot{a} + \pi a.$$

Using

$$\frac{p}{P^N} = \frac{\widetilde{P}^{\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}$$

from Eqs. (1) and (2), we obtain the budget constraint in real terms as

$$\dot{a} = (R-\pi)a - Rm + \alpha^{\alpha}(1-\alpha)^{1-\alpha}\widetilde{P}^{-\alpha}\left[\widetilde{P}\left(y^T - c^T\right) + \left(y^N - c^N\right)\right]. \tag{3}$$

The maximization problem of the representative household in Country 1 is

$$\max \int_0^{\infty} u\left(c, m, l^T, l^N\right)e^{-\rho t}dt, \quad \rho > 0,$$

subject to Eq. (3), where ρ is the time discount rate and c is the consumption aggregator given by

$$c = \left(c^T\right)^{\alpha}\left(c^N\right)^{1-\alpha}, \quad 0<\alpha \le 1. \tag{4}$$

Additionally, the instantaneous utility is specified as

$$u\left(c, m, l^T, l^N\right) = \frac{\left(c^{\gamma}m^{1-\gamma}\right)^{1-\sigma}}{1-\sigma} + \psi\left(1-l^T-l^N\right), \quad 0<\gamma<1, \quad \sigma>0, \quad \psi>0,$$

[3] A liquidity trap in which nominal interest rates cannot be negative is considered in Airaudo and Zanna (2004).

[4] For instance, monetary authority controls the current nominal interest rate in response to either the contemporaneous or forward-looking inflation rate.