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*Published in:*
De Economist: Tijdschrift voor alle standen, tot bevordering van volkswelvaart, door verspreiding van eenvoudige beginselen van staatshuishoudkunde

*Publication date:*
1990

DE ECONOMIST 138, NR. 2, 1990

# FISCAL POLICY IN AN OPTIMIZING MODEL WITH FINITE LIVES AND ENDOGENOUS LABOUR SUPPLY

BY

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## 1 INTRODUCTION

This is not the first paper on the effects of fiscal policy. There is an ongoing historical debate on this subject. Broadly, there are two parties in the debate.

The first party is formed by economists believing that prices are perfectly flexible and markets always clear. We call this party 'the classicals.' According to this view an expansionary fiscal policy does not increase production because supply is not changed. As a consequence private spending is crowded out by government expenditures through inflation.

The second party is called 'the Keynesians.' Traditionally these economists believe that prices are not perfectly flexible and output is determined unilaterally by demand. Consequently, they believe that fiscal policy has positive effects. It implies extra demand and thus increases production and decreases (Keynesian) unemployment. In contradistinction to classical economics which had a firm foundation in general equilibrium theory, Keynesian economics did not initially have a microeconomic base. This foundation was lead during the sixties and the seventies, however, resulting in the 'classics' of disequilibrium theory by Barro and Grossman [3] and Malinvaud [13]. The traditional Keynesian setting with output determined by demand is only one of the possible regimes in this modern Keynesian or disequilibrium theory. Production may as well be determined unilaterally by supply in what Malinvaud labels 'the regime of classical unemployment.' Moreover, there may be spill-over effects to the goods market from other non-clearing markets such as the labour market.

In 1982 Blanchard and Sachs [5] presented an intertemporal disequilibrium model with rational expectations. They studied the consequences of a demand shock in the short run, when there is rationing, as well as in the long run, when prices are fully adjusted. Fiscal policy is not only a demand shock, however. Government expenditures have to be financed.

When taxes are raised in order to finance government consumption there will be tax crowding out. Traditionally, Keynesian economists have stressed the

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Haavelmo effect. Haavelmo [9] argued that fiscal expansion financed by lump-sum taxation increases production and employment. However, others have argued that the Haavelmo effect may be inverted when a tax increase leads to higher wages (see Knoester [12]) or when a distortionary instead of a lump-sum tax is levied. The effect of replacing a lump-sum tax by a distortionary tax was studied by Van de Klundert and Peters [10] using an extended version of the Blanchard-Sachs model.

Taxes do not have to be raised immediately in order to finance fiscal expansion. Allowing for a temporary budget deficit, taxation can be shifted forward in time. In this case the budget deficit can be financed by issuing bonds or by raising the money stock.

According to the Ricardian equivalence theorem (Barro [2]) there are no effects of temporary substitution of debt for lump-sum taxes. This theorem is based on a set of strong assumptions. (see *e.g.* Tobin and Buiter [19]). Blanchard [4] showed that the theorem breaks down when the assumption of infinitely living consumers is reset by finitely lived agents and a life insurance is allowed for along the lines of Yaari [20]. This result was generalized by Buiter [6], who gives necessary and sufficient conditions for debt neutrality in an economy with finitely lived agents and population and productivity growth. In this paper Buiter uses a rule for lump-sum taxes that relates the tax level to the government budget deficit. This rule prevents escalation of government debt. Without such a rule bond finance is unstable and the solvency or no-Ponzi-game condition for the government is not satisfied.

The Blanchard-Yaari framework in combination with Buiter's tax rule is popularized by Van der Ploeg (see *e.g.* [17][18][11][14]). Most of these papers deal with monetary and fiscal policy in open economies. The only exception is Marini and Van der Ploeg [14]. They present results of monetary and fiscal policy in a closed economy, but only for the long run when prices are fully flexible. The other papers do not deal with sticky goods prices either. Some of them have sticky (nominal or real) wages. However, firms are never rationed in the labour market.

In this paper we analyze the impact of balanced budget, money-financed and bond-financed fiscal policy in a closed economy in the short run as well as in the long run. The model used is basically the same as the model in van de Klundert and Peters [10]. Wages and prices are sticky and perfectly anticipated by the agents. Labour supply is endogenous and labour scarcity is also allowed for. There is one important difference. While their model was based on intertemporal optimization by an infinitely long living representative consumer we have introduced finitely lived agents along the lines of Blanchard-Yaari. In order to satisfy the solvency condition for the government in case of a non-balanced budget policy we had to add a tax rule to the model. Instead of using Buiter's tax rule, we adopted the intuitively appealing rule that taxes are increased (decreased) when there is a budget deficit (surplus).

The paper is organized as follows. In section 2 we present the model, describing the behaviour of consumers, firms, the government and the markets. Section 3 elaborates on the effects of fiscal policy and taxation, in the short run as well as in the long run. These effects are illustrated by numerical simulation experiments. Section 4 is a concluding section.

## 2 THE MODEL

### 2.1 *The Consumers*

In this model consumers have finite horizons. In general, aggregation becomes difficult in an economy of finitely lived agents. Being of different ages and having different horizons, agents differ in level and composition of wealth and in propensity to consume out of wealth. In view of this problem we use the simple population and age structure presented by Blanchard [4]. Agents face, throughout their lives, a constant probability of death $\pi$. Thus, their expected life-time is $(1/\pi)$ and does not depend on their age. Consequently, agents of different ages have different levels of wealth but have the same propensity to consume. At any instant of time a large cohort, whose size is normalized to be $\pi$, is born. This implies that the size of a cohort declines non-stochastically through time. A cohort born at time zero has a size, as of time $t$, of $\pi \cdot e^{-\pi \cdot t}$. At any moment population is equal to one. These assumptions allow for aggregation. Denote by $X(s)$ a variable of an individual agent born at time $s$ and by $X$ the aggregate counterpart, both as of time $t$. Then,[1]

$$X = \int_{-\infty}^{t} \{X(s) \cdot \pi \cdot e^{\pi(s-t)}\} \mathrm{d}s. \tag{1}$$

Uncertainty about death implies that consumers may leave unanticipated bequests or debts. Private markets may, however, provide insurance risklessly. Given free entry and a zero profit condition, agents will receive (pay) a rate $\pi$ to pay (receive) one good contingent on their death. We assume that agents contract to have all of their financial wealth return to the life-insurance company contingent on their death. So, if $A(s)$ is the financial wealth of a consumer born at time $s$ he receives $\pi \cdot A(s)$ if he does not die. If he dies he pays $A(s)$ to the insurance company. The financial wealth of a consumer consists of bonds $(B)$, equity $(E)$, and cash balances $(M)$. At any moment, the government pays the actual nominal interest rate on bonds. So, the rate of return on bonds always equals the nominal interest rate $R$. The return on shares consists of dividend $(D)$ and increases in share prices $(\dot{E})$. It is assumed that bonds and equity are perfect substitutes. So, the rate of return on equity equals the nominal

1 We use capitals for nominal variables. Lower case characters denote real variables. Time subscripts are generally dropped for convenience. A list of symbols can be found in the appendix.

interest rate:

$$\frac{D+\dot{E}}{E}=R. \tag{2}$$

The consumers are assumed to have a maximum available time $l_m$ that does not depend on their age. They can decide to use part of this time ($l$) to work for firms. In that case, they get payed a nominal wage $P_l$ per unit of time. So wage income is equal to $l \cdot P_l$. This is added to the financial wealth. Financial wealth decreases because the government levies a lump-sum tax $T$ and because of the purchase of consumption goods ($c$). The price of consumption is equal to the price of output ($P_y$). So, financial wealth of a consumer born at time $s$ evolves according to:

$$\dot{A}=A(s)\cdot(R+\pi)-R\cdot M(s)+l(s)\cdot P_l-T-c(s)\cdot P_y. \tag{3}$$

Suppose the consumer works all the available time for the firm. In that case his wage income is $P_l \cdot l_m$. Define $H$, the human capital of a consumer, as the net present value of his ability to work minus his tax liabilities, discounted at the rate of return on financial wealth including the insurance premium:

$$H=\int_t^{\infty}\{(l_m\cdot P_l-T)\cdot e^{\int_z^t\{R_\tau+\pi\}\mathrm{d}\tau}\}\mathrm{d}z. \tag{4}$$

Note that the consumer's human wealth does not depend on his age, so it coincides with aggregate human wealth. Total wealth of a consumer born at time $s$ ($W(s)$) can now be defined as:

$$W(s)=H+A(s). \tag{5}$$

It follows from the equations above that $W(s)$ evolves according to:

$$\dot{W}(s)=(R+\pi)\cdot W(s)-R\cdot M(s)-c(s)\cdot P_y-(l_m-l(s))\cdot P_l. \tag{6}$$

We impose a transversality condition in the form of a life time budget constraint:

$$\int_t^{\infty}\{[c(s)\cdot P_y+(l_m-l(s))\cdot P_l+R\cdot M(s)]\cdot e^{\int_z^t\{R_\tau+\pi\}\mathrm{d}\tau}\}\mathrm{d}z\leq W(t). \tag{7}$$

That is, we rule out a strategy of infinite consumption supported by unbounded borrowing by imposing the restriction that the present value of all net expenses from time $t$ on may not exceed wealth at time $t$. This condition is sometimes referred to as a no-Ponzi-game condition.

The consumer maximizes expected lifetime utility subject to the dynamic budget constraint and the no-Ponzi-game condition. It is assumed that his intertemporal utility ($U$) is additively separable in time with a rate of time preference $v$:

$$U = \int_t^\infty \{u \cdot e^{v \cdot (t-z)}\} \mathrm{d}z. \tag{8}$$

Instantaneous utility ($u$) can be represented by a Cobb-Douglas function:

$$u = \gamma_c \cdot ln(c(s)) + \gamma_m \cdot ln\left(\frac{M(s)}{P_y}\right) + \gamma_g \cdot ln(g) + \gamma_l \cdot ln(l_m - l(s)) \tag{9}$$

$$(\gamma_c + \gamma_m + \gamma_l = 1),$$

where $g$ stands for government expenditures. The constant probability of death implies that the expected life time utility can be found from the intertemporal utility function by increasing the time-preference rate by $\pi$.

The model we use is atomistic. That is, the number of consumers is large and each individual consumer is negligibly small as compared to the aggregate of all consumers. Therefore, variables on the aggregate level are exogenous in the model of the individual consumer. We need to make some assumption about the consumer's anticipation of these variables. In order to avoid systematic forecasting errors we assume that he anticipates them rationally. As the model is deterministic at the aggregate level, this means that the consumer has perfect foresight with respect to wages, prices and interest rates. The same assumption is made with respect to taxes and government expenditures.

The consumer may encounter restrictions on the markets for consumption goods and labour:

$$l(s) \leq \bar{l}_d(s), \tag{10}$$

$$c(s) \leq \bar{c}_s(s). \tag{11}$$

This implies that an assumption has to be made about the anticipation of future constraints. It is not self-evident that the consumer should also have perfect foresight with respect to these constraints as is often assumed (see *e.g.* [5][10][16]). This requires a lot of information as these constraints are variables on the individual level. Not only should consumers know the aggregate excess demand (supply) in the markets, they should also know how it is allocated over the individual consumers. It seems more in line with the atomistic model to assume that the individual consumer, as he is negligibly small as compared to the market, does not expect to be rationed. By this assumption we rule out intertemporal spill-over effects. Note that, because of the Cobb-Douglas instantaneous utility function, there are no static spill-over effects either.

Using Pontryagin's maximum principle, we find the following solution for the consumer's maximization problem:

$$c_d(s) = \frac{\gamma_c \cdot (v+\pi) \cdot W(s)}{P_y}, \tag{12}$$

$$l_s(s) = l_m - \frac{\gamma_l \cdot (v+\pi) \cdot W(s)}{P_l}, \tag{13}$$

$$M(s) = \frac{\gamma_m \cdot (v+\pi) \cdot W(s)}{R}, \tag{14}$$

where $c_d$ stands for the demand for consumption goods and $l_s$ for the supply of labour. Actual consumption and actual employment is the minimum of supply and demand:

$$c(s) = min(c_d(s), \bar{c}_s(s)), \tag{15}$$

$$l(s) = min(l_s(s), l_d(s)). \tag{16}$$

Note that the demand for private consumption is not influenced by government consumption. This means we can think of government consumption as being real public goods. If this were not the case, the value of the government expenditures should be added to private wealth for the part they save private consumption. Due to the simple population and age structure the equations for the aggregate of all consumers are the exact analogue of the equations for the individual consumer, except for the dynamic budget constraint. From the definition of aggregate wealth it follows that:

$$\dot{W} = \pi \cdot W(t) - \pi \cdot W + \int_{-\infty}^{t} \{\dot{W}(s) \cdot \pi \cdot e^{(s-t) \cdot \pi}\} ds, \tag{17}$$

where $W(t)$ is the wealth of a new-born consumer. As there are no bequests, this is equal to his human wealth:

$$W(t) = H. \tag{18}$$

From (1), (6), (17) and (18) it follows that:

$$\dot{W} = R \cdot W + \pi \cdot H - c \cdot P_y - (l_m - l) \cdot P_l - R \cdot M. \tag{19}$$

2.2 *The Firms*

It is assumed that there is a large number of firms. All firms are identical and exist infinitely long. Therefore, the model for the individual firm coincides with the model for the aggregate of all firms. Firms produce non-storable output $y$ using two factors of production, capital $k$ and labour $l$. Technology is characterized by a C.E.S.-production function with an elasticity of substitution $\sigma$. So, output is given by:

$$y = \varepsilon \cdot \{\alpha \cdot k^{(\sigma-1)/\sigma} + (1-\alpha) \cdot l^{(\sigma-1)/\sigma}\}^{\sigma/(\sigma-1)}. \tag{20}$$

The capital stock depreciates exponentially at a rate $\delta$. The accumulation equation is:

$$\dot{k} = i - \delta \cdot k, \tag{21}$$

where, as usual, $i$ is investment. In order to get a well-defined investment function we introduce installation costs of capital. The opportunity cost of investment ($j$), consisting of purchase costs and installation costs, are given by the following linearly homogeneous function:

$$j = i + \frac{(i - \delta \cdot k)^2}{2 \cdot \psi \cdot k}. \tag{22}$$

In the present model, the conditions of the Modigliani-Miller theorem hold, so it does not matter how firms are financed. For convenience it is assumed that the firms are fully financed with equity and investment is financed from retained earnings. No new equity is ever issued. Holding a share of the firm gives right to a stream of dividends, which by consequence may be negative. The dividend of the firm is given by:

$$D = y \cdot P_y - l \cdot P_l - j \cdot P_y. \tag{23}$$

Like the consumer model, the model of the firm is atomistic. Firms have perfect foresight with respect to the time paths of wages, prices and interest rates. Given these time paths, they maximize the value of the firm, which equals the total value of shares and is given by:

$$E = \int_t^\infty \{D \cdot e^{-\int_t^z R_\tau d\tau}\} \mathrm{d}z. \tag{24}$$

There is the possibility that the amount of goods the firms can sell is restricted:

$$y \leq \bar{y}_d, \tag{25}$$

or that the amount of investment goods they can buy has an upper bound:

$$j \leq \bar{j}_s. \tag{26}$$

If firms are not rationed in the output market, they may be confronted with a constraint on the amount of labour they can hire[2]:

$$l \leq \bar{l}_s. \tag{27}$$

Analogous to the consumer model, we rule out intertemporal spill-over effects by assuming that firms do not anticipate to be rationed. In contradistinction to the consumer model there are static spill-over effects, however.

The following equations can be derived from the necessary conditions for an optimal solution of the firm's optimization problem that can be found using Pontryagin's maximum principle. The demand for investment goods ($i_d$) is given by:

$$i_d = \delta \cdot k + \psi \cdot k \cdot (q-1), \tag{28}$$

where $q$ is Tobin's $q$, which is given by:

$$q = \frac{E}{P_y \cdot k}. \tag{29}$$

The demand for investment goods including installation costs ($j_d$) is:

$$j_d = i_d + \frac{(i_d - \delta \cdot k)^2}{2 \cdot \psi \cdot k}. \tag{30}$$

This demand can not always be satisfied. The actual opportunity costs of investment are given by:

$$j = min(j_d, \bar{j}_s). \tag{31}$$

Actual investment can then be derived from (22):

$$i = \delta \cdot k + \psi \cdot k \cdot \left(-1 + \sqrt{1 + \frac{2 \cdot (j - \delta \cdot k)}{\psi \cdot k}}\right). \tag{32}$$

The notional demand for labour ($l_d$) is given by:

$$l_d = k \cdot \alpha^{\sigma/(\sigma-1)} \cdot \left[\left((1-\alpha) \cdot \varepsilon \cdot \frac{P_y}{P_l}\right)^{1-\sigma} - (1-\alpha)\right]^{\sigma/(1-\sigma)}. \tag{33}$$

The supply of goods ($y_s$) which determines the level of production when the

2 We have assumed stockpiling is not possible, so firms cannot be simultaneously rationed in the goods market and the labour market.

classical regime prevails follows from substitution of equation (33) in the production function:

$$y_s = \varepsilon \cdot [\alpha \cdot k^{(\sigma-1)/\sigma} + (1-\alpha) \cdot l_d^{(\sigma-1)/\sigma}]^{\sigma/(\sigma-1)}. \tag{34}$$

It may not be possible to sell all these products because of a lack of demand. If the demand constraint in the goods market is binding, that is, if the Keynesian regime prevails, the demand for labour is given by:

$$l_k = \left[ \frac{\left(\frac{\bar{y}_d}{\varepsilon}\right)^{(\sigma-1)/\sigma} - \alpha \cdot k^{(\sigma-1)/\sigma}}{1-\alpha} \right]^{\sigma/(\sigma-1)}. \tag{35}$$

It may be the case that the supply of labour is less than the demand for labour. Then the repressed inflation regime prevails and production is given by:

$$y_l = \varepsilon \cdot [\alpha \cdot k^{(\sigma-1)/\sigma} + (1-\alpha) \cdot l_s^{(\sigma-1)/\sigma}]^{\sigma/(\sigma-1)}. \tag{36}$$

Actual production and actual employment are given by:

$$y = min(y_s, \bar{y}_d, y_l), \tag{37}$$

$$l = min(l_d, l_k, \bar{l}_s). \tag{38}$$

### 2.3 *The Government*

As we have already seen, the government buys goods from the firms ($g$), pays interest on bonds and levies lump-sum taxes. The government budget deficit ($F$) is given by:

$$F = R \cdot B + g \cdot P_y - T. \tag{39}$$

This government deficit can be financed by issuing bonds or by increasing the money stock:

$$F = \dot{B} + \dot{M}. \tag{40}$$

We impose a solvency or no-Ponzi-game condition on the government in order to prevent escalation of government debt. This implies that a rule for government expenditures or taxes is needed. As we want government expenditures to be exogenous so that we can use this as an instrument for fiscal policy we have to specify a tax rule.

Buiter [7] introduced a general tax rule that relates the level of taxes to the budget deficit (which in his model equals the increase in government debt) and the stock of bonds:

$$T = T_0 + \zeta_1 \cdot B + \zeta_2 \cdot \dot{B} \tag{41}$$

This rule stabilizes the economy when $(R-\zeta_1)/(1+\zeta_2)<0$. This leaves two possibilities. The first is $\zeta_1 < R$ and $\zeta_2 < -1$. This has some counterintuitive consequences. It implies that taxes are lower when the budget deficit is larger. Furthermore government expenditures always lead to a decrease in government debt in the long run. The same applies for the variant of this general tax rule in another paper by Buiter [6]. This rule, which relates the level of taxes only to the budget deficit ($\zeta_1 = 0$), is often used, *e.g.* by Marini and Van der Ploeg [14]. The second possibility is $\zeta_1 > R$ and consequently $\zeta_2 > -1$. In this case an increase in government expenditures always increases the long-run level of government debt.

As we want to analyse the consequences of fiscal policy financed by either increasing government debt or increasing the money stock without increasing government debt, we do not use Buiter's tax rule. Instead we specify a tax rule that allows different long-run levels of taxes and government debt. This is done by relating the change of taxes to the budget deficit. That is, we assume that taxes are increased (decreased) when there is a budget deficit (surplus):

$$\dot{T} = \zeta \cdot F, \quad \zeta > 0. \tag{42}$$

This rule balances the government budget in the long run, provided $\zeta$ is not too small. The smaller is $\zeta$, the more the adjustment of taxes is shifted forward in time. Note that this tax rule also rules out the possibility of an exploding money stock.

In the sequel we discuss three government policies. The first policy is the balanced-budget policy. This policy appears as the limiting case when $\zeta$ tends to infinity. At any moment taxes are adjusted so as to make the budget deficit equal to zero. This implies that the stock of bonds and the stock of money do not change when this policy is used. The other two policies are policies with a finite value for $\zeta$. The difference between them is the way the budget deficit is financed. The second policy is a bond-finance policy. The government holds the money stock constant and finances the deficit by issuing bonds. The third policy is a money-finance policy. The stock of bonds is held constant and the decifit is financed by money creation.

### 2.4 *The Markets*

In the preceding sections we analyzed the behaviour of households, firms and the government. We now tie together the different pieces by considering market clearing and price formation. We assume that the market for money always clears. Therefore, the aggregate equivalent of equation (14) can be used to determine the interest rate. Wages and prices are fixed in the short run. Consequently, the markets for labour and for goods do not clear. The short side of the market determines actual output and actual employment. The constraints on demand and supply introduced in subsections 2.1 and 2.2 ought to be explained in this way. Total demand for goods is the sum of the demand for goods for consumption, for investment and for government expenditures:

$$y_d = c_d + j_d + g. \tag{43}$$

When actual production ($y$) falls short of total demand for goods, there is rationing. We assume that the government expenditures are not rationed. The demand for consumption and investment is rationed according to the following scheme:

$$c_s = c_d - \xi \cdot (y_d - y), \tag{44}$$

$$j_s = j_d - (1-\xi) \cdot (y_d - y). \tag{45}$$

Prices and wages react to excess demand (supply). There is no unambiguity, however, in what is meant by excess demand in fixprice theory, effective or notional excess demand. When price changes are related to effective excess demand there is an infinite number of stationary states. All of these states are not Pareto-efficient and leave possibilities for mutual advantageous trade (see Van de Klundert and Peters [10]). There is one exception, however: the Walrasian equilibrium. This Pareto-efficient equilibrium is the unique stationary state of the model when prices react to notional excess demand. Therefore, we choose for the latter[3]:

$$\frac{\dot{P}_y}{P_y} = \theta_y \cdot (y_d - y_s), \tag{46}$$

$$\frac{\dot{P}_l}{P_l} = \theta_l \cdot (l_d - l_s). \tag{47}$$

### 2.5 *The Stationary State*

It is clear from the price equations (46) and (47) that the stationary state is a Walrasian equilibrium. Consequently, the market constraints are not binding. As there are no capital adjustment costs in the stationary state, Tobin's $q$ is equal to one. This implies that the value of the firm equals the value of the capital stock. The marginal product of labour equals the real wage rate. The marginal product of capital is equal to the marginal cost of capital, which is

3 It can be shown that the stationary state of an analogous model with price formation microeconomically based on monopolistic price-setting converges to the Walrasian equilibrium when the price-elasticity of demand tends to infinity (see Meijdam [15]).

equal to $(R^* + \delta)$, where $R^*$ is the interest rate in the stationary state. Inserting these results in the production function gives the real wage rate and the net-output/labour ratio:

$$\frac{P_l}{P_y} = (1-\alpha)\cdot\varepsilon\cdot\left[(1-\alpha) + \frac{(1-\alpha)\cdot\alpha}{\left(\frac{(R^*+\delta)\cdot}{\alpha\cdot\varepsilon}\right)^{\sigma-1} - \alpha}\right]^{1/(\sigma-1)}, \tag{48}$$

$$\frac{y-\delta\cdot k}{l} = \frac{\varepsilon\cdot\left(\frac{(R^*+\delta)}{\alpha\cdot\varepsilon}\right)^{\sigma} - \delta}{\left[\frac{1-\alpha}{((R^*+\delta)/(\alpha\cdot\varepsilon))^{\sigma-1} - \alpha}\right]^{\sigma/(1-\sigma)}}. \tag{49}$$

Denote the former by $\omega$ and the latter by $\lambda$. Then the real wealth in the stationary state can be derived from the fact that production equals the demand for goods:

$$\frac{W}{P_y} = \frac{\lambda\cdot l_m - g}{(v+\pi)\cdot\gamma_c + \frac{(v+\pi)\cdot\gamma_l\cdot\lambda}{\omega}}. \tag{50}$$

The demand for goods, for leisure and for real cash balances can now be derived. Given the supply of money, the latter determines the price level.

The supply of money in the stationary state can not be derived from the equations of the model. This implies that it is not possible to tell *a priori* at which nominal level the economy will stabilize after it is hit by an exogenous shock. This phenomenon, characterized by a zero root for one of the state variables of the system, is called hysteresis (see *e.g.* Buiter [8]). The same accounts for the stock of bonds. For any stock of bonds there is a level of taxes that balances the government budget. It can not be derived from the equations of the model at which stock of bonds the economy will stabilize. The money stock and the stock of bonds can have an effect on the real stationary state, however.

As we have seen, given the interest rate, the real stationary state can be derived. Using these relations, the interest rate can be determined from the aggregate dynamic budget constraint (19):

$$R = v + \pi\cdot\frac{A}{W}. \tag{51}$$

It follows that in case of infinite lives ($\pi = 0$) the interest rate equals the time preference rate $\nu$. So, in this case the interest rate, and therefore the real stationary state, does not depend on the composition of wealth.[4] Consequently, money is neutral in the long run and the Ricardian equivalence theorem holds in this case. This implies that the level of the stock of bonds has no real effects. An increase in the stock of bonds means an increase in interest payouts to the consumption households. At the same time taxes increase by the same amount to keep the government budget balanced. Because future returns on bonds and future taxes are discounted at the same rate there are no wealth effects. Note that it follows that the effects of an increase in the money stock are the same, whether it is achieved by scattering helicopter money or by open market policy.

When lives are finite and there is a life insurance the Ricardian equivalence theorem does not hold. This was first noted by Blanchard [4]. He showed that consumers use a larger discount rate in discounting taxes than in discounting the return on financial wealth. The reason for this is that people currently alive may not be alive at the time a future tax is levied. Of course, the same accounts for future returns on financial wealth, but this is compensated by the life insurance premium. So consumers are not indifferent to the level of the stock of bonds. According to Blanchard's analysis total wealth increases when the stock of bonds increases. However, his analysis is based on a model of a small open economy where the interest rate is exogenous. In case of a closed economy, where the interest rate is endogenously determined, this conclusion may well be reversed. As can be seen from equation (51), the stationary state interest rate depends on the composition of wealth. A larger stock of bonds implies that a larger part of wealth has to be held in the form of financial assets. In order to realize this the interest rate has to rise. The larger interest rate implies a stronger discounting of future income and decreases wealth. This effect may well dominate the effect pointed out by Blanchard. In fact, our numerical simulations show that it does (see the next section).

The neutrality of money in the long run is also destroyed when lives are finite and there is a life insurance. Increasing the stock of money causes an increase in the price level. This implies (*ceteris paribus*) that the real stock of bonds declines. Thus, the part of real wealth consisting of financial assets decreases and the interest rate falls. Therefore, the real stationary state changes. It is interesting to note that it follows that the real stationary state does not change when the stock of bonds and the stock of money are changed by the same percentage. In that case, all wealth components increase by this percentage and the interest rate does not change.

4 When lives are finite but there is no insurance, the interest rate is also independent of the composition of wealth. Consequently, in this case money is also neutral in the long run and the Ricardian equivalence theorem holds.

## 3 FISCAL POLICY AND TAXATION

### 3.1 *The Effects in the Long Run*

In this subsection we look at the long-run effects of fiscal policy. It is assumed that the economy is in the stationary state in the long run. For the moment assume that the money stock and the stock of bonds are not changed and taxes are adjusted to ensure a balanced budget in the stationary state.

In case of infinitely long-living consumers an increase in government consumption decreases private wealth, as is evident from section 2.5. This implies that the demand for real cash balances decreases and the price level rises. Consumption is crowded out, through the inflationary tax as well as through the real tax. The demand for leisure decreases with the demand for consumption and real cash balances. This implies an increase in labour supply. As the output-labour ratio is not changed, output increases. So, there is a Haavelmo effect in this case, be it for other reasons than Haavelmo had in mind. Because the Ricardian equivalence theorem holds and money is neutral in the long run, this result does not change when the stock of bonds or the money stock is changed.

When lives are finite (and an insurance exists) the decrease in human wealth caused by a balanced-budget fiscal policy drives up the interest rate. As noted by Marini and Van der Ploeg [14] this has a negative effect on production. In their model, where labour supply is constant, this leads to more than 100% crowding out of consumption. However, when labour supply is endogenous, as in our model, the negative effect may well be outweighed by the positive effect on production from the extra supply of labour caused by the decrease in wealth. In that case there is a Haavelmo effect and consumption is crowded out less than 100% (see Table 1). The Haavelmo effect is weaker than in the case of infinitely-lived consumers, however.

In case of a bond-financed fiscal expansion the rise of the interest rate is larger and the Haavelmo effect is weakened even more (see Table 2). This result is opposite to the result in Marini and Van der Ploeg [14] where a bond-financed fiscal expansion leads to a lower interest rate. The reason for this is the different tax rule they use. According to this rule a bond-financed fiscal expansion counterintuitively leads to a lower stock of bonds in the long run.

A money-financed fiscal policy causes inflation. This decreases the part of real wealth held in the form of financial assets. Consequently, the interest rate falls and the Haavelmo effect is stronger (see Table 3).

A government caring for the welfare of the consumers should not focus on the effects on production but on the effects on consumers' utility. Looking at the consumers' utility function we see that government expenditures increase welfare directly. This effect is the same for all consumers, independent of their age and their wealth. There are also indirect effects on the utility, however. Because agents differ in age and in level and composition of wealth these indirect effects differ among consumers. An individual may have the 'luck' to

TABLE 1 - BALANCED-BUDGET FISCAL EXPANSION

| period → variable↓ | 0 | 1 | 2 | 5 | 10 | stationary state |
|---|---|---|---|---|---|---|
| $y$ | 0.00 | 0.02 | 0.04 | 0.08 | 0.11 | 0.13 |
| $c$ | −1.15 | −1.12 | −1.09 | −1.02 | −0.97 | −0.94 |
| $i$ | 0.18 | 0.19 | 0.18 | 0.15 | 0.12 | 0.11 |
| $k$ | 0 | 0.02 | 0.03 | 0.07 | 0.09 | 0.11 |
| $l$ | 0.00 | 0.03 | 0.04 | 0.08 | 0.12 | 0.14 |
| $P_y$ | 0 | 0.24 | 0.41 | 0.72 | 0.93 | 1.02 |
| $P_l$ | 0 | 0.06 | 0.19 | 0.55 | 0.84 | 0.99 |
| $R$ | −0.18 | −0.12 | −0.08 | −0.00 | 0.05 | 0.08 |
| $D$ | −0.20 | 0.47 | 0.79 | 1.08 | 1.18 | 1.21 |
| $T$ | 6.41 | 6.60 | 6.74 | 6.99 | 7.15 | 7.23 |
| $E$ | 1.01 | 1.07 | 1.10 | 1.13 | 1.13 | 1.13 |
| $H$ | −0.90 | −0.84 | −0.79 | −0.66 | −0.57 | −0.52 |
| $W$ | −0.18 | −0.12 | −0.08 | −0.00 | 0.05 | 0.08 |
| $u$ | −0.14 | −0.16 | −0.14 | −0.06 | 0.00 | 0.06 |
| $U$ | −0.04 | −0.03 | −0.02 | 0.01 | 0.03 | 0.06 |
| Regime | CU | RI | RI | RI | RI | EQ |

TABLE 2 - BOND-FINANCED FISCAL EXPANSION

| period → variable↓ | 0 | 1 | 2 | 5 | 10 | stationary state |
|---|---|---|---|---|---|---|
| $y$ | 0.00 | 0.02 | 0.03 | 0.07 | 0.09 | 0.10 |
| $c$ | −1.14 | −1.12 | −1.09 | −1.02 | −0.97 | −0.95 |
| $i$ | 0.16 | 0.17 | 0.15 | 0.12 | 0.08 | 0.07 |
| $k$ | 0 | 0.02 | 0.03 | 0.06 | 0.07 | 0.07 |
| $l$ | 0.00 | 0.02 | 0.03 | 0.08 | 0.12 | 0.13 |
| $P_y$ | 0 | 0.25 | 0.43 | 0.77 | 1.01 | 1.15 |
| $P_l$ | 0 | 0.06 | 0.20 | 0.58 | 0.90 | 1.07 |
| $R$ | −0.13 | −0.07 | −0.02 | 0.07 | 0.14 | 0.18 |
| $D$ | −0.18 | 0.51 | 0.85 | 1.18 | 1.31 | 1.40 |
| $T$ | 0 | 1.77 | 3.25 | 6.35 | 8.86 | 10.46 |
| $F$ | 0.72 | 0.60 | 0.50 | 0.29 | 0.11 | 0 |
| $B$ | 0 | 1.48 | 2.73 | 5.33 | 7.44 | 8.78 |
| $E$ | 1.03 | 1.10 | 1.14 | 1.17 | 1.20 | 1.22 |
| $H$ | −0.83 | −0.91 | −0.97 | −1.08 | −1.19 | −1.26 |
| $W$ | −0.13 | −0.07 | −0.02 | 0.07 | 0.14 | 0.18 |
| $u$ | −0.12 | −0.13 | −0.12 | −0.05 | −0.02 | −0.04 |
| $U$ | −0.06 | −0.05 | −0.04 | −0.02 | −0.02 | −0.04 |
| Regime | CU | RI | RI | RI | RI | EQ |

TABLE 3 - MONEY-FINANCED FISCAL EXPANSION

| period → variable↓ | 0 | 1 | 2 | 5 | 10 | stationary state |
|---|---|---|---|---|---|---|
| $y$ | −0.44 | −0.38 | −0.30 | −0.06 | 0.13 | 0.16 |
| $c$ | −2.22 | −2.10 | −1.92 | −1.46 | −1.06 | −0.91 |
| $i$ | 1.25 | 1.15 | 1.03 | 0.73 | 0.45 | 0.18 |
| $k$ | 0 | 0.11 | 0.21 | 0.38 | 0.45 | 0.18 |
| $l$ | −0.85 | −0.85 | −0.77 | −0.48 | −0.17 | 0.14 |
| $P_y$ | 0 | 1.91 | 3.50 | 7.12 | 10.81 | 15.85 |
| $P_l$ | 0 | 1.05 | 2.45 | 6.43 | 10.69 | 15.89 |
| $R$ | 5.53 | 4.58 | 3.83 | 2.35 | 1.15 | −0.08 |
| $D$ | −1.42 | 2.74 | 5.09 | 8.63 | 11.57 | 15.96 |
| $T$ | 0 | 2.33 | 4.29 | 8.60 | 12.67 | 17.74 |
| $F$ | 0.95 | 0.79 | 0.65 | 0.39 | 0.19 | 0 |
| $M$ | 1.95 | 3.61 | 5.01 | 7.22 | 10.64 | 14.89 |
| $E$ | 7.64 | 8.78 | 9.65 | 11.49 | 13.32 | 16.05 |
| $H$ | 5.42 | 6.51 | 7.53 | 9.96 | 12.42 | 15.54 |
| $W$ | 5.53 | 6.63 | 7.57 | 9.74 | 11.92 | 14.80 |
| $u$ | −1.99 | −1.48 | −0.97 | 0.08 | 0.72 | 0.19 |
| $U$ | −0.00 | 0.18 | 0.33 | 0.59 | 0.67 | 0.19 |
| Regime | RI | RI | RI | RI | RI | EQ |

have died long before the government presents the bill for the public goods he enjoyed, so that a consumer of a subsequent generation has to pay for something he did not get. This makes it troublesome to analyze the total welfare effect of fiscal policy. In order to get an idea about this effect we have chosen a 'social welfare indicator,' namely the welfare of the 'average consumer.' That is, the expected lifetime utility of a consumer who possesses average wealth. The indirect effect of fiscal policy on the welfare of the average consumer is negative because of a loss of wealth. Whether this negative effect dominates the positive direct effect depends on the level of government expenditures. In fact there is an optimal level of government expenditures. Above this level the utility of the average consumer decreases when government expenditures are increased, while below this level it increases. In case of infinite lives this optimal level can easily be calculated using the results of section 2.5. We find:

$$g^* = \frac{\gamma_g}{1+\gamma_g} \cdot l_m \cdot \lambda. \tag{52}$$

The interpretation of this formula is straightforward. As $\lambda$ is the stationary state net-output/labour ratio, $l_m \cdot \lambda$ is the maximum attainable net output in the stationary state. The utility of the average consumer is optimized if this maximum net output is spent on the four utility-giving goods $(g, M/P_y, c, (l_m - l))$ according to the marginal utilities of these goods.

### 3.2 *The Short-run Results*

In this section we discuss the short-run results of fiscal policy and taxation. The discussion is based on the results of simulation experiments with the model presented in section 2. We only present results for the variant with finite lives. The short-run results for the model with $\nu = 0$ are qualitatively the same. There is one important exception, however. In case of infinite lives the Ricardian equivalence theorem holds. Consequently, the results for the balanced budget policy and the bond-financed non-balanced budget policy coincide. This is not true for the money-financed non-balanced budget policy because money is not neutral in the short run due to sticky prices. All simulation experiments start in the stationary state of the model. The parameter values used and the initial stationary state values are presented in the appendix.[5]

Fiscal expansion and taxation lead in the long run to a new stationary state. The trajectory from the old stationary state to the new stationary state is indicated in the tables by presenting percentage deviations from the old stationary state for a number of periods.[6] The time paths are found by applying the method of multiple shooting, as described by Ascher *et al.* [1].

Table 1 presents the results of an unanticipated ten percent increase in government expenditures ($g = 0.121$ at $t = 0$) in case of a balanced-budget policy. We see that total wealth falls initially. This is a result of the increase in taxes which causes a decrease in human wealth which exceeds the increase in the value of shares. Consequently, the demand for consumption, leisure and real cash balances falls. The decrease in real cash balances leads to a decrease in the interest rate. The higher share price, due to anticipated lower interest rates and higher dividends, causes an increase in demand for investment goods. Together with the additional demand for goods by the government this more than offsets the decrease in the demand for goods by consumers. As the real wage is fixed initially, the supply of goods does not increase. The regime of classical unemployment (CU) prevails and there is rationing of investment and consumption. Actual investment still increases, however, and therefore the dividend initially falls. Due to the excess demand for goods prices start to rise. This causes a decrease in real wealth and thus increases the supply of labour. Real wages fall. This partly offsets the growth of the supply of labour but at the same time it increases the demand for labour. Therefore, after one period the repressed inflation (RI) regime prevails. Production has increased by 0.02 per-

5 Sensitivity analysis shows that the results are reasonably robust to small changes in the parameters.

6 The budget deficit is presented as a percentage of national income.

cent by then. This evolution continues and the economy slowly converges to the new stationary state. So, although production growth is initially constrained by production capacity, the Haavelmo effect works in the short run.

Because government expenditures were below the optimal level in the initial stationary state, the welfare of the average consumer has increased in the new stationary state. However, this is outweighed by the decrease in welfare during the adjustment process. The expected lifetime utility of the average consumer at the moment of the fiscal expansion ($U$ at $t = 0$) decreases. So a government looking at this welfare indicator should not increase government expenditures.

Table 2 presents the results for the same impulse when a feedback policy with $\zeta = 0.3$ and bond finance is used. That is, the increase in taxes is delayed and the resulting budget deficit is financed by issuing bonds. The money stock is not changed. Total wealth initially falls and there is classical unemployment as in the case of a balanced-budget policy. As a result of the postponed tax, the initial decrease in wealth is less than when the budget is kept in balance. Consequently, instantaneous utility ($u$) is a little larger. The difference is small, however, because the larger wealth can not be consumed because of rationing. So, initially there is not much difference with the balanced budget policy. However, there is a budget deficit of 0.7% of national income now, which is financed by issuing bonds. This drives up the interest rate. Therefore, production grows less and after a few periods real wealth is lower than in the case of a balanced budget policy. Consequently, consumption falls more and the average consumer's utility is lower. In the long run it is below the old stationary state level. At the moment of fiscal expansion the expected lifetime utility of the average consumer falls by 0.06%, which is more than when the budget is kept in balance. So, the lower utility in the long run outweighs the initial increase in utility.

Table 3 presents the results of fiscal expansion when the increase in tax is shifted forward in time and the resulting budget deficit is financed by issuing money. Because of the anticipation of a monetary impulse, the value of the shares and the wealth increase initially. The higher value of shares stimulates investment demand. The increased wealth implies an increase in demand for consumption, leisure and real cash balances. Thus, the supply of labour falls and, as the supply of real cash balances is not changed initially, the interest rate rises. The repressed inflation regime prevails immediately and production falls, although demand increases. After rationing, investment is still above the old steady state level and capital is accumulated. Wages rise, due to the excess demand for labour. The higher interest rate in combination with the increase in government expenditures causes a budget deficit of almost one percent of national income. In order to finance this the stock of money is increased. According to the feedback policy, the budget deficit leads to an increase in taxes. At the same time, the excess demand for goods causes inflation. Real wealth decreases, as does the demand for consumption, leisure and real cash balances. As inflation lags a little behind money growth, the supply of real cash balances increases and the interest rate has to fall. After one period the anticipated monetary expansion is only partly realized and the situation is analogous to the initial situation. Still the repressed inflation regime prevails, although the labour market constraint to the firm is a little less binding. The same mechanisms work and the economy slowly converges to a new stationary state. When we compare this stationary state to the long-run results in case of a balanced-budget policy we see that the money supply has increased by almost 15%. Due to this the interest rate is below the old stationary state level and the long-run capital stock and level of production are larger than in the case of a balanced-budget policy. The same accounts for the long-run level of utility. So a money-finance policy has positive effects in the long run. During the adjustment process instantaneous utility is first below the level in the event of a balanced-budget policy due to the severe rationing of consumption. This is outweighed by the much higher utility level later on, however. Lifetime utility of the average consumer at $t=0$ is larger than when the government budget is kept in balance. So, the total effect of shifting taxation forward in time and financing the resulting budget deficit by money creation is positive. It is tempting to conclude that the more taxation is postponed (and thus the more monetary expansion there is) the better it is. This is not true, however. Simulation experiments show that expected lifetime utility is larger when taxes are increased a little faster. When for instance a tax rule with $\zeta=0.5$ is used, expected lifetime utility at the moment of the money-financed fiscal expansion rises by 0.08%. The reason for this is that the initial negative effects of a money-finance policy are smaller when taxes increase faster.

## 4 CONCLUSIONS

We can draw the following conclusions from the analysis of the effects of fiscal policy and taxation in a closed economy consisting of finitely-lived consumers as presented in this paper.

When there is a life insurance in such an economy, the Ricardian equivalence theorem does not hold. So, the real stationary state of the economy depends on the level of the stock of bonds. Moreover, money is not neutral in the long run when lives are finite.

Given the money stock and the stock of bonds there is a level of government expenditures that maximizes the lifetime utility of the average consumer in the long run. However, the government should not automatically increase the expenditures when they are below this level. Negative utility effects during the adjustment process may outweigh the long-run utility gain. Starting from a Walrasian equilibrium, in the case of a balanced-budget fiscal expansion where expenditures are financed by increasing lump-sum taxes, there is something like a Haavelmo effect.

When taxation is shifted forward in time and the resulting budget deficit is financed by issuing bonds production increases less, as this drives up the interest rate. Delaying the adjustment of taxes increases production extra when the budget deficit is financed by money creation, however. In fact, this is the best way to finance fiscal expansion in this model. The adjustment of taxes should not be postponed too long, however. In that case the anticipated monetary expansion is so large that the initial increase in wealth leads to a much lower supply of labour. This causes a repressed inflation regime with severe rationing of consumption and decreases lifetime utility.

## APPENDICES

### A PARAMETER VALUES

| | |
|---|---|
| $\alpha = 0.25$ | $\theta_y = 0.2$ |
| $\varepsilon = 0.25$ | $\theta_l = 0.1$ |
| $\sigma = 0.4$ | $\delta = 0.1$ |
| $\psi = 0.125$ | $\nu = 0.08$ |
| $\gamma_c = 0.85$ | $\pi = 0.02$ |
| $\gamma_g = 0.1$ | $\gamma_l = 0.1$ |
| $M_0 = 1.0$ | $\gamma_m = 0.05$ |
| $B_0 = 1.0$ | $\xi = 0.7$ |
| $l_m = 9.0$ | $\zeta = 0.3$ |
| $g = 0.11$ | |

### B STATIONARY STATE

| | |
|---|---|
| $y = 1.518$ | $c = 1.018$ |
| $i = 0.390$ | $k = 3.902$ |
| $l = 7.804$ | $P_y = 1.483$ |
| $P_l = 0.148$ | $R = 0.089$ |
| $D = 0.514$ | $F = 0$ |
| $T = 0.252$ | $B = 1.000$ |
| $M = 1.000$ | $E = 5.786$ |
| $H = 9.968$ | $W = 17.754$ |
| $U = -2.075$ | |

### C LIST OF SYMBOLS

We use capitals for nominal variables, lower case characters denote real variables.

$A$ financial wealth
$B$ stock of bonds
$c$ actual consumption

$c_d$ demand for consumption goods
$c_s$ supply of consumption goods
$D$ dividend
$E$ equity
$F$ government budget deficit
$g$ government expenditures
$H$ human wealth
$i$ actual investment (excluding installation costs)
$i_d$ demand for investment goods (excluding installation costs)
$j$ actual investment
$j_d$ demand for investment goods
$j_s$ supply of investment goods
$k$ capital stock
$l$ actual employment
$l_d$ notional demand for labour
$l_k$ Keynesian demand for labour
$l_s$ supply of labour
$M$ money stock
$P_l$ nominal wage
$P_y$ price
$q$ Tobin's $q$
$R$ nominal interest rate
$T$ lump-sum tax
$u$ instantaneous utility
$U$ lifetime utility
$W$ total wealth
$y$ actual production
$y_d$ demand for goods
$y_l$ labour constrained supply of goods
$y_s$ notional supply of goods

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## *Summary*

### FISCAL POLICY IN AN OPTIMIZING MODEL WITH FINITE LIVES AND ENDOGENOUS LABOUR SUPPLY

In this paper the impact of balanced budget, money-financed and bond-financed fiscal policy is analyzed, in the short run as well as in the long run. The analysis is based on an optimizing model of a closed economy that displays perfect foresight of agents and sticky wages and prices. Consumers have finite planning horizons modeled according to the Blanchard-Yaari framework. Labour supply is endogenized by including leisure in the utility function. Labour scarcity is also allowed for. The results are illustrated by numerical simulation experiments.