Tax Inefficiency, Public Debt Stabilization, and Monetary Policy Arrangements in Emerging Economies

Tax Inefficiency, Public Debt Stabilization, and Monetary Policy Arrangements in Emerging Economies

Ha Thanh Nguyen
Banking Academy, State Bank of Vietnam

and

Makoto Kakinaka
International University of Japan

September 2006

Tax Inefficiency, Public Debt Stabilization, and Monetary Policy Arrangements in Emerging Economies[*]

Ha Thanh Nguyen
Banking Academy, State Bank of Vietnam

and

Makoto Kakinaka
International University of Japan

Abstract

Public debt stabilization has been considered important in the recent trend of institutional reforms of monetary arrangements in emerging economies. One crucial issue separating emerging from developed economies is that emerging economies often face serious inefficiency associated with tax collection, such as corruption, reducing the capability of controlling the primary budget balance as well as the entire public debt. This paper studies the relationship between tax-related inefficiency and public debt stabilization under two designs of monetary policies: inflation targeting and discretionary monetary arrangements. The result is that such inefficiency not only induces a higher level of public debt in the steady state but also reduces the adjustment speed for public debt stabilization, irrespective of monetary arrangements. This study also shows that the discretionary monetary arrangement enhances the adjustment speed for public debt more effectively, but which monetary arrangement is more effective in reducing the long-run level of public debt is highly dependent on the degree of tax-related inefficiency. In particular, the discretionary monetary arrangement could induce a higher level of public debt compared to the inflation targeting arrangement when the degree of tax-related inefficiency is either small or large enough.

---

1 Introduction

Public debt stabilization has been recently a prominent concern in most emerging economies since prolonged excessive public debt could affect negatively economic activities.[1] IMF (2003) reports that public debt has roughly averaged at the level of 70% of GDP with a sharp increase in the early 1990s for most emerging economies in spite of their various efforts to implement public debt stabilization programs.[2] One important issue in this paper is that emerging economies often struggle against the inefficiency associated with tax collection due to various causes such as corruption and unmatured tax-related infrastructure (see, e.g., Hindrick, Keen, and Muthoo (1999) and Martinez-Vazquez, Arze, and Boex (2004)).[3] This tax-related inefficiency, referred to as 'tax inefficiency,' may be closely linked to 'corruption in tax collection,' where tax leakage occurs since tax officials engage in bureaucratic corruption by stealing from the treasury of public revenue or allowing widespread tax evasions.[4]

At the same time, one can recognize a recent trend that most emerging economies have adopted various institutional reforms of monetary arrangements toward mainly two possible designs: inflation targeting and discretionary monetary arrangements. Since tax inefficiency and monetary arrangements could influence the capability of controlling public debt, they should be taken into consideration when we discuss public debt problems in emerging economies. The main objective of this paper is to study how tax-related inefficiency affects public debt stabilization under each of the two major designs of the monetary arrangement.

The discussion of the two designs of monetary arrangements is important for policymakers in emerging economies.[5] The recent reforms toward the floating (although 'dirty') exchange

---

[1]A possible reason may be related to the crowd-out effect on investment or the reduction in the rate of capital accumulation (see, e.g., Blanchard (1985)).

[2]For some countries, such as Argentina, Ecuador, Uruguay, Turkey, Pakistan and Lebanon, public debt climbed up to the range of 100%-150% of GDP in 2002.

[3]Hindrick, Keen, and Muthoo (1999) cite the report by Haque and Sahay (1996) in which a former Thai Prime Minister estimated that the elimination of corruption would raise tax collection by 50% in Thailand.

[4]A number of aspects relates to corruption have been studied theoretically and empirically. Shleifer and Vishny (1993) explain why in less-developed economies the level of corruption is so high through studying the determinants of corruption. For a review of issues on the causes and consequences of corruption, see, e.g., Bardhan (1997).

[5]Much analysis has been done in the discussions of commitment and discretion in monetary arrangements (see, e.g., Kydland and Prescott (1977), Barro and Gordon (1983), Alesina and Tabellini (1987), Jensen (1994), Walsh (1995), Svensson (1997b), Dixit and Lambertini (2001), Dixit and Lambertini (2003), and Lambertini

rate regime have allowed the central banks to adopt the discretionary monetary arrangement (see, e.g., Hawkins (2005)).[6] The strategic interaction has arisen from a possible conflict between the central bank and the fiscal authority under this arrangement. At the same time, some emerging economies, such as Mexico, Thailand, and Indonesia, have been pursuing the inflation targeting arrangement (see, e.g., Bernanke and Mishkin (1997), Svensson (1997a), Svensson (1997b), and Svensson (1999)).[7] Contrary to the discretionary monetary arrangement, that arrangement enforces the central bank to pursue the target inflation that has been predetermined through some institutional and operational processes. In fact, the two monetary arrangements mentioned above might be complements rather than substitutes, i.e., the central bank can independently decide its monetary policy with some range of the target inflation. Although we admit this situation, analyzing the role of tax inefficiency under each of the two polar monetary regimes and comparing these results would be valuable in the discussion of public debt stabilization in emerging economies.

There have been some literature on theoretical aspects of the relation between public debt and policy arrangements, in particular, as the outcome of strategic interactions under the independence of the central bank, which typically faces a conflict on whether fiscal or monetary policies should be emphasized for public debt stabilization. Tabellini (1986) and van Aarle, Bovenberg, and Raith (1995) analyze a dynamic link among fiscal deficits, public debt, and the monetary base in a framework of differential game between the central bank and the fiscal authority.[8] Beetsma and Bovenberg (1997) and Beetsma and Bovenberg (1999) also investigate the policy interaction on the evolution of public debt in the context of European monetary union.

A related issue that has not extensively been explored in the existing literature is on the relation among the tax-related issue, monetary arrangements, and the evolution of public

---

(2006)).

[6]Historically, most of less-developed economies lacking credibility in their monetary policy had adopted the fixed exchange regime, where they peg their currency to an anchor country's currency to import low inflation so that their monetary policy is no longer effective.

[7]See also Walsh (2003) for review of inflation targeting.

[8]Petit (1989) also studies strategic interactions between monetary and fiscal authorities in a framework of differential game, although the role of public debt is not considered explicitly.

debt in emerging economies. The severity of tax inefficiency could be a particular institutional feature in emerging economies, as most of previous works are devoted for developed economies, where such an issue is not considered significant. Huang and Wei (2003) and Huang and Wei (2005) may be among a few works to incorporate the tax collection problem, such as corruption, into a static model with several monetary arrangements in developing countries, although public debt problems are not considered. Based on the model developed by Alesina and Tabellini (1987), they derive various implications of weak tax collection on the monetary institutions designed to deal with the credibility problem in emerging economies. In contrast to their static model, to our best knowledge, this study would be the first attempt to explicitly incorporate the tax inefficiency into a dynamic model of the evolution of public debt.

This study first examines the role of tax inefficiency under the inflation targeting arrangement, where the central bank involves a strict commitment to a given target inflation rate. Following the analytical framework of Tabellini (1986), we formulate the dynamics to analyze the resulting outcomes of public debt stabilization. The tax inefficiency is introduced in the budget constraint of the government, as in Huang and Wei (2003). It leads to the restriction of the government's capacity in managing the primary budget balance and in turn could significantly alter the evolution of public debt. This paper then extends the model to the case of the discretionary monetary arrangement with dynamic policy interaction, where the fiscal authority and the central bank are independently responsible for fiscal and monetary policies. This differential game is examined using an open-loop Nash equilibrium, where the two players are assumed to access to a commitment structure that enforces them to pre-commit to a future course of action. In contrast, a closed-loop Nash equilibrium does not require such commitment structure, but it cannot be solved analytically in general.[9] Although this equilibrium may be more appropriate to describe the strategic interaction, we restrict ourselves into an open-loop Nash equilibrium to analytically identify the major results of the interac-

---

[9]In comparison with an open-loop Nash equilibrium, a closed-loop Nash equilibrium has an advantage in relaxing the commitment structure of the game at the cost of more analytical complexity. In a closed-loop Nash equilibrium, each player optimally chooses its controlled instruments, taken into the account both current and future influences of its opponent's moves through the evolution of state (i.e., public debt) of the game. A closed-loop Nash equilibrium is left for a future study.

tion. A possible justification may be that such binding commitments could be facilitated by surveillance by some other legislative authority, and departures of announced strategies would give rise to serious loss of reputation to players (see, e.g., van Aarle, Bovenberg, and Raith (1995)).

The result is that tax inefficiency has non-trivial impacts on the steady state outcome as well as the speed of adjustment for public debt stabilization. Irrespective of monetary policy arrangements (a strict commitment to target inflation or discretionary monetary policy with the independence of the central bank), tax inefficiency not only induces a higher level of the public debt stock and a lower level of government expenditures in the steady state, but also reduces the speed of adjustment for public debt. This is because tax inefficiency reduces the capability of the fiscal authority in controlling its primary budget balance. Furthermore, the impact of a change in tax inefficiency on the tax rate and the inflation rate in the steady state is highly dependent on the level of tax inefficiency. These are partially consistent with those in Huang and Wei (2003), although they do not focus on public debt due to their static model.

This study also makes a comparison of the outcomes under each of the two polar monetary arrangements and shows that given the degree of tax inefficiency, the discretionary monetary arrangement enhances more the adjustment speed for public debt, but which monetary arrangement is more effective in reducing the long-run level of public debt is highly dependent on the level of tax-related inefficiency. In particular, the discretionary monetary arrangement could induce a higher level of public debt compared to the inflation targeting arrangement when the degree of tax-related inefficiency is either small enough or large enough. In contrast, the discretionary monetary arrangement could induce a lower level of public debt when the degree of tax-related inefficiency is in the intermediate range. The independence gives the central bank an incentive in increasing or decreasing inflation tax for its own interest, and this positive or negative externality changes the fiscal authority's capability to control the primary budget balance and the overall balance. Our results suggest that policymakers should consider not only monetary institutional arrangements but also tax-related inefficiency to achieve public debt stabilization effectively.

The remainder of this study is structured as follows. In Section 2, we describe the basic elements of our model of tax inefficiency with the fiscal authority and the central bank, following Alesina and Tabellini (1987) and Huang and Wei (2003). Section 3 analyzes the role of tax inefficiency under two polar monetary arrangements: the first is the inflation targeting arrangement where the central bank involves a strict commitment to a fixed target inflation; and the second is the discretionary monetary arrangement where the fiscal authority and the central bank are independently responsible for fiscal and monetary policies with a possible conflict. Based on these characterizations, the comparison of the two monetary arrangements is discussed. Section 4 provides some conclusions.

2 The Model

We consider a small open economy with an infinite horizon and a deterministic environment. At any time t, production is taken place by competitive firms whose revenue is taxed by the tax rate $\tau_t \in [0, 1)$. Following Alesina and Tabellini (1987) and Jensen (1994), output is assumed to be governed by:

$$y_t = \alpha(\pi_t - \pi_t^e - \tau_t), \tag{1}$$

where y_t, π_t and π_t^e are log of real output, inflation, and expected inflation, respectively, at period t with $\alpha > 0$.[10] Equation (1) is a conventional Lucas supply function augmented by tax distortion, where unexpected inflation increases output, and higher taxes lower output. The tax rate τ_t on firms is the only source of the fiscal authority's revenue. Without tax distortion, we obtain $y_t = 0$ in a rational expectation equilibrium, where inflation is anticipated, i.e., $\pi_t = \pi_t^e$. An important property of the formulation in Alesina and Tabellini (1987) is that the need to provide government expenditures is enough to generate an inflation bias.[11]

---

[10]For a more careful explanation for the assumed environment and the derivation of the modified Lucas supply function, see, e.g., Alesina and Tabellini (1987), Jensen (1994), and Beetsma and Bovenberg (1997).

[11]This is partially related to the finding in Sargent and Wallace (1981) that inflation is a fiscal phenomenon when the central bank cannot choose how much of the budget deficit to monetize.

The dynamic link in the model is given by the government budget constraint. The government expenditures and payments on debt are financed through its actual tax revenues, seigniorage, and new debt. Let d_t denote the ratio of debt to output, g_t the ratio of government expenditures to output, $\hat{\tau}_t$ the ratio of government revenues to output, and $r > 0$ the interest rate on debt. Following Tabellini (1986) and Jensen (1994), the budget constraint of the government can be approximated by:

$$\dot{d}_t = rd_t + g_t - \hat{\tau}_t - \pi_t. \tag{2}$$

The assumption that r is constant requires that there is a flat demand for government debt. A fixed interest rate may be consistent with the fact that most emerging economies are a small open economy, which implies that the government finances its loan in an international debt market. The term π_t is an approximation of monetary seigniorage from the quantity money equation. To rule out the trivial strategy of infinite borrowing, the solvency of government is ensured by the transversality condition, referred to as the no-Ponzi game restriction: $\lim_{t \to \infty} d_t e^{-rt} = 0$.

The central assumption in this paper is that government revenues are decreased by 'tax inefficiency,' i.e., the inefficiency associated with tax collection, due to various reasons like corruption. To capture this, following Huang and Wei (2003), we assume that:

$$\hat{\tau}_t = (1 - \phi)\tau_t, \tag{3}$$

where $\phi \in [0, 1)$ represents the degree of tax inefficiency in an economy.[12] The higher ϕ is, the more inefficient tax collection will be. This implies that the tax rate on output paid by firms to the government is τ_t, while the actual tax revenue is only $(1 - \phi)\tau_t$ due to the tax inefficiency. We should offer a brief discussion on a rationale of tax inefficiency. The inefficiency may originate in various forms of tax leakage, in particular, in emerging economies. Bribery by private agents to tax officials for evading tax liability or relaxing tax collection enforcement

---

[12]The value of $1 - \phi$ in this study is consistent with the fiscal capacity index in Huang and Wei (2003).

has been widespread with a weak tax-related infrastructure in terms of legal and enforcement frameworks (see, e.g., Martinez-Vazquez, Arze, and Boex (2004)). The amount of tax revenue leakage, $\phi\tau_t$, may be jointly shared by corrupted tax officials and firms owners. Consequently, the more serious degree of tax inefficiency is associated with a reduction in the actual accrue of tax collection to the government, resulting in the reduced capability of government to control over the primary budget balance $(1-\phi)\tau_t - g_t$.

We consider the central bank and the fiscal authority who are responsible for conducting monetary and fiscal policy, respectively. This study examines two monetary arrangements: inflation targeting and discretionary arrangements. Inflation targeting is a monetary arrangement where the central bank commits to a target level of inflation rate, $\pi_t = \hat{\pi}$, and the fiscal authority regulates the tax rates τ_t and government expenditures g_t. Inflation target has been adopted in many developed countries, such as Australia, Canada, and New Zealand. Recently it has been gradually becoming popular even in emerging countries including Thailand and Indonesia although many developing countries are reluctant to adopt the inflation targeting arrangement (see, e.g., Eichengreen, Masson, Savastano, and Sharma (1999)).[13] In practice, the inflation target is a range rather than a point due to the existence of unanticipated shocks. However, for simplicity, this study considers that the target inflation is just a point, assuming away the unanticipated shocks. Moreover, to focus on the relationship between tax inefficiency and public debt stabilization, we do not discuss how the central authorities chooses the fixed target inflation, assuming that the target inflation $\hat{\pi}$ is already determined outside of our model. The discussion on how the target inflation is decided would be left for a future research.

In contrast, discretionary arrangement is a monetary arrangement where the central bank independently controls over inflation π_t, and the fiscal authority regulates the tax rates τ_t

---

[13]Historically, as many developing countries lack credibility in their monetary policy, these countries pegged their currency to a major anchor country's currency through adopting the fixed exchange rate regime. As a common practice, a currency-board arrangement is a monetary framework in which domestic monetary base is rigidly pegged to the anchor country's currency and domestic high-powered money must be backed up by foreign reserves. This regime may be interpreted as one form of inflation targeting in the sense that the country imports the anchor country's low level of inflation. However, it has also been acknowledged that the rise in the inflation rate in the anchor country was one of the important reasons why the Bretton-Woods system collapsed in the 1970s (see, e.g., McKinnon (1993)).

and government expenditures g_t. In this case, monetary and fiscal policies are decentralized so that the strategic interaction between the central bank and the fiscal authority arises from a possible conflict between the two branches of policy-makers in managing public debt, as discussed in Tabellini (1986). The central bank would like to reduce excessive public debt mainly through raising taxes or reducing government spending while the fiscal authority would like to receive substantial support for debt management from debt monetization by the central bank. Such decentralization has been prevailing in not only most developed countries but also some developing countries. Indeed, the above two monetary regimes may be complements rather than substitutes, i.e., the central bank can independently decide its monetary policy with some range of the target inflation. However, we believe that examining the two polar regimes would be valuable to understand the role of monetary arrangements and to provide some useful guideline for policymakers in the discussion of public debt stabilization.

To capture these policy arrangements, the instantaneous loss functions of the central bank and the fiscal authority are taken to be quadratic in public debt d, as a state variable, output y, inflation rate π, and government expenditures g. Specifically, the loss function of the central bank is represented by:

$$L_{\mathrm{C}} = \frac{1}{2} \int_0^\infty [d_s^2 + \lambda_{\mathrm{C}} y_s^2 + \mu_{\mathrm{C}} \pi_s^2 + \delta_{\mathrm{C}} (g_s - \hat{g})^2] e^{-\beta s} ds, \tag{4}$$

and the loss function of the fiscal authority is represented by:

$$L_{\mathrm{F}} = \frac{1}{2} \int_0^\infty [d_s^2 + \lambda_{\mathrm{F}} y_s^2 + \mu_{\mathrm{F}} \pi_s^2 + \delta_{\mathrm{F}} (g_s - \hat{g})^2] e^{-\beta s} ds, \tag{5}$$

where $\beta > 0$ denotes the subjective rate of time preference that is assumed to be identical for both authorities, and $\hat{g} > 0$ represents the desired government expenditure-output ratio that is constant and identical for both authorities. The higher β implies that the policymakers are more impatient. We assume that $\lambda_{\mathrm{C}} = \lambda_{\mathrm{F}} \equiv \lambda$, $\mu_{\mathrm{C}} > \mu_{\mathrm{F}} = 0$ and $0 = \delta_{\mathrm{C}} < \delta_{\mathrm{F}}$, so that the central bank and the fiscal authority are equally conservative over output, and the central bank is more conservative over inflation but is less conservative over government expenditure than

8

the fiscal authority. These specifications require that both policymakers wish to minimize the deviations of public debt, output, inflation rate and government expenditures from some ideal levels (targets). For simplicity, the ideal levels (targets) for public debt, output and inflation rate are assumed to be zero.[14] Notice that zero is the level of full employment output or the log of output without tax distortion in a rational expectation equilibrium.

It should be noted that policymakers wish to minimize the deviations of government expenditures from the same positive ideal level, $\hat{g}$, as discussed in Alesina and Tabellini (1987) and Jensen (1994). The assumption that $\hat{g}$ is positive implies that the policymakers wish to tolerate some inflation and some tax distortions in exchange for a positive amount of government expenditures.[15] Furthermore, a motivation for the inclusion of public debt in the loss function is that the stabilization of public debt is a real concern for not only the fiscal authority but also the central bank in emerging economies in terms of fiscal sustainability, as discussed in Mihaljek and Tissot (2003) and IMF (2003). In particular, the process of public debt stabilization from excessive public debt is also an important concern in this study.

3   Analysis

This section analyzes the impact of tax inefficiency on the evolution of public debt under the two polar monetary arrangements: the inflation targeting arrangement and the discretionary monetary arrangement. Under the inflation targeting, the central bank in an emerging country commits to some fixed target inflation rate, i.e., $\pi_t = \hat{\pi}$, and the fiscal authority chooses a sequence of government expenditures and the tax rates over time.

Under the discretionary monetary arrangement, the policy game starts between the fiscal authority and the central bank. In this study, we solve this dynamic policy game using an open-

---

[14]In this paper, the 'ideal' level is referred to in the sense that the policymakers minimize the quadratic form of the sub-payoff loss in the instantaneous loss functions, (4) and (5), if they attain the ideal level. More generally, we allow the ideal levels of public debt, output and inflation rate to be different from zero, as in van Aarle, Bovenberg, and Raith (1995). However, this modelling strategy would not affect the natures of our results.

[15]Jensen (1994) emphasizes that the inclusion of government expenditures in the loss function reflects citizens' utility from various forms of government spending on public services, education, health programs, and social security. Alesina and Tabellini (1987) and Huang and Wei (2003) interpret government expenditures as a source of the provision of public goods.

lop Nash equilibrium. In the equilibrium, players simultaneously commit to a strategy, taking as given the current and future actions of the opponent. In terms of institutional arrangements, this equilibrium concept could be interpreted as the fiscal authority and the central bank simultaneously submitting their strategies to a legislative authority enforcing these plans as binding commitments. This legislative authority may be an institution conducting surveillance of economic policies (see, e.g., van Aarle, Bovenberg, and Raith (1995)).[16]

3.1 Inflation Targeting Arrangement

This subsection examines the impact of tax inefficiency on public debt stabilization under the inflation targeting. In this monetary regime, the policymakers fixes seigniorage revenue associated with the target inflation $\hat{\pi}$.

The loss function of the government is identical to that of the fiscal authority without any role of the central bank. Then, the equilibrium can be derived by minimizing the current-value Hamiltonian, $H_\mathrm{A} = \frac{1}{2}[d_t^2 + \lambda y_t^2 + \delta_\mathrm{F}(g_t - \hat{g})^2] + m_{\mathrm{A},t}(rd_t + g_t - \bar{\tau}_t - \hat{\pi})$, with respect to $\{g_t, \tau_t\}$, where $m_{\mathrm{A},t}$ represents the marginal valuation of public debt as perceived by the government or the fiscal authority as the co-state variable associated with the government budget constraint. Notice that the output is linked with the inflation rate and the tax rate by equation (1) with $\pi_t = \hat{\pi}$. The optimality conditions of this dynamic program yields (we drop time subscript without any miscomprehension):

$$\alpha^2 \lambda(\pi - \pi^e - \tau) + (1 - \phi)m_\mathrm{A} = 0; \tag{6}$$

$$\delta_\mathrm{F}(g - \hat{g}) + m_\mathrm{A} = 0; \tag{7}$$

$$\dot{m}_\mathrm{A} = (\beta - r)m_\mathrm{A} - d. \tag{8}$$

---

[16]The commitment structure makes the time path of policy instruments are independent of the state of dynamic system. It is contrast to a closed-loop Nash equilibrium of such a policy game which does not require the commitment structure. In a closed-loop Nash equilibrium, taking the best response of its opponent as given each policy player optimally chooses its controlled instruments taken into the account both current and future influences of its opponent's moves through the evolution of state (i.e., public debt) of the game. Hence, in a closed-loop Nash equilibrium the time path of policies instrument are contingent on the state of dynamic system.

Equations (6) to (8) imply how the fiscal authority conducts its policies to achieve the defined objective. Equation (6) says that the tax rate is set such that the per-period marginal loss from an increase in the tax rate in term of output equals its marginal gain from reducing public debt in the future, and equation (7) requires that the government expenditure is set such that the per-period marginal gain from an increase in the government expenditure equals its marginal loss from increasing public debt in the future. Finally, equation (8) says that the decrease in the marginal valuation of public debt would be balanced with the current and future marginal contribution it creates. Then, imposing an ex-post condition of rational expectation: $\pi_t^e = \hat{\pi}$, this problem yields the following linear differential system:

$$
\begin{bmatrix} \dot{\tau}_A \\ \dot{g}_A \\ \dot{d}_A \end{bmatrix} = \begin{bmatrix} \beta - r & 0 & -\frac{1-\phi}{\alpha^2 \lambda} \\ 0 & \beta - r & \frac{1}{\delta_F} \\ -(1-\phi) & 1 & r \end{bmatrix} \begin{bmatrix} \tau_A \\ g_A \\ d_A \end{bmatrix} - \begin{bmatrix} 0 \\ (\beta - r)\hat{g} \\ \hat{\pi} \end{bmatrix}. \tag{9}
$$

The specification of our linear quadratic dynamic model implies that for any $\phi \in [0,1)$, there exists a unique steady state $(\bar{\tau}_A, \bar{g}_A, \bar{d}_A)$ in the system (9), and that the unique steady state is stable if the determinant of the 3×3 matrix is less than zero, or $M_A \equiv \frac{1}{\delta_F} + \frac{(1-\phi)^2}{\alpha^2 \lambda} - (\beta - r)r > 0$.

We now characterize the steady state as a long-run outcome under the inflation targeting arrangement. Setting $\dot{\tau}_A = 0$, $\dot{g}_A = 0$, and $\dot{d}_A = 0$ in the system (9), we arrive at the ratio of public debt to output in the steady state:

$$
\bar{d}_A = \left[\frac{1}{\delta_F} + \frac{(1-\phi)^2}{\alpha^2 \lambda} - (\beta - r)r \right]^{-1} (\beta - r)(\hat{g} - \hat{\pi}) \equiv \frac{\beta - r}{M_A} (\hat{g} - \hat{\pi}). \tag{10}
$$

Notice that the parameter β represents the degree of impatience of the policymakers. We assume that the ideal level of government expenditures cannot be financed only by the inflation tax so that $\hat{g} > \hat{\pi}$. We also assume that the policymakers are not very impatient so that $\beta < r + \frac{1}{r\delta_F}$, which ensures that $M_A > 0$ for any $\phi \in [0,1)$. Our specification with equation (10) implies that the ratio of public debt to output in the steady state is negative if the policymaker is patient enough such that $\beta \in (0, r)$, and it is positive if the policymaker is

11

impatient enough such that $\beta \in (r, r + \frac{1}{r\delta_{\mathrm{F}}})$.

To understand the intuition on whether public debt in the steady state is above or below its ideal level of zero, we notice that the patient policymaker cares more about the future payoff, while the impatient cares more about the current payoff. This implies that the patient policymaker attempts to reduce the future payoff loss at the expense of the current payoff, while the impatient policymaker attempts to reduce the current payoff loss at the expense of the future payoff. Notice that in the steady state public debt must be balanced with the inflation tax and the primary budget position, i.e., $r\bar{d}_{\mathrm{A}} = \hat{\pi} + [(1 - \phi)\bar{\tau}_{\mathrm{A}} - \bar{g}_{\mathrm{A}}]$. Suppose first that the policymaker is so patient that $\beta < r$. Since she pays more attention to the future payoff by reducing tax distortion and increasing government expenditure closer to its ideal level of $\hat{g}$ in the future, public debt would be below its ideal level of zero (public balance surplus in our model) in the steady state. In contrast, suppose that the policymaker is so impatient that $\beta > r$. Since she pays more attention to the current payoff by reducing tax distortion and increasing government expenditures in the current time, the primary budget deficit, $g_t - (1 - \phi)\tau_t$, would be relatively high. To balance the future public budget with the current high deficit, the policymaker is likely to pursue a higher tax rate and a lower government expenditure in the future, which would induce public debt above its ideal level of zero in the steady state.

Since this paper focuses on public debt stabilization problem associated with a higher level of public debt, we assume in the rest of the paper that $\hat{g} > \hat{\pi}$ and $\beta \in (r, r + \frac{1}{r\delta_{\mathrm{F}}})$, so that there is a stable, positive level of public debt in the steady state. Furthermore, using equation (10), the ratio of government expenditure to output, the tax rate, and (log of) output in the steady state are respectively given by:

$$\bar{g}_{\mathrm{A}} = \hat{g} - \frac{1}{\delta_{\mathrm{F}} M_{\mathrm{A}}}(\hat{g} - \hat{\pi}); \quad \bar{\tau}_{\mathrm{A}} = \frac{1 - \phi}{\alpha^2 \lambda M_{\mathrm{A}}}(\hat{g} - \hat{\pi}); \quad \bar{y}_{\mathrm{A}} = -\frac{1 - \phi}{\alpha \lambda M_{\mathrm{A}}}(\hat{g} - \hat{\pi}). \quad (11)$$

The steady state depends on the two important parameters, the target inflation, $\hat{\pi}$, and the degree of tax inefficiency, ϕ. From equations (10) and (11), in the steady state, public debt and the tax rate are decreasing in the target inflation, while government expenditures and

output are increasing in the target inflation. Concerning the discussion of how tax inefficiency affects the steady state, differentiating equations (10) and (11) with respect to ϕ implies the following results (see the Appendix for the proof):

Proposition 1 *Suppose that the central bank involves a commitment to target inflation $\hat{\pi} \in [0, \hat{g})$ with the degree of tax inefficiency $\phi \in [0, 1)$. Then, (1) $\partial \bar{d}_A / \partial \phi > 0$ for any $\phi \in [0, 1)$; (2) $\partial \bar{g}_A / \partial \phi < 0$ for any $\phi \in [0, 1)$; and (3) there exists a unique $\tilde{\phi}_A \in [0, 1]$ such that $\partial \bar{\tau}_A / \partial \phi > 0$ and $\partial \bar{y}_A / \partial \phi < 0$ for any $\phi \in [0, \tilde{\phi}_A)$, and $\partial \bar{\tau}_A / \partial \phi < 0$ and $\partial \bar{y}_A / \partial \phi > 0$ for any $\phi \in (\tilde{\phi}_A, 1)$.*[17]

This proposition provides several important results. First, a rise in tax inefficiency reduces the government's capability to control the primary budget balance through a reduction in the actual accrue of tax collection, which results in a decrease in government expenditures and an increase in overall public debt. Second, the impact of a rise in tax inefficiency on the tax rate falls into two ranges, as in Huang and Wei (2003). For moderate tax inefficiency such that $\phi \in [0, \tilde{\phi}_A)$, the optimal response to a rise in tax inefficiency is to raise the tax rate $(\partial \bar{\tau}_A / \partial \phi > 0)$. In contrast, for severe inefficiency such that $\phi \in (\tilde{\phi}_A, 1)$, the optimal response to a rise in tax inefficiency is to reduce the tax rate $(\partial \bar{\tau}_A / \partial \phi < 0)$. Economic intuitions are as follows. When the inefficiency is in the lower range, the government could impose taxes more to compensate for the lost revenue in response to an increase in tax inefficiency. In contrast, when the inefficiency is more severe, a given increment in tax revenue becomes too expensive to collect in terms of forgone output. As a result, the optimal response to an increase in tax inefficiency is to reduce the tax revenue collection.

Concerning the speed of adjustment for public debt, the dynamics can be derived in the following form: $d_t = (d_0 - \bar{d}_A)e^{-h_A t} + \bar{d}_A$, where d_0 represents the level of public debt in the initial time $t = 0$, and h_A represents the adjustment speed of public debt such that:

$$h_A \equiv \frac{\sqrt{\beta^2 + 4M_A} - \beta}{2} > 0. \tag{12}$$

We assume that d_0 is large enough so that public debt decreases over time. Then, we deduce

---

[17]The critical value of ϕ must satisfy $\tilde{\phi}_A = 1 - \alpha[\lambda\{\frac{1}{\delta_F} - (\beta - r)r\}]^{1/2}$, if it is interior.

the following results under inflation targeting arrangement (see the Appendix for the proof):

Proposition 2 *Suppose that the central bank involves a commitment to target inflation $\hat{\pi} \in [0, \hat{g})$ with the degree of tax inefficiency $\phi \in [0, 1)$. Then, the adjustment speed for public debt is decreasing in the degree of tax inefficiency, i.e., $\partial h_A / \partial \phi < 0$ for any $\phi \in [0, 1)$.*

Tax inefficiency reduces the capability to control its primary budget balance, which in turn reduces the adjustment speed for public debt. Propositions 1 and 2 provide important implications related to the relationship between tax inefficiency, public debt in the steady state, and the speed of adjustment. Countries with severe tax inefficiency struggle not only with a relatively higher level of public debt but also with relatively slower speed of public debt stabilization. Figure 1 illustrates the impact of a rise in tax inefficiency (from ϕ_L to ϕ_H with the initial public debt d_0) on the process of public debt stabilization (the steady state level of public debt is increased from $\bar{d}(\phi_L)$ to $\bar{d}(\phi_H)$).

3.2 Discretionary Monetary Arrangement

This subsection examines the impact of tax inefficiency on public debt stabilization under the discretionary monetary arrangement, where the fiscal authority and the central bank are independently responsible for fiscal and monetary policies, respectively, and the central bank plays an independent role in controlling the inflation rate, π_t. As a solution concept of the dynamic policy game, we use an open-loop Nash equilibrium where both players simultaneously pre-commit to a strategy, taking as given the current and future actions of the opponent.

The current-value Hamiltonians for the central bank and the fiscal authority are described by $H_C = \frac{1}{2}[d^2 + \lambda y^2 + \mu_C \pi^2] + m_C(rd + g - \bar{\tau} - \pi)$ and $H_F = \frac{1}{2}[d^2 + \lambda y^2 + \delta_F(g - \hat{g})^2] + m_F(rd + g - \bar{\tau} - \pi)$, respectively, where m_C and m_F are respectively the marginal valuation of public debt as perceived by the central bank and the fiscal authority, as the co-state variable associated with the government budget constraint. Applying dynamic programming with the above Hamiltonians, the open-loop Nash equilibrium solves the set of generalized Hamilton-Jacobi

conditions for the central bank:

$$\alpha^2 \lambda (\pi - \pi^e - \tau) + \mu_C \pi - m_C = 0; \tag{13}$$

$$\dot{m}_C = (\beta - r)m_C - d; \tag{14}$$

and the set of generalized Hamilton-Jacobi conditions for the fiscal authority:

$$\alpha^2 \lambda (\pi - \pi^e - \tau) + (1 - \phi)m_F = 0; \tag{15}$$

$$\delta_F (g - \hat{g}) + m_F = 0; \tag{16}$$

$$\dot{m}_F = (\beta - r)m_F - d. \tag{17}$$

The economic interpretation for each condition is similar to the one of equations (6) to (8) under the inflation targeting arrangement. Equation (13) states that the central bank sets inflation such that the per-period marginal loss from an increase in inflation in term of output and inflation itself equals its marginal gain from reducing public debt in the future. Similarly, equation (15) shows that the fiscal authority sets the tax rate such that the per-period marginal loss from an increase in the tax rate in term of output equals its marginal gain from reducing public debt in the future, and equation (16) requires that the fiscal authority sets government expenditure such that the per-period marginal gain from an increase in government expenditure equals its marginal loss from increasing public debt in the future. Finally, equations (14) and (17) say that the decrease in the marginal valuation of public debt would be balanced with the current and future marginal contribution it creates. Then, imposing an ex-post condition of rational expectation: $\pi_t^e = \pi_t$, this problem yields the following linear differential system:

$$\begin{bmatrix} \dot{\tau}_O \\ \dot{g}_O \\ \dot{\pi}_O \\ \dot{d}_O \end{bmatrix} = \begin{bmatrix} \beta - r & 0 & 0 & -\frac{1-\phi}{\alpha^2 \lambda} \\ 0 & \beta - r & 0 & \frac{1}{\delta_F} \\ 0 & 0 & \beta - r & -\frac{2-\phi}{\mu_C} \\ -(1-\phi) & 1 & -1 & r \end{bmatrix} \begin{bmatrix} \tau_O \\ g_O \\ \pi_O \\ d_O \end{bmatrix} - \begin{bmatrix} 0 \\ (\beta - r)\hat{g} \\ 0 \\ 0 \end{bmatrix}. \tag{18}$$

Our specification of the linear quadratic dynamics implies that for any $\phi \in [0, 1)$, there exists a unique steady state $(\bar{\tau}_O, \bar{g}_O, \bar{\pi}_O, \bar{d}_O)$ in the system (18), and that the unique steady state is stable if the determinant of the 4×4 matrix is less than zero, or $M_O \equiv \frac{1}{\delta_F} + \frac{(1-\phi)^2}{\alpha^2 \lambda} + \frac{2-\phi}{\mu_C} - (\beta - r)r > 0$. The assumption of $\beta \in (r, r + \frac{1}{r\delta_F})$ ensures that $M_O > 0$.

We next characterize the steady state in the open-loop Nash equilibrium under the discretionary monetary policy. Setting $\dot{\tau}_O = 0$, $\dot{g}_O = 0$, $\dot{\pi}_O = 0$ and $\dot{d}_O = 0$ in the system (18), we arrive at the ratio of public debt to output in the steady state:

$$\bar{d}_O = \left[\frac{1}{\delta_F} + \frac{2-\phi}{\mu_C} + \frac{(1-\phi)^2}{\alpha^2 \lambda} - (\beta - r)r \right]^{-1} (\beta - r)\hat{g} \equiv \frac{\beta - r}{M_O} \hat{g}. \tag{19}$$

Similar to the discussion in the previous subsection, assuming $\beta \in (r, r + \frac{1}{r\delta_F})$, our specification with equation (19) implies that the ratio of public debt to output in the steady state is positive for any $\phi \in [0, 1)$.[18] Using equation (19), the tax rate, the ratio of government expenditure to output, inflation, and (log of) output in the steady state are respectively given by:

$$\bar{g}_O = \left[1 - \frac{1}{\delta_F M_O} \right] \hat{g}; \quad \bar{\tau}_O = \frac{1-\phi}{\alpha^2 \lambda M_O} \hat{g}; \quad \bar{\pi}_O = \frac{2-\phi}{\mu_C M_O} \hat{g}; \quad \bar{y}_O = -\frac{1-\phi}{\alpha \lambda M_O} \hat{g}. \tag{20}$$

Concerning the discussion of how tax inefficiency affects the steady state, differentiating (19) and (20) with respect to ϕ implies the following results (see the Appendix for the proof):

Proposition 3 *Suppose that the central bank is independent of the fiscal authority with the degree of tax inefficiency ϕ. Then, (1) $\partial \bar{d}_O / \partial \phi > 0$ for any $\phi \in [0, 1)$; (2) $\partial \bar{g}_O / \partial \phi < 0$ for any $\phi \in [0, 1)$; (3) there exists a unique $\tilde{\phi}_O \in [0, 1]$ such that $\partial \bar{\tau}_O / \partial \phi > 0$ and $\partial \bar{y}_O / \partial \phi < 0$ for any $\phi \in [0, \tilde{\phi}_O)$, and $\partial \bar{\tau}_O / \partial \phi < 0$ and $\partial \bar{y}_O / \partial \phi > 0$ for any $\phi \in (\tilde{\phi}_O, 1)$; and (4) there exists a unique $\check{\phi}_O \in [0, 1]$ such that $\partial \bar{\pi}_O / \partial \phi > 0$ for any $\phi \in [0, \check{\phi}_O)$ and $\partial \bar{\pi}_O / \partial \phi < 0$ for any $\phi \in (\check{\phi}_O, 1)$.[19]*

The first three results related to public debt, government expenditures and the tax rate in the

---

[18]Similar to the discussion under the inflation targeting arrangement, whether public debt in the steady state is above or below its ideal level of zero depends on the sign of $\beta - r$.

[19]The critical value of $\tilde{\phi}_O$ is $\tilde{\phi}_O = 1 - \alpha[\lambda\{\frac{1}{\delta_F} + \frac{1}{\mu_C} - (\beta - r)r\}]^{1/2}$, and the critical value of $\check{\phi}_O$ is a smaller root of the equation $\frac{(1-\check{\phi}_O)(3-\check{\phi}_O)}{\alpha^2 \lambda} + (\beta - r)r = \frac{1}{\delta_F}$, if they are interior.

steady state can be interpreted in the same manner as in the equilibrium under the inflation targeting arrangement in Proposition 1. A rise in the tax inefficiency increases public debt but reduces government expenditures in the steady state. Moreover, the impact on the tax rate in the steady state is not monotone as under the inflation targeting arrangement and as in Huang and Wei (2003).

The important distinction between Propositions 1 and 3 is whether or not the inflation rate is decided by the central bank as a discretionary monetary policy. The impact of a rise in tax inefficiency on the inflation rate is also nonmonotone and falls into two ranges, as in Huang and Wei (2003). For moderate tax inefficiency such that $\phi \in [0, \check{\phi}_\mathrm{O})$, the optimal response to a rise in tax inefficiency is to raise the inflation rate ($\partial \bar{\pi}_\mathrm{O}/\partial \phi > 0$). In contrast, for severe inefficiency such that $\phi \in (\check{\phi}_\mathrm{O}, 1)$, the optimal response to a rise in tax inefficiency is to reduce the inflation rate ($\partial \bar{\pi}_\mathrm{A}/\partial \phi < 0$). These results imply the followings. When the tax inefficiency is in the lower range such that $\phi < \min\{\tilde{\phi}_\mathrm{O}, \check{\phi}_\mathrm{O}\}$, not only would the fiscal authority impose taxes more but also the central bank would impose inflation tax more in order to compensate for the lost revenue in response to an increase in tax inefficiency. In contrast, when the inefficiency is more severe such that $\phi > \max\{\tilde{\phi}_\mathrm{O}, \check{\phi}_\mathrm{O}\}$, not only would the fiscal authority impose taxes less but also the central bank would impose inflation tax less.

Figure 2 illustrates the inverse U-shaped relationship between the degree of tax inefficiency, ϕ, and the steady state level of inflation rate, $\pi_\mathrm{O}(\phi)$, under the discretionary monetary arrangement. To understand the logic behind this, recall that for the central bank, the marginal benefit with respect to inflation in terms of output is $\alpha^2 \lambda \tau$, and the marginal loss in terms of inflation itself is $\mu_\mathrm{C}\pi$. Consider a case in which tax inefficiency is moderate or severe so that ϕ is small enough or large enough. In this case, the marginal benefit in terms of output is small since the tax rate is low from the result in Proposition 3 (3). This might lead to a low level of marginal loss in terms of inflation itself, which allows the central bank to set a lower inflation tax. In contrast, for the intermediate case in which tax inefficiency is neither moderate nor severe so that ϕ is neither small enough nor large enough, the marginal benefit in terms of output is large since the tax rate is high. This might lead to a high level of marginal

loss in terms of inflation itself, which allows the central bank to set a higher inflation tax. The independence gives the central bank an incentive in increasing or decreasing inflation tax for its own interest, which induces the positive or negative externality to the fiscal authority. This would cause the fiscal authority's capability to change in terms of controlling the primary budget balance and the overall public debt.

Concerning the speed of adjustment for public debt under the discretionary monetary arrangement, the dynamics can be derived in the following form: $d_t = (d_0 - \bar{d}_O)e^{-h_O t} + \bar{d}_O$, where h_O represents the adjustment speed of public debt such that:

$$h_O \equiv \frac{\sqrt{\beta^2 + 4M_O} - \beta}{2} > 0. \tag{21}$$

Similar to the result in Proposition 2, we deduce the following result in the open-loop Nash equilibrium:

Proposition 4 *Suppose that the central bank is independent of the fiscal authority with the degree of tax inefficiency ϕ. Then, the adjustment speed for public debt is decreasing in the degree of tax inefficiency, i.e., $\partial h_O / \partial \phi < 0$ for any $\phi \in [0, 1)$.*

Similar to the results under the inflation targeting arrangement, Propositions 3 and 4 show that countries with severe tax inefficiency struggle not only with relatively higher level of public debt but also with relatively slower speed of public debt stabilization.

3.3 Comparison of Monetary Arrangements

In the previous subsections, we have examined the roles of tax inefficiency under the two polar monetary arrangements: the inflation targeting and the discretionary monetary arrangements. This subsection makes a comparison of these monetary regimes focusing on the fixed target level of inflation rate $\hat{\pi} \in [0, \hat{g}]$ and the degree of tax inefficiency $\phi \in [0, 1)$. We define the difference in public debt in the steady state between under the two polar monetary arrangements

by:

$$\Delta \bar{d} \equiv \bar{d}_O - \bar{d}_A = \frac{\beta - r}{M_O} \hat{g} - \frac{\beta - r}{M_A} (\hat{g} - \hat{\pi}). \tag{22}$$

Using equation (22), the difference in government expenditures and the tax rate in the steady state between under the two polar monetary arrangements are given by:

$$\Delta \bar{g} \equiv \bar{g}_O - \bar{g}_A = -\frac{1}{\delta_F(\beta - r)} \Delta \bar{d}; \qquad \Delta \bar{\tau} \equiv \bar{\tau}_O - \bar{\tau}_A = \frac{1 - \phi}{\alpha^2 \lambda(\beta - r)} \Delta \bar{d}. \tag{23}$$

Moreover, the difference in inflation rate in the steady state between under the two polar monetary arrangements is given by:

$$\Delta \bar{\pi} \equiv \bar{\pi}_O - \hat{\pi} = \frac{2 - \phi}{\mu_C(\beta - r)} \bar{d}_O - \hat{\pi}. \tag{24}$$

By the state equation (2) with $\dot{d} = 0$ and equations (22), (23) and (24), we obtain:

$$\Delta \bar{d} = -\frac{\beta - r}{M_A} \Delta \bar{\pi}, \tag{25}$$

which implies that the difference in public debt is negatively related to that in inflation rate. Notice that by equations (23), the signs of $\Delta \bar{g}$ and $\Delta \bar{\tau}$ are also dependent on that of $\Delta \bar{\pi}$. By equations (24) and (25), we deduce the following results related to the comparison of the two monetary arrangements in terms of the relationship between the target inflation rate, $\hat{\pi} \in [0, \hat{g}]$, and the steady state level of public debt as a long-run outcome:

Proposition 5 *Suppose that the target inflation $\hat{\pi}$ is small enough so that $\hat{\pi} < \bar{\pi}_O$ or $\Delta \bar{\pi} > 0$. Then, public debt in the steady state is smaller under the discretionary monetary arrangement than under the inflation targeting arrangement, i.e., $\Delta \bar{d} < 0$. On the other hand, suppose that the target inflation $\hat{\pi}$ is large enough so that $\hat{\pi} > \bar{\pi}_O$ or $\Delta \bar{\pi} < 0$. Then, public debt in the steady state is larger under the discretionary monetary arrangement, i.e., $\Delta \bar{d} > 0$.*

Suppose that the target inflation $\hat{\pi}$ is small enough close to zero so that $\Delta\bar{\pi} > 0$ in equation (24). This implies that, by equation (25), public debt in the steady state is smaller under the discretionary monetary arrangement, i.e., $\Delta\bar{d} < 0$. Moreover, by equations (23), government expenditure is larger and the tax rate is lower under the discretionary monetary arrangement, i.e., $\Delta\bar{g} > 0$ and $\Delta\bar{\tau} < 0$. In contrast, if the target inflation is large enough close to $\hat{g}$ so that $\Delta\bar{\pi} < 0$ in equation (24), we obtain the opposite results, i.e., $\Delta\bar{d} > 0$ and $\Delta\bar{g} < 0$.

The results in Proposition 5 are due to the fact that the discretionary monetary policy enables the central bank to control the inflation tax for its own interest, although whether the discretionary monetary arrangement makes the central bank set the inflation rate higher than under the targeting inflation is ambiguous. If the resulting inflation tax is large enough under the discretionary monetary arrangement, this arrangement allows the fiscal authority to improve its capability of controlling the primary debt balance and public debt in the steady state so that $\Delta\bar{d} < 0$, $\Delta\bar{g} > 0$ and $\Delta\bar{\tau} < 0$. On the other hand, if the resulting inflation tax is small enough, the discretionary monetary arrangement causes the fiscal authority to reduce its capability of controlling the primary debt balance and public debt in the steady state so that $\Delta\bar{d} > 0$, $\Delta\bar{g} < 0$ and $\Delta\bar{\tau} > 0$.

We now attempt to examine the relationship between the degree of tax inefficiency and the steady state level of public debt with some additional assumptions, although this relationship is in general complex to explain all exclusive cases. From Proposition 3, recall that there exists a unique $\check{\phi}_{\mathrm{O}} \in [0,1]$ such that $\partial\bar{\pi}_{\mathrm{O}}/\partial\phi > 0$ for any $\phi \in [0, \check{\phi}_{\mathrm{O}})$ and $\partial\bar{\pi}_{\mathrm{O}}/\partial\phi < 0$ for any $\phi \in (\check{\phi}_{\mathrm{O}}, 1)$. It is assumed that $\check{\phi}_{\mathrm{O}} \in (0,1)$ is interior and that the target inflation rate is such that $\hat{\pi} \in (\max\{\bar{\pi}_{\mathrm{O}}(0), \bar{\pi}_{\mathrm{O}}(1)\}, \bar{\pi}_{\mathrm{O}}(\check{\phi}_{\mathrm{O}}))$, where $\bar{\pi}_{\mathrm{O}}(\phi)$ is the inflation rate in the steady state under the discretionary monetary policy with ϕ as given. This requires that there exist two critical values, ϕ_1 and ϕ_2, with $0 < \phi_1 < \phi_2 < 1$, such that $\Delta\bar{\pi}(\phi) \equiv \bar{\pi}_{\mathrm{O}}(\phi) - \hat{\pi} > 0$ for any $\phi \in (\phi_1, \phi_2)$ and $\Delta\bar{\pi}(\phi) \equiv \bar{\pi}_{\mathrm{O}}(\phi) - \hat{\pi} < 0$ for any $\phi \in (0, \phi_1) \cup (\phi_2, 1)$. Figure 2 illustrates the graphs of $\hat{\pi}$ and $\bar{\pi}_{\mathrm{O}}(\phi)$ on the (ϕ, π)-space, where the resulting inflation rate is higher under the discretionary monetary arrangement than the target inflation rate under the inflation targeting arrangement if $\phi \in (\phi_1, \phi_2)$, and otherwise the resulting inflation rate

is lower under the discretionary monetary arrangement. Then, by Proposition 5, we deduce the following results:

Proposition 6 *Suppose that $\check{\phi}_O \in (0,1)$ and $\hat{\pi} \in (\max\{\bar{\pi}_O(0), \bar{\pi}_O(1)\}, \bar{\pi}_O(\check{\phi}_O))$. If the degree of tax inefficiency is either large enough or small enough such that $\phi \in (0, \phi_1) \cup (\phi_2, 1)$, public debt in the steady state is larger under the discretionary monetary arrangement than under the inflation targeting arrangement, i.e., $\Delta \bar{d} > 0$. On the other hand, if the degree of tax inefficiency is neither large enough nor small enough such that $\phi \in (\phi_1, \phi_2)$, public debt in the steady state is smaller under the discretionary monetary arrangement, i.e., $\Delta \bar{d} < 0$.*

This result is highly dependent on the relation between the degree of tax inefficiency and the target inflation rate. Notice that as the target inflation is set at a lower level under the inflation targeting arrangement, the discretionary monetary arrangement is more attractive for the reduction of public debt (although it may be associated with a higher inflation rate), and the region of ϕ in which public debt in the steady state is smaller under the discretionary monetary arrangement than under the inflation targeting arrangement ($\Delta \bar{d} < 0$) becomes larger. Notice also that if the target inflation is low enough so that $\hat{\pi} < \min_{\phi \in [0,1)} \bar{\pi}_O(\phi)$, public debt in the steady state is smaller under the discretionary monetary arrangement than under the inflation targeting arrangement, i.e., $\Delta \bar{d} < 0$, for all ϕ. In contrast, if the target inflation is high enough so that $\hat{\pi} > \max_{\phi \in [0,1)} \bar{\pi}_O(\phi)$, public debt is larger under the discretionary monetary arrangement, i.e., $\Delta \bar{d} > 0$, for all ϕ.

Furthermore, by equations (12) and (21) with $M_A < M_O$, we obtain the difference in the adjustment speed for public debt stabilization:

$$h_O - h_A \equiv \frac{\sqrt{\beta^2 + 4M_O} - \sqrt{\beta^2 + 4M_A}}{2} > 0,$$

which implies the following result:

Proposition 7 *For any $\phi \in [0,1)$, the adjustment speed is faster under the discretionary monetary arrangement than under the inflation targeting arrangement, i.e., $h_O > h_A$.*

Propositions 6 and 7 provide some important implications of monetary institutions on the long-run outcome as well as the speed of adjustment. Under the discretionary monetary arrangement, the independence gives the central bank an incentive in increasing or decreasing inflation rate. This produces the positive or negative externality associated with the inflation rate for the fiscal authority, and in turn affects the fiscal authority's capability to control the primary budget balance. If the central bank sets a higher inflation rate inducing the positive externality, it would be possible for the fiscal authority to set a lower tax rate for mitigating tax distortion on output and to set a larger government expenditure toward the optimal level. On the other hand, if the central bank sets a lower inflation rate inducing the negative externality, the fiscal authority must set a higher tax rate and a smaller government expenditure. Furthermore, the discretionary monetary policy attains faster adjustment speed of public debt stabilization irrespective of the positive or negative externalities compared to the inflation targeting arrangement.

4   Conclusion

In many emerging economies, public debt has recently been a big concern in policy discussions. In this study, we examined the role of tax inefficiency associated with corruptions or weak-tax related infrastructures on public debt stabilization in emerging economies under the two polar monetary regimes: the inflation targeting and the discretionary monetary arrangements, in other words, commitment versus discretion. We incorporated tax inefficiency into the framework, developed by Tabellini (1986) and Huang and Wei (2003), to analyze the evolution of public debt and to do comparisons of these two monetary arrangements.

Our finding showed that tax inefficiency has a non-trivial impact on public debt stabilization. Irrespective of which monetary arrangement is adopted, such inefficiency increases the long-run level of public debt and reduces the adjustment speed for public debt stabilization. We also found that the discretionary monetary arrangement enhances more the adjustment speed for public debt than the inflation targeting arrangement, but which monetary arrangement is more effective in reducing the long-run level of public debt is highly dependent on the

degree of tax-related inefficiency. In particular, the discretionary monetary arrangement could induce a higher level of public debt compared to the inflation targeting arrangement when the degree of tax-related inefficiency is either small enough or large enough. In contrast, the discretionary monetary arrangement could induce a lower level of public debt when the degree of tax-related inefficiency is in the intermediate range. These results are important for policymakers since the effectiveness of public debt stabilization depends on monetary arrangements as well as tax-related inefficiency in an economy.

There would be several potential directions to further study on related issues, which could not be explained in the present paper. First, one crucial issue is on pre-commitment problem of the central bank and the fiscal authority. As in Tabellini (1986), a closed-loop equilibrium or a feedback-Nash equilibrium might be more appropriate to capture the situation where each player simultaneously move and cannot commit to a specific course of actions. Second, cooperation among policymakers would alter public debt stabilization since the central bank and the fiscal authority jointly decide some policy measures, as examined in Tabellini (1986) and van Aarle, Bovenberg, and Raith (1995). Indeed, it has been widely acknowledge that they closely cooperate with each other in various forms. In this situation, bargaining strength of the central bank should also be discussed. Third, our study does not consider how the target inflation rate is determined under the inflation targeting arrangement (see Walsh (2003) for reviews of inflation targeting). The optimal target inflation could be one crucial issue for the discussion of public debt stabilization from the perspective of socially efficient monetary arrangement. Fourth, we consider tax inefficiency as exogenously given and does not carefully take into account any causes of tax inefficiency associated with corruption and weak tax-related infrastructures (see, e.g., Shleifer and Vishny (1993) and Bardhan (1997)). In a real world, the government's effort to fight corruption and to improve the fiscal capability is so common in most emerging economies that tax inefficiency itself could be endogenous, as in Huang and Wei (2003).

Although we admit the above mentioned problems, we believe, to our best knowledge, that our analysis would be a first attempt to assess the dynamic relationship among tax

inefficiency, public debt stabilization, and monetary policy arrangements. We are hopeful that our findings could clarify some important policy implications in managing public debt. Furthermore, one of our aims is to inspire future researches for investigation of various issues in emerging economies.

5 Appendix

Proof of Proposition 1 Differentiating M_A with respect to ϕ yields $\frac{\partial M_A}{\partial \phi} = \frac{2(\phi-1)}{\alpha^2 \lambda} < 0$ for any ϕ. This immediately yields $\frac{\partial \bar{d}_A}{\partial \phi} > 0$ and $\frac{\partial \bar{g}_A}{\partial \phi} < 0$ since it is assumed that $\hat{g} - \hat{\pi} > 0$ and $\beta > r$. Differentiating $\bar{\tau}_A$ and $\bar{y}_A$ with respect to ϕ yields:

$$\frac{\partial \bar{\tau}_A}{\partial \phi} = -\frac{1}{\alpha}\frac{\partial \bar{y}_A}{\partial \phi} = -\frac{\hat{g} - \hat{\pi}}{\alpha^2 \lambda M_A^2}\left[\frac{1}{\delta_A} - (\beta - r)r - \frac{(1-\phi)^2}{\alpha^2 \lambda}\right].$$

Since it is assumed that $M_A > 0$ for all ϕ, there exists a unique value $\tilde{\phi}_A \in [0,1]$ such that $\frac{\partial \bar{\tau}_A}{\partial \phi} > 0$ for $\phi \in [0, \tilde{\phi}_A)$ and $\frac{\partial \bar{\tau}_A}{\partial \phi} < 0$ for $\phi \in (\tilde{\phi}_A, 1)$. Solving $\frac{\partial \bar{\tau}_A}{\partial \phi} = 0$ yields $\tilde{\phi}_A = 1 - \alpha[\lambda\{\frac{1}{\delta_F} - (\beta - r)r\}]^{1/2}$ if it is interior. □

Proof of Proposition 2 The negative value of the speed of the adjustment $-h_A$ is a negative root of the characteristic equation $k^2 - \beta k - M_A = 0$. Solving the above quadratic equation yields equation (12). Since $\frac{\partial M_A}{\partial \phi} < 0$, we obtain $\frac{\partial h_A}{\partial \phi} < 0$, which is the desired result. □

Proof of Proposition 3 Differentiating M_O with respect to ϕ yields $\frac{\partial M_O}{\partial \phi} = \frac{2(\phi-1)}{\alpha^2 \lambda} - \frac{1}{\mu_C} < 0$ for any ϕ. This immediately yields $\frac{\partial \bar{d}_O}{\partial \phi} > 0$ and $\frac{\partial \bar{g}_O}{\partial \phi} < 0$ since it is assumed that $\beta > r$. Differentiating $\bar{\tau}_O$ and $\bar{y}_O$ with respect to ϕ yields:

$$\frac{\partial \bar{\tau}_O}{\partial \phi} = -\frac{1}{\alpha}\frac{\partial \bar{y}_O}{\partial \phi} = -\frac{\hat{g}}{\alpha^2 \lambda M_O^2}\left[\frac{1}{\delta_A} + \frac{1}{\mu_O} - (\beta - r)r - \frac{(1-\phi)^2}{\alpha^2 \lambda}\right].$$

Since it is assumed that $M_O > 0$ for all ϕ, there exists a unique value $\tilde{\phi}_O \in [0,1]$ such that $\frac{\partial \bar{\tau}_O}{\partial \phi} > 0$ for $\phi \in [0, \tilde{\phi}_O)$ and $\frac{\partial \bar{\tau}_O}{\partial \phi} < 0$ for $\phi \in (\tilde{\phi}_O, 1)$. Solving $\frac{\partial \bar{\tau}_O}{\partial \phi} = 0$ yields $\tilde{\phi}_O = 1 - \alpha[\lambda\{\frac{1}{\delta_F} + \frac{1}{\mu_O} - (\beta - r)r\}]^{1/2}$ if it is interior. For the impact of ϕ on inflation in the steady

state, differentiating $\bar{\pi}_{\mathrm{O}}$ yields:

$$\frac{\partial \bar{\pi}_{\mathrm{O}}}{\partial \phi} = -\frac{\hat{g}}{\mu_{\mathrm{C}} M_{\mathrm{O}}^2} \left[\frac{1}{\delta_{\mathrm{A}}} - (\beta - r)r - \frac{(1-\phi)(3-\phi)}{\alpha^2 \lambda} \right].$$

Since it is assumed that $M_{\mathrm{A}} > 0$ for all ϕ, there exists a unique value $\check{\phi}_{\mathrm{O}} \in [0,1]$ such that $\frac{\partial \bar{\pi}_{\mathrm{O}}}{\partial \phi} > 0$ for $\phi \in [0, \check{\phi}_{\mathrm{O}})$ and $\frac{\partial \bar{\pi}_{\mathrm{O}}}{\partial \phi} < 0$ for $\phi \in (\check{\phi}_{\mathrm{O}}, 1)$. The critical value of $\check{\phi}_{\mathrm{O}}$ is a smaller root of the equation $\frac{(1-\check{\phi}_{\mathrm{O}})(3-\check{\phi}_{\mathrm{O}})}{\alpha^2 \lambda} + (\beta - r)r = \frac{1}{\delta_{\mathrm{F}}}$, if it is interior. $\square$

References

ALESINA, A., AND G. TABELLINI (1987): "Rules and Discretion with Noncoordinated Monetary and Fiscal Policies," *Economic Inquiry*, 25, 619–630.

BARDHAN, P. (1997): "Corruption and Development," *Journal of Economic Literature*, 35, 1320–1346.

BARRO, R., AND D. GORDON (1983): "Rules, Discretion, and Reputation in a Model of Monetary Policy," *Journal of Monetary Economics*, 12, 101–122.

BEETSMA, R., AND L. BOVENBERG (1997): "Central Bank Independence and Public Debt Policy," *Journal of Economic Dynamics and Control*, 21, 873–894.

——— (1999): "Does Monetary Unification Lead to Excessive Debt Accumulation?," *Journal of Public Economics*, 74, 299–325.

BERNANKE, B. S., AND F. S. MISHKIN (1997): "Inflation Targeting: A New Framework for Monetary Policy?," *Journal of Economic Perspectives*, 11, 653–684.

BLANCHARD, O. J. (1985): "Debt, Deficits and Finite Horizon," *Journal of Political Economy*, 93, 233–247.

DIXIT, A., AND L. LAMBERTINI (2001): "Monetary-Fiscal Policy Interactions and Commitment versus Discretion in a Monetary Union," *European Economic Review*, 45, 977–987.

——— (2003): "Interactions of Commitment and Discretion in Monetary and Fiscal Policies," *American Economic Review*, 93, 1522–1542.

EICHENGREEN, B., P. MASSON, M. SAVASTANO, AND S. SHARMA (1999): "Transition Strategies and Nominal Anchors on the Road to Greater Exchange-Rate Flexibility," *Princeton Essays in International Finance*, No. 213.

HAQUE, N. U., AND R. SAHAY (1996): "Do Government Wage Cuts Close Budget Deficits? Costs of Corruption," *International Monetary Fund Staff Papers*, 43, 745–778.

HAWKINS, J. (2005): "Globalisation and Monetary Operation in Emerging Economies," *Bank for International Settlements*, BIS Papers No. 23, 59–80.

HINDRICK, J., M. KEEN, AND A. MUTHOO (1999): "Corruption, Extortion and Evasion," *Journal of Public Economics*, 74, 395–430.

HUANG, H., AND S.-J. WEI (2003): "Monetary Policies for Developing Countries: The Role of Corruption," *NBER Working Paper Series*, 10093.

——— (2005): "Monetary Policies for Developing Countries: The Role of Institutional Quality," *CEPR Discussion Paper*, No. 4911.

IMF (2003): "Public Debt in Emerging Economies: Is It Too High?," *World Economic Outlook 2003*.

JENSEN, H. (1994): "Loss of Monetary Discretion in a Simple Dynamic Policy Game," *Journal of Economic Dynamics and Control*, 18, 763–779.

KYDLAND, F., AND E. PRESCOTT (1977): "Rules rather than Discretion: The Inconsistency of Optimal Plans," *Journal of Political Economy*, 85, 473–491.

LAMBERTINI, L. (2006): "Monetary-Fiscal Interactions with a Conservative Central Bank," *Scottish Journal of Political Economy*, 53, 90–128.

MARTINEZ-VAZQUEZ, J., F. J. ARZE, AND J. BOEX (2004): "Corruption, Fiscal Policy, and Fiscal Management," *Working Papers fr1003, Development Alternatives, Inc., Fiscal Reform in Support of Trade Liberalization Project.*

MCKINNON, R. I. (1993): "The Rules of the Game: International Money in Historical Perspective," *Journal of Economic Literature*, 31, 1–44.

MIHALJEK, D., AND B. TISSOT (2003): "Rules and Discretion with Noncoordinated Monetary and Fiscal Policies," *BIS Paper*, No. 20, 10–37.

PETIT, M. (1989): "Fiscal and Monetary Policy Co-ordination: a Differential Game Approach," *Journal of Applied Econometrics*, 4, 161–179.

SARGENT, T., AND N. WALLACE (1981): "Some Unpleasant Monetarist Arithmetic," *Federal Reserve Bank of Minneapolis Quarterly Review*, 5, 1–17.

SHLEIFER, A., AND R. W. VISHNY (1993): "Corruption," *Quarterly Journal of Economics*, 108, 599–617.

SVENSSON, L. (1997a): "Inflation Forecast Targeting: Implementing and Monitoring Inflation Targets," *European Economic Review*, 93, 1111–1146.

——— (1997b): "Optimal Inflation Targets, 'Conservative' Central Banks, and Linear Inflation Contracts," *American Economic Review*, 87, 98–114.

——— (1999): "Inflation Targeting as a Monetary Policy Rule," *Journal of Monetary Economics*, 43, 607–654.

TABELLINI, G. (1986): "Money, Debt and Deficits in A Dynamic Game," *Journal of Economic Dynamics and Control*, 10, 427–442.

VAN AARLE, B., L. BOVENBERG, AND M. RAITH (1995): "Monetary and Fiscal Policy Interaction and Government Debt Stabilization," *Journal of Economics*, 62, 111–140.

WALSH, C. E. (1995): "Optimal Contracts for Central Bankers," *American Economic Review*, 85, 150–167.

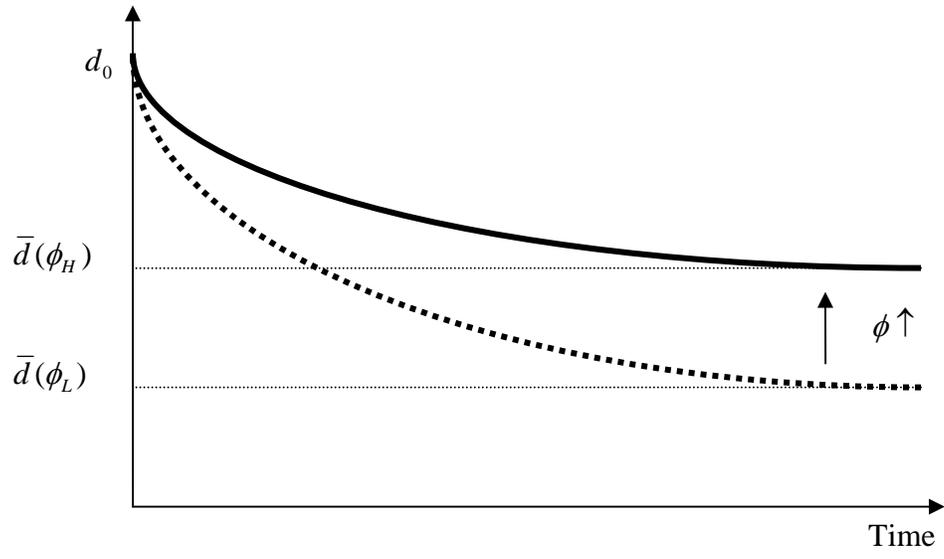——— (2003): *Monetary Theory and Policy.* The MIT Press, Cambridge, Massachusetts.

Figure 1

Figure 2