Money and growth revisited

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MONEY AND GROWTH REVISITED

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Abstract

The Ramsey-Romer model of endogenous growth is extended to allow for holdings of real money balances and government debt as well as capital and for non-interconnected generations of households. Tax-financed increases in government consumption and debt depress growth prospects and boost inflation, as long as a positive birth rate ensures that future taxes are shouldered by future, yet unborn, generations. Debt-financed increases in government consumption depress growth and boost inflation even more. Money-financed increases in government consumption depress growth less but increase inflation by more. Giving subsidies through an increase in monetary growth is non-neutral, since this increases real growth and thus inflation increases by a lesser amount than monetary growth. Bond-financed increases in monetary growth lead to a larger increase in real growth and a smaller increase in inflation. If there are costs of adjustment for investment, cuts in monetary growth and increases in government debt and government consumption induce an increase in the real interest rate.

JEL classification: 023, 111, 311, 320.

Keywords: endogenous growth, finite lives, population growth, Ricardian equivalence, overlapping generations, capital accumulation, non-neutrality of money.

Contents

1 Introduction

The question of whether monetary policies can affect real growth prospects of an economy is one of the most crucial but at the same time most neglected questions of our profession. The objective of the present paper is to provide a coherent framework in which monetary growth can permanently affect the real growth rate of the economy. This means that an increase in monetary growth no longer leads to an equiproportional increase in the inflation rate, and also that money is no longer the sole determinant of inflation in the long run. It shall be shown that increases in government debt and government consumption damage growth prospects and thus increase inflation even with a constant rate of growth of the nominal money supply. Before it is explained how these very unorthodox results are obtained, it is useful to pay some attention to previous attempts to analyse the non-neutrality of money.

The effectiveness of monetary growth in influencing real outcomes has been hotly debated by academics for many years. As long as one stays within the realms of the rational expectations paradigm and abstracts from issues such as overlapping wage contracts, it is accepted by large parts of the profession that money is neutral in the sense that only unanticipated changes in the supply of money can cause deviations of output from its natural rate. However, the debate on the superneutrality of money is far from settled, as many believe that monetary policy can affect the natural rate of output itself.

On the one hand, there is the well-known argument, due to Tobin (1965), which says that money is not superneutral because an increase in the anticipated growth of the nominal supply of money reduces the real interest rate and increases the long-run capital-output ratio [1]. On the other hand, the rationale for such a Tobin effect has been denied by a strand of literature focussing on infinite-horizon, representative-agent models. Sidrauski (1967b) first established such a superneutrality result in a model where agents have an inelastic supply of labour, derive utility from the consumption of goods and real money balances [2], and agents form expectations adaptively. Fischer (1979b) and Asako (1983) replicated this result under the assumption that

[1] The same result is obtained in Sidrauski (1967a), who uses adaptive expectations, in Fischer (1979a) and Begg (1980), who use rational expectations, and in Lucas (1975), who uses a new classical equilibrium business cycle model.

[2] Feenstra (1986) shows that the procedure of entering money in the utility function is formally equivalent to entering liquidity costs in the budget identity of the representative

agents have perfect foresight and established that, as long as preferences are non-separable, non-neutralities can only occur during the transition path towards long-run equilibrium [3].

In recent years, it has become clear that there is a close connection between Sidrauski's superneutrality result and Ricardian debt neutrality. When one leaves the world of representative households or dynasties with an operational intergenerational bequest motive and infinite horizons and moves to a world populated by non-interconnected households without such a bequest motive, increases in monetary growth accompanied by lump-sum transfers have real effects. Weil (1986) establishes this result for an economy with infinitely-lived households and a positive birth rate, whilst van der Ploeg and Marini (1988) and van der Ploeg (1990) obtain a similar result for an economy where households have finite lifetimes and where the birth rate equals the probability of death [4]. An increase in monetary growth leads in the long run to a fall in the real interest rate and an increase in the capital-output ratio, so that money is not superneutral.

In the literature discussed so far money only affects the rate of economic growth in the short run, because in the steady state the real growth rate of the economy is given by the sum of population growth and an exogenous rate of labour-augmenting technical progress. This means that inflation is in the long run entirely a monetary phenomenon. In the short run economic growth is faster when the capital-output ratio is lower and thus the marginal productivity of capital is higher than in steady state as then households have a greater incentive to postpone consumption, but in the long run the growth rate is exogenous. This is because the literature on money and growth has always been cast in terms of the neoclassical theory of economic growth, as developed by Solow (1956), Swan (1956) and Cass (1965). After more than three decades of neoclassical growth theory without production externalities, a very exciting new brand of theories has emerged which permits economists

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household, so that Sidrauski's result is not as restrictive as it seems at first sight.

[3] Dornbusch and Frenkel (1973) and Fischer (1974) show that superneutrality also no longer holds when money is a factor of production. Brock (1974) obtains departures from superneutrality by allowing for an endogenous labour supply, i.e. by introducing leisure into the utility function of the representative household in a non-separable fashion.

[4] Aiyagari and Gertler (1985) use the more conventional overlapping generations model of Diamond (1965) to discuss the validity of various monetarist propositions under alternative budgetary rules.

to tackle old questions with new tools.

These new theories are based on the by now classic papers of Romer (1986) and Lucas (1988). They allow for an endogenous long-run growth rate of the economy by assuming that production is proportional to a broad measure of the capital stock. The capital stock should thus be thought of as to include the physical stock of machines, the stock of ideas or knowledge both of the individual firm and of its competitors, and the stock of infrastructural public goods, all of which can be augmented through investment. These theories allow production externalities, arising from learning by doing, R&D and infrastructural public goods, to affect the marginal productivity of capital, the real interest rate and thus the growth rate of the economy. However, macroeconomic fiscal and monetary policies cannot affect the growth rate of the economy in these new theories of endogenous economic growth. The reason is that the new theories of endogenous growth are based on the Ramsey (1928) model which assumes infinitely-lived households or dynasties with a fully operative intergenerational bequest motive and thus implies Ricardian debt neutrality. This is obviously an unnecessarily restrictive framework for addressing questions about the effectiveness of fiscal and monetary policy and one should not be surprised that in such a framework money must be superneutral. However, in Alogoskoufis and van der Ploeg (1990) we show that once the Romer-Lucas theories of endogenous growth are extended to allow for non-interconnected overlapping generations of households, macroeconomic demand-side policies have real effects. This extension introduces consumption externalities arising from missing markets, as current generations cannot trade with future, yet unborn generations. It follows that an increase in government debt arising from an intertemporal shift in taxation and an increase in government consumption reduce the growth rate of the economy. The mechanism is that future taxes are partially shouldered by future, yet unborn generations so that private consumption rises (is not fully crowded out), less resources are available for private saving and investment and thus the growth rate falls. The objective of the present paper is to reconsider these issues within the context of a monetary model of endogenous growth and overlapping generations and to address the question of how monetary growth affects inflation and the real growth rate of the economy.

Section 2 formulates a monetary model of endogenous growth and non-interconnected overlapping generations. There is no operational bequest motive, so that the birth of new generations destroys Ricardian debt neutrality. Output is proportional to the own capital stock and the aggregate capital stock, which allows for the simplest possible formulation of learning by doing and endogenous growth. The demand for money is derived by including real money balances in the utility function. This approach may be justified in terms of less trips to the bank, less menu costs and more leisure time, but remains a trifle ad hoc, as almost all models of monetary economies. Section 3 demonstrates that, when there is no new entry of non-interconnected generations, Ricardian debt neutrality holds and thus monetary growth, government consumption and government debt do not affect the real growth rate and the inflation rate. In other words, debt neutrality implies that money is superneutral and that government consumption leads to 100 per cent crowding out of private consumption. Section 4 considers a money-capital economy in which taxes are the residual mode of government finance. It is established that a positive birth rate raises the national income share of private consumption, depresses the real growth rate and increases inflation. Monetary growth is no longer neutral. It affects the real growth of the economy, so that inflation does not rise by the same amount. Balanced-budget increases in government consumption are shown to cut real growth and boost inflation. Section 5 examines what happens when monetary growth is the residual model of government finance. Section 6 allows for changes in government debt and shows that postponing taxes reduces growth and increases inflation. Bond-financed changes in government consumption are shown to reduce growth prospects more than tax-financed changes whilst money-financed changes reduce growth less. Similarly, when open market operations are used to raise monetary growth, real growth rises by more and inflation by less than when subsidies are used to raise monetary growth. Section 7 briefly examines the case of non-separable preferences. Section 8 introduces costs of adjustment for investment. This makes the real interest rate endogenous and thus introduces an additional channel through which money and government debt can affect real growth and inflation rates. Section 9 concludes with a summary of results.

2 Overlapping generations, money and endogenous growth

2.1 Household behaviour and aggregation

Departures from Ricardian debt neutrality (Barro, 1974) are ensured in an economy of overlapping generations without intergenerational bequest motive, as long as the birth rate, β, is positive (Weil, 1985; Buiter, 1988). There is a constant probability of death, λ, so that the rate of population growth is defined by $n \equiv \beta - \lambda$. The uncertain lifetimes approach of Yaari (1965) and Blanchard (1985) corresponds to the special case of no population growth ($n = 0$), in which case the birth rate equals the death rate ($\beta = \lambda$). It is thus not necessary to have finite lifetimes in order to depart from debt neutrality.

The representative household of the cohort born at time s solves at time t the following problem:

$$\underset{\bar{c}(s,v),\bar{m}(s,v)}{\text{Max}} \int_t^{\infty} \exp[-(\rho + \lambda)(v - t) \log(\Omega(\bar{c}(s,v), \bar{m}(s,v)))\, dv \tag{1}$$

subject to the household's instantaneous flow identity

$$\frac{d\bar{a}(s,t)}{dt} = [r(t) + \lambda]\bar{a}(s,t) + \bar{j}(s,t) - \bar{\tau}(s,t) - \bar{c}(s,t) - [r(t) + p(t)]\bar{m}(s,t) \tag{2}$$

and the household's solvency condition

$$\lim_{v \to \infty} \exp\left(-\int_t^v [r(w) + \lambda]dw\right) \bar{a}(s,v) = 0 \tag{3}$$

where ρ denotes the pure rate of time preference, $r(t)$ denotes the real market rate of interest at time $t, p(t)$ denotes the rate of inflation at time t, and $\bar{c}(s,t), \bar{m}(s,t), \bar{a}(s,t), \bar{j}(s,t)$ and $\bar{\tau}(s,t)$ denote at time t the levels of consumption, holdings of real money balances, non-human wealth, dividends and lump-sum taxes (net of transfers) of a household born at time s, respectively.

Equation (1) says that the household maximises expected utility, where the effective discount rate corresponds to the sum of the probability of death and the pure rate of time preference. Comprehensive consumption, $\bar{x}(s,t)$, consists of consumption of goods plus interest foregone on money holdings:

$$\bar{x}(s,t) \equiv \bar{c}(s,t) + [r(t) + p(t)]\bar{m}(s,t) = q(t)\bar{u}(s,t) \tag{4}$$

where $q(t)$ denotes the ideal cost-of-living index associated with the basket of physical goods and real money balances at time t, and $\bar{u}(s,t) \equiv \Omega(\bar{c}(s,t), \bar{m}(s,t))$ denotes the instantaneous sub-utility at time t of a household born at time s. $\Omega(.)$ is assumed to be homothetic and homogenous of degree one. At stage 1 the household decides on comprehensive consumption and at stage 2 the household allocates it between consumption of goods and real money balances. Equation (2) says that the return on assets, consisting of a market rate of interest plus a life insurance premium plus dividends, minus taxes must either be consumed or saved. When the household is alive it receives a premium of $\lambda\bar{a}$ on its assets and when it dies the estate goes to the insurance company, hence the premium is actuarially fair. Free entry and exit ensure that the insurance industry is efficient and makes no profits. There is no labour and thus no wage income in this model. Equation (3) ensures that households cannot play Ponzi games. Together with (2) and (4), it yields the household's present-value budget constraint,

$$\int_t^\infty \bar{x}(s,v)\exp\left(-\int_t^v [r(w)+\lambda]dw\right)dv \leq \bar{a}(s,t) + \int_t^\infty [\bar{j}(s,v) - \bar{\tau}(s,v)]\exp\left(-\int_t^v [r(w)+\lambda]dw\right)dv \tag{5}$$

which says that the present value of comprehensive consumption should be less than non-human wealth plus the present value of dividends minus the present value of future tax liabilities.

Stage 1 yields the familiar tilt of comprehensive consumption:

$$\frac{d\bar{x}(s,t)}{dt} = [r(t) - \rho]\bar{x}(s,t) \tag{6}$$

Upon substitution of (6) into (5), one obtains:

$$\bar{x}(s,t) = (\rho+\lambda)\{a(s,t) + \int_t^{\infty} [\bar{j}(s,v) - \bar{\tau}(s,v)]\exp\left(-\int_t^v [r(w)+\lambda]dw\right) dv\} \quad (7)$$

The comprehensive consumption function is linear in wealth plus the present value of after-tax dividends, because (1) implies a constant elasticity of intertemporal substitution. In fact, (1) corresponds to a unit-elastic intertemporal utility function so that the propensity to consume out of wealth does not depend on the real interest rate. The propensity to consume increases with the probability of death.

The fraction of the cohort born at time s which is still alive at time t equals $\beta L(s)\exp[-\lambda(t-s)] = \beta\exp(\beta s)\exp(-\lambda t)$, where $L(s) \equiv \exp(ns)$ denotes the population size at time s. This enables one to define population aggregates, say $X(t) \equiv \beta \exp(-\lambda t) \int_{-\infty}^{t} \bar{x}(s,t)\exp(\beta s)ds$. Aggregation over all cohorts, using the fact that newly born individuals do not inherit any wealth, $\bar{a}(s,s) = 0$, yields:

$$\dot{X}(t) = [r(t) - \rho + n]X(t) - \beta(\lambda+\rho)A(t) \quad (8)$$

$$\dot{A}(t) = r(t)A(t) + J(t) - T(t) - X(t) \quad (9)$$

Note that population growth appears in (8), because (8) refers to a population aggregate. Also, note that (9) does not contain an insurance premium, because such a premium constitutes a transfer from those who die to those who survive and thus does not affect the aggregate return on assets.

Stage 2 of the household's decision problem requires that the marginal rate of substitution between goods and real money balances equals the opportunity costs of holding real money balances (i.e. the nominal interest rate), $\Omega_m/\Omega_c = r + p$, so that $\bar{c}(s,t) = \Gamma(r(t)+p(t))\bar{m}(s,t)$, where $\Gamma' > 0$. Upon substitution into (4) and aggregation, one obtains:

$$M = \Psi(r+p)X, \quad \Psi' = -(1+\Gamma')\Psi^2 < 0 \quad (10)$$

$$C = \Phi(r+p)X, \quad \Phi' = [(r+p)\Gamma' - \Gamma]\Psi^2 \gtrless 0 \quad (11)$$

$$q = [\Psi(r+p)\Omega(\Gamma(r+p),1)]^{-1}. \tag{12}$$

Homotheticity implies that goods and real money balances are normal goods. A CES utility function, say $\Omega(.) = [\gamma c^{\eta} + (1-\gamma)m^{\eta}]^{\frac{1}{\eta}}, \eta \neq 1, 0 < \gamma < 1$, yields $\Gamma(.) = [\gamma\left(\frac{r+p}{1-\gamma}\right)]^{\sigma}, \Psi(.) = (1-\gamma)[(1-\gamma)(r+p) + \gamma(r+p)^{\sigma}]^{-1}$ and $\Phi(.) = [1 + \left(\frac{1-\gamma}{\gamma}\right)^{\sigma}(r+p)^{1-\sigma}]^{-1}$ where $\sigma \equiv (1-\eta)^{-1}$ denotes the elasticity of substitution between goods and real money balances. Cobb-Douglas sub-utility function ($\sigma = 1$) implies $\Phi(.) = \gamma$ so that $\Gamma(.) = \left(\frac{\gamma}{1-\gamma}\right)(r+p), \Psi = \left(\frac{1-\gamma}{r+p}\right)$ and $q = \gamma^{-\gamma}\left(\frac{r+p}{1-\gamma}\right)^{1-\gamma}$. In general, the budget share of goods rather than real money balances decreases (increases) with the nominal interest rate when the income (substitution) effect dominates, which is the case when σ is less (greater) than unity.

2.2 Behaviour of firms

There are a large number of competitive firms who maximise their net worth. Following the recent literature on endogenous growth, for example Romer (1986, 1989, 1990), Lucas (1988), King, Plosser and Rebelo (1988) and Barro (1990), constant returns to scale with respect to a broad measure of the capital stock is assumed. Here attention is focussed on budgetary demand-side policies rather than on supply-side policies. Hence, use is made of a simple model of endogenous growth which emphasises production externalities such as learning by doing and spill-overs of knowledge from other firms and ignores the effects of social infrastructure on the productivity of capital. To be specific, the production function of the representative firm is of the Cobb-Douglas variety and is given by

$$Y(t) = \theta K(t)^{\eta}\bar{K}(t)^{1-\eta}, \quad 0 < \eta \leq 1 \tag{13}$$

where $Y(t), K(t)$ and $\bar{K}(t)$ denote the level of production, the own capital stock and the aggregate capital stock at time t, respectively. Production exhibits constant returns to scale with respect to K and $\bar{K}$. If η is less than unity, there is learning by doing because then knowledge from one producer spills over and increases the output of other producers. Capital accumulation satisfies

$$\dot{K}(t) = I(t) - \delta K(t) \tag{14}$$

where $I(t)$ denotes private investment at time t and δ denotes the depreciation rate. Producers borrow and lend at a given market rate of interest and maximise the present value of their net revenues. This means that, in the absence of adjustment costs, the marginal productivity of capital should equal the rental charge plus the depreciation charge. In symmetric equilibrium one must have $Y = \theta K$ and $r = \eta\theta - \delta$. The presence of learning by doing means that private rate of return on assets is less than the social rate of return.

Since $(r + \delta)K = \eta Y \leq Y$, the national income exceeds the income from private capital. Learning by doing and spill-overs from knowledge of other firms in the economy induce some income for which firms do not need to pay. These profits are handed back to the owners of the firms, i.e. the households, irrespective of their age, so that $J = (1 - \eta)Y$.

2.3 Government

The government can either print money or issue real (indexed) debt (D). Public consumption (G) plus interest on the public debt (rD) must be financed by taxes (T), borrowing ($\dot{D}$) or printing money (μM). This gives rise to the flow budget identity of the government:

$$\dot{D}(t) = r(t)D(t) + G(t) - T(t) - \mu(t)M(t) \tag{15}$$

where $\mu(t)$ and $\mu(t)M(t)$ denote the rate of growth in the nominal supply of money and the seigniorage revenues extracted from the private sector at time t, respectively. Solvency requires that the present value of government debt as time tends to infinity converges to zero. Solvency implies the present-value budget constraint of the government:

$$\int_t^{\infty} \exp[-\int_t^{v} r(w)dw]G(v)dv + D(t) \leq$$

$$\int_t^\infty \exp[-\int_t^v r(w)dw][T(v)+\mu(v)M(v)]dv. \tag{16}$$

Hence, the present value of future government consumption plus the current government debt must not exceed the present value of taxes plus seigniorage revenues.

The government has four instruments at its disposal, viz. G, T, μ and $\dot{D}$, of which three can be chosen freely and the fourth one follows residually from the present-value government budget constraint. The national income share of government consumption, $g \equiv G/Y$, is always assumed to be exogenous. Section 4 refers to tax finance and considers a pure money-capital economy without government debt in which taxes are the residual instrument, $T = G - \mu M$, and g and μ are exogenous. Section 5 refers to money finance and considers a money-capital economy in which monetary growth is the residual instrument, $\mu = (G-T)/M$. Section 6 refers to bond finance and allows for government debt and intertemporal shifts in taxation whilst keeping g and μ exogenous. To ensure solvency, it is necessary to specify a tax rule which arrests the explosion of government debt:

$$T = \tau_0 Y + \tau_1 D. \tag{17}$$

Hence, the tax-GDP ratio consists of an autonomous component (τ_0) plus a component which is proportional to the government debt-GDP ratio. Solvency requires that τ_1 exceeds the growth-corrected real interest rate.

2.4 Equilibrium

Equilibrium in the product and money markets requires:

$$Y = C + I + G \tag{18}$$

$$\dot{M} = [\mu - p]M. \tag{19}$$

The asset menu of households consists of capital, money and government bonds. Together with equilibrium on the equity and bond markets, one then has $A = K + M + D$.

The real growth in the level of national income is defined as $\omega \equiv \dot{Y}/Y = \dot{K}/K$ and the per-capita growth rate (or the endogenous rate of labour-augmenting technical progress) is defined as $\pi \equiv \omega - n$. It is convenient to express all variables in fractions of the national income, which are denoted by lower-case rather than upper-case letters. The model can then be summarised by three differential equations for the private consumption-GDP ratio, money-GDP ratio and the government debt-GDP ratio:

$$\dot{c} = (\eta\theta - \delta - \rho - \pi)c - (n + \lambda)(\lambda + \rho)\Phi(\eta\theta - \delta + p)[\left(\frac{1}{\theta}\right) + m + d] \quad (20)$$

$$\dot{m} = (\mu + \eta\theta - \delta - \pi - n)m - [\Phi(\eta\theta - \delta + p)^{-1} - 1]c \quad (21)$$

$$\dot{d} = (\eta\theta - \delta - \pi - n - \tau_1)d + g - \tau_0 - \mu m \quad (22)$$

where the per-capita real growth rate is given by

$$\pi = \theta(1 - c - g) - \delta - n \quad (23)$$

and the rate of inflation by

$$p = \Gamma^{-1}(c/m) - \eta\theta + \delta. \quad (24)$$

Equation (23) is the condition for equilibrium in the goods market. It says that the growth rate of the economy equals the propensity to save divided by the capital-output rate, minus the depreciation rate. This condition therefore corresponds to the Harrod-Domar (HD) rule familiar from the older literature on economic growth.

Sections 3-5 restrict attention, for simplicity, to the case of Cobb-Douglas sub-utility functions ($\sigma = 1$), so that $\Phi(r + p) = \gamma$. Section 6 then briefly examines the more general class of CES sub-utility functions.

3 Ricardian debt neutrality and endogenous growth

It is useful to have a benchmark before deriving the more surprising results of this paper. This benchmark corresponds to the situation in which Ricardian debt neutrality holds, which is the case when there is no new entry of non-interconnected generations of households and the birth rate is zero ($\beta = n + \lambda = 0$). Figure 1 demonstrates how the national income share of private consumption and per-capita growth are determined. The HD locus slopes downwards, because a higher national income share of private consumption implies a lower share of investment and thus a lower growth rate of the capital stock. The Ramsey-Romer (RR) rules says that the growth rate of private consumption equals the difference between the market interest rate, given by the productivity of capital minus the rate of depreciation, and the pure rate of time preference. A high interest rate induces households to save and postpone consumption, and thus corresponds to a high growth rate. Because the rate of growth does not depend on the national income share of private consumption, as long as debt neutrality holds, the RR rule is vertical. It follows that the equilibrium per-capita growth rate of the economy ($\pi = \eta\theta - \delta - \rho$) only depends on economic policy in as far as the government is able to influence, through investment in infrastructure, the marginal productivity of capital. The per-capita growth rate does not depend on intertemporal shifts in taxation and government debt, on the national income share of government consumption, or on the monetary growth rate. It does decrease as households become more impatient and as the degree of learning by doing increases.

The equilibrium national income share of private consumption ($c = c^* \equiv \left(\frac{\rho - n}{\theta}\right) + 1 - \eta - g$) increases with the pure rate of time preference and the degree of learning by doing but decreases with the rate of population growth and the national income share of government consumption (move from E to E'). However, the national income share of private consumption does not depend on intertemporal shifts in taxation, government debt or on monetary growth. In fact, an increase in government consumption leads to 100 per cent crowding out of private consumption so that private investment and thus the growth rate of the economy are unaffected. These policy neutrality results hold for the general class of homothetic sub-utility functions.

Insert Figure 1: Debt neutrality and endogenous growth

Since debt neutrality implies a dichotomy between the real and monetary sides of the economy, it is possible to obtain from equations (21) and (24) alone a nonlinear differential equation for the rate of inflation:

$$\dot{p} = (\eta\theta - \delta + p)(\omega + p - \mu), \quad \omega = \eta\theta - \delta - \rho + n. \tag{25}$$

The perfect-foresight solution of this Bernoulli equation is given by

$$p(t) = \left(\int_t^\infty \exp\left(-\int_t^v [\rho - n + \mu^e(w,t)]dw\right) dv\right)^{-1} - \eta\theta + \delta, \tag{26}$$

where $\mu^e(w,t)$ denotes the expectation of $\mu(w)$ conditional on all information available at time t. Hence, the equilibrium rate of inflation depends on an average of all future monetary growth rates and does not depend on budgetary demand-side policies whatsoever. The rate of inflation increases when households become more impatient, when the population growth rate falls, when the marginal productivity of capital falls, when the degree of learning by doing increases and when the depreciation rate increases, because in all these cases the real growth rate of the economy falls. Steady-state inflation equals the excess of monetary growth over growth in the real national product, $p = \mu - \omega$.

These results suggest that money is superneutral as long as debt neutrality holds. The remainder of the paper focuses therefore attention on economies in which new non-interconnected generations of households enter and as a result debt neutrality does not hold.

4 Finance by lump-sum taxation

This section considers an economy with a positive birth rate, a constant government debt-GDP ratio, and lump-sum taxation as the residual mode of government finance. Substitution of (23) into (20) and (21) yields:

$$\dot{c} = \theta c^2 + [\theta g + n - \rho - (1-\eta)\theta]c - (n+\lambda)(\lambda+\rho)\gamma[\left(\frac{1}{\theta}\right) + m + d] \tag{20'}$$

$$\dot{m} = \theta cm + [\theta(g + \eta - 1) + \mu]m - \left(\frac{1-\gamma}{\gamma}\right)c. \qquad (21')$$

Figure 2 presents the phase diagram associated with this system of differential equations. The $\dot{c} = 0$ locus reduces to the Ramsey-Romer rule, $c = c^* \equiv \left(\frac{\rho-n}{\theta}\right) + 1 - \eta - g$, when the birth rate is zero, which is as discussed in Section 3 independent of real money balances. In general, the birth rate is positive and the $\dot{c} = 0$ locus slopes upwards in the quadrant where both c and m are positive, as an increase in m means that households have more wealth and thus consume more. The $\dot{c} = 0$ locus is a quadratic and achieves a minimum value of m when $c = \frac{1}{2}c^*$. Because the $\dot{c} = 0$ locus cuts both the RR rule and the horizontal axis in the region where m is negative, i.e. when $m = -\left(\frac{1}{\theta}\right) - d$, the $\dot{c} = 0$ locus slopes upwards in the positive quadrant. Because households anticipate the entry of new non-interconnected generations who help to carry the burden of future taxes, they consume more for a given level of real money balances than they would have done otherwise. Consequently, the $\dot{c} = 0$ locus is in the relevant quadrant above the RR rule. The $\dot{m} = 0$ locus goes through the origin, slopes upwards and has an asymptote, given by $m = \left(\frac{1-\gamma}{\gamma\theta}\right)$. There are two forces at work. The first is that an increase in private consumption must, for a given nominal interest rate, be associated with an increase in holdings of real money balances. The second is that an increase in private consumption leaves less resources for investment, so that the real growth rate falls, the inflation rate and the nominal interest rate rise, and consequently holdings of real money balances fall. The first force ensures that the locus slopes upwards, whilst the second force ensures that it does not cross the asymptote.

Insert Figure 2: National income shares of private consumption and real money balances under tax finance.

If there is an unanticipated permanent shock, holdings of real money balances and consumption immediately jump to their new equilibrium levels. There can be no transitional dynamics, because both these variables are non-predetermined. It is instructive to also consider the determination of the equilibrium levels of inflation and real per-capita growth. This is illustrated in Figure 3. The points describing equilibrium in the money market must lie on the MM locus, $p \equiv \mu - n - \pi$, which says that growth in the nominal level of national income (i.e. per-capita real growth plus population growth plus inflation) must equal monetary growth. The points describing equilibrium in the goods market lie on the GG locus:

$$c = 1 - g - \left(\frac{\delta + n + \pi}{\theta}\right) = \left(\frac{(n+\lambda)(\lambda+\rho)\gamma[\left(\frac{1}{\theta}\right) + d]}{\eta\theta - \delta - \rho - \pi - [\frac{(n+\lambda)(\lambda+\rho)(1-\gamma)}{\eta\theta - \delta + p}]}\right) \quad (27)$$

which is obtained upon substitution of the (steady-state) consumption and money demand functions, (20)-(21), into the Harrod-Domar rule, (23). In the absence of entry of new non-interconnected generations of households ($n + \lambda = 0$), debt neutrality must holds. Hence, (27) reduces to the familiar Ramsey-Romer rule, and economic growth is independent of demand-side policies and inflation ($\pi = \eta\theta - \delta - \rho$). A higher rate of inflation leads, as the real interest rate is given by technology and supply-side policy, to a higher nominal interest rate, so depresses holdings of real money balances and consequently reduces private wealth and private consumption. In general, this leads to more resources being available for investment purposes so that the growth rate of the economy increases. This is why the GG locus slopes upwards. It can be established from Figure 2 and equation (27) that the GG locus lies entirely to the left of the RR rule.

Insert Figure 3: Inflation and real per-capita growth under tax finance.

Before balanced-budget changes in monetary and fiscal policy are considered, it is useful to point out that the absence of an intergenerational bequest motive combined with the birth of new generations induces households to allocate a greater proportion of income to private consumption and to hold more real money balances. This means that a smaller share of income is devoted to investment and saving, so that the real per-capita growth rate is less and consequently the inflation rate is higher for a given rate of growth in the nominal money supply than in a world in which debt neutrality holds (compare E_1 with E_0 in Figures 2 and 3).

If households become more patient (lower value of ρ), it is straightforward to establish that the $\dot{c} = 0$ and the RR loci shift downwards in Figure 2 so that the equilibrium national income share of private consumption and holdings of real money balances fall. As a result, there is more room for investment so that the real growth rate rises and the rate of inflation falls (the GG and RR loci in Figure 3 shift to the right). Note that more patience reduces inflation, irrespective of whether there is a zero or a positive birth rate.

4.1 Non-neutrality of monetary growth

Consider an increase in monetary growth and assume that the seigniorage revenues are given back to the private sector in the form of lump-sum transfers (independent of the age of the recipients). Such a "helicopter drop" increases inflation and nominal interest rates, so that the desired holdings of real money balances fall. Consequently, both the $\dot{m} = 0$ locus in Figure 2 and the MM locus in Figure 3 shift upwards. In a Ricardian world the inflation and nominal interest rates increase by exactly the same amount as monetary growth, because the national income share of private consumption and thus the share of investment and the real growth rate are unaffected (move from E_0 to E_0').

However, when the benefits of future tax cuts or subsidies can no longer be fully enjoyed because households may no longer be alive or because they have to be shared with future, yet unborn generations, private consumption falls. As a result there are more resources available for investment, the real growth rate rises and the inflation rate rises by less than monetary growth (move from E_1 to E_1'). Increases in monetary growth are thus non-neutral in two senses: the real growth rate of the economy increases and inflation is not entirely a monetary phenomenon. The first type of non-neutrality is also found in economies with non-interconnected overlapping generations of households and decreasing returns to capital. These models, however, provide the micro foundations of the Tobin effect in the sense that they show that an increase in monetary growth depresses the real interest rate and thus boosts capital accumulation and the level of output (Marini and van der Ploeg, 1988). Here, a sustained effect of monetary growth on the real growth rate of the economy, rather than on the level of output, is found. It is to our knowledge the first time that the second type of non-neutrality, i.e. changes in monetary growth lead to less than equiproportionate changes in steady-state inflation, has been pointed out in the literature.

4.2 Government consumption reduces growth and causes inflation

A balanced-budget increase in the national income share of government consumption depresses the share of private consumption and thus shifts the $\dot{c} = 0$ locus and the RR locus in Figure 2 downwards. It also shifts the $\dot{m} = 0$ locus in Figure 2 upwards. The GG locus shifts upwards in Figure 3, but the RR locus in Figure 3 is unaffected. In an economy in which debt neutrality holds, there is thus 100 per cent crowding out of private consumption so that the national income shares of investment and saving, the real growth rate and the inflation rate are unaffected. Holdings of real money balances fall by the same percentage as private consumption (move from E_0 to E_0'').

In an economy in which the burden of future taxes is shared with future, yet unborn generations, private consumption is not fully crowded out. As a result, less resources are available for private investment so that the real growth rate falls. Because the inflation and nominal interest rates rise, holdings of real money balances fall by a greater percentage than private consumption (move from E_1 to E_1''). This is, to our knowledge, the first time that a consistent model has been posited which suggests a direct positive association between balanced-budget changes in the national income share of government consumption and the inflation rate.

5 Finance by printing money

This section assumes that monetary growth is the residual mode of government finance and that the tax rate and the national income shares of government consumption and government debt are exogenous constants. Monetary growth must thus generate sufficient seigniorage revenues to finance the primary deficit plus real debt service:

$$\mu = \left(\frac{\theta(c + g + \eta - 1)d + g - \tau}{m} \right). \tag{28}$$

Upon substitution of (28) into (21'), one obtains:

$$\dot{m} = \theta cm + \theta(c + g + \eta - 1)d + \theta(g + \eta - 1)m + g - \tau - \left(\frac{1 - \gamma}{\gamma} \right) c. \tag{21''}$$

If one starts with a position of no government debt and a zero primary deficit, monetary growth is zero and the $\dot{m} = 0$ locus is the same irrespective of there is tax finance (TF) or money finance (MF). Figure 4 then shows the effects of an increase in the national income share of government consumption under these two modes of government finance. Since the expansion of monetary growth that is associated with the increase in government consumption also crowds out private consumption, it is clear that a money-financed increase in government consumption leads to more crowding out of private consumption, a smaller fall in investment and thus a smaller fall in the real growth rate of the economy than a balanced-budget increase in government consumption (move from E to E'' rather than to E' in Figure 4). Obviously, the price one has to pay for money finance is a higher increase in the inflation rate than under tax finance. Note that, when Ricardian debt neutrality holds, neither a tax-financed nor a money-financed change in the national income share of government consumption affects the real growth rate of the economy.

Insert Figure 4: Effect of an increase in the national income share of government consumption under tax finance and under money finance.

6 Finance by issuing bonds

6.1 Intertemporal shifts in taxation

Consider a cut in the current fraction of national income collected in taxes, followed by gradual increases in the tax rate as the ratio of government debt to national income rises over time. The present value of increases in future taxes must exactly equal the cut in current taxes. The steady-state effects of such a postponement of taxes may be deduced from the effects of an increase in the ratio of government debt to national income on equations (20') and (21'). When there is no entry of new non-interconnected generations of households, Ricardian debt neutrality prevails since the national income shares of private consumption and real money balances are unaffected as households realise that the current tax cut must be fully paid for by future taxes. As a result, real growth and inflation rates are unaffected. However, when there is a positive birth rate and no bequest motive, a tax cut boosts private consumption as households realise that future taxes are also paid for by future, yet unborn generations (as can be seen from the effects of an upward shift of the $\dot{c} = 0$ locus in Figure 2). This leaves less resources for investment and saving, so that the real growth rate falls and consequently the inflation rate increases (as can be seen from the effects of an upward shift of the GG locus in Figure 3). Hence, a transitory tax cut leads to a long-run fall in real growth and a permanent increase in inflation. It follows that future taxes must rise by more than in conventional theories of economic growth, because the growth-corrected real debt service rises not only due to the increase in government debt but also due to the increase in the growth-corrected real interest rate. The literature on the burden of government debt thus gains an entirely new perspective once cast within the new theories of endogenous growth. Government debt is bad because it damages investment and thus growth prospects, and boosts inflation, even though the real interest rate and monetary growth rate are unaffected.

It is straightforward to establish that the short-run effects of a transitory tax cut on the national income share of private consumption are larger than the long-run effects. Hence, in the short run real growth falls and inflation rises by more than in the long run. The development of the ratio of government debt to national income follows from:

$$\dot{d} = \theta c d - (\tau_1 - \theta g) d + g - \tau_0 - \mu m. \qquad (22')$$

As over time the share of private consumption falls and real growth rises, the burden of real debt service falls and the process of arresting the growth in government debt becomes a bit more easy.

6.2 Government consumption

The effects of a bond-financed increase in government consumption may be deduced from adding the affects of a balanced-budget increase in government consumption to the effects of a gradual increase in government debt. The effects of the first shock are less than 100 per cent crowding out of private consumption and thus a fall in the real growth rate and an increase in inflation (see Section 4.2). The effects of the second shock are an increase in private consumption, a fall in real growth and an increase in inflation (see Section 6.1). It thus follows that a bond-financed increase in government consumption leads to less crowding out of private consumption, a larger fall in the real growth rate and a larger increase in inflation than a tax-financed increase in government consumption. A money-financed increase in government consumption leads, however, to more crowding out of private consumption and thus to a smaller fall in the real growth rate than a tax-financed increase in government consumption. Of course, if Ricardian debt neutrality holds, these three modes of government finance do not affect the national income shares of private consumption and investment or the real growth rate, albeit that money finance induces an increase in inflation.

6.3 Open-market operations

Consider an increase in monetary growth implemented through open-market purchases of government bonds. The effects of an increase in monetary growth implemented through handing back lump-sum transfers to households is a reduction in the national income share of private consumption, an increase in real growth, and a less than 100 per cent increase in inflation (see Section 4.1). The long-run effects of buying back government debt and gradually cutting taxes are a fall in the national income share of private consumption, an increase in real growth and a fall in inflation (see Section 6.1). It follows that the use of open-market operations to raise monetary growth leads to a larger reduction in private consumption, a larger increase in real growth and a smaller increase in inflation than the use of subsidies. Note that the use of open-market purchases to raise monetary growth has no real effects in an equivalent model with diminishing rather than constant returns to capital (Marini and van der Ploeg, 1988).

7 Non-separable preferences

If one allows for the more general class of CES sub-utility function ($\sigma \neq 1$), the nominal interest rate is given by $\left(\frac{1-\gamma}{\gamma}\right)\left(\frac{C}{M}\right)^{\frac{1}{\sigma}}$ and equations (20') and (21') become :

$$\dot{c} = \theta c^2 + [\theta g + n - \rho - (1-\eta)\theta]c - (n+\lambda)(\lambda+\rho)\gamma \left(\frac{\left(\frac{1}{\theta}\right) + m + d}{\gamma + (1-\gamma)(c/m)^{\frac{1-\sigma}{\sigma}}} \right) \tag{20''}$$

$$\dot{m} = \theta c m + [\theta(g + \eta - 1) + \mu]m - \left(\frac{1-\gamma}{\gamma}\right)\left(\frac{c}{m}\right)^{\frac{1}{\sigma}} m. \qquad (21''')$$

If the birth rate is zero and debt neutrality holds, $c = c^*, \pi = \eta\theta - \delta - \rho$ and $p = \mu - \eta\theta + \delta + \rho - n$ are as before. Long-run holdings of real money balances are now given by $m = \left(\frac{1-\gamma}{\gamma(\mu+\rho-n)}\right)^{\sigma} c^*$, so that the negative effects of a higher rate of monetary growth on holdings of real money balances is greater when the elasticity of substitution between goods and real money balances is higher.

The extreme case of an infinite elasticity of substitution leads to an exogenously given nominal interest rate, $\left(\frac{1-\gamma}{\gamma}\right)$, so that the rate of inflation, $p = \left(\frac{1-\gamma}{\gamma}\right) - \eta\theta + \delta$, is independent of monetary and/or fiscal policies. Per-capita real growth, $\pi = \mu - n - \left(\frac{1-\gamma}{\gamma}\right) + \eta\theta - \delta$, then increases one-for-one with the rate of monetary growth. The national income share of private consumption, $c = \left(\frac{1-\gamma}{\gamma\theta}\right) - \left(\frac{\mu}{\theta}\right) + 1 - \eta - g$, decreases one-for-one with the national income share of government consumption, irrespective of whether debt neutrality holds or not, and decreases with the rate of growth in the nominal money supply.

8 Money, government debt and the real interest rate

So far, the analysis has assumed a constant real interest rate. This is somewhat unrealistic, because one expects money and government debt to affect the real interest rate. For example, in conventional models of economic growth with diminishing returns to capital and finite lives an increase in monetary growth induces a Tobin effect in the sense that the real interest rate is reduced and the capital-output ratio is increased (Marini and van der Ploeg, 1988). The simplest way to make the real interest rate endogenous in the new theories of growth, apart from attempting to use supply-side policies to affect the marginal productivity of capital, is to introduce convex costs of adjustment for investment (Barro and Sala-i-Martin, 1990; Alogoskoufis and van der Ploeg, 1990).

The representative firm then maximises the present value of net revenues:

$$\underset{I(v)}{\text{Max}} \int_t^{\infty} [\theta K(v)^{\eta} \bar{K}(v)^{1-\eta} - I(v) - \phi I^2(v)/K(v)] \exp[-\int_t^v r(w)dw]dv \quad (29)$$

subject to (14), where ϕ denotes the cost-of-adjustment parameter. Costs of adjustment are proportional to the investment rate. The optimal investment programme then satisfies in symmetric equilibrium:

$$I = \left(\frac{q-1}{2\phi}\right) K \quad (30)$$

$$[r + \delta - (\dot{q}/q)]q = \eta\theta + \phi(I/K)^2 \quad (31)$$

where q denotes the value of capital to the firm (Tobin's Q). Equation (30) comes from the condition that the marginal cost of adjusting the capital stock plus the purchase cost of investment goods must equal Tobin's Q. Equation (31) says that the user cost of capital (i.e. the rental charge plus depreciation charge minus capital gains) must equal the marginal productivity of capital plus the marginal reduction in adjustment costs arising from an additional unit of capital. Since $I/K = \pi + n + \delta$, one obtains from (30) and (31) the following long-run relationship:

$$r + \delta = \left(\frac{\eta\theta + \phi(\pi + n + \delta)^2}{1 + 2\phi(\pi + n + \delta)}\right) \quad (32)$$

If costs of adjustment are zero, the real interest rate is constant ($r = \eta\theta - \delta$ if $\phi = 0$). If costs of adjustment are positive and firms do not make losses, (32) defines a negative relationship between the real interest rate and the real growth rate of the economy. The point is that a higher real interest rate reduces Tobin's Q and thus reduces the investment rate and the real growth rate. Equation (32) is portrayed as the production locus in Figure 5. If $\sigma \equiv 1$, the growth in private consumption is given by:

$$\pi = r - \rho - (n + \lambda)(\lambda + \rho)\{\left(\frac{\gamma[(\frac{1}{\theta}) + d]}{1 - g - (\delta + \pi + n)/\theta}\right) + \left(\frac{1 - \gamma}{r + \mu - \pi - n}\right)\} \quad (33)$$

Equation (33) defines a positive relationship between the real interest rate and the per-capita growth rate, because a high real interest rate induces households to postpone consumption. Also, an increase in the real interest rate depresses human wealth and private consumption and thus boosts real growth. Equation (33) is portrayed as the consumption locus in Figure 5. Adjustment costs for investment imply in the long-run equilibrium a lower real growth rate and a lower real interest rate (E_1 rather than E_0).

An expansion of government debt shifts up the consumption locus, so leads to a fall in real growth and an increase in the real interest rate (move from E_1 to E_1'). It also leads to an increase in inflation and nominal interest rates. A tax-financed increase in government consumption has similar effects on the real interest rate and the real growth rate. An expansion of monetary growth has the opposite effects. It shifts down the consumption locus and leads to an increase in real growth and a fall in the real interest rate (which is the Mundell effect).

Insert Figure 5: Adjustment costs for investment and the real interest rate

The previous theories of endogenous growth adopted the assumption of Ricardian debt neutrality and consequently encountered an empirical puzzle. If preferences (ρ) are relatively stable and shifts in technology and more specifically the productivity of capital are common, the consumption locus is relatively fixed whilst the production locus moves about. This implies a positive correlation between real interest rates and growth rates, but empirically it is hard to detect such a correlation. Barro and Sala-i-Martin (1990) therefore extend their model and show that growth in the variety of consumer products is like a shift in the rate of time preference, so that a significant amount of technical progress involving types of consumer products relative to technical change involving varieties of capital goods may explain the lack of correlation between real interest rates and growth rates. The present analysis suggests a much more straightforward explanation: changes in budgetary policies move about the consumption locus and suggest, if anything, a negative correlation between real interest rates and growth rates.

9 Concluding remarks

The literature on money and growth has been reconsidered in the light of the production externalities stressed by the new theories of endogenous growth. As long as Ricardian debt neutrality holds, monetary growth does not affect the national income shares of private consumption and investment or the real growth rate and is thus the sole determinant of inflation. Also, government consumption leads to 100 per cent crowding out of private consumption and thus does not affect the real growth and inflation rates either. In order to have an interesting analysis of macroeconomic policy issues, it is crucial to depart from debt neutrality. This is achieved when there is no operational bequest motive and entry of future, yet unborn generations of households, because then the burden of future taxes is shared with new generations. As a result, for a given stance of monetary and fiscal policy, the national income share of private consumption is higher and consequently the real growth rate is less and the inflation rate of the economy is higher than in an economy populated by dynasties with an operational bequest motive. An increase in monetary growth is thus not superneutral and, in addition, leads to a less than 100 per cent increase in the inflation rate. If the increase in monetary growth is accompanied by open-market purchases of bonds rather than lump-sum subsidies, there is a larger increase in real growth and a smaller increase in inflation, so that money is even less neutral. A balanced-budget increase in the national income share of government consumption leads to less than 100 per cent crowding out of private consumption, a fall in the real growth rate and an increase in inflation. A money-financed increase in government consumption leads to less crowding out and thus to a smaller fall in real growth and a bigger increase inflation than a tax-financed increase. On the other hand, a bond-financed increase in government consumption leads to a bigger fall in real growth and a smaller increase in inflation than a tax-financed increase in government consumption. In general, an increase in government debt, arising from an intertemporal shift in taxation, reduces real growth and boosts inflation. If there are costs of adjustment for investment, increases in monetary growth lower real interest rates (Mundell effect) whilst increases in the government debt-GDP ratio raise real interest rates. Once the new theories of endogenous growth are cast within a framework of non-interconnected overlapping generations, the analysis of macroeconomic policies and the debates on the burden of government debt and the causes of inflation gain an exciting new perspective.

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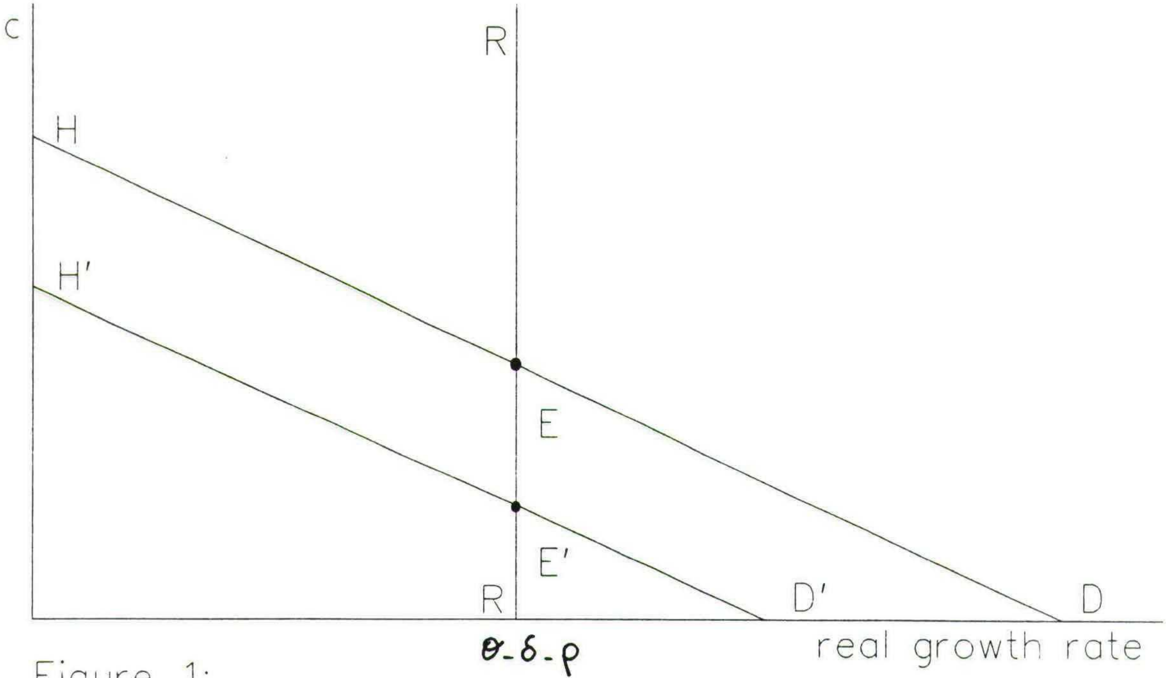

Figure 1:

Debt neutrality and endogenous growth

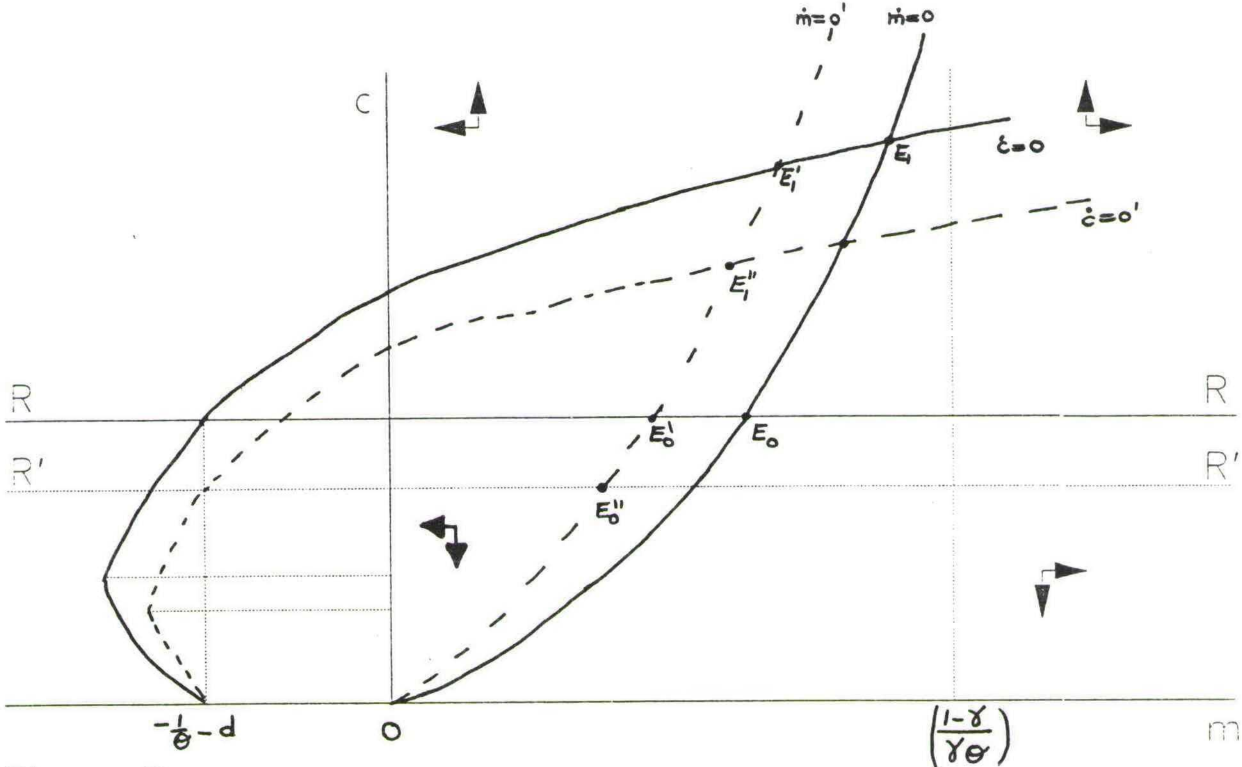

Figure 2:
National income shares of private consumption and real money balances under tax finance

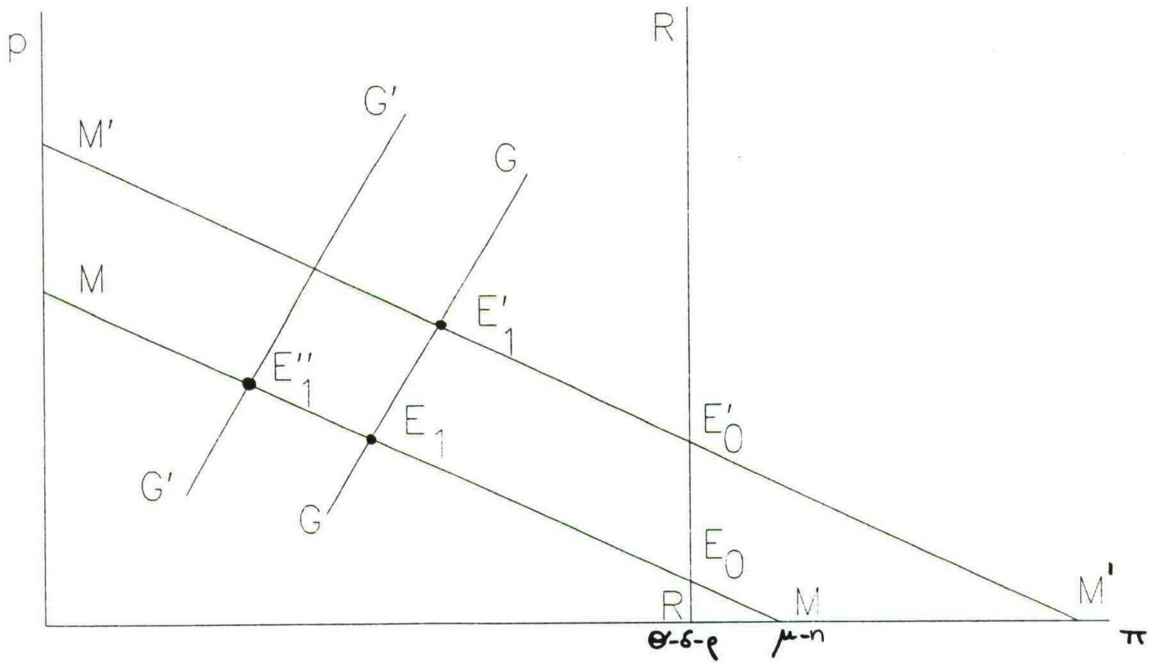

Figure 3:

Inflation and real per-capita growth under tax finance

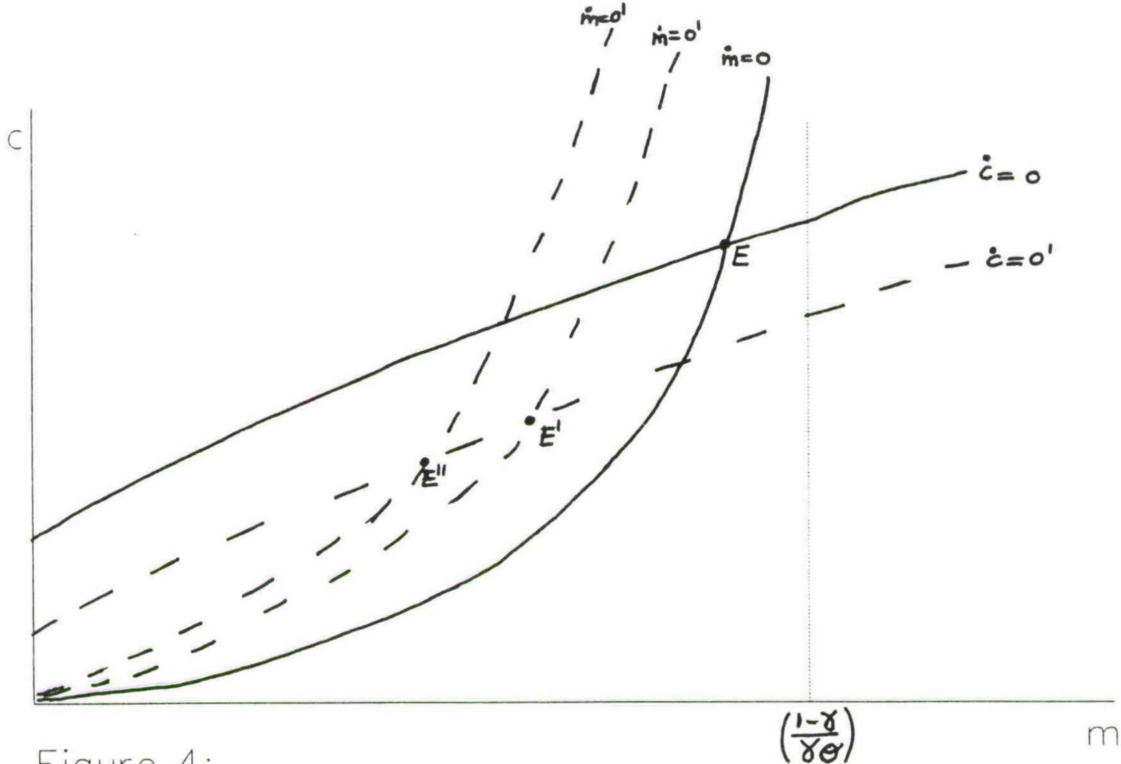

Figure 4:
Effect of an increase in the national income share of government consumption under tax finance and under money finance

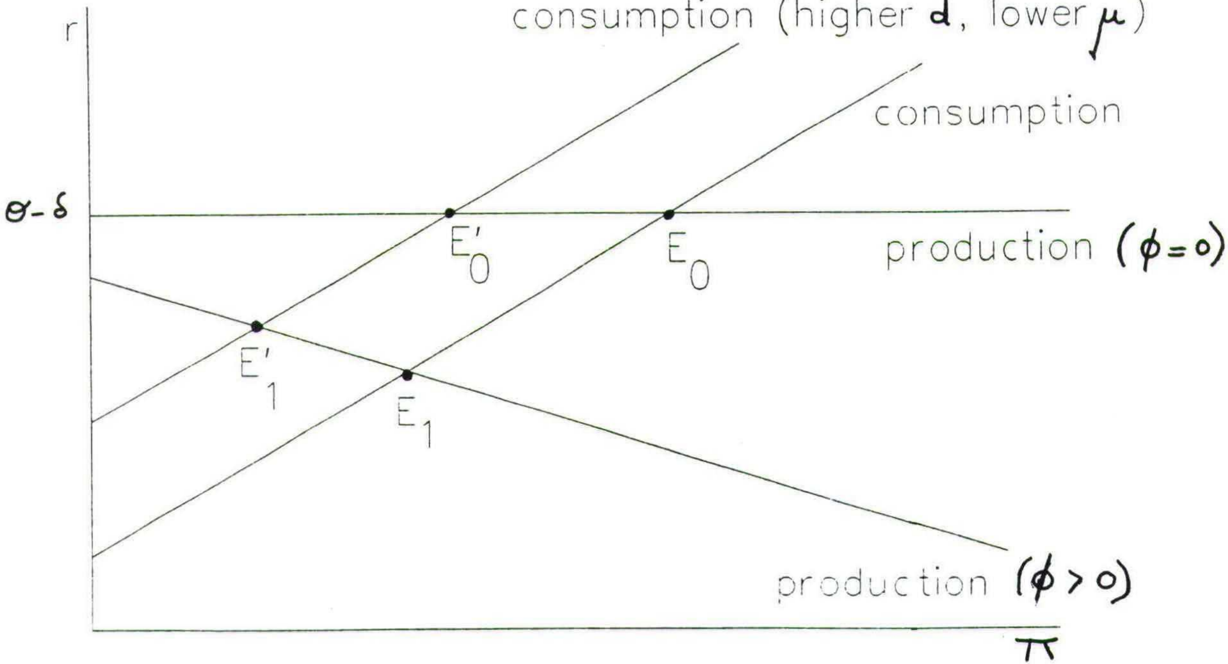

Figure 5:

Adjustment costs for investment and the real interest rate

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