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Government Financing in an Endogenous Growth Model With Financial Market Restrictions

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Abstract: In this paper, we develop an endogenous growth model with market regulations on explicitly modeled financial intermediaries to examine the effects of alternative government financing schemes on growth, inflation, and welfare.

We find that in the presence of binding legal reserve requirements, a marginal increase in government spending need not result in a reduction in the rate of economic growth if it is financed with an increase in the seigniorage tax rate. Raising the seigniorage tax base by means of an increase in the reserve requirement retards growth and has an ambiguous effect on inflation. An increase in income tax–financed government spending also suppresses growth and raises inflation although not to the extent that the required seigniorage tax rate alternative would. Switching from seigniorage to income taxation as a source of government finance is growth-reducing but deflationary. From a welfare perspective, the least distortionary way of financing an increase in the government spending requirements is by means of a marginal increase in the seigniorage tax rate. Finally, under the specification of logarithmic preferences, the optimal tax structure is indeterminate.

JEL classification: E62, E44, O42

Key words: government financing, endogenous growth, financial intermediaries

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1. Introduction

The literature born out of the pioneering work of Romer (1986), Lucas (1988) and Rebelo (1991), has focused on the sorts of economic policies that can enhance the growth performance of a country.[1] One strand of this endogenous growth literature examines the effects of alternative government financing schemes in a growing economy. This strand of the literature attempts to answer questions such as; how should a government finance its spending over time; by raising income taxes or printing money? The answer may, of course, depend on the evaluation criterion. Alternative financing policies may rank differently from growth, inflation and welfare perspectives. To date, we know from Van der Pleog and Alogoskoufis (1994) and Palivos and Yip (1995) that there seems to be a trade-off between the inflationary and growth consequences of alternative financing policies. The first authors develop their results in an endogenous growth model with non-interconnected overlapping generations. They analyze the effects of lump-sum-tax-financed, debt-financed and money-financed increases in government spending on growth and inflation. The second set of authors assess the relative merits of seigniorage and income tax financing in an endogenous growth model with a generalized cash-in-advance constraint. They find that income tax financing is more detrimental to growth but less inflationary than seignorage financing

However, according to Espinosa and Yip (1999), the finding of a trade-off between the inflationary and growth consequences of alternative financing policies may warrant re-examination when the operation of financial intermediaries is formally acknowledged. For example, they find that with explicit modeling of financial intermediaries, the effects on growth and inflation of alternative government financing schemes will depend on the location of the initial equilibrium as well as the depositors' degree of risk aversion.

In this paper, we introduce a financial market restriction in the form of a legal reserve requirement on intermediaries. Specifically, we consider a life cycle model

[1]For comprehensive references, we refer the readers to the books written by Aghion and Howitt (1998) and Barro and Sala-i-Martin (1995).

where spatial separation and limited communication creates a role for currency in transactions and liquidity preference shocks create a role for financial intermediaries. The government relies on two alternative sources of revenues: seigniorage (monetary policy) and wage taxation (fiscal policy) to finance its exogenously given expenditure sequence. This set up recognizes the fact that fiscal and monetary policy cannot be set independently of each other due to the government's budget constraint. In our analysis we follow Romer (1986) and adopt the simplest structure that allows for perpetual growth by postulating an externality in goods production.

Under unobstructed financial intermediation, a unique equilibrium exists if and only if agents are fairly risk averse; otherwise, multiple balanced growth paths emerge. When agents are fairly risk averse, an expansion in government expenditures retards growth and raises inflation. Moreover, tax-financed government spending is more distortionary to economic growth, but less inflationary than the seignorage financing alternative. For a given level of government spending (as a constant fraction of output), a switch from seigniorage to income taxation is deflationary but growth reducing. On the other hand, when agents are not too risk adverse, the effects of fiscal spending expansion and a switch of financing methods depend on the initial equilibrium, and a Tobin-type relation of growth and inflation may emerge.

The introduction of legal reserve requirements (the more realistic case), further introduces a number of qualifications to the inflationary, growth and welfare analysis of alternative government financing schemes. First, independently of the agents' degree of risk aversion, uniqueness of equilibrium is always attained (as in Pleog and Alogoskoufis (1994) and Palivos and Yip (1995)), even when these reserve requirements are not binding. Second, there is an additional dimension to the distinction between seigniorage and income tax finance of government spending. It matters whether changes in seigniorage come about because of changes in the seigniorage tax base (i.e., the reserve requirement level) or the seigniorage tax rate. For example, a marginal increase in government spending need not result in a reduction in the rate of economic growth if it is financed with an increase in the seigniorage tax rate. For a given government spending - output ratio, raising the seigniorage tax base by means of an increase in the reserve requirement retards growth and has an ambiguous effect on inflation. An increase in income tax financed government spending also suppresses growth and raises inflation although not to the extent that the required seigniorage tax rate alternative would.

Switching from seigniorage to income taxation as a source of financing is growth reducing but deflationary.

As expected, an expansion of fiscal spending always lowers welfare. However, if the original binding reserve requirement is set above the inflation-minimizing level, then we can establish the following welfare ranking. Financing the increase in government spending via an increase in the income tax dominates the equilibrium resulting from the required increase in the reserve requirement. However, financing the increase in government spending via an increase in the seigniorage tax rate dominates the equilibria resulting from the required increase in the reserve requirement and the income tax. In addition, for a given level of government spending, switching from seigniorage financing to income tax financing reduces welfare. Finally, under the specification of logarithmic preferences, the optimal tax structure is indeterminate in the sense that there exists a continuum of "income tax rate - reserve requirement" pairs that maximizes welfare.

The organization of the paper is as follows. The next section provides a description of the basic model while section 3 performs the analysis of the balanced-growth-path equilibrium under full financial intermediation. Section 4 continues the balanced-growth-path equilibrium analysis in the presence of financial market restrictions that take the form of legal reserve requirements. Section 5 studies the welfare consequences of various government policies and section 6 concludes the paper.

2. The Model

Consider an economy consisting of an infinite sequence of two-period lived overlapping generations as well as an initial old generation. There is no population growth and each generation contains a continuum of identical agents.

In each period, young agents are assigned to one of the two symmetric locations in the economy. We normalize the mass of the young population in each location to unity. During their second period of life, agents are transferred with probability π to another location and are allowed to remain in their original location with probability $(1 - \pi)$. There are only two assets available in the economy: fiat money (M_t) and capital (K_t). All savings are therefore in terms of these two assets.

2.1. Preferences

Agents' preferences are represented by the following isoelastic utility function:

$$U(C_2) = -C_2^{-\gamma}/\gamma, \tag{2.1}$$

where C_2 denotes age 2 consumption and $\gamma > -1$. All agents are endowed with one unit of labor which they supply inelastically in their first period for which they get paid the real wage w_t.[2] Since individuals do not derive utility from young-age consumption, all wage income is saved.

2.2. Technology

In each location of the economy, a perishable consumption good is produced, at each date t. Individual firms use physical capital (K_t) and labor (L_t) to produce final output (Y_t) according to the production function

$$Y_t = A\overline{K_t}^{\,1-\alpha} K_t^{\alpha} L_t^{1-\alpha}, \tag{2.2}$$

where, as in Romer (1986), $\overline{K_t}$ is the aggregate capital stock (taken as given by individual agents) which enters the production function due to the presence of spillover externalities. A unit of capital at $t+1$ is obtained by foregoing a unit of consumption good at t. For simplicity, we assume full depreciation of capital at each date.

Profit maximization of perfectly competitive firms implies that factors of production are paid their marginal products. Since, $\overline{K_t} = K_t$ and $L_t = 1$ in equilibrium, the rental rate of capital r_t and the real wage rate w_t are given by

$$r_t = \alpha A\overline{K}_t^{1-\alpha}(K_t/L_t)^{\alpha-1} = \alpha A, \tag{2.3}$$

$$\textit{and } w_t = (1-\alpha)A\overline{K}_t^{1-\alpha}(K_t/L_t)^{\alpha \cdot} = (1-\alpha)AK_t. \tag{2.4}$$

2.3. Government

The government raises revenue to finance its non-productive expenditures G_t by printing money (i.e., seigniorage, $[M_t - M_{t-1}]/P_t$) and/or imposing a proportional

[2]With unit mass of constant population and inelastic unit labor supply, our notations can be used for aggregate and per capita quantities interchangably.

wage income tax (τw_t), where P denotes the price level. The consolidated government budget constraint is then given by

$$G_t = \tau w_t + [M_t - M_{t-1}]/P_t. \tag{2.5}$$

To allow for balanced growth, we further assume that government spending is a constant fraction of total output so that, $G_t = \beta Y_t$, where $\beta \in (0, 1)$ will be the policy parameter that indicates how large government spending is relative to the size of the economy.

2.4. Financial Intermediation

As in Diamond and Dybvig (1983, henceforth D-D), financial intermediaries can be viewed as cooperative entities consisting of coalitions formed by young agents. Each young agent deposits her entire savings, $(1 - \tau)w_t$, in a bank while financial intermediaries hold both fiat money and capital. Notice that the possibility of relocation plays a similar role as the liquidity preference shock in D-D and makes room for a positive demand for real holdings of money even if money is dominated in the rate of return. In this model, fiat money is the only means of smoothing consumption in the presence of relocation (liquidity shocks). We depict the timing assumptions in Figure 1. We also assume that the realizations of relocations are i.i.d. across young agents and their distribution is known to all agents, so that while idiosyncratic uncertainty exists, there is no aggregate uncertainty. Financial intermediaries arise endogenously here because, unlike individual agents, they can exploit the law of large numbers when constructing their portfolio.[3]

If banks hold fiat money M_t, which is supplied by the government and the old inelastically, they receive a gross real return $P_t/P_{t+1} \equiv R_t^m$. On the other hand, banks receive r_{t+1} on their capital investment. Finally, banks pay individual depositors moving to *another* location a gross real return R_t^a while they pay R_t^s to those agents *staying* at the original location.

The banks' portfolio problem consists of maximizing their customers' (young agents') welfare taking into account the possibility that some of their customers face a sudden relocation. To that end, banks must hold fiat money as reserves which captures the notion that financial intermediaries fulfill a liquidity provision role in the economy. In addition, banks invest in capital to satisfy the needs of their customers that stay at the original location. In equilibrium, banks choose a

[3]See, for example, Bencivenga and Smith (1991) and Greenwood and Smith (1997) .

vector of deposit returns and a portfolio allocation q_t (the fraction of total savings invested in capital) to maximize the expected utility of a depositor which is given by:

$$V_t \equiv -\pi[(1-\tau)w_t R_t^a]^{-\gamma}/\gamma - (1-\pi)[(1-\tau)w_t R_t^s]^{-\gamma}/\gamma, \tag{2.6}$$

subject to two resource constraints. First, there are π agents going to another location who must be given fiat money, which is accomplished by using the bank's holdings of currency. Since the return paid to each unit of fiat money is R_t^m, the following condition has to hold:

$$\pi R_t^a = R_t^m(1-q_t). \tag{2.7}$$

The $(1-\pi)$ agents staying in the same location will be repaid from the banks' capital investment. Given the rental rate of capital is r_{t+1}, the choice of R_t^s must satisfy the following second resource constraint:

$$(1-\pi)R_t^s = r_{t+1}q_t. \tag{2.8}$$

The solution to maximizing (2.6) subject to the resource constraints (2.7) and (2.8) is given by[4]

$$q_t = \frac{\Phi_t}{1+\Phi_t} \equiv q(R_t^m), \tag{2.9}$$

where $\Phi_t \equiv \left(\frac{1-\pi}{\pi}\right)\left(\frac{R_t^m}{\alpha A}\right)^{\gamma/(1+\gamma)}$.

2.5. Equity Market

According to Greenwood and Smith (1997), it is possible that agents trade assets in active equity market when banks are regulated, i.e., relocated agents seek to sell their capital holdings in equity markets to agents who are not relocated. Suppose q_t is subject to regulation, say by reserve requirement in the form of a ceiling $\overline{q}$. Then as shown in Greenwood and Smith (1997), if $\overline{q} < 1-\pi$, all financial activity will occur in unregulated or informal markets. This then imposes a strict limit on the magnitude of the reserve requirement that a government can impose. In the analysis of financial repression in section 4, we focus on the case where

[4] An implicit assumption behind this bank portfolio problem that carried out throughout the paper is that $\alpha A > R^m$. Otherwise, the bank will never choose to invest in capital stock.

$1-\pi < \overline{q} < q(R^m)$ so that the reserve requirement will be binding and savings will still be intermediated.

This completes our description of the model.

3. Laissez-Faire Banking

In order to satisfy the liquidity needs of young agents commuting to a new location, banks hold a fraction $(1-q_t)$ of the total savings, $(1-\tau)w_t$, in the form of fiat money:

$$m_t \equiv M_t/P_t = (1-q_t)(1-\tau)w_t.$$

Substituting (2.4) and (2.9) into the above expression of m_t, we get a simple expression for the demand for real holdings of currency as a function of the return to currency (the inverse of the inflation rate) and after-tax income

$$m_t = \frac{(1-\tau)(1-\alpha)AK_t}{1+\Phi_t(R_t^m)}. \tag{3.1}$$

Since banks invest a portion q_t of aggregate savings in capital accumulation at each date, we get the following goods market equilibrium condition:

$$K_{t+1} = q_t(1-\tau)w_t. \tag{3.2}$$

Substituting (2.4) and (2.9) into (3.2), we obtain the equilibrium gross growth rate of the capital stock[5]:

$$\theta = K_{t+1}/K_t = \frac{(1-\tau)(1-\alpha)A\Phi(R^m)}{1+\Phi(R^m)}. \tag{3.3}$$

Since (2.2) implies that $Y_t = AK_t$ along a balanced growth path, θ is also the equilibrium rate of output growth. Next, we rewrite the government budget constraint (2.5) as

$$\beta Y_{t+1} - \tau w_{t+1} = m_{t+1} - m_t P_t/P_{t+1}. \tag{3.4}$$

From (3.1), m_t is growing at the same rate as the capital stock so that $m_{t+1} = \theta m_t$. Together with (2.4), (2.9) and (3.3), equation (3.4) can be written as

[5] By definition, intensive variables remain unchanged at the balanced growth equilibrium, we henceforth suppress the time subscript for these variables.

$$\beta - (1-\alpha)\tau + \frac{R^m}{A}\frac{1-q(R^m)}{q(R^m)} = (1-\tau)(1-\alpha)[1-q(R^m)]. \tag{3.5}$$

For future reference, define $\Psi(R^m)$ and $\Gamma(R^m)$ to be the left hand side and right hand side of (3.5), respectively. Notice that one can solve for R^m in (3.5) and then for θ in (3.3).

3.1. Existence and Uniqueness

In this section we review some of the properties of laissez-faire banking equilibria. The following proposition states that whether we have one or more than one balanced growth path depends on the agents' degree of risk aversion. In particular, uniqueness of a non-trivial equilibrium is guaranteed if agents are sufficiently risk averse.[6]

Proposition 1 *Consider the case where $(1-\alpha)[\tau + (1-\tau)\pi] > \beta > (1-\alpha)[\tau + (1-\tau)\pi] - \frac{\alpha\pi}{1-\pi}$. Then, there exists a unique non-trivial balanced growth equilibrium if and only if agents are "fairly" risk averse, i.e. $\gamma \geq 0$. If $\gamma < 0$, then generically there are either two balanced growth equilibrium paths or none.*

Figures 2a and 2b depict, respectively, equilibria under $\gamma > 0$ and $0 > \gamma > -1$. As stated in the proposition, when $\gamma > 0$, a given fiscal policy – represented by the parameters pair (β, τ)– can be associated with different equilibrium rates of growth and inflation.

To understand why there is a unique equilibrium when agents exhibit a higher degree of risk aversion than the logarithmic preferences case, we note that in this case there is no seigniorage Laffer curve. On the other hand, when agents exhibit a lower degree of risk aversion than the logarithmic preferences case, a standard seigniorage Laffer curve emerges. Thus different points on the Laffer curve lead to different rates of growth because these points are associated with different nominal interest rates, and hence with different compositions of capital and reserves in the portfolio of the financial intermediaries. In an endogenous growth model, this portfolio composition matters for growth.

[6]The proof of this proposition is given in Espinosa and Yip (1999) and we will not repeat it here.

3.2. Comparative Statics

In the remainder of the section, we provide results on growth and inflation under alternative government financing methods. We first rewrite the government budget constraint (3.5) as

$$\beta = (1-\alpha)\tau + \frac{1-q(R^m)}{Aq(R^m)}(\theta - R^m). \tag{3.6}$$

Notice that the first term on the right hand side is taxation revenue and the second term is seigniorage. In particular, for the second seigniorage term, $\frac{1-q(R^m)}{Aq(R^m)}$ denotes the seigniorage tax base and $(\theta - R^m)$ is the seigniorage tax rate.

Result 1 When agents are fairly risk averse (i.e., $\gamma > 0$), an expansion in government spending retards growth and raises the rate of inflation. Moreover, tax-financed government spending is more detrimental to growth but less inflationary than seigniorage finance.

Proof. From (3.3) and (3.5), whenever $\gamma > 0, \Phi'(R^m) > 0$, and an increase in government spending financed via seigniorage has the following inflationary and growth effects.
$d\theta/d\beta = \frac{(1-\alpha)(1-\tau)}{(1+\Phi)^2\Delta}\frac{\partial\Phi}{\partial R^m} < 0$ and $dR^m/d\beta = 1/\Delta < 0$ (where $\Delta = -\frac{(1-\alpha)(1-\tau)}{1+\Phi}$ $\left[\frac{1-R^m/\theta}{1+\Phi}\frac{\gamma}{1+\gamma}\frac{\Phi}{R^m} - \frac{\frac{\gamma}{1+\gamma}-(1+\Phi)}{(1-\alpha)(1-\tau)A\Phi}\right] < 0$). For income tax financing, we need to impose the additional restrictions $d\beta = (1-\alpha)d\tau$. From (3.6), the corresponding comparative statics expressions are; $d\theta/d\beta = \left(1 + \frac{R^m}{\gamma\theta}\right)\frac{A(1-\alpha)(1-\tau)}{(1+\Phi)^2\Delta}$ $\frac{\partial\Phi}{\partial R^m} < 0$ and $dR^m/d\beta = \frac{1}{(1+\Phi)\Delta} < 0$. ■

To understand the intuition of this result, we note that there are two opposing effects at work in determining the relation between inflation and growth. On the one hand, as inflation rises, financial intermediaries need to adjust their holdings of real balances (by changing their nominal cash holdings) in order to guarantee adequate provision of liquidity services to those agents facing relocation. As a result, the holdings of real balances in the portfolio of financial intermediaries rise and q drops. This represents the income effect of an increase in the rate of inflation on the intermediaries' portfolio. On the other hand, as the inflation rate goes up, the rate of return to real balances relative to capital falls which leads to an increase in q induced by the substitution effect. Result 1 then says that on net, whenever agents exhibit a "high degree of risk aversion," the income effect dominates the portfolio substitution effect. Higher inflation causes banks to increase reserve holdings, having as a consequence a drop in capital accumulation and growth. Finally, as income taxation affects the engine of growth directly, it has a larger negative effect on growth. At the same time, it is less inflationary than the seigniorage finance alternative.

Now recall that when agents have a low degree of risk aversion, multiple equilibria may arise and consequently, the comparative statics results on inflation and growth will depend on the location of the initial equilibrium. Bearing this in mind, below we report the inflationary and growth effects of an increase in government financing needs.

Result 2 Whenever savers exhibit a low degree of risk aversion ($0 > \gamma > -1$), an increase in government spending that is financed exclusively with either seigniorage or income tax revenue, raises (reduces) both the rate of inflation and the rate of growth in the low (high) inflation equilibrium and in each equilibrium, growth and inflation are positively related.

Proof. Whenever $0 > \gamma > -1, \Phi'(R^m) < 0$ and $\Delta > (<) 0$ for the high (low) -inflation equilibrium. The relevant expressions to analyze the growth and inflationary effects of an increase in government spending to be financed via seigniorage are as follows. $d\theta/d\beta = \frac{(1-\alpha)(1-\tau)\Phi'}{(1+\Phi)^2\Delta}$ and $dR^m/d\beta$

$= 1/\Delta$. Also, from (3.3), the tax-financing case yields $d\theta/d\beta = (1 + \frac{R^m}{\gamma\theta})\frac{A(1-\alpha)(1-\tau)\Phi'}{(1+\Phi)^2\Delta}$ and $dR^m/d\beta = 1/(1+\Phi)\Delta$. The result that $d\theta/dR^m < 0$ then follows. ■

Note that for the $0 > \gamma > -1$ case, there is a conventional Laffer curve. On each side of it, the effects of inflation on the composition of financial intermediaries' assets –between capital investment and reserves – is different. Regardless of whether the increase in government spending as a fraction of output is financed exclusively with seigniorage or with an income tax, if the original equilibrium is the high (low) inflation one, an increase in seigniorage requirements will be associated with a drop (increase) in capital investment. Consequently if the original equilibrium is the high (low) inflation equilibrium, an increase in seigniorage needs will be accompanied by a drop (increase) in the rate of economic growth. Consequently this result is a version of the Tobin effect.

Result 3 Given a constant fraction (β) of output as government expenditures, if agents are fairly risk averse, then a switch of financing method from inflation to income taxation is deflationary and growth reducing. If agents exhibit a low degree of risk aversion instead, then the effects on growth and inflation depend on the initial equilibrium, but such a switch of financing method yields a positive relation between inflation and growth.

Proof. The situation studied can be characterized by $d\beta = 0$ and $d\tau > 0$. It can be verified from (3.3) and (3.5) that, whenever $\gamma > 0$, $dR^m/d\tau = -\frac{(1-\alpha)\Phi}{(1+\Phi)\Delta} > 0$ and $d\theta/d\tau = \frac{(1-\alpha)^2(1-\tau)AR}{(1+\Phi)^2\gamma\theta\Delta}\frac{\partial\Phi}{\partial R^m} < 0$. If $0 > \gamma > -1$, then $dR^m/d\tau$ and $d\theta/d\tau$ have opposite signs. ■

Whenever $\gamma > 0$, there is no Laffer curve and seigniorage is increasing in the inflation rate (i.e., inversely relate to R^m). As the introduction of income taxation reduces the need for seigniorage, we have a lower rate of inflation. However, taxing wage income directly reduces savings, capital accumulation and growth in this case.

Alternatively, when $0 > \gamma > -1$ and a conventional Laffer curve appears, the decline in seigniorage may cause the rate of inflation to fall or rise according to the location of the original equilibrium. For instance, at the high-inflation equilibrium, we are operating along the upward-sloping portion of the Laffer curve in the seigniorage-R^m space so that a drop in seigniorage will be associated with an increase in the inflation rate. Since the portfolio substitution effect dominates the income effect according to Result 2, this leads to higher capital accumulation and growth. The results will be reversed when we are located at the low-inflation equilibrium initially.

4. Financial Market Regulations: Reserve Requirements

We now introduce an arbitrary government-imposed reserve requirement. We specify this reserve requirement as a ceiling on the fraction of a bank's portfolio that can be held in the form of capital. Let $\overline{q}$ denote the reserve requirement. From (2.9), we restrict $\overline{q} < q(R^m)$ so that the reserve requirement becomes binding.

With the binding reserve requirement, (3.3) and (3.5) become

$$\theta = K_{t+1}/K_t = (1-\tau)(1-\alpha)A\overline{q}, \tag{4.1}$$

$$\beta - (1-\alpha)\tau + \frac{R^m}{A}\frac{1-\overline{q}}{\overline{q}} = (1-\tau)(1-\alpha)(1-\overline{q}). \tag{4.2}$$

From (4.1) one immediately notes that relative to any laissez-faire equilibria, under this market restriction, the growth performance of an economy is reduced. Defining $\overline{R^m}$ by $\overline{R^m} = q^{-1}(\overline{q})$, we now proceed to characterize the inflationary features of the new equilibria in our two cases.

4.1. Case 1: $\gamma > 0$

Suppose that $\overline{q}$ is set so that $\overline{q} < q(R_E^m)$ where R_E^m denotes the unique equilibrium in Proposition 1. When agents are fairly risk averse so that $\gamma > 0$, (2.9) yields $q'(R^m) > 0$ so that $\overline{q} < q(R_E^m) \Leftrightarrow \overline{R^m} < R_E^m$. We then have

$$\Psi(R^m) = \begin{cases} \beta - (1-\alpha)\tau + \frac{R^m}{A}\frac{1-q(R^m)}{q(R^m)} & if \quad R^m \leq \overline{R^m}, \\ \beta - (1-\alpha)\tau + \frac{R^m}{A}\frac{1-\overline{q}}{\overline{q}} & if \quad R^m > \overline{R^m}, \end{cases} \tag{4.3}$$

$$\Gamma(R^m) = \begin{cases} (1-\tau)(1-\alpha)[1-q(R^m)] & if \quad R^m \leq \overline{R^m}, \\ (1-\tau)(1-\alpha)(1-\overline{q}) & if \quad R^m > \overline{R^m}. \end{cases} \tag{4.4}$$

We illustrate (4.3) and (4.4) in Figure 3.

From (4.3) and (4.4), it is clear that whenever $R^m < \overline{R^m}$, these equations coincide with each of the corresponding sides of (3.5). The unique equilibrium denoted by R_{FR}^m lies, as indicated in Figure 3, in the domain where $R^m > \overline{R^m}$. As illustrated in the figure, the imposition of a binding reserve requirement could lead to either a higher or a lower rate of inflation in the BGP equilibrium. In the following proposition, we list the sufficient conditions under which a binding reserve requirement would lead to a lower rate of inflation.

Proposition 2 *Suppose that individuals are fairly risk averse ($\gamma > 0$). Then the imposition of a binding reserve requirement will lead to a lower rate of inflation if $\overline{q} \geq \overline{q}^m \equiv 1 - \sqrt{\frac{\beta-(1-\alpha)\tau}{(1-\alpha)(1-\tau)}}$.*

Proof. Let R_{FR}^m denote the (inverse) equilibrium rate of inflation that satisfies (4.2). From (3.5) and (4.2), we then get

$$\begin{aligned} R_{FR}^m - R_E^m &= \Xi\left[\frac{\beta-(1-\alpha)\tau}{(1-\alpha)(1-\tau)} - (1-\overline{q})[1-q(R_E^m)]\right] \\ &\geq \Xi(1-\overline{q})[q(R_E^m) - \overline{q}] > 0, \end{aligned}$$

where $\Xi \equiv \frac{A(1-\tau)(1-\alpha)[q(R_E^m)-\overline{q}]}{(1-\overline{q})[1-q(R_E^m)]} > 0$ and the weak inequality follows from the assumption that $\overline{q} \geq \overline{q}^m$. The result follows. ■

4.2. Case 2: $-1 < \gamma < 0$

Let us denote the low-(high-) rate of return on money equilibrium by R_L^m (R_H^m) respectively. We divide the analysis of this case into two subcases:
(i) $q(R_L^m) < \overline{q} < q(R_H^m)$,
(ii) $\overline{q} < q(R_L^m)$.

When agents are not too risk averse so that $\gamma < 0$, (2.9) yields $q'(R^m) < 0$. Hence, in the first subcase where $q(R_L^m) < \overline{q} < q(R_H^m)$, we have $R_L^m > \overline{R^m} > R_H^m$. We then have

$$\Psi(R^m) = \begin{cases} \beta - (1-\alpha)\tau + \frac{R^m}{A}\frac{1-\overline{q}}{\overline{q}} & if \quad R^m \leq \overline{R^m}, \\ \beta - (1-\alpha)\tau + \frac{R^m}{A}\frac{1-q(R^m)}{q(R^m)} & if \quad R^m > \overline{R^m}, \end{cases} \tag{4.5}$$

$$\Gamma(R^m) = \begin{cases} (1-\tau)(1-\alpha)(1-\overline{q}) & if \quad R^m \leq \overline{R^m}, \\ (1-\tau)(1-\alpha)[1-q(R^m)] & if \quad R^m > \overline{R^m}. \end{cases} \tag{4.6}$$

Figure 4a depicts the equilibrium for this subcase. As shown in Figure 4a, there is a unique BGP equilibrium coinciding with the low-inflation equilibrium displayed in Figure 2b. Notice that although the reserve requirement is not binding in this BGP equilibrium, it will have real effects on the economy. The real effects come from the elimination of the high-inflationary equilibrium.[7] Proposition 3 states formally this result.

Proposition 3 *If individuals are not too risk averse ($\gamma < 0$) and the reserve requirement is set in between the two original equilibria, i.e., $q(R_L^m) < \overline{q} < q(R_H^m)$, then the reserve requirement does not bind but it eliminates the high-inflation BGP equilibrium.*

We now move to the analysis of subcase (ii). When $\overline{q} < q(R_L^m)$, we have $\overline{R^m} > R_L^m > R_H^m$. Letting R_{FR}^m be the equilibrium rate of return to fiat money

[7] We like to point out that it is not clear that the high-inflation equilibrium that is eliminated is a less desirable equilibrium. As is shown in Section 5 below, welfare is an increasing function of growth, but a decreasing function of inflation. Although the low-inflation BGP equilibrium delivers a lower rate of inflation, it is associated with a lower rate of economic growth.

under this reserve requirement, we have – as illustrated in Figure 4b– that $R_L^m > R_{FR}^m > R_H^m$. This implies that increasing the reserve requirement above the level of reserve requirements associated with the laissez faire low-inflation BGP equilibrium, guarantees bindingness. The new binding reserve requirement equilibrium will feature a lower rate of growth and a higher rate of inflation (a stagflation phenomenon) vis-a-vis the low inflation equilibrium under laissez faire. We prove this result formally below.

Proposition 4 *If individuals are not too risk averse ($\gamma < 0$) and the reserve requirement is set such that $\overline{q} < q(R_L^m)$, then the reserve requirement binds and $R_L^m > R_{FR}^m > R_H^m$.*

Proof. From (4.2),

$$R_{FR}^m = \{(1-\tau)(1-\alpha)(1-\overline{q}) - [\beta - (1-\alpha)\tau]\} \frac{A\overline{q}}{1-\overline{q}}.$$

Likewise, R_i^m $(i = L, H)$ can be obtained accordingly:

$$R_i^m = \{(1-\tau)(1-\alpha)(1-q(R_i^m)) - [\beta - (1-\alpha)\tau]\} \frac{Aq(R_i^m)}{1-q(R_i^m)}.$$

Next, since $R_H^m < R_L^m$, we have

$$\frac{\beta - (1-\alpha)\tau}{(1-\tau)(1-\alpha)} < [1 - q(R_H^m)][1 - q(R_L^m)]. \tag{4.7}$$

Similarly, we can derive

$$R_{FR}^m < R_L^m \Leftrightarrow \frac{\beta - (1-\alpha)\tau}{(1-\tau)(1-\alpha)} < (1-\overline{q})[1 - q(R_L^m)], \tag{4.8}$$

$$R_H^m < R_{FR}^m \Leftrightarrow \frac{\beta - (1-\alpha)\tau}{(1-\tau)(1-\alpha)} < (1-\overline{q})[1 - q(R_H^m)]. \tag{4.9}$$

Recall that $\overline{q} < q(R_L^m) < q(R_H^m)$, we have $1 - \overline{q} > 1 - q(R_L^m) > 1 - q(R_H^m)$. This last inequality together with (4.7) then imply that both (4.8) and (4.9) must be satisfied at the BGP equilibrium. The result follows. ■

4.3. Comparative Statics

As we have seen, it is possible to have a non-binding reserve requirement that produces real effects. For the $\gamma < 0$ case where the high inflation equilibrium is eliminated, the relevant comparative statics results are those of the low inflation equilibrium described in section 3. For all other non-binding reserve requirement equilibria, the comparative static results of section 3 remain unchanged. When the reserve requirement binds so that $\overline{q} < q(R_E^m)$ the comparative static results of alternative government financing policies can be traced from (4.1) and (4.2). The results turn out to be very different from those obtained when financial intermediaries are not restricted. We first rewrite (4.2) along the lines of (3.6):

$$\beta = (1-\alpha)\tau + \frac{1-\overline{q}}{A\overline{q}}(\theta_{FR} - R_{FR}^m). \tag{4.10}$$

As before, the right hand side of equation (4.10) describes the two sources of government revenue; income taxation and seigniorage. In Results 4 - 6 below, we present a formal description of the growth and inflation consequences of alternative government financing methods, each of which is followed by a brief intuition.

Result 4 When the reserve requirement binds at the BGP equilibrium, an expansion in government spending financed exclusively with an increase in the seigniorage tax rate has no effect on growth. On the other hand, an increase in income tax-financed government spending suppresses growth and raises the rate of inflation, although not to the extent in the former financing scheme.

Proof. From (4.1) and (4.2), the marginal effects of an expansion in β financed exclusively through seigniorage, can be traced by setting $d\tau = 0$. It is straightforward then to obtain $d\theta_{FR}/d\beta = 0$ and $dR_{FR}^m/d\beta = -A\overline{q}/(1-\overline{q}) < 0$. Now, tracing the inflation-growth consequences of increasing government spending exclusively via increases in income taxation requires setting $d\beta = (1-\alpha)d\tau$. And it follows that $d\theta_{FR}/d\beta = dR_{FR}^m/d\beta = -A\overline{q} < 0$. ■

In the absence of any changes in income tax, the rate of growth in the economy is pegged by the binding reserve requirement. Moreover, for a given level of the binding reserve requirement, increases in the amount of seigniorage revenue are associated with increases in the seigniorage tax rate. As a result, an expansion in government spending financed with an increase in the seigniorage tax rate must raise the inflation rate. On the other hand, when a government finances an increase in its spending solely with income taxes, economic growth slows down. For a given level of the binding reserve requirement, a drop in the rate of growth leads to a drop in the seigniorage tax base. In order to maintain the total seigniorage revenues as a fraction of output unchanged, this drop in the seigniorage base has to be offset by an increase in the inflation rate.

Result 5 When the reserve requirement binds at the BGP equilibrium, for a given β (the fraction of government expenditures to output), a switch of financing method from seigniorage to income taxation is deflationary but growth reducing.

Proof. From (4.1) and (4.2), it is straightforward to obtain $d\theta_{FR}/d\tau = -(1-\alpha)A\overline{q} < 0$ and $dR^m_{FR}/d\tau = (1-\alpha)A\overline{q}^2/(1-\overline{q}) > 0$. ■

Other things equal, given a constant government spending as a fraction of output, an increase in the income tax rate, reduces the need for seigniorage revenue, which, for a given binding reserve requirement, results in a reduction of the seigniorage tax rate.

Finally, in many instances, governments that have been unwilling to increase income taxes and reduce the fraction of government expenditures to output, but at the same time want to reduce the rate of inflation, opt for financial repression (i.e., a reduction in $\overline{q}$). The next result states the effects on inflation and growth of an increase in the degree of financial repression.

Result 6 When the reserve requirement binds at the BGP equilibrium, a reduction in $\overline{q}$ lowers economic growth and has an ambiguous effect on the equilibrium rate of inflation.

Proof. From (4.1) and (4.2), it is straightforward to obtain $d\theta_{FR}/d\overline{q} > 0$ and $dR^m_{FR}/d\overline{q} = \frac{1}{1-\overline{q}}\left[\frac{R^m_{FR}}{\overline{q}} - \theta_{FR}\right] \gtrless 0$. ■

For a given fiscal deficit (net of income taxes) as a fraction of output, an increase in the reserve requirement represents a drop in the rate of economic growth and an increase in the seigniorage tax base. If, for example, the increase in the degree of repression is high enough so that the decline in the seigniorage tax rate (resulting from the drop in the economic growth rate) is larger than the rise in the seigniorage tax base, one can observe a rise in the rate of inflation so as to leave the total seigniorage revenue unchanged. This explains the ambiguity result in the proposition.

5. Welfare

In this section, we examine the effects of fiscal, monetary and reserve requirement policy interactions from a welfare perspective.[8] To that end, we adopt the standard practice of identifying the discounted sum of utilities of current and future generations as the welfare criterion:

$$\Omega = \sum_{t=0}^{\infty} \rho^t V_t,$$

where V_t is the indirect utility function given in (2.6).[9] To insure boundedness of Ω, we follow Barro (1990) in assuming $\rho < \theta^\gamma$. Our point of departure is the following result the proof is omitted.

Result 7 The welfare indicator, Ω, is an increasing function of θ_{FR} and R^m_{FR}.

5.1. Comparative Statics

In this section, we consider the welfare effects of a change in government spending under alternative financing methods. Not surprisingly in this model, since β does not enter individuals' utility function, regardless of the financing method, an increase in the government spending reduces welfare. What is of interest is whether alternative government financing methods can be ranked according to our welfare criterion. The answer is not trivial when one considers that both seigniorage and income taxation have ambiguous effects on welfare. For example,

[8]For an example of a related analysis in the context of exogenous growth, see Bhattacharya et. al. (1997). In this section, we focus the analysis on the case where the reserve requirement is binding. The other cases where reserve requirement is not binding have been discussed in Espinosa and Yip (1999).

[9]Since our main concern is allocative efficiency, we follow the conventional practice to ignore the initial old's utility in the evaluation of social welfare [see, for example, Wang (1993)].

although seigniorage financing is more inflationary than raising taxes, the latter retards growth which yields an adverse effect on welfare. With this in mind we are able to establish the following results.

Proposition 5 If $\overline{q}^m > \overline{q}$, then an increase in government spending via an increase in the seigniorage tax rate dominates the equilibrium resulting from the required increase in the income tax. Also, financing the increase in government spending via an increase in the income tax rate in turn dominates the equilibrium resulting from the required increase in the reserve requirement. Finally, for a given level of government spending, switching from seigniorage financing to income tax financing reduces welfare.

Proof Tedious but straightforward algebra yields

$$\left.\frac{d\Omega}{d\beta}\right|_{seigniorage\ tax-rate} - \left.\frac{d\Omega}{d\beta}\right|_{income\ tax} = \left[\frac{(K_0)^{-\gamma}A\overline{q}}{\theta_{FR}^{\gamma}-\rho}\right]\Upsilon(\theta_{FR}, R_{FR}^m, \overline{q}, \pi, \gamma, \rho),$$

$$\left.\frac{d\Omega}{d\beta}\right|_{seigniorage\ tax-rate} - \left.\frac{d\Omega}{d\beta}\right|_{seigniorage\ tax-base} = \left[\frac{(K_0)^{-\gamma}(A\overline{q})^2(1-\alpha)(1-\tau)}{(\theta_{FR}^{\gamma}-\rho)(\theta_{FR}-R_{FR}^m)}\right] \times\Upsilon(\theta_{FR}, R_{FR}^m, \overline{q}, \pi, \gamma, \rho),$$

$$\left.\frac{d\Omega}{d\beta}\right|_{seigniorage\ tax-base} - \left.\frac{d\Omega}{d\beta}\right|_{income\ tax} = -\left[\frac{(K_0)^{-\gamma}A\overline{q}R_{FR}^m}{(\theta_{FR}^{\gamma}-\rho)(\theta_{FR}-R_{FR}^m)}\right] \times\Upsilon(\theta_{FR}, R_{FR}^m, \overline{q}, \pi, \gamma, \rho),$$

$$\frac{d\Omega}{d\tau} = -\left[\frac{(K_0)^{-\gamma}A(1-\alpha)\overline{q}}{\theta_{FR}^{\gamma}-\rho}\right]\Upsilon(\theta_{FR}, R_{FR}^m, \overline{q}, \pi, \gamma, \rho),$$

where $\Upsilon(.) \equiv \left\{\frac{\theta_{FR}^{\gamma-1}}{\theta_{FR}^{\gamma}-\rho}\left[\pi\left(\frac{1-\overline{q}}{\overline{q}}\frac{R_{FR}^m}{\pi}\right)^{-\gamma} + (1-\pi)\left(\frac{\alpha A}{1-\pi}\right)^{-\gamma}\right] - \left(\frac{1-\overline{q}}{\overline{q}}\frac{R_{FR}^m}{\pi}\right)^{-\gamma-1}\right\}$. If $\Upsilon(.) > 0$, we have $d\Omega/d\beta\ |_{seigniorage\ tax-rate} - d\Omega/d\beta\ |_{income\ tax} > 0$, $d\Omega/d\beta\ |_{seigniorage\ tax-rate} - d\Omega/d\beta\ |_{seigniorage\ tax-base} > 0$, $d\Omega/d\beta\ |_{seigniorage\ tax-base} - d\Omega/d\beta\ |_{income\ tax} < 0$ and $d\Omega/d\tau < 0$. A sufficient condition for this to be true is that $\left(\frac{\theta_{FR}^{\gamma-1}}{\theta_{FR}^{\gamma}-\rho} - \frac{\overline{q}}{R_{FR}^m(1-\overline{q})}\right) > 0$. Since $\frac{\theta_{FR}^{\gamma-1}}{\theta_{FR}^{\gamma}-\rho} > \frac{1}{\theta_{FR}}$, this together with

(4.1) and (4.2) yield the sufficient condition $1-2\overline{q} < (1-\overline{q}^m)^2$. Rearranging the condition yields $\overline{q} < (1-\overline{q}^m/2)\overline{q}^m < \overline{q}^m$. Thus, if $\overline{q}^m > \overline{q}$, then we have

$$d\Omega/d\beta \mid_{seigniorage\ tax-rate} - d\Omega/d\beta \mid_{income\ tax} > 0,$$

$$d\Omega/d\beta \mid_{seigniorage\ tax-rate} - d\Omega/d\beta \mid_{seigniorage\ tax-base} > 0,$$

$$d\Omega/d\beta \mid_{seigniorage\ tax-base} - d\Omega/d\beta \mid_{income\ tax} < 0,$$

and $d\Omega/d\tau < 0$. ■

5.2. Optimal Tax Structure: A Logarithmic Preference Case

As pointed out in Espinosa (1995) and others, a reserve requirement is equivalent to a direct tax on deposits. An interesting question in the Ramsey tradition would be: what is the income tax-deposit tax combination that would maximize Ω subject to the government's budget constraint?[10]

To that end, we start by recognizing that

$$\frac{d\Omega}{d\overline{q}} = \left[\frac{(K_0)^{-\gamma} A(1-\alpha)(1-\tau)}{\theta_{FR}^{\gamma} - \rho}\right] \Upsilon(\theta_{FR}, R_{FR}^m, \overline{q}, \pi, \gamma, \rho).$$

Moreover, using the expression for $d\Omega/d\tau$ from the proof of Proposition 5, we can see that

$$\overline{q}(d\Omega/d\overline{q}) = -(1-\tau)(d\Omega/d\tau).$$

This implies that the first order conditions for optimality with an interior solution; $d\Omega/d\overline{q} = 0$ and $d\Omega/d\tau = 0$, yield the same equation

$$\Upsilon(\theta_{FR}, R_{FR}^m, \overline{q}, \pi, \gamma, \rho) = 0. \tag{5.1}$$

Thus, equation (5.1) characterizes the *optimal combination* of $\overline{q}$ and τ in the BGP equilibrium.

In order to obtain closed-form solutions and to gain additional insight, we focus in the case where the utility function takes the logarithmic form. In this instance, the welfare criterion can be simplified to

$$\Omega_{LOG} = \frac{\rho \ln \theta_{FR}}{(1-\rho)^2} + \frac{\pi \ln R_{FR}^m}{1-\rho} + \frac{\pi \ln(1-\overline{q}) + (1-\pi)\ln \overline{q}}{1-\rho} + B, \tag{5.2}$$

[10]See Bencivenga and Smith (1992) for a similar analysis in the context of exogenous growth.

where $B \equiv \frac{1}{1-\rho}\{\ln[(1-\alpha)(1-\tau)AK_0 + (1-\pi)\ln(\alpha A) - \pi \ln \pi\}$. The first order conditions for this problem will include $d\Omega/d\overline{q} = 0$ and $d\Omega/d\tau = 0$ which is the basis of the following proposition.

Proposition 6 *For the welfare criterion described in 5.2, there is a continuum of welfare-maximizing* $(\overline{q}, \tau)$ pairs *satisfying the relation*

$$\overline{q} = \frac{1-\alpha-\beta}{(1-\tau)(1-\alpha)[1+\pi(1-\rho)]}.$$

This result is, of course, specific to the definition of income in this model. However, the result illustrates that, at least in some settings, *even when one abstracts from collection costs*, an optimizing government may choose to trade financial repression for lower income taxes.

Finally, from a welfare perspective, one should not necessarily prescribe a level of financial repression that minimizes inflation. In principle, the welfare-maximizing set of degree of repression, $\overline{q}^*$, will not coincide with the inflation-minimizing degree of financial repression, $\overline{q}^m$, because the latter can be associated with 'too little growth.' Specifically, our next proposition shows that minimizing inflation only results in an above-optimal level of financial repression.

Proposition 7 *The inflation-minimizing reserve requirement is higher than the corresponding welfare-maximizing level, i.e.,* $\overline{q}^m < \overline{q}^*$.

Proof Recall that $\overline{q}^*$ satisfies $\frac{d\Omega_{LOG}}{d\overline{q}} = 0$ where

$$\frac{d\Omega_{LOG}}{d\overline{q}} = \frac{\rho}{\theta_{FR}(1-\rho)^2}\frac{d\theta_{FR}}{d\overline{q}} + \frac{1-\pi-\overline{q}}{(1-\rho)(1-\overline{q})\overline{q}} + \frac{\pi}{R^m_{FR}(1-\rho)}\frac{dR^m_{FR}}{d\overline{q}}.$$

Since $\frac{d\theta_{FR}}{d\overline{q}} > 0$ and $1-\pi > \overline{q}$, the first two terms on RHS are positive. Next, recall that $\overline{q}^m$ satisfies $\frac{dR^m_{FR}}{d\overline{q}} = 0$ and so we have $\frac{d\Omega_{LOG}(\overline{q}^m)}{d\overline{q}} > 0$. Given that $\frac{d\Omega_{LOG}}{d\overline{q}}$ is strictly decreasing in $\overline{q}$ (i.e., $\frac{d^2\Omega_{LOG}}{d\overline{q}^2} < 0$), we have $\overline{q}^m < \overline{q}^*$. ■

6. Concluding Remarks

This paper develops an endogenous growth model with financial market restrictions to examine the effects of government finance on growth, inflation and welfare.

With unrestricted financial intermediaries, a unique equilibrium exists if and only if agents are fairly risk averse; otherwise, multiple equilibria emerge. Financial restrictions eliminate multiple equilibria and modify altogether the ultimate implications of alternative government policies relative to the laissez faire case.

When the reserve requirement binds at the BGP equilibrium, an expansion in the seigniorage tax rate raises the rate of inflation but has no effect on growth. Alternatively, increasing the income tax to meet the same government spending requirements suppresses growth and also leads to higher inflation, although not to the extent resulting from the required increase in seigniorage. Moreover, a switch of financing method from seigniorage to income taxation is deflationary but growth reducing.

From a welfare perspective, the paper provides a robusteness stamp on the analyses that deal specifically with reserve requirements in the context of deficit finance. Studies such as Freeman (1987) and Espinosa (1995) find that the imposition of reserve requirements is not justified on efficiency grounds. Finally, like in other set-ups, the reserve requirement that minimizes inflation may not coincide with the optimal level of reserve requirement.

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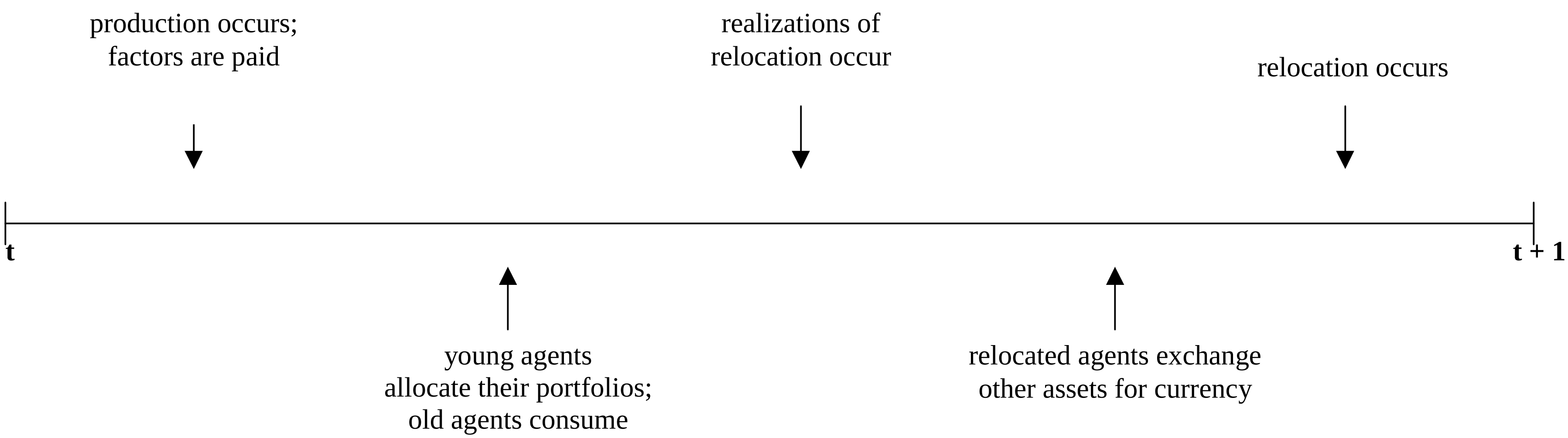

Figure 1
Timing of Events

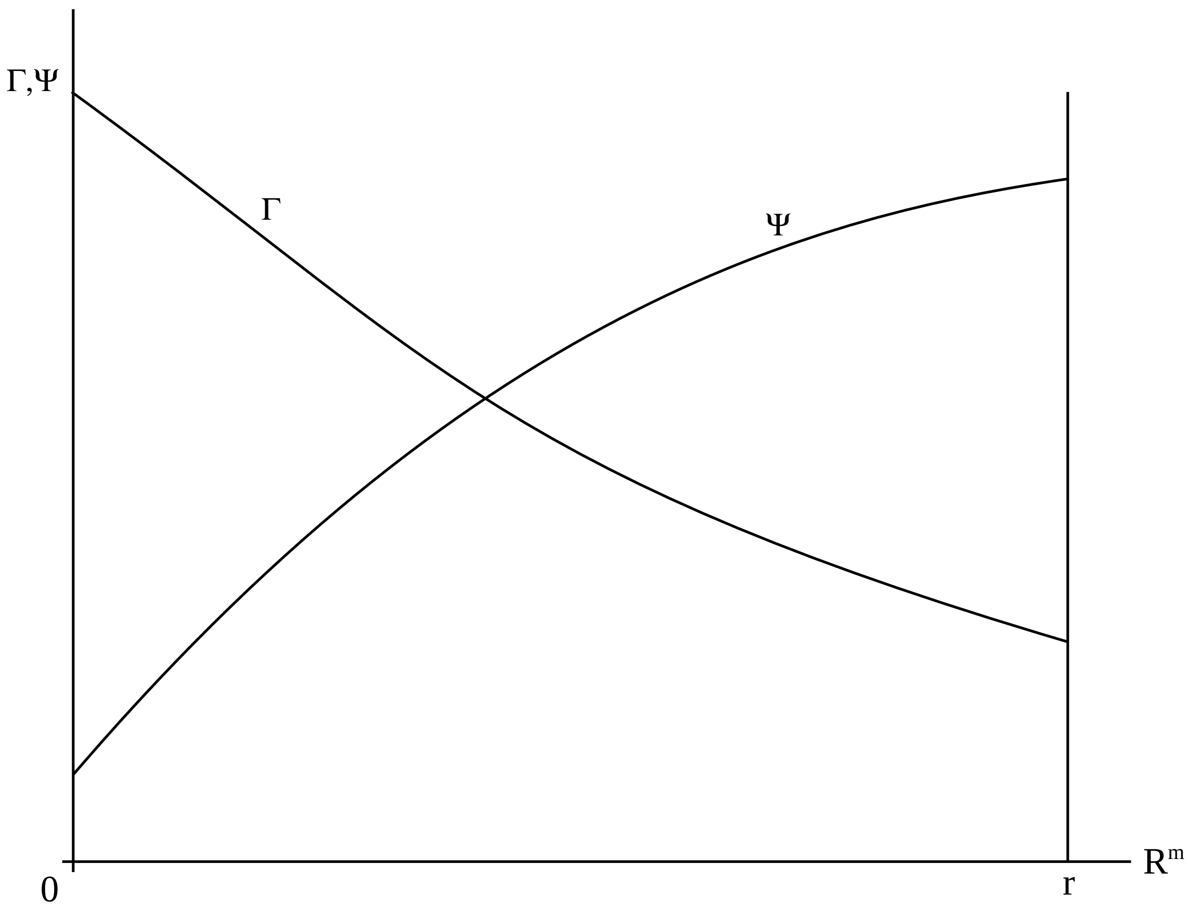

Figure 2a ($\gamma > 0$)

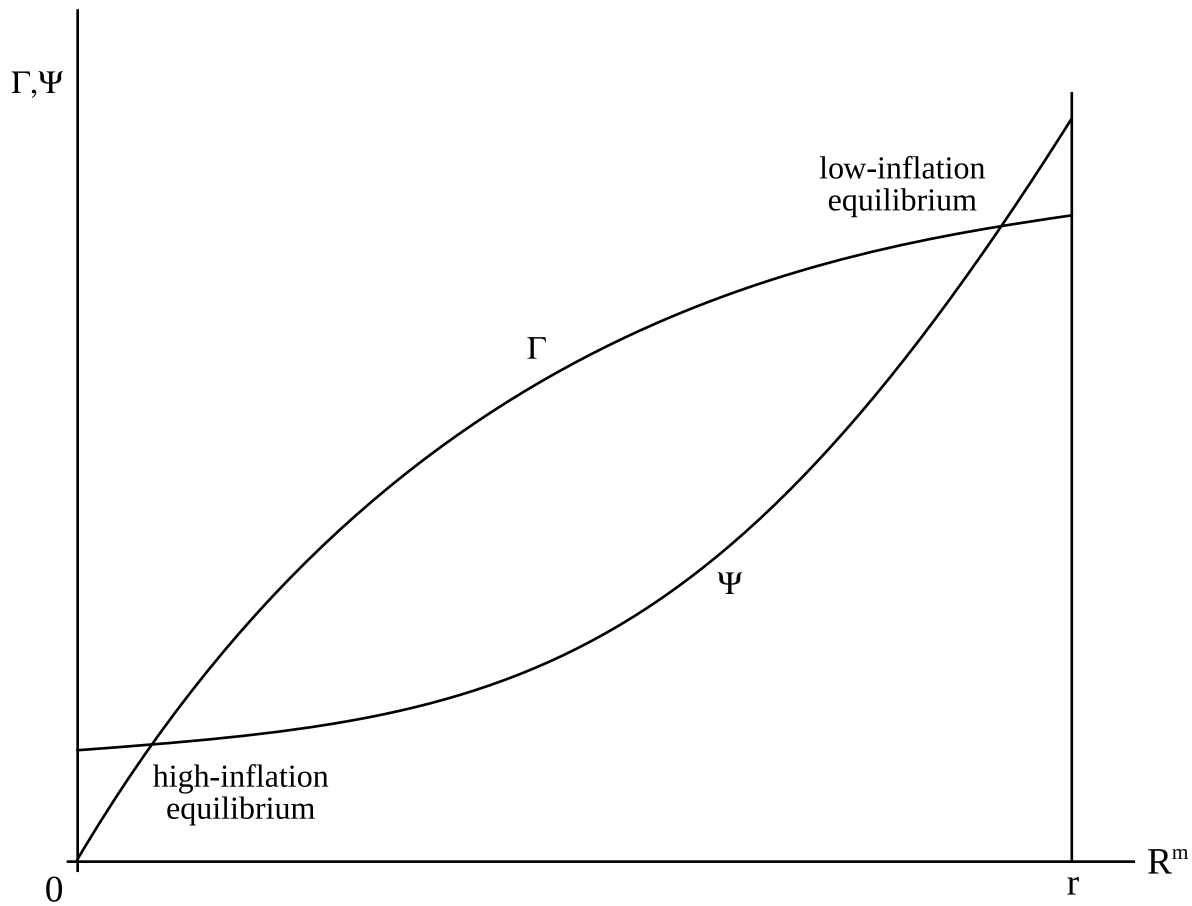

Figure 2b ($-1 < g < 0$)

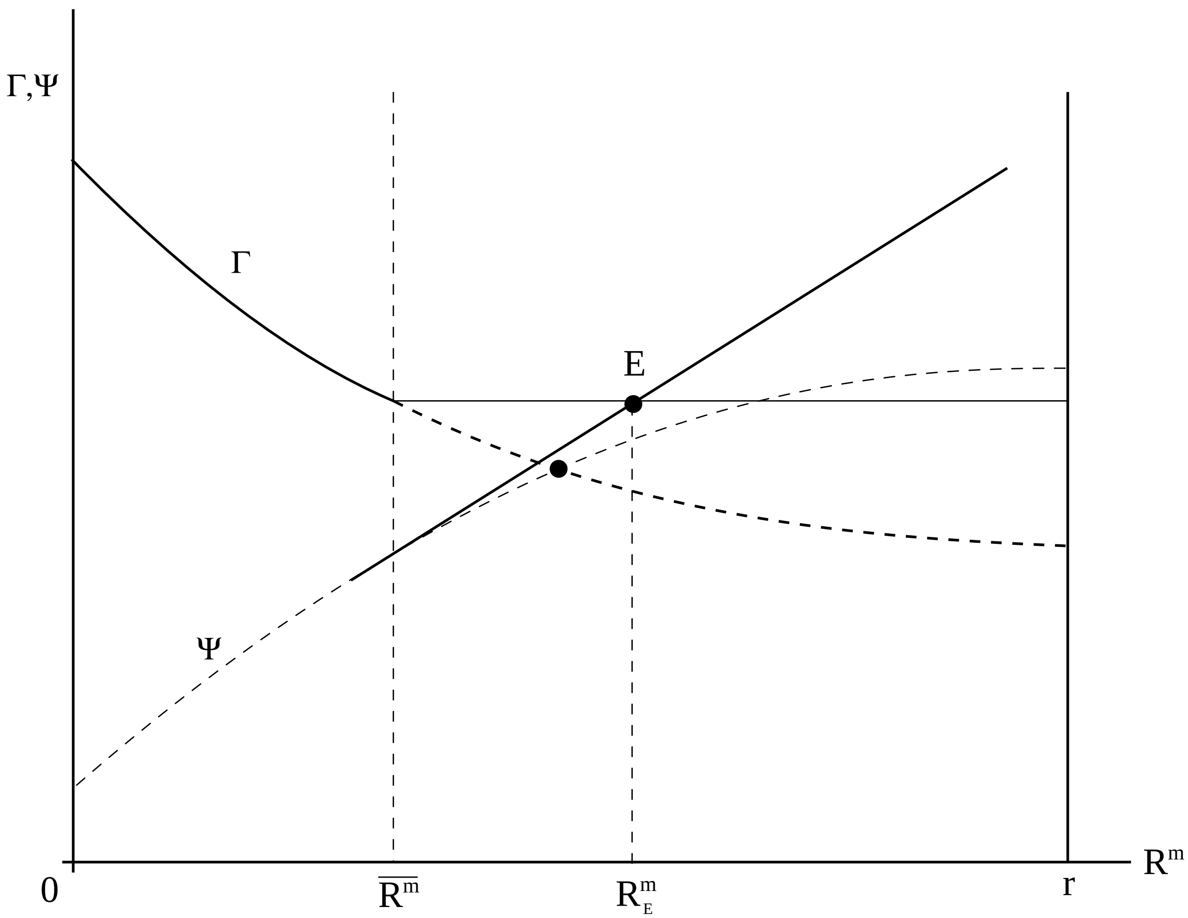

Figure 3 (g > 0)

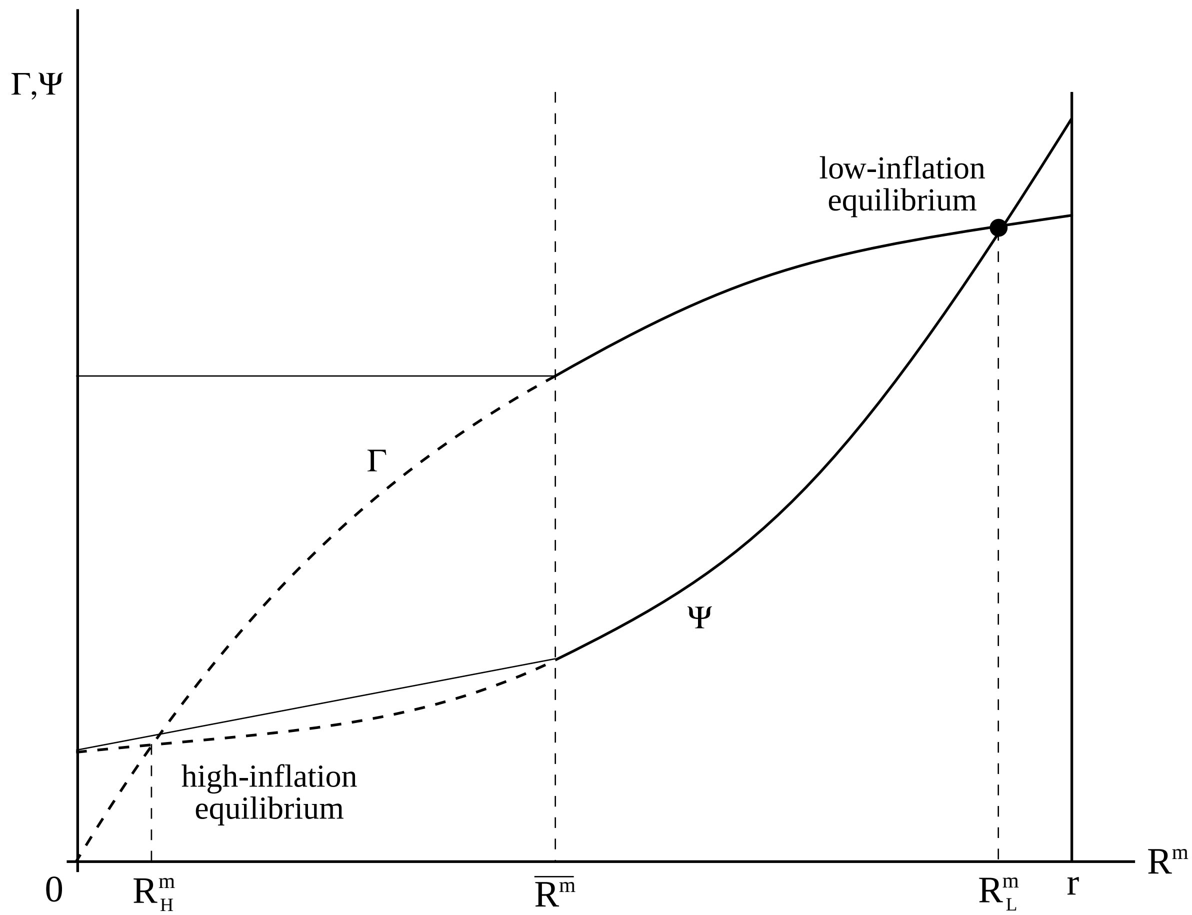

Figure 4a (–1 < g < 0)

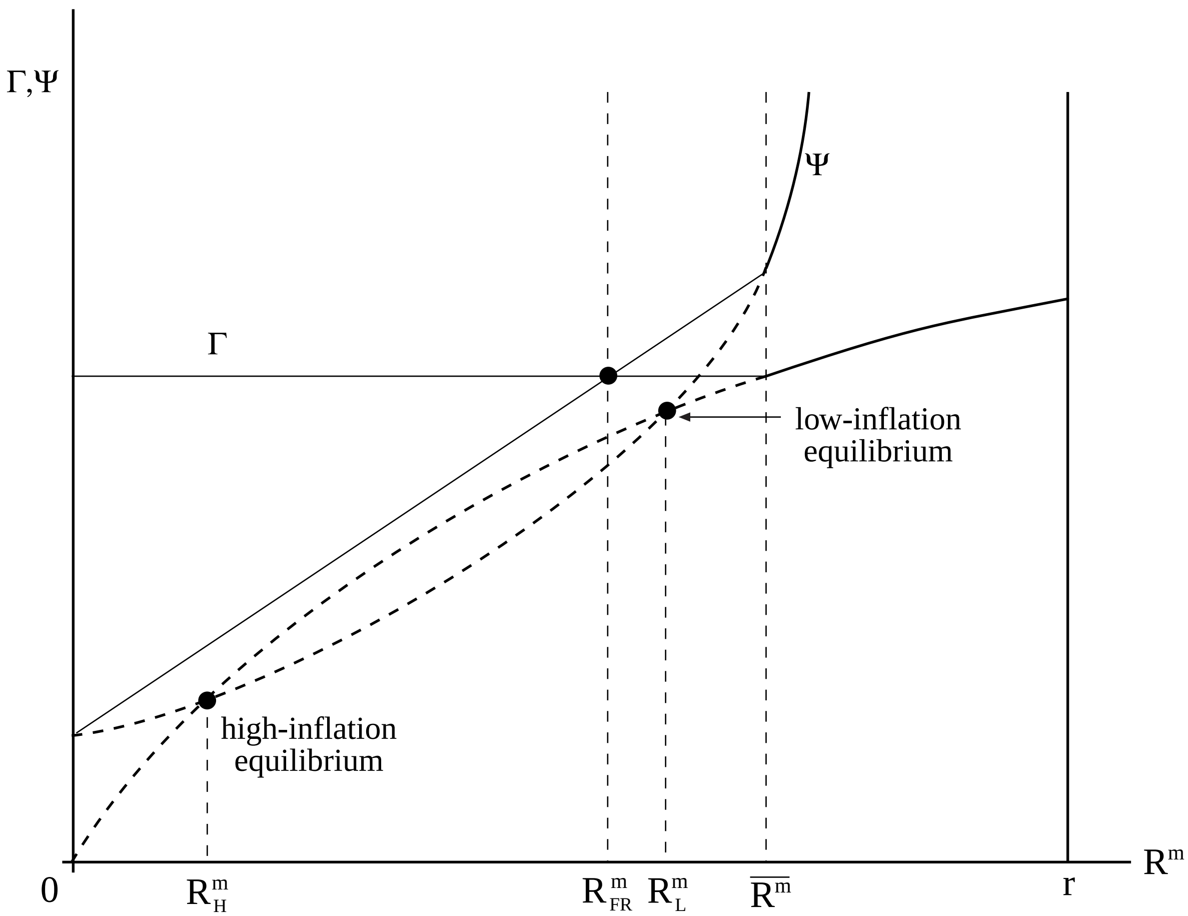

Figure 4b (–1 < g < 0)