# Optimal Fiscal and Monetary Policy in a Growing Economy with Imperfect Competition

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**Abstract**

We show, in a transactions-based monetary endogenous growth model with imperfect competition, that both money and income tax are beneficial to long-run economic growth if the monopoly power in the product market is sufficiently strong. Since the threshold value for the degree of imperfect competition that allows for a positive growth effect of income tax is higher than that in the case of money growth, a positive relationship between money and growth is easier to be found than in the case of income taxation. We also show that, although imperfect competition and transactions cost interact, there is a clear division of government policy in correcting distortions present in the economy. The optimal policy has the feature that the Friedman rule holds continuously, the seigniorage is time varying, and income taxes are smooth over time. All the qualitative results are robust to the endogeneity of labor supply.

*Keywords*: Optimal Fiscal and Monetary Policy, Imperfect Competition, Endogenous Growth.

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## 1 Introduction

Can monetary and fiscal policy affect the economy's growth rate? How should monetary and fiscal policy be set? These are two of the long-standing questions in macroeconomics that constantly face policy-makers. Since the seminal works of Romer (1986) and Lucas (1988), an extensive amount of literature has used endogenous growth models to address the first question under the assumption of *perfect competition*. In general, it is agreed that factor income taxes induce decreases in the economic growth rate and that whether or not consumption tax is distorting depends on whether or not labor supply is endogenous.[1] Besides, money is found to be growth rate-retarding unless monetary policy has an inter-generational redistribution effect or the agents pursue a wealth-enhanced social status.[2] The second question has also been extensively studied since the classical contribution of Friedman (1969), which proposed a simple policy rule that the nominal interest rate should be set at zero. Specifically, given that money is costless to produce, Pareto optimality requires a zero nominal interest rate such that social and private costs of money holdings coincide. Recent studies based on dynamic general equilibrium models with infinite horizons and *perfect competition* also find the Friedman rule and stable distortionary income taxes to be optimal in alternative monetary models, both deterministic and stochastic (see, for example, Lucas and Stokey (1983), Kimbrough (1986a,b), Chari, et al. (1991), Guidotti and Végh (1993), Correia and Teles (1996), and Chari, et al. (1996)).[3]

The primary objective of this paper is to revisit the above two questions in a context of *imperfect competition*, in an attempt to examine whether or not the answers will change when market structure is taken into consideration. In the literature, Fukuda (1996) and Shaw, et al. (2006) are by far the only two studies that attempts to answer the first question within an imperfectly competitive environment. However, in Fukuda (1996), the role of imperfect competition is not clearly explored in his work; although a positive growth effect of money is found to be possible, it has nothing to do with monopoly power but is rather caused by a social technology that displays strong increasing returns in labor. Shaw, et al. (2006) investigate

[1] See King and Rebelo (1990), Rebelo (1991), Bond and Wang (1996), and Turnovsky (2000), among many others.

[2] See, for example, Marquis and Reffett (1991), Gomme (1993), van der Ploeg and Alogoskoufis (1994), Mino and Shibata (1995), Gong and Zou (2001), and Jha, et al. (2002).

[3] Although the Friedman rule is almost always optimal in models with an infinitely-lived representative agent, it is not necessarily optimal in overlapping generations models (Weiss, 1980; Freeman, 1993; Smith, 2002). Bhattacharya, et al. (2005) point out that this result stems from the inter-generational transfers that occur in overlapping generations models.

the regime of pure interest rate pegging. It is shown that the long-run relationship between the rates of nominal interest and economic growth is unambiguously negative, regardless of the degree of imperfect competition.

Studies related to the second question include Khan, et al. (2003), Schmitt-Grohé and Uribe (2004a,b), Siu (2004), and Shaw, et al. (2006), among which Khan, et al. (2003), Schmitt-Grohé and Uribe (2004a), and Siu (2004) all point out that price stickiness induces deviation from the Friedman rule. Schmitt-Grohé and Uribe (2004b) show in a flexible-prices context that the nominal interest rate can be used as an indirect tax on monopoly profits and hence it is optimal to deviate from the Friedman rule by setting a time-varying nominal interest rate. Siu (2004) explains this non-optimality result of the Friedman rule as stemming from the assumption that monopoly profits are not taxed. Shaw, et al. (2006) then turn the story to an endogenous growth setting. In essence, Shaw, et al.'s (2006) model is an extension of Siu's (2004) model in that they introduce capital accumulation but confine their analysis to the flexible-prices case only. They show that the (non-)optimality of the Friedman rule crucially depends on whether or not there are capital externalities. In particular, when capital generates productive externalities, it is optimal to tax holdings of money in order to eliminate the wedge between returns to money and capital. If capital externalities are absent, then the Friedman rule holds even under imperfect competition.

The model we construct here is close to that of Schmitt-Grohé and Uribe (2004b) and Shaw, et al. (2006). Specifically, we consider unceasing economic growth driven by capital externalities as in Shaw, et al. (2006), imperfect competition in the final-goods sector as in Schmitt-Grohée and Uribe (2004b), and flexible prices. However, our model differs from theirs in that we assume that money facilitates transactions of *output*. As we will see later, this specification provides a new and valuable insight into the effect of money on the equilibrium gross markup of prices over marginal cost. To be specific, in an economy where money facilitates transactions of output, money distorts the real-side economy by affecting the equilibrium gross markup, thus causing the economy to have a higher equilibrium gross markup and a lower capital rental rate. This effect is absent in all other monetary models. Its implications are twofold. The first concerns the growth rate effects of fiscal and monetary policy. In particular, we find that when monopoly power is weak (including the case of perfect competition), both money and income tax are harmful to economic growth. This result is consistent with that found in most of the existing literature based on perfect competition. Nevertheless, we show that as firms gain sufficient monopoly power, both money and income tax become beneficial to the economy's long-run growth. This result is worth noticing in that existing theoretical works that obtain a positive growth rate effect of money are founded on either the inter-generational redistribution effect in overlapping generations models or the wealth effect caused by the pursuit of social status. This paper provides a brand new channel for generating a positive growth rate effect of money. In the existing empirical literature, although many authors, such as Kormendi and Meguire (1985), Roubini and Sala-i-Martin (1992), De Gregorio (1993), and Barro (1995), find evidence of a negative relationship between inflation and economic growth, Levin and Renelt (1992), Levin and Zervos (1993), and Clark (1997) show that the empirical linkages between long-run economic growth and monetary-policy indicators are fragile to small alterations in the conditional information set. Moreover, Gomme (1993) even lists the inflation-real growth rate correlations of 82 countries from 1949 to 1989, 62 of which exhibit a negative correlation and the remainder of which exhibit a positive correlation. Bullard and Keating (1995) even find a positive relationship. This paper's finding may provide a new direction for future empirical studies. Moreover, we show that the threshold value for the degree of imperfect competition that allows for a positive growth effect of income tax is higher than that in the case of money growth. This finding may act as a theoretical explanation to why a positive relationship between money (inflation) and growth is easier to be found than in the case of income taxation in empirical works.

As for the second implication, this has to do with the optimal public policy. To be specific, as money distorts the real-side economy by affecting the equilibrium gross markup, the optimal monetary policy requires the monetary authority to supply a sufficient amount of money so as to reduce the transaction costs and the equilibrium gross markup to their minimum values. In so doing it can remove distortions created by money. In addition, the large amount of money pushes the marginal benefit from money holdings to zero. Because in equilibrium the marginal benefit from and cost of money holdings must coincide, where the latter is the nominal interest rate, the zero marginal benefit from money thus implies the validation of the Friedman rule. Thus, our result supports Siu's (2004) argument that as long as prices are flexible, the Friedman rule must be optimal, even in our model where capital generates productive externality. In contrast to Shaw, et al. (2006), we find that the wedge between real returns to capital and money, which is driven by capital externalities, is eliminated by an income subsidy, rather than a tax on money holdings as in Shaw, et al. (2006). This causes the optimal income subsidy rate to be bigger than that of Guo and Lansing (1999). It should be noted that subsidizing capitalists is equivalent to subsidizing investment, and hence it can promote production activities and economic growth. It is straightforward to show that when capital externalities are absent, we recover Guo and Lansing's (1999) result that factor taxes help to correct the monopoly inefficiency only. This finding shows that Guo and Lansing's (1999) result is robust for this monetary endogenous growth model with market power in the final-goods sector.[4] Finally, to sustain the Friedman rule and stable tax on income, the monetary authority must adjust its money growth rate to changes in economic conditions. Therefore, the optimal seigniorage will be time varying in transition. By contrast, in the steady state, since every thing has settled down, the optimal seigniorage will be a constant and will involve a subsidy so as to induce a larger holding of money balances by the private agents.

To sum up, we show that, although imperfect competition and transactions cost interact, the optimal policy mix turns out to be simple and easily understood by the public. To be specific, we find a clear division of government policy in correcting distortions that are present within the economy. Fiscal policy is responsible for distortions from the production side, including monopolistic distortions and capital externalities. Monetary policy, on the other hand, is responsible for distortions created by money itself, through affecting the gross markup.

The remainder of this paper is organized as follows. Section 2 develops a monetary endogenous growth model with monopoly power in the final-goods sector. Section 3 investigate the growth rate effects of fiscal and monetary policies. Section 4 obtains the optimal fiscal and monetary policy. Section 5 concludes.

## 2 The Economy

Our description of the model closely follows that of Dupor (2001).[5] The economy is populated by a continuum of identical household-firms, a government, and a central bank. Each household-firm's preferences can be described by the lifetime utility function

$$U = \int_0^\infty \ln c_t e^{-\rho t} dt, \tag{1}$$

where $c_t$ is consumption, and $\rho \in (0, 1)$ is the rate of time preference.

[4] Guo and Lansing (1999) perform their analysis within a real model with an imperfectly competitive intermediate-goods market.

[5] For an alternative way of describing the model, please see, for example, Benhabib, et al. (2001) and Schmitt-Grohé and Uribe (2004a,b); all will lead to the same result.

The consumption good $c_t$ is a composite good made of a continuum of differentiated goods. Each household-firm is the monopolistic producer of one variety using the production technology

$$y_t^s = A_t \hat{k}_t^{\alpha}, \quad \alpha \in (0,1), \tag{2}$$

where $y_t^s$ is output, $\hat{k}_t$ is capital hired by the household-firm, and $A_t$ represents productive externalities that are taken as given by the firm. Following van der Ploeg and Alogoskoufis (1994) and Barro and Sala-i-Martin (1995) and to allow for a balanced growth path, we specify that the externality takes the form: $A_t = \eta \overline{k}_t^{1-\alpha}$, where $\overline{k}_t$ is the average economic-wide stock of capital and $\eta > 0$ is a parameter.

Assume that the household's preferences over the differentiated goods is of the CES form. Then, we can derive that the demand for one differentiated good, $y_t^d$, is as follows:[6]

$$y_t^d = Y_t^d d(\frac{P_t}{\overline{P}_t}), \tag{3}$$

where $P_t$ is the price that the firm charges for its good, $\overline{P}_t$ is the aggregate price level, and $Y_t^d$ is the level of aggregate-demand for output. The function $d(\cdot)$ is assumed to be twice continuously differentiable, to be decreasing, and to satisfy $d(1) = 1$ and $d'(1) < -1$,[7] where $d'(1)$ denotes the equilibrium price elasticity of the demand function faced by the individual firm and thus indexes the degree of monopolistic distortion in the economy. When $d'(1) \to \infty$, the demand function becomes perfectly elastic and the product market becomes perfectly competitive. For notational convenience, we let $\sigma \equiv -d'(1)$, which represents the elasticity of substitution between any two differentiated goods. It follows that a higher value of $\sigma$ represents a lower degree of monopolistic distortion.

Given the price that the firm charges for the good it produces, its sales are demand-determined and are equal to

$$A_t \hat{k}_t^{\alpha} = Y_t^d d(\frac{P_t}{\overline{P}_t}). \tag{4}$$

The household-firm faces the following capital accumulation constraint:

$$\dot{k}_t = i_t - \delta k_t, \quad k_0 > 0 \text{ given}, \tag{5}$$

[6] The mathematical derivation is available upon request.

[7] The restrictions on $d(1)$ and $d'(1)$ are necessary for the existence of a symmetric equilibrium; see Schmitt-Grohé and Uribe (2004a,b).

where $i_t$ denotes investment and $\delta \in [0, 1]$ is the capital depreciation rate.

The household holds nominal money balances $M_t$ to facilitate transactions of output. Let us denote $m_t \equiv M_t/\overline{P}_t$ as real money balances and $s_t \equiv m_t/y_t^s$ as the real money balances-output ratio, where the latter is the inverse of the output velocity of money. Following Kimbrough (1986a,b), Correia and Teles (1996), Zhang (2000), Jha, et al. (2002), and Schmitt-Grohé and Uribe, (2004a,b), among others, and to allow for a balanced growth path, the transactions cost technology is summarized by a rate of loss in real output as follows:

$$\phi_t = \phi(s_t), \tag{6}$$

where $\phi(\cdot)$ is assumed to be twice continuously differentiable and to satisfy $\phi_t' < 0$, $\phi_t'' \geq 0$, $\lim_{s_t \to 0} \phi_t = 1$, $\lim_{s_t \to \overline{s}} \phi_t = \overline{\phi} \in (0, 1)$, and $\phi'(\overline{s}) = 0$, where we refer to $\overline{s}$ as the satiation level of money. The assumption of the existence of $\overline{s}$ is to ensure that the Friedman rule need not be associated with an infinite demand for money.

The household also holds nominal government bonds $B_t$ that pay the nominal interest rate $R_t$. Let $a_t \equiv m_t + b_t$ denote the household's real financial wealth, where $b_t \equiv B_t/\overline{P}_t$ represents real government bonds. Then, the household-firm's flow budget constraint is described by:

$$\dot{a}_t = \frac{P_t}{\overline{P}_t}(1 - \phi_t)y_t^s - r_{kt}\hat{k}_t + r_{kt}k_t - c_t - i_t + (R_t - \pi_t)a_t - R_t m_t - T_t, \;\; a_0 > 0 \text{ given}, \tag{7}$$

where $r_{kt}$ is the capital rental rate, $\pi_t$ is the inflation rate, and $T_t$ represents the household's real tax bill which is given by

$$T_t = \tau_{yt}[\frac{P_t}{\overline{P}_t}(1 - \phi_t)y_t^s - r_{kt}\hat{k}_t + r_{kt}k_t] + \tau_t, \tag{8}$$

where $\tau_{yt}$ is the income tax rate and $\tau_t$ is lump-sum taxes.

The household-firm's objective is to choose a sequence $\{c_t, m_t, a_t, i_t, k_t, \hat{k}_t, P_t\}_{t=0}^{\infty}$ so as to maximize (1) subject to (4)-(8), taking as given $a_0$, $P_0$, and the time paths of $\tau_{yt}$, $\tau_t$, $R_t$, $\pi_t$, $Y_t^d$, $r_{kt}$, and $\overline{P}_t$.

Assume that the central bank keeps the nominal money balances growing at a constant rate $\mu$. The nominal money supply thus evolves through time according to

$$M_t = M_0 e^{\mu t}, \;\; M_0 > 0 \text{ given}. \tag{9}$$

The government issues bonds and borrows from the central bank to finance its deficits. The flow budget constraint of the government is thus given by

$$\dot{M}_t + \dot{B}_t = R_t B_t - \overline{P}_t T_t. \tag{10}$$

In what follows, we focus our attention on symmetric equilibria where $k_t = \hat{k}_t = \overline{k}_t$, $P_t = \overline{P}_t$, and $y_t^s = y_t^d = y_t$. Then, from (5), (7), (10), and the first-order necessary conditions for the household-firm's optimization, we can derive the following symmetric equilibrium conditions:

$$\begin{aligned}
\dot{k}_t &= (1-\phi_t)y_t - c_t - \delta k_t, && (11)\\
R_t &= -(1-\tau_{yt})\phi_t', && (12)\\
(1-\tau_{yt})r_{kt} - \delta &= R_t - \pi_t, && (13)\\
r_{kt} &= [(1-\phi_t)(\sigma-1)/\sigma + \phi' s_t]\alpha y_t/k_t, && (14)\\
\dot{c}_t/c_t &= R_t - \pi_t - \rho, && (15)\\
\dot{m}_t/m_t &= \mu - \pi_t, && (16)\\
y_t &= \eta k_t. && (17)
\end{aligned}$$

Equation (11) is the resource constraint. Equation (12) states that the nominal interest rate equals the marginal benefit from holding real money balances. Equation (13) is the Fischer equation. Equation (14) indicates that the capital rental rate equals the marginal product of capital, $MPK_t = \alpha y_t/k_t$, divided by the equilibrium gross mark-up, $G_t \equiv [(1-\phi_t)(\sigma-1)/\sigma + \phi_t' s_t]^{-1}$. Equation (15) is the standard Keynes-Ramsey consumption rule. Equation (16) holds when the money market clears. Equation (17) is the aggregate production function.

We would like to engage in some discussion on (14) because it lays out some important insights for a monetary economy. Specifically, in real models such as Benhabib, et al. (2001), Dupor (2001), and Schmitt-Grohé and Uribe (2004a,b), the equilibrium gross mark-up of prices over marginal cost equals $[(\sigma-1)/\sigma]^{-1} > 1$ . It is clear that in this monetary economy where money facilitates transactions of output, the equilibrium gross mark-up depends *not only* on the degree of market imperfection (which is captured by $\sigma$), *but also* on the real balances-output ratio $s_t$. Moreover, the functional form of $G_t$ clearly discloses that imperfect competition ($\sigma$) and transactions cost ($\phi$) interact. Since $[(1-\phi_t)(\sigma-1)/\sigma + \phi_t' s_t]^{-1} > [(\sigma-1)/\sigma]^{-1}$, we immediately have:

**Proposition 1:** *In an economy where money facilitates transactions of output, money distorts the real-side economy by affecting the equilibrium gross markup, causing the economy to have a higher equilibrium gross markup and a lower capital rental rate.*

Furthermore, it is easy to obtain that an increase in the degree of market imperfection ($\sigma$ falls) raises the equilibrium mark-up and reduces the capital rental rate. On the other hand, the real balances-output ratio affects the equilibrium mark-up and the capital rental rate with ambiguous signs. To see this, let us differentiate $G_t$ with respect to $s_t$ and obtain

$$\frac{dG_t}{ds_t} = \frac{\phi_t'' s_t}{G_t^2}\left(\frac{1}{\sigma\varsigma} - 1\right) \gtrless 0, \text{ if } \sigma \lessgtr \frac{1}{\varsigma}, \tag{18}$$

where $\varsigma \equiv |d \ln R_t / d \ln s_t|$ denotes the elasticity of the nominal interest rate with respect to the real money balances-output ratio. Equation (18) reveals that in an economy where the degree of imperfect competition is relatively high/low, an increase in the real balances-output ratio will raise/lower the equilibrium gross mark-up. The reasoning behind this is as follows. A simple derivation gives the net marginal product of capital as $(1 - \phi_t + \phi_t' s_t)\alpha\eta$, which is increasing in the real balances-output ratio. Thus, in response to an increase in the real balances-output ratio, the firms will increase their demand for capital so as to produce more and earn more profits. This will in turn raise the capital rental rate. On the other hand, an increase in the real balances-output ratio will also induce the household to invest more today so that it can harvest the high returns in the future. This expands the supply of capital, thus lowering the capital rental rate. If the firms are characterized by high degrees of monopoly power, the increased demand for capital will be relatively small, and thus the equilibrium capital rental rate will fall. Given that the marginal product of capital is fixed (at $\alpha\eta$), the equilibrium gross mark-up will rise accordingly. Similarly, we can infer that if the firms' monopoly power is weak, then an increase in the real balances-output ratio will result in a lower equilibrium gross mark-up by raising the equilibrium capital rental rate.

# 3 Balanced Growth Path

We focus on the economy's balanced growth path (BGP) along which output, consumption, capital, real money balances, and real government bonds exhibit a common, positive constant growth rate denoted by $\theta$. Let $z_t \equiv c_t/k_t$ be the consumption-capital ratio. With this transformation, the model's symmetric equilibrium conditions (11)-(17) can be expressed as an autonomous pair of differential equations

$$\dot{z}_t = \{z_t - [1 - \phi(s_t) - \alpha(1 - \tau_{yt})/G(s_t)]\eta - \rho\}z_t, \tag{19}$$

$$\dot{s}_t = [\mu + (1-\tau_{yt})\phi'(s_t) + \dot{z}_t/z_t + \rho]s_t, \tag{20}$$

where $G(s_t) \equiv \frac{1}{(1-\phi_t)(\sigma-1)/\sigma+\phi_t' s_t}$ is the equilibrium gross mark-up of prices over marginal cost.

Given the above dynamical system (19) and (20), the BGP equilibrium is characterized by a pair of positive real numbers $(z^*, s^*)$ that satisfy $\dot{z}_t = \dot{s}_t = 0$. It is apparent that the steady-state solutions $z^*$ and $s^*$ are solved recursively. Specifically, from (20) we first solve $s^*$, which satisfies the following equation:

$$-(1-\tau_{yt})\phi'(s^*) = \mu + \rho \tag{21}$$

where the left-hand side is the marginal benefit of holding money balances, which equals the nominal interest rate in equilibrium. Given that the transactions cost technology is smooth, $s^*$ is unique. Then, we can obtain from (19) the expression of $z^*$ as

$$z^* = [1-\phi(s^*) - \alpha(1-\tau_{yt})/G(s^*)]\eta + \rho, \tag{22}$$

where $G(s^*) \equiv \frac{1}{(1-\phi)(\sigma-1)/\sigma+\phi' s^*} > 1$. It is clear that $z^*$ also uniquely exists. With (21) and (22), it follows that the common (positive) rate of economic growth $\theta$ is

$$\theta = \frac{(1-\tau_{yt})\alpha\eta}{G(s^*)} - \delta - \rho \;\text{ or }\; [1-\phi(s^*)]\eta - z^* - \delta, \tag{23}$$

which is also unique. Equations (21), (22), and (23) reveals that this economy has a unique BGP equilibrium. It can be further demonstrated that this unique BGP displays saddle-path stability and equilibrium uniqueness.

We are interested in how money growth and income tax will affect the economy's long-run growth rate when there is monopoly power in the product market. By taking total differentiation on (21), (22), and (23), we find that the growth effect of money (or inflation) and income tax are given by

$$\frac{d\theta}{d\mu} = -\alpha\eta s^*(1-\frac{1}{\sigma\varsigma}) \gtrless 0, \text{ if } \sigma \lessgtr \frac{1}{\varsigma}, \tag{24}$$

$$\frac{d\theta}{d\tau_{yt}} = -\frac{\alpha\eta}{G(s^*)} + \alpha\eta s^*(1-\frac{1}{\sigma\varsigma})\phi' \gtrless 0, \text{ if } \sigma \lessgtr 1 - \frac{\phi' s^*}{\varsigma(1-\phi)} < \frac{1}{\varsigma}. \tag{25}$$

As is clearly shown, both money and income tax have ambiguous effects on the long-run economic growth rate and the degree of imperfect competition ($\sigma$) plays a crucial role. Specifically, first notice from (24) and (25) that when the product market exhibits perfect competition

($\sigma \to \infty$), both money and income tax damage the economy's long-run growth rate ($\frac{d\theta}{d\mu} < 0$ and $\frac{d\theta}{d\tau_{yt}} < 0$). This is a standard result found in the literature with a perfectly competitive environment (see King and Rebelo (1990), Marquis and Reffett (1991), Rebelo (1991), Gomme (1993), Mino and Shibata (1995), Bond and Wang (1996), Turnovsky (2000), Jha, et al. (2002), among many others). The negative relationships between the economic growth rate and money and income tax remain true if the firms have low degrees of monopoly power. However, as monopoly power becomes strong, both money and income tax will be beneficial to the economy's long-run growth. Thus, we have:

**Proposition 2:** *Money and income tax represses long-run economic growth when the degree of monopolistic distortion is low. However, as the firms acquire sufficiently strong monopoly power, both money and income tax are beneficial to long-run economic growth.*

Let us explain the case of monetary policy first. An increase in the money growth rate causes high inflation, which constitutes a high nominal interest rate. Since the nominal interest rate is the opportunity cost of holding money balances, the households will reduce their money holdings, which will lead to a low real balances-output ratio. By referring to (18), we know that when the degree of imperfect competition is low, the gross mark-up will rise in response. This will in turn reduce the net rate of return on capital, and will hence discourage investment. As a result, economic growth will be retarded. Similarly, we can infer that when the degree of imperfect competition is high, an increase in the money growth rate will eventually raise the long-run economic growth rate.

Next, we turn to the case of income taxation. Note from (23) that there are two channels through which income tax affects the economic growth rate. The first channel (a *direct* one) is that through which the after-tax net rate of return on capital is reduced, given that the gross mark-up is unchanged. Its effect is to discourage investment and it thus represses economic growth (this effect is captured by the first term appearing on the right-hand side of (25)). The second channel (an *indirect* one) is that through which the equilibrium gross mark-up is affected. Specifically, an increase in the income tax rate will reduce the marginal benefit of holding money balances ($-(1-\tau_{yt})\phi'(s^*)$). This will in turn discourage the household's willingness to hold money balances, which will give rise to a lower real balances-output ratio. By following the same logic in terms of explaining the effect of the money growth, we know that the subsequent effect (on the gross mark-up, on investment, and hence on economic growth) can be in the opposite direction, depending on the strength of the monopoly power (this effect is captured by the second term appearing on the right-hand side of (25)). Thus, as shown in (25), the threshold value for the degree of imperfect competition that allows for a positive growth effect of income tax will be higher than that in the case of money growth. We conjecture that this is the reason why a positive relationship between money (inflation) and growth is easier to be found than in the case of income taxation in empirical works.

## 4 Optimal Fiscal and Monetary Policy

In the previous section we have explored the growth effect of money and income tax. This section goes a step further in investigating the optimal fiscal and monetary policy in the presence of monopoly power. Let us consider the extent to which the policy-makers in the decentralized economy are able to set the money growth rate and the income tax rate so that the equilibrium in that economy replicates the first-best outcome obtained by the central planner. The policy is reported in the following proposition:

**Proposition 3:** *The first-best policy is*

$$\begin{aligned}\tau_{yt}^{1st} &= -\frac{(1-\alpha)\sigma+\alpha}{\alpha(\sigma-1)} < 0, \forall t,\\ \mu_t^{1st} &= -z_{pt}, \forall t, \text{ and } \mu_t^{1st} = -\rho < 0, \text{ in the steady state,}\\ R_t^{1st} &= 0, \forall t.\end{aligned}$$

**Proof:** The planner's objective is to choose a sequence $\{c_{pt}, m_{pt}, k_{pt}\}_{t=0}^{\infty}$ so as to maximize the household's lifetime utility function (1) subject to the resource constraint (11) and the aggregate production function (17). From the first-order conditions we derive $\phi'(s_{pt}) = 0$ and $\dot{c}_{pt}/c_{pt} = (1-\phi)\eta - \delta - \rho$. $\phi'(s_{pt}) = 0$ implies that at any point in time $s_{pt}$ is a constant (at $\overline{s}$), which implies that $\dot{m}_{pt}/m_{pt} = \dot{y}_{pt}/y_{pt} = \dot{k}_{pt}/k_{pt} = (1-\overline{\phi})\eta - z_{pt} - \delta$. By comparing the above equations with their competitive-equilibrium counterparts, we can then derive the above first-best policy. Finally, since in the BGP equilibrium $c_{pt}$ and $m_{pt}$ grow at the same rate, from the above differential equations of $c_{pt}$ and $m_{pt}$ we derive that $z_{pt} = \rho$ in the steady state and hence $\mu_t^{1st} = -\rho$. ¤

Proposition 3 puts forth some important results that are comparable to the existing literature. First, although imperfect competition and transactions cost interact, as the functional form of the gross markup shows, we find a clear division of government policy in correcting distortions that are present in the economy – fiscal policy is responsible for distortions from the production side, while monetary policy is responsible for distortions created by money itself. To be more specific, regarding fiscal policy, we find that income tax is used for correcting monopolistic distortions ($\sigma$) and the capital externalities ($\alpha$). Since both will lead to inefficient production levels by the firms, the optimal policy will involve income subsidies so as to encourage investment. With regard to monetary policy, notice first from Proposition 1 that money helps reduce transaction costs and distorts the economy by affecting the equilibrium gross markup. Thus, the monetary authority should supply a sufficient amount of money so as to reduce the transaction costs and the equilibrium gross markup to their minimum values $\overline{\phi}$ and $G_t = [(1 - \overline{\phi})(\sigma - 1)/\sigma]^{-1}$, respectively, thereby removing the distortions created by money. Notice from (14) and (23) that this will help increase the equilibrium capital rental rate and thus the economic growth rate to their maximum values.

Second, as we take a closer look at Proposition 3, we find that the optimal income subsidy rate is greater than that of Guo and Lansing (1999) since, apart from market imperfections, this model's capital generates productive externalities. To correct these positive externalities, the government should subsidize capitalists and entrepreneurs further. It is straightforward to prove that when the productive externalities are absent, we arrive at Guo and Lansing's (1999) result that the income tax is used solely for remedying monopolistic distortions. This indicates that Guo and Lansing's (1999) result is robust in the case of this monetary endogenous growth model with imperfect competition. With regard to monetary policy, we find that the Friedman rule holds continuously and that the optimal seigniorage is time varying in transition and is fixed at $-\rho$ in the steady state. The reasoning behind this is as follows. In order to remove the distortions created by money, the monetary authority will supply a large amount of money. This reduces the marginal benefit from money holdings to zero. Since in equilibrium the marginal benefit from and cost of money holdings must be equal, where the latter is the nominal interest rate, we obtain that the Friedman rule holds. To sustain the Friedman rule and maintain a stable income tax as described above, the monetary authority must adjust its money supply to changes in economic conditions. Therefore, the optimal seigniorage will be time varying in transition. In the steady state, since everything has settled down, the optimal seigniorage will be a constant and will involve a subsidy so as to induce larger holdings of money balances by the private agents.

Our finding regarding the optimality of the Friedman rule is consistent with Siu (2004) but contrasts with Schmitt-Grohé and Uribe (2004a,b) and Shaw, et al. (2006). Specifically, Schmitt-Grohé and Uribe (2004a,b) show that when there is monopoly power in the economy, the Friedman rule ceases to be optimal. Siu (2004) then points out that Schmitt-Grohé and

Uribe's (2004b) result that the Friedman rule is not optimal for a flexible-prices economy stems from the assumption that monopoly profits are not taxed; once monopoly profits are taxed, the Friedman rule will be optimal. Besides, Siu (2004) demonstrates that price stickiness induces deviation from the Friedman rule. With a different viewpoint, Shaw, et al. (2006) argue that in a flexible-prices economy where money is introduced using a cash-in-advance constraint, it is optimal to tax holdings of money (by setting a positive nominal interest rate) when capital generates productive externalities. The monetary authority taxes holdings of money in an effort to eliminate the wedge between the real rate of return on capital and money, which is driven by the capital externalities. Thus, Shaw, et al. (2006) conclude that when productive externalities are absent, the Friedman rule remains optimal. In this paper, we follow Shaw, et al. (2006) in introducing capital externalities to form the engine for endogenous growth. However, we find that the Friedman rule holds and that the wedge between the real rate of return on capital and money is eliminated by an income subsidy. The private agents' holdings of money balances help to reduce transactions costs. This, together with the income subsidy, leads to a higher net rate of return on capital, and hence promotes investment and economic growth. It can be demonstrated that our conclusion on the optimality of the Friedman rule is robust to the endogeneity of labor supply; even when the government levies different sources of income at different tax rates, the Friedman rule is still optimal.[8]

# 5 Conclusion

By constructing a monetary endogenous growth model with an imperfectly competitive product market, this paper aims to study the growth effects of money (inflation) and income tax as well as the optimal monetary and fiscal policy mix. We consider an economy where private agents supply their labor time inelastically and hold money balances to facilitate transactions of output, and there is ongoing economic growth. To found the engine for endogenous growth, we assume that capital generates productive externalities.

Our main findings are summarized as follows. First, with regard to the growth effect of money and income tax, we find that when the monopolistic distortions in the economy are small (including the case of perfect competition), both money and income tax are harmful to economic growth. However, as firms gain sufficient monopoly power, money and income tax become beneficial to the economy's long-run growth. We also show that the threshold value

[8] The detail mathematical proofs are available upon request.

for the degree of imperfect competition that allows for a positive growth effect of income tax is higher than that in the case of money growth. This may provide a theoretical explanation to why a positive relationship between money and growth is easier to be found than in the case of income taxation in empirical works.

Second, with regard to the optimal fiscal and monetary policy, we find that even if imperfect competition and transactions cost interact, there is a clear division of government policy in correcting distortions that are present in the economy. Specifically, fiscal policy should be used for correcting distortions from the production side, including monopolistic distortions and capital externalities. On the other hand, monetary policy is responsible for distortions created by money itself. This result obviously contrasts with that of Shaw, et al. (2006), who argue that the production inefficiency resulting from the capital externalities is remedied by monetary policy and hence the Friedman rule does not hold.[9] In addition, we find that the optimal policy has the feature whereby the Friedman rule holds continuously, the seigniorage is time varying, and income taxes are smooth over time. This result is consistent with Siu's (2004) finding, but contrasts with the result of Schmitt-Grohé and Uribe (2004a,b) and Shaw, et al.'s (2006), which shows that the Friedman rule may not be optimal when there is monopoly power in the product market.

It is worth mentioning that although we assume inelastic labor supply and a common income tax rate, relaxing these assumptions will not alter the qualitative results derived in the present paper, including both the ambiguous growth rate effect of fiscal and monetary policies, the clear division of government policy in correcting distortions, and the optimality of the Friedman rule. However, the fact that Shaw, et al. (2006) obtain different results - that the growth rate effect of monetary policy is immune to the degree of imperfect competition and that the Friedman rule is non-optimal - in a different monetary endogenous growth model reveals that the way money is introduced into the economy matters.

One immediate extension of our analysis is to introduce a sluggish nominal price adjustment into our model. As demonstrated by Khan, et al. (2003), Schmitt-Grohé and Uribe (2004a), and Siu (2004), price stickiness keeps the Friedman rule from being optimal. Khan, et al. (2003) (p.826) also make a statement that helps us understand the underlying function more easily: "...If the price level is constant, then the nominal interest rate must mirror the real interest rate, violating Friedman's rule..." We plan to pursue this research project in the near

[9] In their model, even when the government does not levy incomes at a common rate and a separate capital income tax is available, the Friedman rule is not necessarily optimal in the first best.

future, which will allow us to examine the robustness of the results of Khan, et al. (2003) and Schmitt-Grohé and Uribe (2004a), as well as our own.

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