Rules versus Discretion on the Choice between Exchange-Rate-Targeting and Monetary-Aggregate-Targeting

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Summary. This paper compares performance of inflation and welfare loss between exchange-rate-targeting and monetary-aggregate-targeting regimes for a small-open economy characterized by a rational expectations model of the Phillips curve and rules-versus- discretion type of policy discipline. We obtain three interesting results. First, if an active contingent rule is credible and followed, then both regimes can result in the same target rate of inflation and the smallest long-run welfare loss. Second, when discretion is undertaken, an exchange-rate-targeting policy is always superior to a monetary-aggregate-targeting one. This finding seems to be consistent with the real world experiences that many small-open countries have adopted exchange rate targeting due to lack of feasible commitment mechanisms. Third, for a simple fixed rule, Friedman-type's monetary-aggregate-targeting policy works better than an exchange-rate-targeting one only under certain circumstances.

Keywords and Phrases: Exchange-rate-targeting, Monetary-aggregate-targeting, Exchange rate regimes, Monetary policy.

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1. Introduction

Literature generates considerable discussion than an agreement about a long-standing fundamental issue in small-open economies, namely: what determines the choice of exchange rate regime? Some contributions to this question focus on the nature and origin of exogenous disturbances, for example, Turnovsky (1984) and Berger, Jensen, and Schjelderup (2001). Others point out the specification of monetary policy, especially the level of transparency and accountability of the monetary authority is influential in the choice of exchange rate regime (Coles and Philippopoulos, 1997, Edwards, 1999, Herrendorf, 1999, Mishkin, 1999, Méon and Rizzo, 2002, and Husain, 2006). The purpose of this paper is to determine the choice of exchange rate regime from a policy discipline perspective that shares the same features as the pioneering analysis of rules versus discretion developed by Kydland and Prescott (1977) and Barro and Gordon (1983). That is to say, to clearly clarify what exchange rate regime works better given the monetary authority has chosen one of the three institutional arrangements, a fixed rule, a contingent rule, and discretion. One regime outweighing the other is justified by a social welfare function related to weighted changes in the inflation rate and unemployment rate.

In this article the choice of exchange rate regime is determined in a rational expectations model of the Phillips curve which takes into account the foreign exchange market constraint explicitly. Previous studies such as Henderson (1979), Frenkel and Aizenman (1982), Herrndorf (1999), Berger, Jensen, and Schjelderup (2001), and Berger (2006) analyze the optimal exchange rate policies without taking into account the accumulation of foreign reserves on the domestic quantity of money supply. Neglecting this constraint conflicts the fact of the unique endogenity of money supply in open economies. It appears that we are the first to apply the Kydland-Prescott, Barro-Gordon framework to small-open economies and model the foreign exchange market constraint explicitly.

Following the leading paper by Obstfeld and Rogoff (1998), literature on new open economy macroeconomics and their applications to exchange rate policies has grown tremendously. The stickiness of price in the price setting process based on the new Keynesian models becomes the mainstream. However, Engel (2000) points out that evidence on price setting is not refined enough to make definitive conclusion about the optimal exchange rate regime. Kollmann (2005) finds that a flexible price model captures the correlation between US and European GDP better and casts doubt on the widespread view that price stickiness is more realistic. In our article the price setting process therefore arises from a model of flexible prices. Nonetheless, it turns out to be observationally equivalent to that in Keynesian sticky price model when there being persistence in the determinants of the price level. In our model, the persistence comes from the supply of money and the flexible exchange rate.

A common approach to choosing an exchange rate regime in the context of rules versus discretion, for example Edwards (1999) and Méon and Rizzo (2002), is treating floating rates as outcome of the optimal discretionary policy and compares them with outcome of the optimal rule-like policy identified as pegged rates.[1] A standard result of

[1] Devereux (2004), although doesn't limit float exchange rate to arise from a discretionary policy, does think pegged exchange rate as a rule.

discretion having positive inflation bias relative to a rule is applied to the choice of exchange rates. This result seems to support the view that pegged exchange rates impose an effective constraint on monetary behavior and thus result in lower inflation over the long run. However, the advantage of the pegged exchange rate over the floating one does not hold straightforward once we allow these two exchange rate regimes to be compared in the three alternative institutional arrangements respectively. Our findings in this paper are distinct from conventional wisdom at least in the following two respects: First, pegged exchange rates outweigh floating exchange rates only when discretion is undertaken; and second, if a simple fixed rule is in force, Friedman-type's monetary-aggregate-targeting policy works better than an exchange-rate-targeting one only under certain circumstances.

This paper proposes the monetary policy instrument to be nominal exchange rates under a pegged rate regime and to be monetary aggregates under a floating rate regime. We then compare macroeconomic performance in terms of inflation and long-run welfare loss for the two alternative regimes under the three institutional arrangements. Some recent articles such as Sopraseuth (2003), Bergvall (2005), and Klein and Shambaugh (2006) show the choice of exchange rate regime does influence macroeconomic performance. In this paper, we assume the monetary authority has pre-commitment technology so that both simple fixed rule and active contingent rule are feasible choices, and we avoid the time inconsistency problem accompanied by the optimal monetary rules. Under each of the institutional arrangements, that represents different level of transparency and accountability, we ask, is exchange-rate-targeting monetary policy superior to monetary-aggregate-targeting one? While Mishkin (1999) sheds light on this question from the real world international experiences, this paper provides the sufficient conditions for a specific monetary policy regime to be chosen within a rules-versus-discretion framework.

The rest of this paper is organized as follows. A rational expectations model of the Phillips curve for a small-open economy is presented in Section 2, where the monetary authority is concerned with both inflation and employment stability, and where the foreign exchange market constraint is taken explicitly. Section 3 describes macroeconomic performance of inflation and long-run welfare loss under a floating exchange rate regime, for each of the three institutional arrangements. Section 4 repeats the same procedure as Section 3 but under a pegged exchange rate regime. A comparison of these two regimes is also included in Section 4. Section 5 concludes the paper.

2. The Model

In this section we develop a rational expectations model of the Phillips curve as well as impose a foreign exchange market constraint for a small-open economy. Without consideration of the foreign exchange market constraint, the influence of the amount of official reserve assets on the supply of money and the domestic price level under pegged exchange rates will be neglected. As for a floating exchange rate regime, we assume the only one monetary policy instrument is monetary aggregates and nominal exchange rates are completely market-determined. Through the adjustment of nominal exchange rates that clear the foreign exchange market, the prices of imports will be determined; in addition with a control of monetary aggregates, so are the domestic price level and the rate of inflation.

The small-open economy is described by equations (1) through (3):

$$u_t = u' - \theta(p_t - \mathrm{E}_{t-1}p_t)\,,\ \ \theta > 0\,, \tag{1}$$

$$p_t = \phi e_t + (1-\phi)m_t\,,\ \ 0 < \phi < 1\,, \tag{2}$$

$$\alpha_0(e_t - p_t) - \alpha_1(\mathrm{E}_t e_{t+1} - e_t) + \alpha_2 x_t = b_{t+1} - b_t\ . \tag{3}$$

Equation (1) is a version of the expectations augmented Phillips curve. It states an increase in the unexpected inflation rate at date *t* will keep the observed rate of unemployment at date *t* (u_t) below the natural rate (u'). Here, p_t is the natural logarithm of domestic price level at date *t*. Term E_t denotes the mathematical expectation operator based on the information set available at date *t*.

For a small-open economy, equation (2) defines the domestic price level as a weighted average of the imports prices of intermediate goods, which are simply determined by the natural logarithm of the nominal exchange rate (e_t) since the natural logarithm of the foreign price level is assumed to be zero, and the natural logarithm of the supply of money (m_t). Note that even though equation (2) can arise from a model of flexible price, it is at the same time consistent with a price-setting process of Keynesian sticky price model due to the persistence in the money supply and the flexible exchange rate. In addition, combining equations (1) and (2) shows that an expansionary monetary policy, or devaluation, declines unemployment rate through an increase in inflation rate. This coincides with a usual implication of Keynesian type models.

The novel feature of the specification of the economy is an explicit introduction of the foreign exchange market constraint, as depicted in equation (3). The first part of equation (3) describes the contents of current account transactions that in turn determined by the real exchange rates $(e_t - p_t)$. The term $(\mathrm{E}_t e_{t+1} - e_t)$ in the second part of equation (3) reflects relative returns of assets that can influence capital account transactions. The variable x_t is a white noise exogenous shock to the foreign exchange market, with mean zero and variance σ^2, and the change in the natural logarithm of official reserve assets ($b_{t+1} - b_t$) measures the growth rate of official reserve assets between dates t and $t+1$.[2] The parameters α_0, α_1, and α_2 are all positive constants.

We assume the supply of money is constituted by domestic credits of the monetary authority (d_t) and official reserve assets, that is,

$$m_t = sd_t + (1-s)\psi b_t.$$

Note the weight s reflects the initial composition of domestic credit and foreign reserves in monetary aggregate. Specifically, d_t is the logarithm of the automous part of domestic credit, in addition to the induced part under sterilization operations. Under a floating exchange rate regime, we let $b_t = b_0$ for all t's and, for simplifying analysis, assume the weight s is equal to one; under a pegged exchange rate regime, we let

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[2] We assume, compared to changes in exchange rates, changes in interest differential are relatively insignificant and thus can be ignored. This assumption seems plausible for those small-open economies having the U.S. as the major trade partner. Besides, by definition of balance of payments accounts, current account transactions plus capital account transactions are equal to changes in the amount, not the growth rate, of official reserve assets. Equation (3) is better understood as an approximation of the determination of official reserve assets.

$d_t = d_0$ for all t's and, for simplifying analysis, assume the weight s is equal to zero. Taking into account the sterilization intervention of the monetary authority under a pegged exchange rate regime, parameter ψ appeared at the determination of the supply of money is interpreted as one minus the sterilization coefficient. Here we assume that fully sterilization ($\psi = 0$) is prohibited to make our open economy model a nontrivial one,[3] and if there is no intervention, $\psi = 1$.

We assume the monetary authority is the sole relevant government decision-making unit and is concerned with both inflation and unemployment stability. The authority looks ahead of the intertemporal loss functions conditioned on the information set at initial date zero,

$$\mathrm{E}_0(1-\beta)\sum_{t=0}^{\infty}\beta^t\left[c(\pi_t - \pi^*)^2 + (u_t - u^*)^2\right],$$

where β is the constant discount factor, $0 < \beta < 1$, and $\pi_t \equiv p_t - p_{t-1}$. We assume the monetary authority has an exogenous inflation target π^* and an exogenous target rate of unemployment u^* that is below the natural rate u'. The parameter c gives the weight to inflation stabilization relative to unemployment stabilization. Finally, assume both the authority and the private agents form their expectations rationally.

The monetary authority sets its institutional arrangements among a simple fixed rule, an active contingent rule, and a discretionary policy at initial date zero. Once an

3 With $\psi = 0$, the authority would always conduct a monetary policy as if there is no balance of payments constraint and the amount of official reserve assets simply reflects the residuals of the foreign exchange market. Practically, no country can sterilize its foreign market imbalance for a very long period.

arrangement is set, the monetary authority has no temptation to change it to an alternative one. In the next section, we start with the discussion of a floating exchange rate regime. We will describe macroeconomic performance of inflation and welfare loss under a floating rate regime for each of the three institutional arrangements.

3. Floating Exchange Rate Regime

Under a floating exchange rate regime, exchange rates will adjust to clear the foreign exchange market, and the supply of money is free from balance of payments constraints and is determined solely by the monetary authority. Without loss of generality, we further choose denominated unit to make the logarithm of initial foreign reserves to be zero ($b_0 = 0$) under a floating rate regime. This makes the supply of money equal monetary aggregates, $m_t = d_t$, and the foreign exchange market constraint, equation (3), can be rewritten as

$$(e_t - p_t) - \alpha_1(\mathrm{E}_t e_{t+1} - e_t) + \alpha_2 x_t = 0\,, \qquad (3)'$$

where α_0 is normalized to be one for simplicity. The nominal exchange rates can be solved forward as follows,

$$e_t = \frac{1-\phi}{1-\phi+\alpha_1}\mathrm{E}_t\sum_{i=0}^{\infty}\delta^i d_{t+i} - \frac{\alpha_2}{1-\phi+\alpha_1}x_t\,,$$

where $\delta = \alpha_1/(1-\phi+\alpha_1)$.

At date zero, the monetary authority sets the function of monetary aggregates according to equation (4) below:

$$d_t = a_0 + a_1 d_{t-1} + a_2 x_t + a_3 x_{t-1}\,,\ \ |a_1| \le \delta^{-1}\,,\ \ t \ge 0\,. \qquad (4)$$

In equation (4), coefficients a_0, a_1, a_2, and a_3 are all policy parameters determined by the monetary authority. The values of these parameters will be chosen optimally according to each of the three institutional arrangements.

Under a floating exchange rate regime with the direct control of monetary aggregates, the monetary authority indirectly controls the price level and the inflation rate. With a commitment, this approach is followed by minimization of the loss function with respect to a whole sequence of monetary aggregates $\{d_t\}_0^\infty$. Under discretion, on the contrary, since the authority chooses monetary aggregates on a period-by-period basis, the private agents' expectations of all relevant variables are taken as exogenous by the authority. The optimal policy under discretion is derived by minimizing the loss function with respect to monetary aggregates in every period respectively.[4]

3.1 A simple fixed rule

Friedman (1968) suggests that the monetary authority adopt a simple rule having no feedback from current and past variables to the money supply. He recommends that the authority cause the money supply to grow at some constant percent rate per year without exception. Following this suggestion, the monetary authority adopts a simple fixed rule and sets the constant growth rate of monetary aggregates to be π^*, the target rate of

[4] Clark, Goodhart, and Huang (1999) clearly states that for rule-like policies, there are two kinds of control variables, namely, the policy instruments and expectations of policy instruments; for discretionary policies, however, the policy instruments are the sole control variables.

inflation. This fixed rule is equivalent to setting $a_0 = \pi^*$, $a_1 = 1$, and $a_2 = a_3 = 0$ in equation (4), the proposed function of monetary aggregates.

The inflation rate for the simple fixed rule under a floating exchange rate regime can be derived as below,

$$\pi_t^{FF} = \pi^* - \frac{\phi\alpha_2}{1-\phi+\alpha_1}(x_t - x_{t-1}).$$

Here, the first superscript "F" denotes "floating" exchange rates, and the second superscript "F" denotes the simple "fixed" rule.

Moreover, we can compute the unconditional expected value of the loss function for the simple fixed rule under floating exchange rates, denoted as L^{FF},

$$L^{FF} = \frac{(2c+\theta^2)\phi^2\alpha_2^2}{(1-\phi+\alpha_1)^2}\sigma^2 + (u' - u^*)^2.$$

It shows the expected value of the loss function depends on the magnitudes of variances of the exogenous disturbance (σ^2), and on the desire of the authority to reduce the natural rate of unemployment from its target rate ($u' - u^*$).

3.2 An active contingent rule

When the monetary authority is committed to an active contingent rule, this implies that it internalizes the impact of its decision rule on the expectations of the private agents. In other words, the monetary authority takes into account how its actions affect the private agents' expectations. It does this by incorporating rational expectations of nominal exchange rates, monetary aggregates, and inflation rates into its proposed policy rule. By minimizing the loss function with respect to monetary aggregates $\{d_t\}_0^\infty$, the optimal contingent rule can be derived. Since the expected price at the initial date $E_{-1}(p_0)$ is given, through differentiation of the objective function we find the function of monetary aggregates at date zero is different from that from period one on. This result is well known as time inconsistency first addressed by Kydland and Prescott (1977). To focus on the long-run performance of inflation and welfare loss, we ignore the different decision rule and outcome in the initial period.

By forward induction on equations implied by the first order conditions, it can be shown that the optimal money supply under the active contingent rule is to have an inflation rate right on its target.[5] Denote the value of inflation as π_t^{FC}, that is,

$$\pi_t^{FC} = \pi^*.$$ [6]

Moreover, the expected value of the long-run loss function in this case (floating exchange rates and the contingent rule) is equal to

$$L^{FC} = (u' - u^*)^2.$$

It is obvious that the loss is smaller than that under the simple fixed rule because the supply of money is optimally set to respond to the exogenous disturbances and the loss function is thus not affected by the variances of the disturbances. On the contrary, the

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5 See Appendix for the mathematical derivation of the contingent rule and the discretionary policy under floating exchange rates.

6 The same result is obtained if we apply the method suggested by McCallum (1997) to solve the problem. McCallum (1997) takes the derivatives of the objective function with respect to all coefficients in the proposed decision function.

volatility of the exogenous disturbances can not be exempt from the loss function under the simple fixed rule.

3.3 A discretionary policy

As discussed above, when the monetary authority does not commit it does not internalize the impact of its decisions on the expectations of the private agents. The monetary authority makes a decision on a period-by-period basis, taking the expectations of the private agents as given. Substituting the expression of p_0 into the objective function, and taking the derivative of the loss function with respect to d_0, we derive the solution which is a function of the given expectations $\mathrm{E}_{-1}\pi_0$. Repeating the same procedure to choose monetary aggregates d_t in every period, we obtain inflation rates, for any date *t*, satisfying the following functional form

$$\pi_t = \pi^* + \frac{\theta}{(c+\theta^2)(1-\beta)}(u' - u^*) + \frac{\theta^2}{c+\theta^2}(\mathrm{E}_{t-1}\pi_t - \pi^*). \tag{5}$$

Since the private agents form their expectations rationally, their expectations of π_t must be consistent with equation (5). A consistent discretionary equilibrium of inflation is expressed below and denoted as π_t^{FD}.

$$\pi_t^{FD} = \pi^* + \frac{\theta(u' - u^*)}{(1-\beta)c}.$$

The discretion solution has a well-known result that inflation bias arises due to attempts by the monetary authority to attain the target rate of unemployment below the natural rate. On the other hand, like inflation under the active contingent rule, the discretionary policy can appropriately respond to the exogenous disturbances and therefore, inflation can be free from volatility. For the same reason, the long-run expected loss of discretion might be less than that under the simple fixed rule. We show the loss below and denote it as L^{FD}.

$$L^{FD} = \left[\frac{\theta^2}{(1-\beta)^2 c} + 1 \right] (u' - u^*)^2 .$$

4. Pegged Exchange Rate Regime

When the monetary authority decides to control nominal exchange rates, it would lose the control of the money supply. Once nominal exchange rates are set, an adjustment of the amount of official reserve assets is needed to satisfy balance of payments constraints. Taking into account the sterilization intervention of the monetary authority under a pegged exchange rate regime, parameter $\psi > 0$ appeared at the determination of the supply of money is interpreted as one minus the sterilization coefficient. Here we assume that fully sterilization ($\psi = 0$) is prohibited to make our open economy model a nontrivial one,[7] and if there is no intervention, $\psi = 1$. In this case, variable d_t is redefined as the autonomous part of domestic credit, in addition to the induced part under sterilization operations.

Because change of money supply is determined by the accumulation of official

7 With $\psi = 0$, the authority would always conduct a monetary policy as if there is no balance of payments constraint and the amount of official reserve assets simply reflects the residuals of the foreign exchange market.

reserve assets if not perfectly sterilized, a pegged rate this period together with the balance of payments constraint guarantee there is no forecasting errors about money supply next period. On the other hand, a complete control of monetary aggregates this period does not guarantee nominal exchange rates next period be free from forecasting errors under a floating rate regime. From this point of view, a pegged rate regime may be superior to a floating rate regime in relative certainty of the money supply and nominal exchange rates.[8]

4.1 A simple fixed rule

The authority decides to adopt a simple fixed rule and set devaluation of nominal exchange rates to be π^*, the target rate of inflation. When $\pi^* = 0$, it is a permanently pegged exchange rate regime; when $\pi^* \neq 0$, it is a crawling peg exchange rate regime. The inflation rates are derived as below,[9]

$$\pi_t^{PF} = \phi\pi^* + (1-\phi)\psi(b_t - b_{t-1}).$$

Here, the first superscript "P" denotes a "pegged" exchange rate and the second superscript "F" denotes the simple "fixed" rule.

Under a simple fixed rule, inflation is stochastic but perfectly predictable. It is influenced by the adjustment of the amount of official reserve assets ($b_t - b_{t-1}$), which is obviously affected by exogenous disturbances of the foreign exchange market occurred in

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8 Here we choose denominated unit to make the logarithm of initial domestic credit to be zero ($d_0 = 0$) under a pegged exchange rate regime for simplicity.

9 Assume $|1-\alpha_0(1-\phi)\psi| \leq 1$, there is convergence on the value of ($b_{t+1} - b_t$) for the fixed rule under a

the last period. The monetary authority can not hit its target π^* every period but it does hit the target on average, $E(\pi_t) = \pi^*$. We compute the long-run expected loss for the simple fixed rule under a pegged exchange rate regime (L^{PF}) as below,

$$L^{PF} = \frac{2c\alpha_2^2(1-\phi)^2\psi^2}{2-\alpha_0(1-\phi)\psi}\sigma^2 + (u' - u^*)^2.$$

A comparison of the rate of inflation using the simple fixed rule under pegged and floating exchange rates shows there is no average inflation bias for both exchange rates. However, a comparison of the expected loss under both exchange rates is not unambiguous and deserves some discussions. First, as the value of θ increases, deviation of unemployment rate from the natural rate becomes more sensitive to unexpected inflation, the loss under floating exchange rates increases; but the parameter θ has no effect on the expected loss under pegged exchange rates. As mentioned above, once nominal exchange rates are pegged, inflation is fully anticipated by the private agents and there is no additional real social cost due to inflation forecasting errors. On the other hand, such cost is unavoidable under floating exchange rates because market-determined nominal exchange rates are not free from the exogenous disturbances, so is inflation not free from forecasting errors.

Second, a lower intensity of intervention by the authority (ψ is high) makes the money supply more vulnerable to exogenous shocks, thus the loss under pegged exchange rates is higher. L^{FF} is not affected by the parameter ψ, thus a floating rate regime is irrelevant to non-intervention cost.

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pegged exchange rate regime.

Finally, the parameter α_0, elasticity of current account transactions to real exchange rates, has a positive impact on L^{PF} because an increase in α_0 causes an increase in volatility of official reserve assets, which in turn increases volatility of inflation and the expected loss. The impact of α_0 on L^{FF} is not directly shown since we have normalized α_0 to be one in discussion under a floating exchange rate regime. However, an increase in α_0 implies a decrease in the relative impact of expected rate of devaluation (α_1) and a decrease in the relative impact of the exogenous disturbances (α_2) on balance of payments. As a decrease in α_1 increases volatility of the foreign exchange market, a decrease in α_2 reduces it. This is shown on the expression of L^{FF}, α_1 on the denominator and α_2 on the numerator, and the overall impact of α_0 on L^{FF} is not determinate.

4.2 An active contingent rule

The optimal contingent rule under pegged exchange rates can be derived by minimizing the loss function with respect to nominal exchange rates $\{e_t\}_0^\infty$ and official reserve assets $\{b_{t+1}\}_0^\infty$ subject to foreign market constraint. We find that the optimal inflation rate is the same for both exchange rate regimes. [10] This result is not surprised because the active contingent rule is designed to pursue minimization of the expected loss over the long run; and from the setting of the loss function, we find minimization would

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[10] Assume the absolute value of the ratio $[\phi-(\alpha_0+\alpha_1)(1-\phi)\psi]/[\phi-\alpha_1(1-\phi)\psi]$ is less than one to guarantee convergency under a pegged exchange rate regime with an active contiugent rule.

be arrived only if there is no inflation bias and inflation volatility. Thus, for both exchange rates, we have the same expected loss.

4.3 A discretionary policy

A policy is discretionary when it is conducted by minimizing the loss function with respect to nominal exchange rates, e_t, and official reserve assets b_{t+1}, subject to foreign market constraint on a period-by-period basis. Since $E_{t-1}\pi_t$ is given at date *t*, a discretionary authority chooses the optimal current devaluation rate and results in the following rate of inflation at date *t*:[11]

$$\pi_t = \pi^* + \left[1 + \frac{\theta^2}{c}\right]^{-1} \left\{ \frac{\theta^2}{c}(E_{t-1}\pi_t - \pi^*) + \frac{\theta\phi[1-\beta+\alpha_0(1-\phi)\psi\beta](u'-u^*)}{c(1-\beta)[\phi(1-\beta)+(\alpha_0+\alpha_1)(1-\phi)\psi\beta]} \right\}.$$

And a consistent discretionary equilibrium of inflation, denoted by π_t^{PD}, becomes

$$\pi_t^{PD} = \pi^* + \frac{\theta\phi[1-\beta+\beta\alpha_0(1-\phi)\psi]}{c(1-\beta)[\phi(1-\beta)+(\alpha_0+\alpha_1)(1-\phi)\psi\beta]}(u'-u^*).$$

Obviously, $\pi_t^{PD} > \pi^*$. Again, just like its counterpart under a floating exchange rate regime, the discretionary equilibrium of inflation under a pegged rate regime is on average above its target value π^* due to the monetary authority's desire of keeping a target rate of unemployment below the natural rate. Furthermore, the long-run expected value of the loss function for the discretionary policy under pegged exchange rates is

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11 Here, assume the absolute value of $[\phi-(\alpha_0+\alpha_1)(1-\phi)\psi]$ is less than ϕ/β to guarantee convergency for the discretionary policy under a pegged exchange rate regime. This is a looser constraint than its counterpart for the active contingent rule.

$$L^{PD} = \left\{ \frac{\theta^2 \phi^2 [1-\beta+\alpha_0(1-\phi)\psi\beta]^2}{c(1-\beta)^2 [\phi(1-\beta)+(\alpha_0+\alpha_1)(1-\phi)\psi\beta]^2} + 1 \right\} (u' - u^*)^2 .$$

A comparison of the values of L^{PD} and the loss of the contingent rule shows the loss of the discretionary policy is larger than that of the contingent rule. But a comparison of the values of L^{PD} and L^{PF} is indefinite, just like their counterparts under a floating exchange rate regime. The expected value of the loss function under the discretionary policy may be smaller than the value under the fixed rule if volatility of the exogenous disturbances is relatively large. This is because the discretionary devaluation is set to optimally respond to the exogenous disturbances while the fixed rule simply takes all volatility.

In addition, a comparison of discretionary outcome of inflation bias and the expected long-run loss between two exchange rate regimes shows both are better under a pegged exchange rate regime than under a floating one. The intuition goes as follows. If the monetary authority intends to exercise accelerating inflation by pegging higher exchange rates, through the adjustment of official reserve assets, the private agents' expectations of higher inflation are formed. Based on a given higher inflation expectation, the authority's intention of creating higher unexpected inflation at date *t*, $\pi_t - \mathrm{E}_{t-1}\pi_t$, through devaluation of nominal exchange rates is somewhat constrained. But under a floating rate regime, a discretionary control of money supply this period does not imply a correct prediction of the equilibrium exchange rates next period. Lack of this connection gives the authority extra ability to create a higher inflation bias for the discretionary policy under a floating exchange rate regime.

5. Conclusions

This paper describes macroeconomic outcome of inflation and welfare loss for a small-open economy characterized by a rational expectations model of the Phillips curve and constrained by the foreign exchange market explicitly. The price setting process can arise from a model of flexible price but is also consistent with Keynesian sticky price model due to the persistence in the money supply and the flexible exchange rate. We compare performance of inflation and welfare loss between monetary-aggregate targeting (floating exchange rates) and exchange-rate targeting (pegged exchange rate), for each of the three institutional arrangements: a simple fixed rule, an active contingent rule, and a discretionary policy. The results show that if the economy has pre-commitment technology that the monetary authority can adopt an active contingent rule, then both monetary-aggregate targeting and exchange-rate targeting result in the same target rate of inflation and the smallest long-run welfare loss among all other choices.

If a simple fixed rule is adopted in practice, depending on the relative magnitude of the parameters in the environment, each monetary target has its own merits. In particular, when deviation of unemployment rate from the natural rate becomes more sensitive to unexpected inflation or the authority's sterilization intervention is more intensive, the loss under pegged exchange rate regime would be less and an exchange-rate targeting would be superior to monetary-aggregate targeting.

Either a contingent rule or a simple fixed rule is in use, there must exist some sort of commitment technology to discipline the monetary authority. As a fact that many developing small-open countries are lack of any commitment mechanism, the consequences of discretionary monetary policies desert more attention. When discretion is undertaken, devaluation of nominal exchange rates induces an increase of inflation expectations formed by the private agents, which automatically binds the ability of the authority to create unexpected inflation. Thus, an exchange-rate-targeting policy results in less inflation bias and less long-run loss than a monetary-aggregate-targeting one. The conclusion seems to provide one reason that many small-open countries have adopted exchange rate targeting. Finally, if volatility of the exogenous disturbances is large enough, the expected value of the loss function under the discretionary policy is always smaller than the loss under the fixed rule in either policy regime.

Appendix

The small-open economy under a floating exchange rate regime is characterized by equations (1), (3)' and

$$p_t = \phi e_t + (1-\phi)d_t, \quad 0 < \phi < 1. \tag{A1}$$

Substituting the monetary aggregates policy rule, equation (4), into the determination of nominal exchange rates, $e_t = \frac{1-\phi}{1-\phi+\alpha_1}\mathrm{E}_t\sum_{i=0}^{\infty}\delta^i d_{t+i} - \frac{\alpha_2}{1-\phi+\alpha_1}x_t$, and arranging the terms, we can rewrite e_t as

$$e_t = \eta_0 + \eta_1 d_t + \eta_2 x_t, \tag{A2}$$

where $\eta_0 = \frac{a_0\delta}{1-a_1\delta}$, $\eta_1 = \frac{1-\delta}{1-a_1\delta}$, and $\eta_2 = \frac{(1-\delta)a_3\delta}{1-a_1\delta} - \frac{\alpha_2}{1-\phi+\alpha_1}$.

From equations (A1), (A2), and (4), we then have,

$\pi_t - \mathrm{E}_{t-1}\pi_t = p_t - \mathrm{E}_{t-1}p_t$

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= \begin{cases} [\phi(\eta_1 a_2 + \eta_2) + (1-\phi) a_2] x_t, & t > 0, \\ [\phi\eta_0 + (1\text{-}\phi) a_0] + [\phi\eta_1 + (1\text{-}\phi)] d_0 + \phi\eta_2 x_0 - \mathrm{E}_{-1} p_0, & t = 0. \end{cases} \tag{A3}
$$

$$
\pi_t = p_t - p_{t-1}
$$

$$
= \begin{cases} [\phi\eta_1 + (1-\phi)](d_t - d_{t-1}) + \phi\eta_2 (x_t - x_{t-1}), & t > 0, \\ [\phi\eta_0 + (1-\phi) a_0] + [\phi\eta_1 + (1-\phi)] d_0 + \phi\eta_2 x_0 + \phi\eta_3 x_{-1} - p_{-1}, & t = 0. \end{cases} \tag{A4}
$$

Equation (A4) shows that under a floating exchange rate regime, with the direct control of monetary aggregates, the monetary authority indirectly controls the price level and the inflation rate.

An active contingent rule

We have the problem $\min_{\{d_t\}} \mathrm{E}_0 (1-\beta) \sum_{t=0}^{\infty} \beta^t \left[c(\pi_t - \pi^*)^2 + (u_t - u^*)^2 \right]$. Since in this case, $u_t - u^* = u' - u^* - \theta(\pi_t - E_{t-1}\pi_t)$, depending only on exogenous variable x_t, our problem therefore simplifies to

$$
\min_{\{d_t\}} \mathrm{E}_0 (1-\beta) \sum_{t=0}^{\infty} \beta^t \left[c(p_t - p_{t-1} - \pi^*)^2 \right] + \left[u' - u^* - \theta(p_0 - E_{-1} p_0) \right]^2 .
$$

Substituting equations (A3) and (A4) into the loss function and minimizing the loss function with respect to monetary aggregates $\{d_t\}_1^{\infty}$, the first order conditions are derived as:

$$
\mathrm{E}_t \left\{ [\phi\eta_1 + (1-\phi)](\pi_t - \pi^*) - \beta[\phi\eta_1 + (1-\phi)](\pi_{t+1} - \pi^*) \right\} = 0, \quad \forall t > 0 .
$$

Slove π_t forward and we have the optimal inflation rate implied by optimal monetary policy $\pi_t^{FC} = \pi^*$. Substituting the definitions of η_i $(i = 0, 1, 2)$ and

$\pi_t = \pi^*$ into (A4) and comparing it with equation (4), it is easy to show that the optimal monetary aggregate process is

$$\begin{aligned} d_t &= a_0 + a_1 d_{t-1} + a_2 x_t - a_3 x_{t-1} \\ &= \pi^* + d_{t-1} + \frac{\phi\alpha_2}{(1-\phi)(1+\alpha_1)} - \frac{\phi\alpha_2}{(1-\phi)(1+d_1)}. \end{aligned}$$

A discretionary policy

At data zero, we have

$$\begin{aligned} p_0 &= \phi e_0 + (1-\phi)d_0 \\ &= \phi\eta_0 + [\phi\eta_1 + (1-\phi)]d_0 + \phi\eta_2 x_0 . \end{aligned}$$

Substituting the expression of p_0 into the objective function, and taking the derivative of the loss function with respect to d_0, we find a constraint between π_0, π_1, and expectations error for π_0:

$$\pi_0 - \pi^* = \beta E_0(\pi_1 - \pi^*) + \frac{\theta}{c}[u' - u^* - \theta(\pi_0 - E_{-1}\pi_0)]. \qquad \text{(A5)}$$

In fact, under the rational expectations assumption and the law of iterated expectations, we have

$$E_0(\pi_t - \pi^*) = \beta E_0(\pi_{t+1} - \pi^*) + \frac{\theta}{c}[u' - u^*], \;\; \forall t > 0. \qquad \text{(A6)}$$

Use (A5) and (A6), we can solve π_0 forward and derive the implied monetary aggregate from the solution of the inflation rate at date zero which is a function of the given expectations $\mathrm{E}_{-1}\pi_0$:

$$\pi_0 - \pi^* = \frac{\theta(u' - u^*)}{(c+\theta^2)(1-\beta)} + \frac{\theta^2}{c+\theta^2} E_{-1}(\pi_0 - \pi^*) .$$

A discretionary monetary authority chooses monetary aggregates d_t in every period, and therefore implies inflation rates, for any date *t*, satisfying equation (5).

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