中央研究院經濟所學術研討論文

IEAS Working Paper

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IEAS Working Paper No. 04-A004

February, 2004

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http://www.sinica.edu.tw/econ/

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TAIWAN

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December 2003

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Abstract This paper sets up an endogenous growth model of an open economy in which the monetary authority implements a gradualist interest-rate rule with targets for inflation and economic growth. We show that, under a passive rule, a monetary equilibrium exists and is unique; moreover, the equilibrium is locally determinate. Under an active rule, the open economy either generates multiple equilibria or does not have any equilibrium. If equilibria exist, the high-growth equilibrium is locally determinate while the low-growth equilibrium is a source. Besides these, the stabilization and growth effects of alternative target policies are also explored in this study.

***Keywords*:** Nominal interest rate rules; gradualism; endogenous economic growth

JEL Classification: F43, E52, O42

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1. Introduction

Price stability and economic growth have long been two of the policy authorities' goals. Due to international financial innovation and erratic money demand, policymakers in many industrial and developing countries have put monetary aggregates aside and have instead used interest rates as the main monetary policy instrument. In practice, the use of interest rates as the policy instrument has often taken place in conjunction with certain targets for inflation and other measures of economic activity. As proposed by Taylor (1993), U.S. monetary policy over the past decade may be described in terms of an interest-rate feedback rule, whereby the federal funds rate is set as a linear function of inflation and output gaps with coefficients of 1.5 and 0.5, respectively. Such an interest-rate rule has been dubbed the Taylor rule.[1] This rule describes U.S. policy in a period in which monetary policy is widely judged to have been unusually successful (Taylor (1999)), suggesting that the rule is worth adopting as a principle of behavior. In fact, such rules have also been shown to adequately describe monetary policies in many other industrialized economies (see, for example, Clarida et al., 2000).

The debate of whether interest-rate rules can contribute to aggregate stability has a long history. Research on this issue can be traced back to the studies of Sargent and Wallace (1975) and McCallum (1981). In their studies with somewhat ad hoc specifications, the stabilization effect of interest-rate rules basically involves examining whether interest rate rules can give rise to the determinacy of the price level. Sargent and Wallace (1975) claim that interest-rate rules are undesirable, because they lead to the indeterminacy of the rational-expectations equilibrium price level. However, McCallum (1981) argues that determinacy is possible if the interest rate feeds back to endogenous state variables such as the price level.

[1] To be concrete, a feedback rule satisfies the Taylor principle if it has an inflation coefficient greater than unity, which implies that, in the event of a sustained increase in the inflation rate by *k* percent, the nominal interest rate will eventually be raised by more than *k* percent. In the relevant literature, such kinds of interest-rate rules are also known as active interest-rate rules. By contrast, a passive rule involves an inflation coefficient of less than unity.

Interest in this issue has been renewed by Taylor's (1993) work. Ever since his pioneering effort, there have been numerous optimizing models that have focused on the indeterminacy of equilibrium under interest-rate rules. The results they obtain are, however, inconclusive. A number of studies, for instance, Leeper (1991), Sims (1994), Woodford (1994), Shmitt-Grohé and Uribr (2000), and Clarida et al. (2000), suggest that Taylor rules can ensure uniqueness of equilibrium. However, other works, such as Benhabib et al. (2001a, 2001b, and 2002), Dupor (2001, 2002), and Meng (2002), show that active rules do not necessarily give rise to the determinacy of equilibrium while passive rules are generally determinate. Generally speaking, the stabilization effect of interest-rate feedback rules is shown to depend crucially on the way in which money affects aggregate demand and supply, the monetary-fiscal regime, the existence of capital accumulation, the adjustment costs of investment, the intertemporal elasticity of substitution, and the steady-state inflation rate, etc.

Two potentially important issues are still unheralded in the literature. First, as a consequence of globalization, the frequent interactions among economies raise the importance of the role of international factors in relation to domestic macroeconomic performance. However, with a few exceptions (Taylor, 2001; McCallum and Nelson, 2001; Erceg (2002)), economists have paid relatively little attention to the discussion regarding the performance of interest-rate rules in an open economy. Secondly, due to their non-growth analytical frameworks, the authors we cited above also do not deal with the problem of whether or not the government can influence the economic growth rate while pursuing price stability. Therefore, the purpose of this paper is to construct a monetary endogenous growth model of an open-economy and use it to explore the stabilization and growth effects of interest-rate rules.

When specifying the monetary rule, we actualize the central bank's operating procedure in that it is assumed to implement a *gradualist* monetary rule, i.e. it gradually adjusts the nominal interest rate toward the targeted level, rather than adjusting the interest rate by an immediate once-and-for-all jump. As is commonly believed by economists, this is the way several central bankers have conducted their monetary policy. Such a belief is supported by evidence that the official interest rates in major countries have been adjusted by small amounts with infrequent reversals (see, for example, Goodhart (1996), Sack (1998), Woodford (1999), and Martin (1999)). In addition, from an empirical point of view, a central banker's first mission is to keep inflation stable; however, it is also to keep an eye on real GDP growth (or other macroeconomic goals). To incorporate this observation into the model, following Smithin (2002), we postulate that the central bank sets the federal funds rate as a function of inflation and growth gaps and accordingly, the central bank is pursuing both inflation and growth stabilization goals.

Our findings provide some important policy implications and contribute to the relevant literature in two respects. First of all, we reexamine the indeterminacy results under interest-rate feedback rules. It is found in an open economy that, if the central bank implements a passive rule, then the monetary equilibrium exists and is unique. Moreover, this unique passive monetary equilibrium is locally determinate. If the central bank implements an active rule, then the open economy either generates multiple equilibria or does not have any equilibrium. If equilibria exist, the high-growth equilibrium is locally determinate while the low-growth equilibrium is a source.

Second, this paper investigates the effects of alternative government target policies on the dynamic performance of a continually growing economy. We show that, in response to an anticipated permanent decrease in the inflation target, the growth rate of the open economy will decline on impact and then continuously fall toward its new stationary level. However, the nominal interest rate and the inflation rate will exhibit a mis-adjustment: they will fall during the period between the policy's announcement and its implementation; once the lower inflation target is realized, the nominal interest and inflation rates will start to increase toward their new and higher stationary levels.

This paper also considers an incredible rise in the growth target. The practical observations have pointed out that the central bank's policy often involves some kind of credibility problem and it has also received a considerable amount of attention in the literature (see, for instance, Calvo, 1986; Drazen and Helpman, 1988). The results that we yield show that the economy can enjoy higher growth during the entire transition if the commitment in regard to the growth target policy is imperfectly credible. This provides a theoretical explanation of why the government often overstates its intended growth target and implements an incredible policy. However, in response to different credibility horizons, the economy will experience quite distinct transitional dynamics. Generally speaking, the results of this study suggest that a nominal interest rate rule that feeds back to both inflation and economic growth can give rise to a double-dividend in terms of both price stability and the expansion of economic growth in the steady state.

The remainder of this paper proceeds as follows. Section 2 develops a small open endogenously-growing model with gradualist nominal interest rate rules. In Section 3 we characterize the balanced growth path and the stability properties of the system. The economy's dynamic response to the target policies is analyzed in Section 4. Section 5 concludes.

2. The model

Consider a small open economy consisting of a representative household, a government, and a central bank. The domestic economy produces and consumes a single traded good, and the foreign price of which is given in the world market. In the absence of any impediments to trade, the law of one price is assumed to hold. By denoting P as the domestic price level, P^* as the world price level, and E as the nominal exchange rate, the law of one price can be described in percentage change terms as follows:

$$\pi = \pi^* + \varepsilon \,, \tag{1}$$

where $\pi\,(\equiv \dot{P}/P)$ is the rate of inflation of the good in terms of domestic currency, $\pi^*\,(\equiv \dot{P}^*/P^*)$ is the rate of inflation of the good in terms of foreign currency, and $\varepsilon\,(\equiv \dot{E}/E)$ is the rate of depreciation of domestic currency.

2.1 The household

The representative household with an infinite planning horizon has access to perfect world capital markets, being able to lend internationally. Let us denote M and B^* as the stocks of nominal money balances and net nominal foreign bonds, respectively. The net nominal foreign bond earns a fixed rate of return, namely, the world nominal interest rate, R^*, in the world bond market. When the world capital market is perfect, the following assets arbitrage condition must hold:

$$R^* - \pi^* = R - \pi \,, \tag{2}$$

where R is defined as the domestic nominal interest rate. Equation (2) is essentially the interest rate parity. The household chooses consumption c, investment i, physical capital k, real money balances $m\,(\equiv M/P)$, and real net foreign bonds $b^*\,(\equiv EB^*/P)$ so as to maximize the discounted sum of future instantaneous utilities:

$$\int_0^\infty \frac{c^{1-\theta}-1}{1-\theta}\cdot \mathrm{e}^{-\rho t}\,\mathrm{d}t, \quad \theta > 0, \quad \rho > 0,$$

where ρ represents the constant rate of time preference and θ is the inverse of the intertemporal elasticity of substitution which measures the curvature of the utility function. For simplicity, the individual's labor supply is assumed to be fixed inelastically.

The domestic output y is produced by means of a simple Ak production technology, i.e. $y = Ak$, where k denotes the domestic capital stock (it can also be treated as a composite of physical and human capital, as suggested by Lucas (1988)) and $A > 0$ is the total factor productivity. The process by which the firm sells its product to the consumers involves transactions cost. Firms, as argued by Dornbusch and Frenkel (1973), hold money balances in order to facilitate transactions. Following Sims (1989) and Zhang (1996), we summarize the transactions cost technology in terms of the rate of loss in real output using the following form:

$$\Phi = \Phi(m, y), \text{ with } \Phi_m < 0 \text{ and } \Phi_y > 0.$$

To sustain a macroeconomic equilibrium with ongoing growth, we further assume that Φ is homogeneous of degree 0 in m and y; more specifically, $\Phi(m, y) = \phi(m/y)$ with $\phi' < 0$, $\phi'' \geq 0$, $\lim_{m/y \to 0} \phi(m/y) = 1$, and $\lim_{m/y \to \infty} \phi(m/y) = \overline{\phi} \in (0,1)$.

Furthermore, in line with Hayashi (1982), Abel and Blanchard (1983), and Turnovsky (1996), the accumulation of physical capital involves adjustment costs Ψ (or installation costs) with a quadratic convex function, i.e.:

$$\Psi(i, k) = i\,(1 + \frac{h}{2}\frac{i}{k}),$$

where $h(> 0)$ is a constant parameter of adjustment costs. The existence of adjustment costs for investment can help us avoid some of the counterfactual results from the open-economy version of the Ramsey model (see Barro and Sala-i-Martin (1995, ch. 3)). Turnovsky (2000) points out that the linear homogeneity of the adjustment cost function is necessary to give rise to non-degenerate dynamics and to be sustained if the stationary equilibrium exhibits ongoing growth.[2] Given that the capital stock does not depreciate, the following physical capital accumulation constraint should be satisfied.

$$\dot{k} = i. \tag{3}$$

At each instant of time, the representative household is bound by a flow constraint linking wealth accumulation to any difference between its gross income and its expenditure. Thus, the household's flow budget constraint is given by:

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[2] Adjustment costs that depend upon investment relative to the capital stock can be justified by learning-by-doing in the installation process. As addressed by Feichtinger et al. (2001, p. 255), "if capital stock is large, a lot of machines have been installed in the past so that this firm has a lot of experience, implying that it is more efficient in installing new machines."

$$\dot{m}+\dot{b}^{*}=y-c-i(1+\frac{h}{2}\frac{i}{k})-\phi(\frac{m}{y})y+[R^{*}+\varepsilon-\pi]b^{*}-\pi m+\tau\,, \tag{4}$$

where the τ are real transfers from the government. Equation (4) states that, if the sum of output, interest income on net foreign bonds, and transfer income from the government exceeds that of expenditure on consumption, investment, transactions cost, and inflation tax, then the representative agent will increase his holdings of either real money balances or real net foreign bonds.

If we denote the real financial asset as $a\equiv m+b^{*}$, then the current-value Hamiltonian for the representative agent's optimization is given by:

$$H=\frac{c^{1-\theta}-1}{1-\theta}+\lambda\cdot\left[(R^{*}-\pi^{*})a+Ak-c-i(1+\frac{h}{2}\frac{i}{k})-\phi(\frac{m}{Ak})Ak-Rm+\tau\right]+q'\cdot i\,,$$

where λ is the shadow value (marginal utility) of wealth in the form of the real financial asset and q' is the shadow value of capital stock. Let the shadow value of wealth be the numéraire. Accordingly, $q\equiv q'/\lambda$ is defined as the market value of capital in terms of the (unitary) price of the real financial asset.

The optimum conditions necessary for this optimization are:

$$c^{-\theta}=\lambda\,, \tag{5}$$

$$\frac{\dot{k}}{k}=\frac{i}{k}=\frac{(q'/\lambda)-1}{h}\equiv\frac{q-1}{h}\,, \tag{6}$$

$$-\phi'(\frac{m}{y})=R\,, \tag{7}$$

$$\frac{\dot{q}}{q}+\frac{1}{q}\left\{[1-\phi(\frac{m}{y})+\phi'(\frac{m}{y})\cdot\frac{m}{y}]A+\frac{(q-1)^{2}}{2h}\right\}=R^{*}-\pi^{*}\,, \tag{8}$$

$$\frac{\dot{\lambda}}{\lambda}=\rho-(R^{*}-\pi^{*})\,, \tag{9}$$

together with (3) and (4), and the transversality conditions of a and k are:

$$\lim_{t\to\infty}\lambda a\,\mathrm{e}^{-\rho t}=0\,, \tag{10a}$$

$$\lim_{t\to\infty}q'k\,\mathrm{e}^{-\rho t}=\lim_{t\to\infty}\lambda qk\,\mathrm{e}^{-\rho t}=0\,. \tag{10b}$$

Equation (5) indicates that the household equates the marginal utility of consumption to the marginal utility of the real financial asset. Equation (6) states the "Tobin *q*" theory of investment. Equation (7) indicates that the marginal benefit of holding real money balances equals the domestic nominal interest rate. Equation (8) is an arbitrage condition, which indicates that the real rate of return on marginal investment should equal the real rate of return on the real financial asset. The former is the sum of expected capital gains, $\dot{q}/q$, the value of the marginal product of capital, and the value of marginal savings on installation costs.

2.2 The government and the central bank

There are no commercial banks in the economy and thus the central bank lends only to the government. Under a regime of flexible exchange rates, foreign reserves are constant over time. Following Agénor and Montiel (1996, pp. 323-326), we normalize the constant level of reserves to zero. Accordingly, given that D is the nominal stock of domestic credit, changes in the real money balances are equal to changes in the real credit stock, i.e.:

$$\dot{m}/m = \dot{d}/d = \mu - \pi , \tag{11}$$

where $d\,(\equiv D/P)$ is the real domestic credit and $\mu\,(\equiv \dot{D}/D)$ is the growth rate of the nominal credit stock. In addition, let us assume that the government forgoes the issuance of domestic bonds to finance its deficit, and distributes seigniorage to the representative household as a transfer payment in a lump-sum manner. Thus, the flow budget constraint of the government can be written as:

$$\tau = \mu m , \tag{12}$$

Putting equations (4), (11), and (12) together, the open economy's consolidated budget constraint can be obtained as follows:

$$\dot{b}^* = [1 - \phi(\frac{m}{y})]y - c - i(1 + \frac{h}{2}\frac{i}{k}) + (R^* - \pi^*)\, b^* . \tag{13}$$

Equation (13) indicates that the economy's accumulation of net foreign bonds is equal to the current account balance, which in turn equals the balance of trade plus the interest payment on net foreign bonds.

Assume that the central bank has an implicit "intermediate target" $\overline{R}$ and follows an interest rate feedback rule.[3] In line with Smithin (2002), we further specify the monetary policy rule as follows:

$$\overline{R} = \alpha_0 + \alpha_\pi(\pi - \overline{\pi}) + \alpha_\gamma(\gamma - \overline{\gamma}) , \tag{14}$$

where α_0 is the constant intercept term and $\overline{\pi}$ and $\overline{\gamma}$ represent the targets for the inflation rate and economic growth rate set by the monetary authorities, respectively. The

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[3] The intermediate target will be associated with an "operating target" level for the federal funds rate.

coefficients $\alpha_\pi > 0$ and $\alpha_\gamma > 0$ measure the extent of the central bank's response to the inflation gap and the growth gap, respectively. Following Leeper (1991), Meng (2002), Benhabib et al. (2001b), and Dupor (2001), we refer to monetary policy as passive if $\alpha_\pi < 1$ and as active if $\alpha_\pi > 1$.

In line with the way in which central bankers in many countries practically conduct their monetary policy (see Woodford, 1999), the interest rate rule is implemented gradually. Under such a gradualist monetary rule, the central bank implements a partial adjustment in the nominal interest rate toward the targeted level $\overline{R}$, rather than adjusting the interest rate by an immediate once-and-for-all jump. This causes the nominal interest rate to move in a particular direction over sustained periods of time. Following Goodhart (1996), Sack (1998), and Woodford (1999), we capture this gradual behavior by specifying that the nominal interest rate follows a law of motion as in the following form:

$$\dot{R} = -\delta \cdot (R - \overline{R}), \tag{15}$$

where the coefficient $\delta\ (> 0)$ measures the degree of inertia in the central bank's response. Equation (15) indicates that the change in the nominal interest rate only partially offsets a deviation from the targeted rate, with the lagged change in the interest rate exerting a significant effect on the dynamics. At each instant of time, the central bank adjusts the credit supply to whatever level is needed for the actual interest rate R to prevail.

Given the international financial assets arbitrage condition in (2) and the nominal interest rate rule in (14), (15) can be rewritten as:

$$\dot{R} = -\delta \cdot (R - \alpha_0) + \delta\alpha_\pi \cdot [(R - \overline{\pi}) - (R^* - \pi^*)] + \delta\alpha_\gamma \cdot (\gamma - \overline{\gamma}). \tag{16}$$

Equation (16) highlights the importance of the international real interest spread in determining the behavior of the nominal interest rate in an open economy.

3. Balanced growth path and stability properties

Differentiating (5) with respect to time and plugging the resulting equation into (9), the optimal change in consumption is derived as:

$$\frac{\dot{c}}{c} = \frac{1}{\theta}(R^* - \pi^* - \rho) \equiv \gamma_c. \tag{17}$$

This is a standard Keynes-Ramsey rule, which indicates that consumption rises (falls) as the real rate of return on the real financial asset $R^* - \pi^*$ exceeds (falls short of) the rate of time preference ρ.

Moreover, from the optimal condition for holdings of real money balances (7), the real balances-output ratio can be derived as:

$$m/y \equiv v(R)\,;\ \ v' \equiv \partial v/\partial R = -1/\phi'' < 0\,.$$

Substituting the above equation into (8), the evolution of the market value of capital q can be rewritten as:

$$\frac{\dot{q}}{q} = R^* - \pi^* - \frac{1}{q}\left\{[1-\phi(v(R)) + \phi'(v(R))\cdot v(R)]A + \frac{(q-1)^2}{2h}\right\}. \tag{8a}$$

In order to satisfy the household's intertemporal budget constraint, given that q exponentially approaches to $\tilde{q}$ along the transitional adjustment path, the transversality condition (10b) holds if and only if:[4]

$$\frac{\tilde{q}-1}{h} < R^* - \pi^*, \tag{18}$$

where $\tilde{q}$ is the stationary value of q, which is determined below. Equation (18) shows that in the long run the rate of capital growth is less than the real rate of return on the real financial asset.

We now turn to the evolution of the output growth rate. Given the *Ak* production function and by combining the definition $\gamma \equiv \dot{y}/y$ with (6), we have:

$$\gamma \equiv \dot{y}/y = \dot{k}/k = (q-1)/h\,. \tag{19}$$

Differentiating (19) with respect to time and combining the resulting equation with (8a), the change in the output growth rate is derived as:

$$\dot{\gamma} = \frac{\dot{q}}{h} = (R^* - \pi^*)(\gamma + \frac{1}{h}) - [1-\phi(v(R)) + \phi'(v(R))\cdot v(R)]\frac{A}{h} - \frac{\gamma^2}{2}\,. \tag{20}$$

Equations (16) and (20) construct a 2×2 (γ, R) dynamic system. Recursively, the evolution of q, $\gamma_{b^*} (\equiv \dot{b}^*/b^*)$ and $\gamma_m (\equiv \dot{m}/m)$ can be determined.[5] It should be noted

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[4] Solving (6) and (9) yields $k(t) = k_0 \exp[\int_0^t (q-1)/h\, d\xi]$ and $\lambda(t) = \lambda_0 \exp[\rho t - (R^* - \pi^*)t]$, where λ_0 is the endogenously-determined initial marginal utility of wealth and k_0 is a given initial stock of domestic capital. Equipped with $k(t)$ and $\lambda(t)$, (10b) is rewritten as:

$$\lim_{t\to\infty} \lambda q k\, e^{-\rho t} = \lambda_0 k_0 \tilde{q} \cdot \lim_{t\to\infty} \exp\{\int_0^t [(q-1)/h] - (R^* - \pi^*)\, d\xi\} = 0\,.$$

This implies that the relationship reported in (18) is true.

[5] Differentiating (7) with respect to time and combining the resulting equation with (16) and (19), the optimal change in m is expressed as:

$$\dot{m}/m = \gamma + \{\delta\cdot(R-\alpha_0) - \delta\alpha_\pi \cdot [R - (R^* - \pi^*) - \bar{\pi}] - \delta\alpha_\gamma \cdot (\gamma - \bar{\gamma})\}/\phi_0'' v_0\,,$$

where ϕ_0'' and v_0 are the endogenously-determined initial values of ϕ'' and v, respectively. In that the transversality condition (10a) is distinct from (10b). Combining (17) with $\theta \dot{c}/c = -\dot{\lambda}/\lambda$ gives the no-Ponzi-game condition $\lim_{t\to\infty} b^* \exp[-(R^* - \pi^*)t] = 0$. Thus, following Turnovsky (1996, 1997), the transversality condition (10a) must be satisfied and it will be held if and only if:[6]

$$c_0 = (R^* - \pi^* - \gamma_c)\cdot\left\{b_0^* + \frac{k_0 \cdot [A' - ((\tilde{q}_0^2 - 1)/2h)]}{R^* - \pi^* - \tilde{\gamma}_0}\right\}, \tag{21a}$$

$$R^* - \pi^* > \gamma_c\,, \tag{21b}$$

$$R^* - \pi^* > \tilde{\gamma} \equiv (\tilde{q} - 1)/h\,, \tag{21c}$$

where A' is defined as $A(1 - \phi(v_0))$ with v_0 denoting the initial real money balances-output ratio, $\tilde{\gamma}$ is the stationary value of the output growth rate, and $\tilde{\gamma}_0$ is the initial equilibrium value of γ. Equation (21a) determines the feasible initial level of real consumption. Equation (21b) imposes an upper bound on the consumption growth rate. Equation (21c) is equivalent to equation (18).

We are ready to analyze the equilibrium characteristic of the dynamic system to which we now turn. At the steady-growth equilibrium, the economy is characterized by $\dot{R} = \dot{\gamma}\,(=\dot{q}) = 0$ and R and γ are at their stationary values, namely $\tilde{R}$ and $\tilde{\gamma}$, respectively. It then follows from equations (7) and (19) that $\tilde{\gamma}_m = \tilde{\gamma}_k = \tilde{\gamma}_y = \tilde{\gamma}\,(= \tilde{q} - 1/h)$ should hold, meaning that, along the balanced growth path, real money balances, physical capital, and real output grow at the same rate $\tilde{\gamma}$.[7]

It follows from (16) and (20) that the steady-state values $\tilde{R}$ and $\tilde{\gamma}$ satisfy the following stationary relationships:

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addition, from (2) and (11) the growth rate of the nominal credit stock is derived as:

$$\mu = \gamma + R - (R^* - \pi^*) + \{\delta\cdot(R - \alpha_0) - \delta\alpha_\pi \cdot [R - (R^* - \pi^*) - \bar{\pi}] - \delta\alpha_\gamma \cdot (\gamma - \bar{\gamma})\}/\phi_0'' v_0\,.$$

[6] From the assumption of *Ak* production technology and $\dot{R} = 0$ in the steady state, we learn that y, k, and m grow at the same rate. By substituting $c(t)$ in (17) and i and $k(t)$ in (14) into (13), we have: $\dot{b}^*(t) = (R^* - \pi^*)b^* + A' k_0 e^{\gamma t} - c_0 e^{\gamma_c t} - \gamma(1 + h\gamma/2)\cdot k_0 e^{\gamma t}$. Given an initial stock b_0^*, we solve this differential equation for $b^*(t) = e^{(R^* - \pi^*)t}[b_0^* + \int_0^t \{[A' - ((q^2 - 1)/2h)]k_0 e^{\gamma\xi} - c_0 e^{\gamma_c \xi}\} e^{-r^* \varsigma}\cdot \mathrm{d}\xi]$. Substituting the above expressions of $b^*(t)$ and $\lambda(t)$ in (9) into (10a), (21) thus can be derived. See Turnovsky (1996) for details.

[7] From (17), the stationary growth rate of real consumption is $\tilde{\gamma}_c = (R^* - \pi^* - \rho)/\theta$. In addition, analogous to Turnovsky (1996), the rate of growth of net real foreign bonds γ_{b^*} converges asymptotically to $max(\tilde{\gamma}_y, \tilde{\gamma}_c)$.

$$-\delta\cdot(\tilde{R}-\alpha_0)+\delta\alpha_\pi\cdot[\tilde{R}-(R^*-\pi^*)-\overline{\pi}]+\delta\alpha_\gamma\cdot(\tilde{\gamma}-\overline{\gamma})=0\,, \tag{16a}$$

$$(R^*-\pi^*)(\tilde{\gamma}+\frac{1}{h})-[1-\phi(v(\tilde{R}))+\phi'(v(\tilde{R}))\cdot v(\tilde{R})]\frac{A}{h}-\frac{\tilde{\gamma}^2}{2}=0\,. \tag{20a}$$

As depicted in Figure 1, the loci $\dot{R}=0$ and $\dot{\gamma}=0$ trace all combinations of $\tilde{\gamma}$ and R that satisfy equations (16a) and (20a), respectively. When the central bank implements a passive monetary rule ($\alpha_\pi<1$), $\dot{R}=0$ is upward sloping in the (γ,R) space, while it is downward sloping when the monetary rule is active ($\alpha_\pi>1$). The locus $\dot{\gamma}=0$ is a convex curve with a negative slope since the transversality condition must hold.[8] Referring to panel A of Figure 1, if the central bank implements a passive interest rate rule, then there exists only one intersection, namely Q_0, of loci $\dot{R}=0$ and $\dot{\gamma}=0$. However, if the central bank implements an active interest rate rule, there are either two intersections, namely Q_0 and Q_0', or no intersection, between loci $\dot{R}=0$ and $\dot{\gamma}=0$, as displayed in panel B of Figure 1. These results lead us to establish the following proposition:

Proposition 1: *If the central bank implements a passive interest rate rule (*$\alpha_\pi<1$*), then the monetary equilibrium of the open economy exists and is unique. However, if the central bank implements an active interest rate rule (*$\alpha_\pi>1$*), the open economy either generates multiple equilibria or does not have any equilibrium.*

Next, based on (16) and (20), we identify the local stability properties of these equilibria presented above. First of all, we linearize the dynamic system (γ,R) around the steady state and derive:

$$\begin{bmatrix}\dot{R}\\ \dot{\gamma}\end{bmatrix}=J\cdot\begin{bmatrix}R-\tilde{R}\\ \gamma-\tilde{\gamma}\end{bmatrix}-\begin{bmatrix}\delta\alpha_\pi\\ 0\end{bmatrix}(\overline{\pi}-\overline{\pi}_0)-\begin{bmatrix}\delta\alpha_\gamma\\ 0\end{bmatrix}(\overline{\gamma}-\overline{\gamma}_0)\,, \tag{22}$$

where

$$J=\begin{bmatrix}-\delta(1-\alpha_\pi) & \delta\alpha_\gamma\\ vA/h & \eta\end{bmatrix},$$

and $\eta\equiv R^*-\pi^*-\tilde{\gamma}>0$ is required by (21c). Let s_1 and s_2 be the two characteristic roots of the Jacobian matrix J in (22). It follows from (22) that the trace and the

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[8] From (16a), we have $\partial R/\partial\gamma\big|_{\dot{R}=0}=\alpha_\gamma/(1-\alpha_\pi)\gtrless 0$ as $\alpha_\pi\lessgtr 1$ and $\partial^2R/\partial\gamma^2\big|_{\dot{R}=0}=0$. From (20a), we have $\partial R/\partial\gamma\big|_{\dot{\gamma}=0}=-(R^*-\pi^*-\tilde{\gamma})/(Av/h)<0$ and $\partial^2R/\partial\gamma^2\big|_{\dot{\gamma}=0}=\{1-(R^*-\pi^*-\tilde{\gamma})^2(v'h/Av^2)\}/(Av/h)$ >0.

determinant of J, respectively, are:

$$Tr(J) \equiv s_1 + s_2 = \eta - \delta(1-\alpha_\pi) \gtrless 0, \tag{23a}$$

$$Det(J) \equiv \Delta = s_1 s_2 = -\delta[(1-\alpha_\pi)\eta + \alpha_\gamma vA/h] \lessgtr 0. \tag{23b}$$

It is easy to learn from (23) that, when the central bank implements a passive rule ($\alpha_\pi < 1$), the Jacobian matrix J has two real roots with opposite signs since $\Delta < 0$. Moreover, because the dynamic system reported in (22) has one jump variable γ and one gradual adjustment variable R, it thus exhibits saddle-point stability. As a result, the unique passive steady-state equilibrium Q_0 depicted in panel A of Figure 1 is locally determinate and there exists a unique growth path converging to it.

By contrast, when the central bank implements an active rule ($\alpha_\pi > 1$), we have $Tr(J) > 0$ and $\Delta \lessgtr 0$ from (23). In this case, the two real roots of J either have opposite signs or are both positive. Furthermore, the sign of Δ is either negative or positive, depending on whether locus $\dot{R} = 0$ is steeper or flatter than locus $\dot{\gamma} = 0$ at the steady-state equilibrium (if equilibria exist).[9] Accordingly, we can conclude that under an active rule the equilibrium with higher growth, such as Q_0 in panel B of Figure 1, is a saddle and thus is locally determinate, whereas the equilibrium with lower growth, such as Q_0' in panel B of Figure 1, is a source. To sum up, we have:

Proposition 2: *Under a passive monetary rule, the unique monetary equilibrium of the open economy is locally determinate. Under an active monetary rule, the high-growth equilibrium is locally determinate, while the low-growth equilibrium is a source.*

4. Transitional dynamics and target policies

In this section we discuss the economic performance in the face of different target policies. To make the analysis meaningful, in what follows we only focus on the case where there are stable equilibria, i.e. point Q_0 in both panel A and panel B of Figure 1.

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[9] Given $\partial R/\partial\gamma|_{\dot{R}=0} = \alpha_\gamma/(1-\alpha_\pi) < 0$ and $\partial R/\partial\gamma|_{\dot{\gamma}=0} = -\eta/(Av/h) < 0$, (23b) can be rewritten as $\Delta = -\delta(1-\alpha_\pi)(vA/h)\cdot[\partial R/\partial\gamma|_{\dot{R}=0} - \partial R/\partial\gamma|_{\dot{\gamma}=0}] \lessgtr 0$. Under an active monetary rule, the sign of Δ is equal to that of $\partial R/\partial\gamma|_{\dot{R}=0} - \partial R/\partial\gamma|_{\dot{\gamma}=0}$.

For expository convenience, we assume that $s_1 < 0 < s_2$. It follows from (22) that the general solutions for R and γ are, respectively:

$$R(t) = \tilde{R}(\overline{\pi}, \overline{\gamma}) + B_1 e^{s_1 t} + B_2 e^{s_2 t}, \tag{24a}$$

$$\gamma(t) = \tilde{\gamma}(\overline{\pi}, \overline{\gamma}) - \frac{\eta - s_1}{vA/h} \cdot B_1 e^{s_1 t} - \frac{\eta - s_2}{vA/h} \cdot B_2 e^{s_2 t}, \tag{24b}$$

where B_1 and B_2 are unknown parameters. Based on (24a) and (24b), in Figure 2 we show two cases: Panel A presents the case of a passive monetary rule ($\dot{R} = 0$ is upward sloping), while Panel B presents the case of an active monetary rule ($\dot{R} = 0$ is downward sloping). As indicated by the direction of the arrows in Figure 2, the loci *SS* and *UU* represent the stable and unstable branches, respectively. Evidently, the convergent saddle path *SS* is downward sloping, while the divergent branch *UU* is upward sloping.[10]

Since the dynamic behavior of the economy around the stable equilibrium in association with both passive and active rules will experience very similar transitional dynamics, in this section we only focus on the case of the active rule and abstract the case of the passive rule. The detailed analysis concerning the case of the passive rule is available upon request from the authors.

4.1 Anticipated reduction in the inflation target

Assume that at the "present" time $t = 0$ the central bank pre-announces that its inflation target will decrease from $\overline{\pi}_0$ to $\overline{\pi}_1 (< \overline{\pi}_0)$ at a specific future date $t = T$. In Figure 3, the initial equilibrium is established at Q_0, where the $\dot{\gamma} = 0$ locus intersects $\dot{R} = 0(\overline{\pi}_0)$. The corresponding initial rates of growth and nominal interest are $\tilde{\gamma}_0$ and $\tilde{R}_0$, respectively. Upon an anticipated permanent decrease in the inflation target, the $\dot{\gamma} = 0$ locus remains intact, while $\dot{R} = 0(\overline{\pi}_0)$ shifts upward to $\dot{R} = 0(\overline{\pi}_1)$.[11] As a result, the new steady-growth equilibrium is at point Q_1, with γ and R being $\tilde{\gamma}_1$ and $\tilde{R}_1$, respectively.

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[10] Given $B_2 = 0$ and $B_1 = 0$ in (24), we have $\partial R / \partial \gamma \big|_{SS} = \delta\alpha_\gamma / [\delta(1 - \alpha_\pi) + s_1] = -(\eta - s_1)/(vA/h)$ and $\partial R / \partial \gamma \big|_{UU} = \delta\alpha_\gamma / [\delta(1 - \alpha_\pi) + s_2] = -(\eta - s_2)/(vA/h)$. Because $\eta - s_1 > 0$ and $\eta - s_2 < 0$, *SS* is downward sloping, while *UU* is upward sloping.

[11] It is clear from (16) and (20) that $\partial R / \partial \overline{\pi} \big|_{\dot{R}=0} = 1/(\alpha_\pi - 1) > 0$ and $\partial R / \partial \overline{\pi} \big|_{\dot{\gamma}=0} = 0$ due to $\alpha_\pi > 1$ under the active monetary rule.

Before we proceed to study the dynamic adjustment, three points should be addressed. First, we denote 0^+ as the instant after the announcement is made by the central bank, as well as T^- and T^+ as the respective instants before and after policy implementation. Second, during the dates between 0^+ and T^-, the inflation target has not yet been reduced and thus point Q_0 should be treated as the reference point to govern the dynamic adjustment. Third, as the inflation target decreases from $\bar{\pi}_0$ to $\bar{\pi}_1$ at the moment T^+, the economy should move to a point exactly on the stable branch *SS* at that instant of time to ensure that the system will converge.

Based on the above information, Figure 3 reveals that, at the instant the policy announcement is made, the economy will jump from point Q_0 to Q_{0^+} on impact. Notice that since the central bank implements a gradual adjustment in the interest rate, the nominal interest rate will remain intact at the original level $\tilde{R}_0$. However, with perfect foresight the public can correctly anticipate that the central bank will eventually raise the nominal interest rate as a result of implementing a lower inflation target $\bar{\pi}_1$. Because this reduction in *R* will decrease the net marginal product of capital in the future,[12] the agents with perfect foresight will instantly decrease their demand for capital, and in turn the market price q will also fall. As a result, Figure 3 indicates that the rate of economic growth instantly decreases from $\tilde{\gamma}_0$ to γ_{0^+}.

The anticipation of a future reduction in the inflation target also leads to a continuous fall in the demand for capital during the dates between 0^+ and T^-. The decumulation of capital will depress the economic growth rate until the date of policy implementation. However, on the other hand, the interest rate feedback rule (14) indicates that the pre-announced effect will induce the central bank to temporarily lower the nominal interest rate. Thus, from 0^+ to T^- both R and γ fall monotonically, and the economy moves gradually from Q_{0^+} to Q_T, as shown by the arrows in Figure 3.

Once the lower inflation target $\bar{\pi}_1$ is realized, there is a continuous rise in the nominal interest rate. The persistent rise in the nominal interest rate means a persistent increase in the opportunity cost of holding money, thereby leading to a continuous reduction in the demand for money. Consequently, the transactions cost rises. Since the

[12] By differentiating the net marginal product of capital $[1-\phi(v(\tilde{R}))+\phi'(v(\tilde{R}))\cdot v(\tilde{R})]$ with respect to the nominal interest rate R, the negative relationship is confirmed.

net marginal product of capital decreases due to the higher transactions cost, the rate of economic growth is further depressed. Thus, the economic growth rate keeps on falling and the nominal interest rate starts to rise as the economy moves along the $SS(\bar{\pi}_1)$ locus towards its new long-run equilibrium Q_1.

We summarize the above results as:

Proposition 3: *In response to an anticipated permanent decrease in the inflation target, the transitional dynamics of the monetary equilibrium exhibits the following properties:*

(i) Instantaneously, the growth rate of the open economy falls and the nominal interest rate remains unchanged;

(ii) In transition, the economic growth rate falls monotonically toward its new stationary value. The nominal interest rate exhibits a mis-adjustment: it falls during the period between the policy's announcement and its implementation and then starts to increase toward a higher new stationary value after the lower inflation target is realized;

Note that Proposition 3 is also true if the central bank implements a passive monetary rule.

It is in our interest to further explore the transitional dynamics of the inflation rate π (which equals the depreciation rate ε given that the purchasing power parity (1) holds continuously). From the interest rate parity $R^* - \pi^* = R - \pi$ in (2), we learn that the evolutionary process of the inflation rate π coincides with that of R at each instant in time. By combining this with the results in Proposition 3, we know that, upon an anticipated permanent reduction in the inflation target, the inflation rate will exhibit mis-adjustment in transition and will rise in the long run.[13] Consequently, the rates of inflation and economic growth exhibit a positive relationship during the period between the policy's announcement and its implementation. Once the lower inflation target is realized, the rates of inflation and economic growth begin to be negatively correlated. Such a negative correlation between π and γ also prevails in the long run.

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[13] From (16a) we have the stationary relations $\tilde{R}_0 = \alpha_0 + \alpha_\pi(\tilde{\pi}_0 - \bar{\pi}_0) + \alpha_\gamma(\tilde{\gamma}_0 - \bar{\gamma}_0)$ and $\tilde{R}_1 = \alpha_0 + \alpha_\pi(\tilde{\pi}_1 - \bar{\pi}_1) + \alpha_\gamma(\tilde{\gamma}_1 - \bar{\gamma}_0)$ corresponding to the target rates of inflation $\bar{\pi}_0$ and $\bar{\pi}_1$, respectively. Under the initial condition, $\tilde{\pi}_0 = \bar{\pi}_0$ and $\tilde{\gamma}_0 = \bar{\gamma}_0$, the following relationship must hold:

$$\tilde{\pi}_1 = \bar{\pi}_1 + (\tilde{R}_1 - \tilde{R}_0)/\alpha_\pi + (\tilde{\gamma}_0 - \tilde{\gamma}_1)\alpha_\gamma/\alpha_\pi .$$

Given $\tilde{R}_1 > \tilde{R}_0$ and $\tilde{\gamma}_1 < \tilde{\gamma}_0$ as stated in Proposition 3, the above relationship indicates that the new stationary rate of inflation $\tilde{\pi}_1$ exceeds the new target rate of inflation $\bar{\pi}_1$.

The above results lead us to establish the following proposition:

Proposition 4: *In response to an anticipated permanent decrease in the inflation target, in the long run the relationship between the rates of inflation and economic growth is negative. However, in the transition the relationship is*

(i) positive during the period between the policy's announcement and its implementation;

(ii) negative after the new inflation target is realized.

A corollary to Proposition 4 is that, under a nominal interest rate rule that feeds back to both inflation and economic growth, regardless of whether it is passive or active, there is a double-dividend in the price stability and economic growth expansion both in the transitional period and in the long run, if the central bank *immediately* (without pre-announcement) changes the inflation target. However, if the central bank chooses to implement a *pre-announced* inflation target policy, the economy will face a tradeoff between price stability and economic growth prior to the date of the new inflation target being realized.

4.2 A change in the growth target with imperfect credibility

The approach in the previous subsection can be easily applied to analyze the announcement effect of a change in $\bar{\gamma}$. However, a more interesting issue is to explore the effect of a target policy regarding $\bar{\gamma}$ in the presence of the central bank's credibility problem, to which we now turn.

Indeed, the central bank's policy often involves some kind of credibility problem and it has also received a considerable amount of attention in the literature (see, for instance, Calvo (1986), Drazen and Helpman (1988), Calvo and Végh (1993), Calvo and Drazen (1998), and Lahiri (2000, 2001). There is a typical example in this context which is that the authorities in many countries often overstate the intended growth target and hence modify their announced policy in the future. This leads to the authorities losing credibility in relation to their commitment, and thereby gives rise to the imperfect credibility problem.

To shed light on this problem, three further assumptions are necessary: (i) at $t = 0$, the policy authority announces it is raising the target rate of economic growth *permanently* from $\bar{\gamma}_0$ to a higher $\bar{\gamma}_1$; (ii) due to the lack of credibility regarding the authority's commitment, the public, however, expects that after a certain period of time the policymaker will modify $\bar{\gamma}_1$ toward a lower level, say, $\bar{\gamma}_2$, which is considered here to be such that $\bar{\gamma}_1 > \bar{\gamma}_2 > \bar{\gamma}_0$;[14] (iii) the public is uncertain about the precise timing of the policy modification, T_p, and has a subjective probability distribution regarding T_p with its distribution function being given by $F(T_p)$. To simplify the analysis without loss of generality, in line with Lahiri (2000), we assume that the distribution has a mass at T^*.

We first consider the case in which the public accurately expects the true credibility horizon, that is, $T^* = T_p$. Under such a simplified situation, during the transition the economy will evolve exactly as follows:

$$\bar{\gamma} = \begin{cases} \bar{\gamma}_1; & 0 \le t \le T^{*-} \\ \bar{\gamma}_2; & t \ge T^{*+} \end{cases} . \tag{24}$$

Figure 4 presents the economy's dynamic response to the policy (24), in which the initial equilibrium Q_0 is the same as that in the previous subsection. Upon the policy change, the $\dot{R} = 0(\bar{\gamma}_0)$ locus shifts downward to $\dot{R} = 0(\bar{\gamma}_1)$, leaving the $\dot{\gamma} = 0$ locus unchanged.[15] The intersection of loci $\dot{R} = 0(\bar{\gamma}_1)$ and $\dot{\gamma} = 0$ is at point Q_1, with γ and R being $\tilde{\gamma}_1$ and $\tilde{R}_1$, respectively. Point Q_1 is the reference point that governs the dynamic adjustment during the period of the temporary target rate of economic growth $\bar{\gamma}_1$. The $SS(\bar{\gamma}_1)$ path is its corresponding saddle-path. Once the growth target is modified to $\bar{\gamma}_2$, the dynamic system will travel along the saddle path $SS(\bar{\gamma}_2)$ in order for the system to be convergent. The associated steady-state equilibrium is Q_2, with the stationary rates of growth and nominal interest being $\tilde{\gamma}_2$ and $\tilde{R}_2$, respectively.

As indicated in Figure 4, given different values of T^*, the economy will have very different impact responses (more specifically, it will jump to a point located between points

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[14] We assume for simplicity that the public accurately expects that the modified level of the growth target is $\bar{\gamma}_2$. If we relax this assumption, the precise dynamic trajectory will depend on the true value of the modified growth target. However, except for the discrete jump at the instant when the true modified growth target is revealed, the qualitative characteristics of the dynamic path will remain the same as in our analysis in this section.

[15] From (16) and (20), we know that under an active rule ($\alpha_\pi > 1$) $\partial R / \partial \bar{\gamma}\big|_{\dot{R}=0} = \beta / (\alpha_\pi - 1) > 0$ and $\partial R / \partial \bar{\pi}\big|_{\dot{\gamma}=0} = 0$.

A and *B*). If T^* is larger, namely T_L^*, then the economy will jump rightward to $Q_{0^+}^L$, a point that is closer to point *A*.[16] By contrast, if T^* is smaller, namely T_S^*, then the economy will jump rightward to $Q_{0^+}^S$, a point that is closer to point *B*. As a consequence, at instant 0^+ the nominal interest rate remains intact while the economic growth rate immediately leaps from $\tilde{\gamma}_0$ to $\gamma_{0^+}^L$ (or $\gamma_{0^+}^S$). Intuitively speaking, under the gradualist monetary rule, the nominal interest rate will remain intact at the original level $\tilde{R}_0 (= R_{0^+})$ at instant 0^+. However, with perfect foresight, the public correctly anticipates that, in response to the higher growth target $\bar{\gamma}_1$, the central bank will eventually reduce the nominal interest rate and that this will cause the net marginal product of capital to rise. Therefore, the agent will instantly increase his demand for capital. This in turn will raise the market price of capital q and cause the economic growth rate to instantly rise from $\tilde{\gamma}_0$ to γ_{0^+}.

It is interesting and worth emphasizing that the initial rise in the economic growth rate increases with the credibility horizon. It follows from the interest rate feedback rule (14) that the initial boost in the economic growth rate induces the central bank to accelerate the reduction in the nominal interest rate. This tends to reduce the opportunity cost of holding money and thus encourages money holdings. As a result, the transactions costs decline and thus capital accumulation and the economic growth rate are given a boost. Graphically, during the dates between 0^+ and T^{*-}, there is a continuous rise in the economic growth rate from $\gamma_{0^+}^L$ ($\gamma_{0^+}^S$) to $\gamma_{T^*}^L$ ($\gamma_{T^*}^S$) and a continuous fall in the nominal interest rate from $\tilde{R}_0 (= R_{0^+})$ to $R_{T^*}^L$ ($R_{T^*}^S$). As indicated by the arrows in Figure 4, the economy proceeds along the unstable path linking the points $Q_{0^+}^L$ ($Q_{0^+}^S$) and $Q_{T^*}^L$ ($Q_{T^*}^S$) to exactly reach the point $Q_{T^*}^L$ ($Q_{T^*}^S$) at $t = T^*$.

From T^{*+} onward, for T_L^* (T_S^*), the economy will travel along the saddle path $SS(\bar{\gamma}_2)$ from point $Q_{T^*}^L$ ($Q_{T^*}^S$) toward the new steady-state equilibrium Q_2. Correspondingly, the economic growth rate to fall (rise) continuously toward $\tilde{\gamma}_2$ while the

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16 We can find a critical credibility horizon T_c such that the economic growth rate exhibits neither overshooting nor undershooting; that is, in response to T_c, the economy will jump to point *C* on impact. We refer to all $T^* > T_c$ as a *long* credibility horizon and to all $T^* < T_c$ as a *short* credibility horizon.

nominal interest rate will rise (fall) monotonically toward $\tilde{R}_2$. Evidently, for a different credibility horizon, the system will adjust exactly in the opposite direction. Intuitively, for T_L^* (T_S^*), at the moment of time T^{*+}, the economic growth rate is higher (lower) than the new target rate $\bar{\gamma}_2$. According to (14), this will induce the central bank to raise (lower) the nominal interest rate. Such a rise (decline) in R discourages (encourages) money holdings and thus leads to an increase (decrease) in the transactions cost. Consequently, investment is discouraged (encouraged) and the economic growth rate declines (rises). Due to the gradualism of the monetary rule, such a dynamic adjustment will persist until the new stationary $(\tilde{\gamma}_2, \tilde{R}_2)$ is achieved.

By comparing $(\tilde{\gamma}_2, \tilde{R}_2)$ with $(\tilde{\gamma}_0, \tilde{R}_0)$, the following proposition is established.

Proposition 5: *In response to an incredible rise in the growth target, the transitional dynamics of the monetary equilibrium exhibits the following properties:*

(i) Instantaneously, the growth rate of the open economy rises while the nominal interest rate remains unchanged; moreover, over a long (short) credibility horizon, the economic growth rate overshoots (undershoots) its long-run response;

(ii) In transition:

(a). During the entire transition, the rates of economic growth and nominal interest exhibit a negative relationship;

(b). During the dates before policy modification, the economic growth rate exhibits a mis-adjustment over a long credibility horizon, while over a short credibility horizon, the economic growth rate exhibits a monotonic rise;

(c). From T^* onward, over a long (short) credibility horizon, the economic growth rate will continuously fall (rise) toward its higher new stationary value.

Given that the evolutionary process of the inflation rate coincides with that of the nominal interest rate at each instant in time, from Proposition 5 we derive the following proposition:

Proposition 6: *Under a nominal interest rate rule regime that feeds back to both inflation and economic growth, regardless of whether it is active or passive, in the event of an incredible growth target policy change, the rates of inflation and economic growth are negatively correlated in the long run.*

Propositions 5 and 6 together point out that, under a nominal interest rate rule that feeds back to both inflation and economic growth, an increase in the growth target can in the long run lead to both price stability and higher economic growth.

In terms of Figure 4, we show that the monetary authority always has incentives to overstate its intended growth target. For this purpose, let us first consider a fully credible policy in which the policy authority announces at $t = 0$ an immediate permanent rise in the growth target from $\bar{\gamma}_0$ to $\bar{\gamma}_2$. Upon the shock, the economy initially jumps from Q_0 to point A in Figure 4 and thereafter converges along the $SS(\bar{\gamma}_2)$ locus toward the new steady-state equilibrium Q_2. Although credible and incredible policies lead to the same long-run outcome, they actually bring out distinct transitional dynamics. By comparing the adjustment paths corresponding to credible (the $Q_0 A Q_2$ trajectory) and incredible policies (the $Q_0 Q^L_{0^+} Q^L_{T^*} Q_2$ trajectory or the $Q_0 Q^S_{0^+} Q^S_{T^*} Q_2$ trajectory), it is easily found that the economy enjoys higher growth during the entire transition period when the growth target policy is incredible. Moreover, the longer the credibility horizon, the more the economy will profit from policy incredibility. Thus, we have:

Proposition 7: *In the absence of reputational costs, there are always incentives for the policy authority to overstate its intended growth target and implement an incredible policy, since the economy can thereby enjoy higher growth during the entire transition.*

Finally, we would like to remind readers that the above discussions proceed under the assumption that the public accurately predicts the true credibility horizon T_p. If the precise date of policy modification T_p differs from T^*, the transitional dynamics becomes more complicated. In the case where policy modification occurs prior to T^* (i.e. $T^* > T_p$), then the economy will jump from its unstable path and pass $Q^L_{0^+}$ ($Q^S_{0^+}$) and $Q^L_{T^*}$ ($Q^S_{T^*}$) horizontally to $SS(\bar{\gamma}_2)$ at that time. Accordingly, the economic growth rate will instantly fall, leaving the nominal interest rate unchanged. From then on, the economy will travel along $SS(\bar{\gamma}_2)$ to asymptotically regain the steady state Q_2. As is evident from Figure 4, as long as the expectation error, $T^* - T_p$, is not too large, the dynamic adjustment from T_p onward will be qualitatively the same as that in the $T^* = T_p$ case. In the case where $T^* = T^*_L$ and $T^*_L - T_p$ is sufficiently large, then, following the instant fall in the economic growth rate, the economic growth rate will continuous rise and the nominal interest rate will continuously fall until the new stationary state $(\tilde{\gamma}_2, \tilde{R}_2)$ is reached.[17]

5. Concluding remarks

The existing literature that embodies the endogenous growth framework is still silent on the effect of nominal interest rate rules in an open economy. In view of this, this paper sets up an endogenous growth model of an open economy in which the central bank implements a gradualist interest-rate rule with targets for inflation and economic growth.

We show that under a passive rule the monetary equilibrium exists and is unique; moreover, it is locally determinate. Under an active rule, the open economy either generates multiple equilibria or does not have any equilibrium. If equilibria exist, the high-growth equilibrium is locally determinate while the low-growth equilibrium is a source. Our results clearly differ from those in previous studies and hence provide new insights for policy implications.

We have also shown, under a nominal interest rate rule that feeds back to both inflation and economic growth, that regardless of whether it is passive or active, an immediate rise in the inflation target stabilizes the price level and promotes economic growth both in the transitional period and in the long run. Nevertheless, under a pre-announced inflation target policy, price stability and the expansion of economic growth cannot be achieved simultaneously during the period between the policy's announcement and its implementation. We also show that, under such an interest rate rule, a higher growth target has a favorable effect on both inflation and economic growth in the long run. In addition, the policy authority always has incentives to overstate its intended growth target and hence will implement an incredible policy. The credibility of the central bank's commitment is shown to play an important role in influencing the transitional dynamics of the macroeconomic variables.

[17] By contrast, when $T^* < T_p$, then at time T^* the public will modify its expectations to a longer credibility horizon. To save space, this paper does not discuss this situation. Detailed discussions are available from the authors upon request.

References

Agénor, P.R., Montiel, P.J., 1996. Development Macroeconomics. Princeton University Press, Princeton, New Jersey.

Barro, R.J., Sala-i-Martin, X., 1995. Economic Growth. McGraw-Hill, New York.

Benhabib, J., Schmitt-Grohe, S., Uribe, M., 2001a. Monetary policy and multiple equilibria. American Economic Review 91,167–186.

Benhabib, J., Schmitt-Grohe, S., Uribe, M., 2001b. The perils of Taylor rules. Journal of Economic Theory 96, 40-69.

Benhabib, J., Schmitt-Grohe, S., Uribe, M., 2002. Avoiding liquidity traps. Journal of Political Economy 110, 535-563.

Calvo, G.A., 1986. Temporary stabilization: predetermined exchange rates. Journal of Political Economy 94, 1319-1329.

Calvo, G.A., Drazen, A., 1998. Uncertain duration of reform. Macroeconomic Dynamics 2, 443-455.

Calvo, G.A., Végh, C.A., 1993. Exchange rate-based stabilization under imperfect credibility. In H. Frisch, A. Worgotter (Eds.), Open-Economy Macroeconomics. McMillan, London.

Clarida, R.H., Galí, J., Gertler, M., 1998. Monetary policy rules in practice: some international evidence. European Economic Review 42, 1033-1067.

Clarida, R.H., Galí, J., Gertler, M., 2000. Monetary policy rules and macroeconomic stability: evidence and some theory. Quarterly Journal of Economics 115, 147-180.

Dornbusch, R., Frenkel, J.A., 1973. Inflation and growth: alternative approaches. Journal of Money, Credit and Banking 5, 141-156.

Drazen, A., Helpman, E., 1988. Stabilization with exchange rate management under uncertainty. In: E. Helpman, A. Razin, E. Sadka (Eds.), Economic Effects of the Government Budget. MIT Press, Cambridge, MA.

Dupor, B., 2001. Investment and interest rate policy. Journal of Economic Theory 98, 85-113.

Dupor, B., 2002. Interest rate policy and investment with adjustment costs. Unpublished Manuscript, Pennsylvania University.

Erceg, C.J., 2002. The choice of an inflation targeting range in a small open economy. American Economic Review Papers and Proceedings 92, 85-89.

Feichtinger, G., Hartl, R.F., Wirl, F., 2001. The dynamics of a simple relative adjustment cost framework. German Economic Review 2, 255-268.

Goodhart, C.A.E., 1996. Why do the monetary authorities smooth interest rates? Special Paper No. 81, LSE Financial Markets Group.

Lahiri, A., 2000. Disinflation programs under policy uncertainty. Journal of International Economics 50, 351–373.

Lahiri, A., 2001. Exchange rate-based stabilizations under real frictions: the role of endogenous labor supply. Journal of Economic Dynamics and Control 25, 1157-1177.

Leeper, E., 1991. Equilibria under active and passive monetary and fiscal policies. Journal of Monetary Economics 27, 129-147.

Lucas, R.E., 1988. On the mechanics of economic development. Journal of Monetary Economics 22, 3-42.

Martin, B., 1999. Caution and gradualism in monetary policy under uncertainty. Bank of England, Working Paper Series, No. 105, December.

Meng, Q., 2002. Monetary policy and multiple equilibria in a cash-in-advance economy. Economics Letters 74, 165-170.

McCallum, B.T., 1981. Price level determinacy with an interest-rate policy rule and rational expectations. Journal of Monetary Economics 8, 319-329.

McCallum, B.T., Nelson, E., 2001. Monetary policy for an open economy: an alternative framework with optimizing agents and sticky prices. NBER Working Paper 8175.

Sack, B., 1998. Does the Fed act gradually? a VAR analysis. FEDS Discussion Paper No. 1998-17, Federal Reserve Board.

Sargent, T.J., Wallace, N., 1975. Rational expectations, the optimal monetary instrument, and the optimal money supply rule. Journal of Political Economy 83, 241-254.

Schmitt-Grohé, S., Uribe, M., 2000. Price level determinacy and monetary policy under a balanced-budget requirement. Journal of Monetary Economics 45, 211-246.

Sims, C.A., 1989. Models and their uses. American Journal of Agricultural Economics 489-494.

Sims, C.A., 1994. A simple model for the study of the determination of the price level and the interaction of monetary and fiscal policy. Economic Theory 4, 381–399.

Smithin, J., 2002. The rate of interest, economic growth, and inflation: an alternative theoretical perspective. Unpublished Manuscript, York University.

Taylor, J.B., 1993. Discretion versus policy rules in practice. Carnegie-Rochester Conference Series on Public Policy 39, 195-214.

Taylor, J.B., 1999. A historical analysis of monetary policy rules. In: Taylor, J.B. (Ed.), Monetary Policy Rules. University of Chicago Press, Chicago.

Taylor, J.B., 2001. The role of the exchange rate in monetary-policy rules. American Economic Review Papers and Proceedings 91, 263-267.

Turnovsky, S.J., 1996. Fiscal policy, growth, and macroeconomic performance in a small open economy. Journal of International Economics 40, 41-66.

Turnovsky, S.J., 1997. Equilibrium growth in a small economy facing an imperfect world capital market. Review of Development Economics 1, 1-22.

Turnovsky, S.J., 2000. Growth in an open economy: some recent developments. Unpublished Manuscript, University of Washington.

Woodford, M., 1994. Monetary policy and price level determinacy in a cash-in-advance economy. Economic Theory 4, 345-380.

Woodford, M., 1999. Optimal monetary policy inertia. NBER Working Paper 7261.

Zhang, J., 1996. A simple pecuniary model of money and growth with transactions cost. Journal of Macroeconomics 18, 127-137.

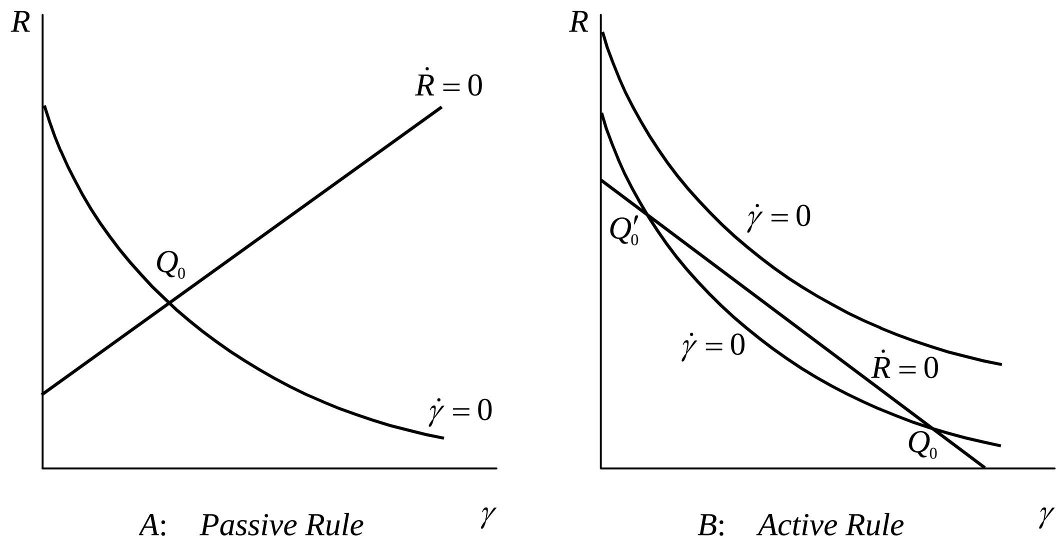

Figure 1. Existence of BGP

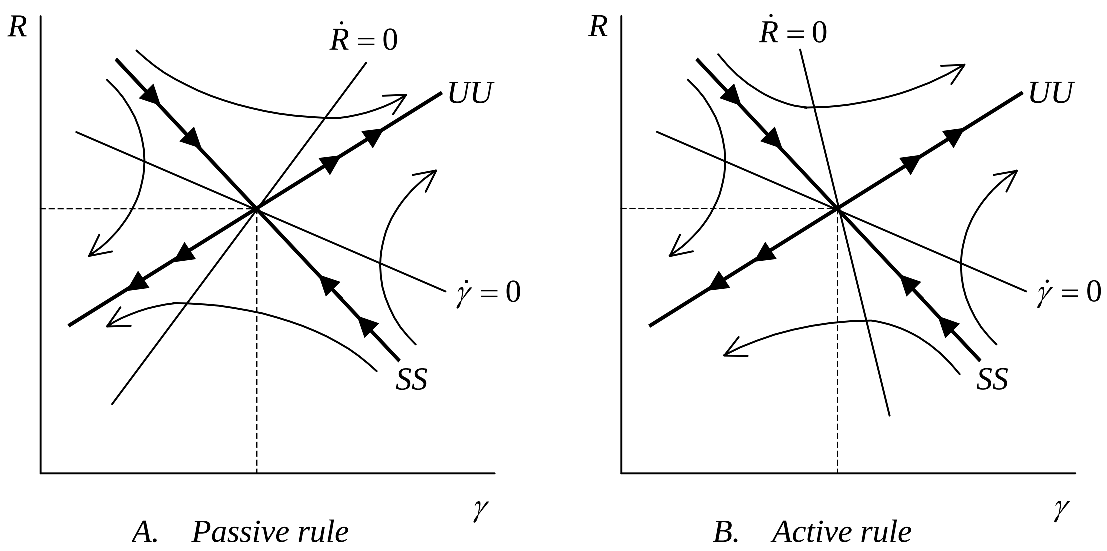

Figure 2. Phase Diagram

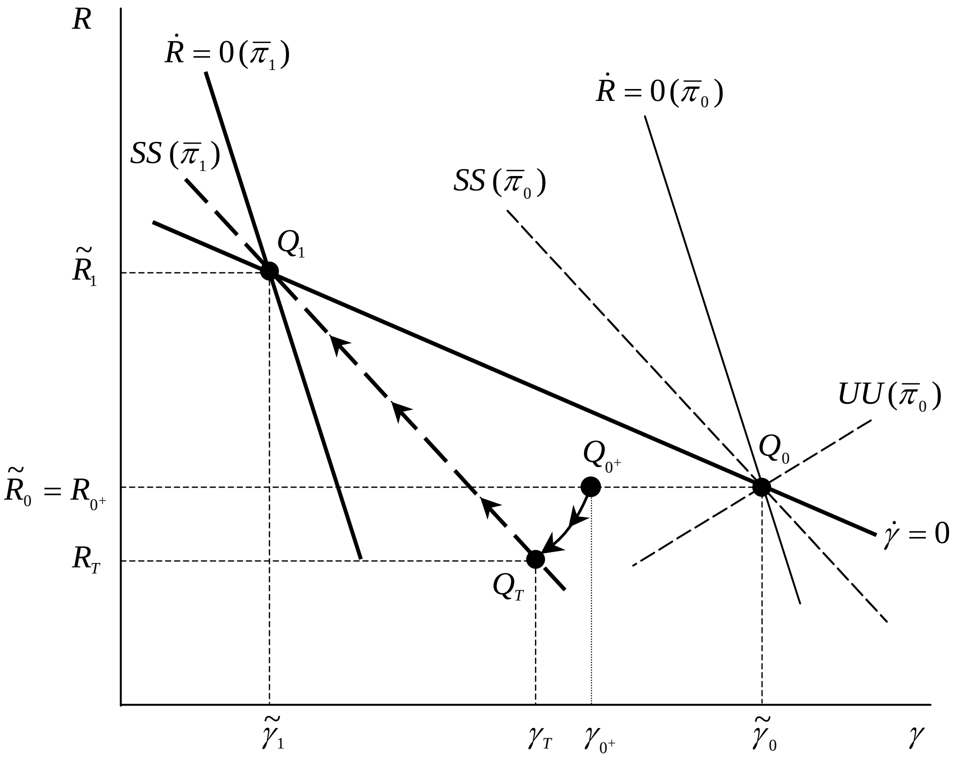

Figure 3. Dynamics responses to an anticipated permanent decrease in the inflation target

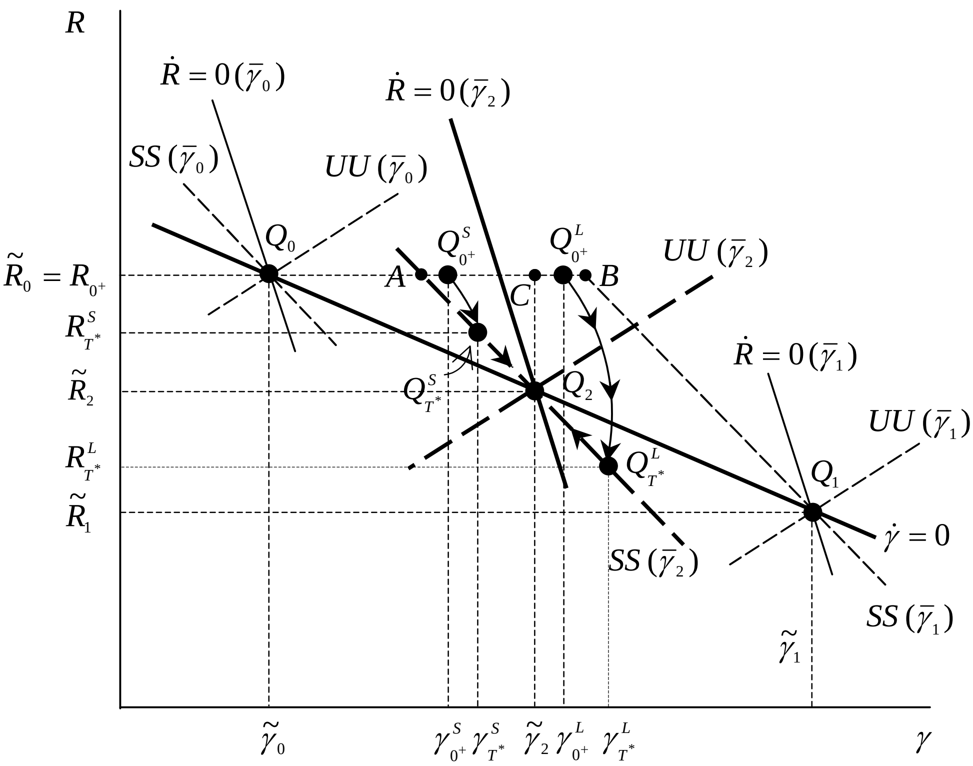

Figure 4. Dynamic responses to an incredible rise in the growth target

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