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(Non)optimality of the Friedman rule and optimal taxation in a growing economy with imperfect competition

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Abstract

This paper shows that if capital generates production externality, there exists a wedge between returns to money and to capital, driving the Friedman rule is not optimal. However, in the absence of capital externality, the Friedman rule may be valid even under imperfect competition.

Keywords: Optimal fiscal and monetary policy; Economic growth; Imperfect competition

JEL classification: E52; E61; E63

1. Introduction

The discussion of optimal monetary policy finds its origins in Bailey (1956) and Friedman (1969). They argued that when a government has access to lump-sum taxation to finance its expenditure, the optimal monetary policy should involve the adoption of a rule (which has been dubbed the Friedman rule) that generates a zero interest rate, corresponding to a zero inflation tax. The logic behind the rule is straightforward. Because there is a wedge between the private marginal cost of holding money (which is

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the nominal interest rate) and the social marginal cost of producing money (which is essentially nil), a positive interest nominal rate will generate inefficiency losses for the society. Thus, to achieve social optimum, the monetary authorities should set the interest nominal rate to be zero in order to eliminate the private opportunity costs. Chari et al. (1996) and Correia and Teles (1996) provide a general conclusion whereby the validity of the Friedman rule crucially depends on the property of consumers' preferences and the role of money for producing transaction services.[1]

Recent research has turned the debate to the environment with nominal rigidity, friction, and imperfect competition. Erceg et al. (2000) and Khan et al. (2003) analyzed the optimal monetary policy in an optimizing-agent model with a staggered nominal wage setting and price setting. They propounded a hybrid rule in which the nominal interest rate responds to either wage inflation or the friction of exchange of wealth for goods. Schmitt-Grohé and Uribe (2004a,b) took into account the imperfections in the goods market and showed that due to these market imperfections the optimal monetary policy deviated from the Friedman rule by setting a positive and time-varying nominal interest rate. Generally speaking, these studies reveal that the Friedman rule holds under perfect competition, while it will be non-optimal under imperfect competition. Departing from their argument, this paper shows that when the economy has two distortions, namely monopoly power and production externality caused by capital formation, the Friedman rule no longer is optimal even if a tax/subsidy scheme is designed to correct the monopoly distortion. The main reason is that when capital generates production externality, there will exist a wedge between returns to money and returns to capital. Since the former are smaller than the latter, it is better to shift the allocation towards capital, so driving the nominal rate to zero is no longer optimal.

To analyze the contentious and important issues more closely, our analytical framework comprises some novel characteristics. In a way that departs from the related literature mentioned above, this paper develops an endogenous growth model with market imperfections, capital formation, and a production externality that is drawn from the work of Benhabib and Farmer (1994) and Romer (1986). On the one hand, it allows us to investigate the growth, inflation, and employment effects of a nominal interest rate peg. On the other hand, it leads us to point out that the conditions for the (non)optimality of the Friedman rule should be modified if a tax on capital income is imposed. In concrete terms, we will show that (i) in a way that differs from the common notion in the literature, the Friedman rule is still optimal even under imperfect competition if the income tax acts as an alternative in terms of removing the production inefficiency caused by market imperfections. There is no unambiguous connection between the Friedman rule and market structure. (ii) The Ramsey planning problem can be supported by implementing a subsidy on income and a positive nominal interest rate to tax inflation. In particular, the optimal interest rate only aims at remedying the production externality and the inefficiency of the credit market, and it does *not* respond in terms of remedying the production inefficiency caused by market imperfections. These results provide new insights for the existing literature.

[1] Phelps (1973) argued that if the government must levy distortionary taxes to finance its expenditure, money should be taxed. By applying the optimal taxation rule provided by Diamond and Mirrlees (1971), in a shopping time model, Kimbrough (1986) showed that, if the transactions technology exhibits constant returns to scale and if taxes on final consumption goods are available, intermediate goods, such as money, should not be taxed. Thus, the Friedman rule turns out to be optimal. Chugh (2003) noted that the optimal monetary policy is not the Friedman rule when consumers' preference features external habit persistence in consumption.

2. The model

The economy we consider consists of households, firms, a government, and a central bank. In what follows, we in turn describe the behavior of each of these agents.

2.1. Firms

In line with Benhabib and Farmer (1994), the production side of the economy includes two sectors: a perfectly competitive final good sector and a monopolistically competitive intermediate goods sector. The final good y is produced using a range of differentiated intermediate inputs, namely, y_j, $j\in[0, 1]$. Thus, the production technology of the final good is given by:

$$y=\left(\int_0^1 y_j^{1-\theta}dj\right)^{1/(1-\theta)};\ \theta\in[0,1). \tag{1}$$

Let P and p_j denote the prices of the final good and the jth intermediate good, respectively. The maximization problem of the representative final good firm is thus: $\max_{y_j} P\left(\int_0^1 y_j^{1-\theta}dj\right)^{1/(1-\theta)}-\int_0^1 p_jy_jdj$. Solving this maximization problem, we have the inverse demand function for the jth intermediate good:

$$P_j=\left(y/y_j\right)^{\theta}P. \tag{2}$$

It is easy to learn that the inverse demand function has a constant price elasticity $1/\theta$. When $\theta=0$, intermediate goods are perfect substitutes in the production of the final good, implying that the intermediate goods sector is perfectly competitive. If $0<\theta<1$, intermediate good firms face a downward-sloping demand curve that can be exploited to manipulate prices; θ thus measures the degree of monopoly of the intermediate good firms. Because the final good market is perfectly competitive, the equilibrium is pinned down by the zero-profit condition. Thus, we obtain: $P=\left(\int_0^1 p_j^{-(1-\theta)/\theta}dj\right)^{-\theta/(1-\theta)}$.

Intermediate good producer j operating in a monopolistic market employs capital k_j and labor n_j to produce its product and sell it to the final good producer at the profit-maximizing price. The technology for producing the jth intermediate good can be expressed by the following Cobb–Douglas production function with labor-augmenting technology:

$$y_j=k_j^{\alpha}\left(A_jn_j\right)^{\beta},\alpha,\beta\in(0,1), \tag{3}$$

where A_j is the index of knowledge available to the jth intermediate good firm. In line with Romer (1986), we assume that learning by doing works through each firm's investment; an increase in a firm's capital stock leads to a parallel increase in its stock of knowledge A_j. In other words, each firm's knowledge is a public good that any other firm can access at zero cost and, accordingly, the production of intermediate goods is subject to a productivity externality. Given that $\bar{k}$ is the average economy-wide stock of capital, we specify $A_j=a\bar{k}^{\eta}$ with parameters $a>0$ and $\eta>0$. To allow for a balanced growth path, we impose a further constraint $\alpha+\beta\eta=1$.

Let r_k and w denote the capital rental rate and the wage rate, respectively. Accordingly, the jth intermediate good firm chooses k_j and n_j so as to maximize its profits:

$$\Pi_j=\left(p_j/P\right)y_j-wn_j-r_kk_j, \tag{4}$$

subject to the demand function of the final good firm (2) and the production function (3). The corresponding first-order conditions are given by:

$$\alpha(1-\theta)\big(p_j/P\big)k_j^{\alpha-1}\big(A_jn_j\big)^{\beta}=r_k \quad \text{and} \quad \beta(1-\theta)\big(p_j/P\big)A_jk_j^{\alpha}\big(A_jn_j\big)^{\beta-1}=w. \tag{5}$$

Note that when $1>\theta>0$, the factor prices r and w are lower than the corresponding marginal products $\alpha(p_j/P)k_j^{\alpha-1}(A_jn_j)^{\beta}$ and $\beta(p_j/P)k_j^{\alpha}(A_jn_j)^{\beta-1}$, respectively. Hence, intermediate firms earn a positive economic profit. Substituting (5) into (4) gives: $\Pi_j=\theta p_jy_j/P\geq 0$ if $\theta\geq 0$.

We confine the analysis to a symmetric equilibrium under which $k_j=\bar{k}=k$, $n_j=n$ and $p_j=p$ for all $j\in[0, 1]$. Accordingly, from (2)–(3) we have $p=P$ and $y_j=y=\hat{A}kn^{\beta}$, where $\hat{A}=a^{\beta}$.

2.2. Households

The economy is populated by a unit measure of identical and infinitely lived households. Letting c be consumption, the representative household's lifetime utility is specified as:

$$U=\int_0^{\infty}\left(\ln c-\frac{n^{1-\chi}}{1-\chi}\right)e^{-pt}dt, \tag{6}$$

where $\rho(>0)$ represents the constant rate of time preference, and the absolute value of $\chi(\leq 0)$ denotes the inverse of the intertemporal labor supply substitution elasticity.

Consumption spending is subject to a cash-in-advance (CIA) or liquidity constraint, i.e.:

$$c\leq m, \tag{7}$$

where $m(=M/P)$ is real money balances with M denoting nominal money balances.

As an owner of firms, the household receives real aggregate profits Π in the form of dividends:

$$\Pi=\int_0^1\Pi_jdj=\int_0^1\big[\big(p_j/P\big)y_j-wn_j-r_kk_j\big]dj, \tag{4a}$$

Thus, subject to an income tax at rate τ, the household's flow budget constraint can be described as:

$$\dot{b}+\dot{m}=(R-\pi)b+(1-\tau)(wn+r_kk+\Pi)-c-i-\pi m+T, \tag{8}$$

where $b(=B/P)$ represents real government bonds (B values are nominal government bonds that pay the nominal interest rate R), $\pi(=\dot{P}/P)$ and the inflation rate, and T the real transfer incomes. It is clear from (8) that labor income wn, capital income k_rk and dividends Π are taxed at the same rate τ.

The representative household maximizes (6) subject to (7) and $\dot{k}=i$ by choosing $\{c, b, m, k, n\}_{t=0}^{\infty}$. We concentrate on the case where the CIA constraint is binding. Letting λ be the shadow value of wealth and ϕ be the Lagrangian multiplier corresponding to (7), the optimal conditions are:

$$(1-\tau)r_k=R-\pi=\phi/\lambda-\pi, \tag{9a}$$

$$n^{-\chi}=(1-\tau)\lambda w, \tag{9b}$$

$$1/c=\lambda(1+R) \tag{9c}$$

$$\dot{\lambda}/\lambda=\rho-(1-\tau)r_k, \tag{9d}$$

$$m=c, \tag{9e}$$

together with (8), $\dot{k}=i$ and, and the transversality conditions, $\lim_{t\to\infty}\lambda m e^{-pt} = \lim_{t\to\infty}\lambda k e^{-pt} = 0$, given that the initial stocks on capital and real money balances are k_0 and m_0, respectively. Due to the fact that ϕ/λ represents the nominal interest rate R (i.e. $\phi=\lambda R$), (9a) is the no-arbitrage condition among holdings of capital, real government bonds, and real money balances. Eq. (9b) indicates the optimal choice for the household's labor supply. Eq. (9c) implies that the marginal utility of consumption equals the sum of the marginal utility of wealth and the marginal utility of holding money. Eq. (9d) is the standard Keynes–Ramsey rule.

2.3. Central bank and government

The central bank adjusts the money supply to whatever level is needed for the targeted interest rate R to prevail. The law of motion governing real money balances is given by:

$$\dot{m}/m = \mu - \pi, \tag{10}$$

where $\mu(\equiv \dot{M}/M)$ is the growth rate of the nominal money stock.

The government finances its expenditures on interest payments and lump-sum transfers by levying income tax at the rate τ and by issuing bonds and money. Thus, the government's flow budget constraint can be written as:

$$\frac{\dot{M}}{P} + \frac{\dot{B}}{P} = Rb + T - \tau(wn + r_k k + \Pi). \tag{11}$$

In addition, putting (4a), (8), (10) and (11) together yields the economy-wild resource constraint:

$$\dot{k} = \hat{A}kn^{\beta} - c. \tag{12}$$

3. Long-run effect of the interest rate peg

Under a symmetric equilibrium, the system of this economy is constituted by:

$$R - \pi = (1-\tau)r_k = (1-\tau)\alpha(1-\theta)\hat{A}n^{\beta}, \tag{13a}$$

$$w = \beta(1-\theta)\hat{A}kn^{\beta-1}, \tag{13b}$$

together with (9b)–(9e), (10), and (12). By defining $z=c/k$, it follows from (9b)–(9e), (10), (12), and (13a)–(13b) that the dynamic system in terms of the transformed variable z can be expressed as:

$$\dot{z}/z = z - \rho + \hat{A}[(1-\tau)\alpha(1-\theta) - 1]\Omega^{\beta/(1-\beta-\chi)}z^{-\beta/(1-\beta-\chi)},$$

where $\Omega \equiv (1-\tau)\beta(1-\theta)\hat{A}/(1+R)$. From the above equation, we can derive $\Delta = \partial\dot{z}/\partial z = [1 - \Phi\Omega^{\beta/(1-\beta-\chi)}\tilde{z}^{(\chi-1)/(1-\beta-\chi)}]\tilde{z} > 0$, where $\Phi \equiv \beta\hat{A}[(1-\tau)\alpha(1-\theta)-1]/(1-\beta-\chi) < 0$. Given that there is one jump variable z in the dynamic system, the equilibrium is thus locally determinate.[2]

[2] If the externality in production technology also involves labor, as in Benhabib and Farmer (1994), then the local indeterminacy occurs. However, to focus our point, it is not necessary to include the labor externality in this model.

At the steady-growth equilibrium, the economy is characterized by $\dot{z}=0$, determining a stationary value $\tilde{z}$. Thus, we have the following stationary relationship:

$$\tilde{z} = \rho - \hat{A}[(1-\tau)\alpha(1-\theta) - 1]\Omega^{\beta/(1-\beta-\chi)}\tilde{z}^{-\beta(1-\beta-\chi)} \tag{14}$$

From (14) it is easy to verify the existence and uniqueness of the balanced growth path (BGP) equilibrium and given that z is a jump variable, there exists a unique path converging to the equilibrium.[3]

Based on (14), simple manipulations lead us to solve the stationary values of employment ($\tilde{n}$), the balanced growth rate ($\tilde{\gamma}$) and the inflation rate ($\tilde{\pi}$) from (9b–9d), (12), and (13a):

$$\tilde{n} = \Omega^{1/(1-\beta-\chi)}\tilde{z}^{-1/(1-\beta-\chi)}, \tag{15a}$$

$$\tilde{\gamma} = \hat{A}\tilde{n}^{\beta} - \tilde{z} = (1-\tau)\alpha(1-\theta)\hat{A}\Omega^{\beta/(1-\beta-\chi)}\tilde{z}^{-\beta/(1-\beta-\chi)} - \rho, \tag{15b}$$

$$\tilde{\pi} = R - (1-\tau)\alpha(1-\theta)\hat{A}\tilde{n}^{\beta} = R - (1-\tau)\alpha(1-\theta)\hat{A}\Omega^{\beta/(1-\beta-\chi)}\tilde{z}^{-\beta/(1-\beta-\chi)}. \tag{15c}$$

Accordingly,

Proposition 1. *Under the balanced growth path equilibrium, decreasing the nominal interest rate (R) will result in a triple dividend in terms of a higher level of employment, a higher balanced growth rate, and a lower inflation rate in the long run. The favorable effect is lessened as monopoly power increases, provided that the (sufficient) condition $\beta>\alpha(1-\tau)(1-\theta)$ holds true.*

Proof. Differentiating (14) and (15a)–(15c) with respect to R, respectively, we have:

$$\frac{\partial\tilde{n}}{\partial R} = -\frac{\Omega^{1/(1-\beta-\chi)}\tilde{z}^{-1/(1-\beta-\chi)}}{\Delta(1-\beta-\chi)(1+R)}<0; \frac{\partial\tilde{\gamma}}{\partial R} = (1-\tau)\alpha(1-\theta)\beta\hat{A}\tilde{n}^{\beta-1}\frac{\partial\tilde{n}}{\partial R}<0; \frac{\partial\tilde{\pi}}{\partial R} = 1 - \frac{\partial\tilde{\gamma}}{\partial R}>1. \tag{16}$$

Based on (16), differentiating $\partial\tilde{n}/\partial R$ with respect to θ further leads to:

$$\frac{\partial}{\partial\theta}\left|\frac{\partial\tilde{n}}{\partial R}\right| = \frac{(1-\tau)\beta^2\hat{A}^2}{(1-\beta-\chi)^2(1+R)^2(\Omega-\Phi\tilde{n}^{1-\chi})^2}\left[-\tilde{n}^{2-\chi} + \frac{(1-\theta)(1-\beta-\chi)}{\beta\hat{A}}(\Omega-\Phi\chi\tilde{n}^{1-\chi})\frac{\partial\tilde{n}}{\partial\theta}\right]<0,$$

where $\partial\tilde{n}/\partial\theta = -\tilde{n}\cdot[(1-\tau)\alpha(1-\theta)\hat{A}\Omega^{\beta/(1-\beta-\chi)}\tilde{z}^{(\chi-1)/(1-\beta-\chi)}+1]/[\Delta(1-\beta-\chi)(1-\theta)]<0$. Similarly, we also have:

$$\frac{\partial}{\partial\theta}\left|\frac{\partial\tilde{\gamma}}{\partial R}\right| = \frac{\partial}{\partial\theta}\left|\frac{\partial\tilde{\pi}}{\partial R}\right| = (1-\tau)\alpha\beta\hat{A}\tilde{n}^{\beta-1}\left[(1-\theta)\frac{\partial}{\partial\theta}\left|\frac{\partial\tilde{n}}{\partial R}\right| - \Theta\left|\frac{\partial\tilde{n}}{\partial R}\right|\right],$$

where $\Theta \equiv \{[\beta-\alpha(1-\tau)(1-\theta)]\hat{A}\Omega^{\beta/(1-\beta-\chi)}\ \tilde{z}^{(\chi-1)/(1-\beta-\chi)} - \chi\}/(1-\beta-\chi)\Delta>0$ under a (sufficient) condition $\beta>\alpha(1-\tau)(1-\theta)$. Given $\Theta>0$, $\partial|\partial\tilde{\gamma}/\partial R|/\partial\theta = \partial|\partial\tilde{\pi}/\partial R|/\partial\theta<0$ is true. □

A lower R leads to a decrease in the opportunity cost of holding money. Thus, the household will increase holdings of money balances and, accordingly, will increase consumption as well (referring to

[3] A mathematical proof is available upon request.

(9e)). Eq. (16) tells us that the household should increase its labor supply (decrease leisure) in order to cope with the increase in the consumption. More labor supply will result in a higher marginal product of physical capital and, as a result, the balanced growth rate will rise. This result contrasts with the common notion whereby a lower nominal interest rate will decrease (rather than increase) the inflation rate. The key reason for this result is that in the endogenous growth model with endogenous labor–leisure choice a high level of employment tends to increase output and this will weaken the effect of monopoly power on the output price.

Of interest, Proposition 1 further indicates that the beneficial effect of the nominal interest rate peg policy is weakened in an economy that is characterized by a higher degree of monopoly, provided that $\beta > \alpha(1-\tau)(1-\theta)$. According to the estimates provided by Jorgenson et al. (1987) and King and Rebelo (1999), the share for the physical capital is about 1/3, while the share for labor ranges between 0.6 and 0.7. Based on this measurement, the sufficient condition $\beta > \alpha(1-\tau)(1-\theta)$ is usually valid and, as a result, the favorable effect is lessened as market power θ increases.

4. Optimal monetary and fiscal policies

In the Pareto optimum, the social planner will internalize the production externality and market imperfections: subject to the aggregate resource constraint (12) and the social technology (3) with externality $A_j = ak^{\eta}$, the social planner chooses c, n and m so as to maximize (6). By letting v be the co-state variable associated with (12), the optimal conditions are given by:

$$1/c = v, \tag{17a}$$

$$n^{-\chi} = v\beta Akn^{\beta-1}, \tag{17b}$$

$$\dot{v}/v = \rho - An^{\beta}, \tag{17c}$$

together with (12) and the transversality conditions $\lim_{t\to\infty} vke^{-pt} = 0$. Comparing these two systems between the centralized and decentralized economies leads to:

Proposition 2. *The optimal income tax and nominal interest rates are:*

$$\tau^* = 1 - 1/[(1-\beta\eta)(1-\theta)] < 0.$$

$$R^* = (1-\theta)(1-\tau^*) - 1 = \beta\eta/(1-\beta\eta) > 0.$$

Proof. From (9c) and (17a), we obtain the relationship: $v = \lambda\,(1+R)$. Based on this relationship, it is easy to derive $\tau^* = 1 - 1/\alpha(1-\theta)$ from (9d), (13a), and (17c). Under the constraint $\alpha + \beta\eta = 1$, the optimal income tax can be re-written as $\tau^* = 1 - 1/[(1-\beta\eta)(1-\theta)] < 0$. On the other hand, substituting (13b) into (9b) and comparing (9b) with (17b) yields $R^* = (1-\theta)(1-\tau^*) - 1$. By substituting the optimal τ^* into this relationship, we can further derive the optimal nominal interest rate R^* stated above. □

Proposition 2 provides interesting and novel results which contribute to new insights in relation to the existing literature. These findings are in turn summarized in what follows. First, if the production externality is absent ($\eta = 0$) and the intermediate goods market is perfectly competitive ($\theta = 0$), then both the optimal income tax and nominal interest rates are zero ($\tau^*=0$ and $R^*=0$). That means that the Friedman rule holds. Secondly, if we ignore the distortions stemming from externalities (i.e. $\eta=0$) and highlight the role of market imperfections $\theta>0$, the results of Proposition 2 will be reduced to $\tau^*=-\theta/(1-\theta)<0$ and $R^*=0$. These results imply that if the optimal fiscal policy (i.e. optimal income tax) plays a decisive role in terms of removing production inefficiency caused by market imperfections, the optimal interest rate will conform to the Friedman rule. This is an interesting case that may surprise us. Schmitt-Grohé and Uribe (2004a,b) propound that the Friedman rule holds under perfect competition, while it will be non-optimal under imperfect competition. In the section that reports their conclusions, they even conjecture that, given market imperfections, the breakdown of the Friedman rule holds in any monetary model. However, Proposition 2 points out that, in the growth model with capital formation, the Friedman rule is optimal even under imperfect competition provided that a unity tax is imposed on labor income, capital income, and profit. This is because such an income tax is an alternative instrument in terms of removing the distortion caused by imperfect competition.

Finally and thirdly, we consider the case in which all market failures are taken into account, i.e. $0<\eta<1$, $\theta>0$. In this case, the Pareto optimal allocation is supportable as a competitive equilibrium by implementing the first-best income tax and nominal interest rate policies as reported in Proposition 2. On the one hand, the socially-optimal fiscal policy is to provide a subsidy to households. Specifically, to remedy these distortions, the optimal subsidy will increase with monopoly power θ and the extent of the production externality $\beta\eta$. On the other hand, a strictly positive nominal interest rate indicates that the Friedman rule is not optimal. In particular, the optimal R^* only aims at remedying the production externality $\beta\eta$ and it is *not* able to serve as an instrument in remedying the production inefficiency caused by market imperfections. To be precise, a higher production externality will correspond to a higher nominal interest rate. The reason for this is that if capital can generate a larger production externality, relative to money, capital formation becomes more rewarding, generating a wedge between returns to money and returns to capital. Thus, it is more costly to produce money and, accordingly, the social planner is more likely to impose a tax on money. Once the social marginal cost of producing money is not essentially zero but is rather a positive value, the optimal interest rate will be positively related to the production externality.

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