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Government debt, human capital, and endogenous growth'

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Government Debt, Human Capital, and Endogenous Growth

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Abstract

This paper examines the effect of government debt on steady-state per capita growth in an endogenous growth model. When fertility is exogenous, government debt has no effect on growth. However, when fertility is endogenous, government debt causes faster growth by reducing fertility and by stimulating human capital investments. Due to its distorting effects, government debt reduces initial welfare but it increases future generations' welfare through increasing the growth rate. To maintain a constant debt income ratio supported by taxes and to maintain a stable population, governments cannot raise debt relative to income limitlessly.

INTRODUCTION

Government debt is recently recurring as one of the central policy issues in many industrialized countries. For more than a century, the effect of government debt on the accumulation of capital has been debated in economic policy analysis. This debate has focused on the validity of the Ricardian equivalence hypothesis asserting that the mix of government debt and nondistorting taxes to finance government expenditures has no real effect on an economy. In models with infinitely-lived agents, government bonds increase private assets by the full amount that offsets the corresponding future tax liabilities for interest payments and the retirement of the debt. Even in a model with finitely-lived agents, Barro (1974) showed that government debt is neutral as long as private intergenerational transfers are positive. In response to the rise in future tax burdens in that model, agents leave more bequests to future generations that exactly offset the effect of public debt when the rate of growth is lower than the interest rate.

Carmichael (1982) extended the neutrality of government debt into the regime where the rate of growth is greater than the interest rate when intergenerational transfers are positive. The same paper also pointed out the sources of nonneutrality of public debt such as differences in discount rates, heterogeneous tastes, uncertainty, and corner solutions. Assuming that private intergenerational transfers are zero in an overlapping-generations model,[1] van der Ploeg and Alogoskoufis (1994) argued that an increase in government debt is neutral without the entry of new generations, and reduces real growth with this entry. Moreover, Drazen (1978) argued that when intergenerational transfers take the form of investments in human capital which have higher marginal returns than investments in physical capital, government bonds affect the equilibrium solution and increase welfare.

In a recent paper, Becker and Barro (1988) showed that the neutrality of social security needs modification if fertility is endogenous. Lapan and Enders (1990) extended Becker and Barro's study to examine the neutrality of government debt and found that this neutrality does not hold when fertility is endogenous. In their model, real effects of government debt exist because the rise in bequests caused by government debt raises the cost of a child. As a result, fertility declines and capital intensity rises. Wildasin (1990) also found similar results.

In this paper, I extend the work of Lapan and Enders (1990) and Wildasin (1990) with operative bequests to consider also human capital investments. As is well known, investments in human capital per child are closely related to the number of children. Also, investments in human capital combined with the accumulation of physical capital enable this model to obtain endogenous growth. Thus, we can examine the direct relationship between the growth rate of per capita income and government debt in contrast to the existing models mentioned above (except van der Ploeg and Alogoskoufis 1994) that studied the relationship between the level of per capita income and public debt.

In the spirit of the recent endogenous growth literature, examining whether a rise in government debt has positive, negative, or no effects on the growth rate of per capita income is of prime interest to both policy makers and economists because even a small change in the growth rate will result in substantial compounding impacts on future generations' standards of living. Considering the growth effect of government debt also gives more significant welfare implications than considering the level effect: the potential gain in future generations' welfare due to public debt in the models without endogenous growth is limited by a higher level of per capita income but it is unlimited in this model if per capita income grows at a higher rate. To keep the model tractable, I assume logarithmic utility functions and Cobb-Douglas production functions.

I found in this paper that when fertility is exogenous, government debt has no real effect on an economy in contrast to the result in Drazen (1978) that also assumes exogenous fertility.[2] When fertility is endogenous, however, a rise in government debt increases bequests, reduces fertility, stimulates investments in human capital per child, and thus speeds up steady-state balanced growth.

As in Barro (1974), when a rise in government debt implies greater future tax burdens, agents leave more bequests to children without changing saving rates in contrast to van der Ploeg and Alogoskoufis (1994) where with the entry of new generations and without operative bequests agents reduce savings in response to a tax-financed rise in government debt. The rise in bequests raises the cost of a child and hence reduces fertility as in the literature. Owing to the trade-off between the quantity and quality of children, the fraction of family income invested in human capital per child rises. As a consequence, the growth rate of per capita income increases. The faster growth has a positive effect on welfare while the decline in fertility has a negative effect on welfare. Initial welfare falls because of the distorting effect on fertility. However, the gain in future generations' welfare from faster growth will eventually outweigh the loss in their welfare. These results hold even if we consider life-cycle savings.

The positive growth effect of government debt differs from the negative one in van der Ploeg and Alogoskoufis (1994) because they abstracted from intergenerational transfers of goods, fertility choices and human capital investments. For growth arises from the spillovers of the average capital in their model, the fall in savings caused by a rise in public debt leads to slower growth.

The paper is organized as follows. Section I introduces the model. Section II studies the equilibrium and derives the results. Section III discusses the case with life-cycle savings, welfare implications, and limitations on increasing the debt income ratios. Section IV concludes the paper.

I. The Model

There is an infinite number of periods and overlapping generations of two-period-lived agents. Let subscript t denote a period in time and L_t the number of old agents living in period t. Each agent has n_t identical children at the beginning of old age. Agents learn when young and are each endowed in old age with one unit of labor time which can be supplied to labor markets or spent on rearing children. Let v denote the units of time needed to rear a child $(0 < v < 1)$.

I assume a simplified version of the utility function in Lapan and Enders (1990). The utility of an old agent, V_t, depends separately on own consumption, c_t, the number of children, n_t, and the utility of each child, V_{t+1}:

$$V_t = \ln c_t + \rho \ln n_t + \alpha V_{t+1}, 0 < \alpha < 1, \rho > 0.$$

In this utility function, α measures the taste for the welfare of each child and ρ the taste for the number of children relative to the taste for own consumption, respectively. Also, following the literature (see e.g. Becker and Barro 1988; Lapan and Enders 1990), I suppress the consumption in childhood from the analysis without affecting the essence of the results. With the logarithmic current-period utility function, this model focuses on interior solutions.

The production function for goods has the form:

$$Y_t = DK_t^{\theta}\big[\sum_{i\in\Omega_t}(l_{t,i}h_{t,i})\big]^{1-\theta}, D>0, 0<\theta<1$$

where K_t is aggregate physical capital, $l_{t,i}$ the input of labor from old agent i, $h_{t,i}$ old agent i's human capital, and Ω_t the set of old agents working in period t. Since agents in the same generation are identical, $h_{t,i} = h_t$ and $l_{t,i} = l_t$ for all i. The human capital of a child, h_{t+1}, depends positively on the amount of goods invested in the child, q_t, and the human capital of the parent, h_t:

$$h_{t+1} = Aq_t^{\delta}h_t^{1-\delta}, A>0, 0<\delta<1.$$

In dealing with formal schooling, q_t could be viewed as the tuition fee. Without affecting the substantive of the results, I ignore the units of time invested by the parent in determining children's human capital for simplicity.

In period t, each old agent devotes vn_t units of time to rearing children, supplies $1 - vn_t$ units of time to labor markets, and earns $(1 - vn_t)w_t$. The government issues one-period bonds that pay the market interest rates. Therefore, investments in government bonds and physical capital are perfect substitutes. To balance its budget, the government may also impose a lump-sum tax τ_t on each old agent. As in Lapan and Enders (1990), this agent inherits a_t from the old parent, and leaves a bequest, a_{t+1}, to each child. The old agent spends the earning and inheritance on own consumption, c_t, on bequests to children, $a_{t+1}n_t$, and on investments in children's human capital, q_tn_t. Then, the old agent's budget constraint is:

$$(1) \quad c_t = a_t(1+r_t) + (1-vn_t)w_t - \tau_t - q_tn_t - a_{t+1}n_t$$

where w and r denote the wage rate and interest rate, respectively. Therefore, with initial human capital h_t and inheritance a_t, each old agent chooses a_{t+1}, n_t, and q_t to maximize utility V_t subject to (1) and $n_t \geq 0$ taking w_t and $1+r_t$ as given. As in Becker and Barro (1988), I assume $a_t > 0$ for all t.

Let b_t denote the outstanding government debt per capita. Then the government budget constraint is:

$$(2) \quad n_t b_{t+1} = b_t(1+r_t) - \tau_t.$$

To keep the debt income ratio constant, the government must raise taxes to pay the interest bills and to retire existing bonds when the interest rate is greater than the multiple of fertility and the growth rate of per capita income (see e.g. Carmichael 1982).

Firms maximize profits on perfectly competitive markets. I assume that physical capital lasts for one period in the production of goods, and hence firms' problems are static. The first-order conditions of firms maximizing profits are:

$$(3) \quad w_t = (1-\theta)D\left[K_t/(L_t\bar{l}_t\bar{h}_t)\right]^{\theta} h_t,$$

$$(4) \quad 1+r_t = \theta D\left(L_t\bar{l}_t\bar{h}_t/K_t\right)^{1-\theta}$$

where $\bar{h}$ is the average human capital and $\bar{l}$ the average labor demand per worker. Equation (3) implies that an old agent's wage rate depends positively on his/her own human capital. Labor markets and capital markets clear when:

$$(5) \quad l_t = 1 - vn_t,$$

$$(6) \quad K_t = L_t(a_t - b_t).$$

Constant returns to scale and perfect competition imply that profits are zero. By Walras' law, the goods market clears as well. Since agents within the same generation are identical, we have the following symmetric conditions: $l_t = \bar{l}_t$, $q_t = \bar{q}_t$, and $h_t = \bar{h}_t$.

II. Results

The problem of an old agent maximizing utility corresponds to the following concave programming problem:

$$V(h_t, a_t) = \max_{a_{t+1}, n_t, q_t} \{ \ln \{ a_t(1+r_t) + (1 - vn_t)w_t - \tau_t - q_t n_t - a_{t+1} n_t \} +$$

$$\rho \ln n_t + \alpha V(h_{t+1}, a_{t+1}) \}$$

s.t. $n_t \geq 0$ where w_t is a function of h_t by (3). The first-order conditions for an interior solution are as follows:

(7) $n_t / c_t = \alpha(1 + r_{t+1})/c_{t+1}$,

(8) $n_t / c_t = \alpha\delta(1 - vn_{t+1})w_{t+1}/(c_{t+1}q_t) + \alpha(1-\delta)q_{t+1}n_{t+1}/(c_{t+1}q_t)$,

(9) $(w_t v + q_t + a_{t+1})/c_t = \rho / n_t$.

Equation (7) means that the utility forgone by leaving one more unit of bequests to children is equal to the utility obtained from improving the welfare of each child by the bequest. By (8), the utility forgone from investing one more unit in each child's human capital equals the utility gained from increasing the welfare of each child by the investment. Equation (9) implies that the utility forgone from consuming less to have one more child (less earnings, more investments in children's human capital, and more bequests) equals the utility obtained from enjoying the child.

Steady-state balanced growth means that Y_t/L_t, K_t/L_t, h_t, c_t, a_t, b_t, q_t, τ_t, and w_t grow at the same rate denoted as $1 + g$. Then, they are all proportional to income, or to labor earnings (since labor income is a constant fraction, $1 - \theta$, of total income) in such an equilibrium:

$$\gamma_a = a_{t+1}n_t/[(1 - vn_t)w_t], \gamma_b = b_{t+1}n_t/[(1 - vn_t)w_t],$$

$$\gamma_c = c_t/[(1 - vn_t)w_t], \gamma_k = k_{t+1}n_t/[(1 - vn_t)w_t],$$

$$\gamma_q = q_t/[(1-vn_t)w_t], \gamma_\tau = \tau_t/[(1-vn_t)w_t]$$

where k_t refers to per worker physical capital K_t/L_t.

Equations (1)-(9), and the symmetric conditions ($l_t = \bar{l}_t$, $q_t = \bar{q}_t$, and $h_t = \bar{h}_t$) characterize the equilibrium. Solving these equations under the steady-state balanced growth conditions gives

(10) $\gamma_k = \alpha\theta/(1-\theta)$,

(11) $\gamma_a = \alpha\theta/(1-\theta) + \gamma_b$,

(12) $$\gamma_c = \frac{(1-\alpha)[1-\alpha\theta(1-\delta)]}{(1-\theta)[1-\alpha(1-\delta)]},$$

(13) $$n = \frac{[1-\alpha(1-\delta)][(1-\theta)(\rho\gamma_c - \gamma_b) - \alpha\theta] - \alpha\delta(1-\theta)}{v\{[1-\alpha(1-\delta)][(1-\theta)(1+\rho\gamma_c-\gamma_b)-\alpha\theta] - \alpha\delta(1-\theta)\}},$$

(14) $$\gamma_q = \frac{\alpha\delta}{[1-\alpha(1-\delta)]n},$$

(15) $$1+g = \left[(A[\gamma_q(1-vn)]^\delta)^{1-\theta}[D(1-\theta)]^\delta(\gamma_k/n)^{\delta\theta}\right]^{1/[1-\theta(1-\delta)]}.$$

Also, $\gamma_\tau = [(1-\alpha)/\alpha]\gamma_b$, which says that the lump-sum tax is proportional to government debt. Notice that from (10)-(15) a unique interior solution in the steady-state balanced growth equilibrium is guaranteed if ρ is large enough that $n > 0$.[3]

Equation (10) means that the ratio of physical capital to labor income (or the capital labor income ratio) γ_k and the saving rate (defined as the ratio of savings in the form of physical capital to total income) are independent of the debt income ratio γ_b.[4] In (11) the bequest ratio γ_a increases with the debt income ratio γ_b. That is, as is well known, a rise in government debt increases bequests as a fraction of family income. As in Barro (1974), (10) and (11) say that agents respond to a rise in government debt (hence an increase in future tax liabilities) by keeping saving rates constant and by leaving more bequests to children. As a result, consumption is a constant fraction of income regardless of the debt income ratio from (12).

Equation (13) implies that increasing the debt income ratio has a negative effect on fertility because a rise in γ_b raises the cost of rearing a child (or the price of a child) through increasing bequests as in Lapan and Enders (1990) and Wildasin (1990). Denote the price of a child as P_n and the price of current consumption as P_c which equals unity. Then we rewrite (9) as $P_n/P_c = w_t v + q_t + a_{t+1} = \rho c_t/n_t = U_n/U_c$ where U_n and U_c are partial derivatives of the current-period utility function $\ln c_t + \rho \ln n_t$ with respect to n_t and c_t, respectively. In this equation, w_t is taken as given, and q_t is not directly affected by γ_b. Therefore, a rise in b_{t+1} raises the relative price of a child $P_n/P_c = w_t v + q_t + a_{t+1}$ by increasing bequests per child a_{t+1}. Consequently, n falls and hence U_n rises to retain the equality in (9). According to (14), a rise in the debt income ratio raises the fraction of family income invested in human capital per child γ_q through decreasing fertility.

In (15), the growth rate depends positively on the capital income ratio (or the saving rate) and the fraction of family income invested in human capital per child, but negatively on fertility. Steady-state growth exists if the right-hand side of (15) is greater than one. Parameters A and D have positive effects on the growth rate but have no effect on other variables. For the purpose of this paper, I assume that A and D are large enough that $g > 0$. The steady-state growth rate $1+g$ increases with γ_b since $\partial\gamma_k/\partial\gamma_b = 0$, $\partial\gamma_q/\partial\gamma_b > 0$, and $\partial n/\partial\gamma_b < 0$. The following summarizes the preceding discussion.

Proposition 1. When governments raise debt as a fraction of income, saving rates remain constant, fertility falls, the fraction of family income invested in human capital per child rises, and per capita growth speeds up.

To see the role of fertility in determining the impacts of public debt on growth, we now set fertility at any given level. When fertility is fixed, the solutions for γ_k, γ_a, γ_q, and g are the same as those in (10), (11), (14), and (15) except that we replace n with any fixed number. Then γ_k, γ_q, and g are all independent of γ_b. That is, public debt is neutral in terms of its impacts on growth, which essentially extends the neutrality of government debt or the Ricardian equivalence into an endogenous growth model with human capital investments. Thus, we have:

Proposition 2. When fertility is exogenous, public debt is neutral: it has no effects on saving rates, human capital investments, and growth.

Proposition 2 differs from the conclusion in Drazen (1978, p. 513-515) because that paper assumes investments in human capital yield higher marginal returns than investments in nonhuman capital. In the present paper, agents invest in both human and nonhuman capital to the extent such that the marginal returns to both investments are always the same by (7) and (8). In these two equations, the right-hand sides represent marginal returns to investments in the two types of capital, and the left-hand sides the marginal costs of the two investments that are equal to each other. To generate this neutrality without operative bequests and with finitely-lived agents, van der Ploeg and Alogoskoufis (1994) need the restriction that there is no entry of new generations because then their model reduces to a special case with one generation making intertemporal consumption-saving decisions. In this special case without human capital investment, the intertemporal consumption-saving decision is sufficient to neutralize government debt as in an infinitely-lived agents model.

III. Discussion

Life-cycle savings

We can also extend this model to consider life-cycle savings with three-period-lived agents where old-aged agents live in retirement as in Carmichael (1982). Following that model, I assume that the government imposes lump-sum tax (τ_t per middle-aged agent) and issues one period bonds (b_t per middle-aged agent):

(16) $n_t b_{t+1} = (1 + r_{t+1}) b_t - n_t \tau_{t+1}$.

Consequently, agents' budget constraints are:

(17) $c_1(t) = a_t + w_t(1 - v n_t) - s_t - b_t - q_t n_t - \tau_t$,

(18) $c_2(t+1) = (b_t + s_t)(1 + r_{t+1}) - n_t a_{t+1}$

where $c_1(t)$ and $c_2(t+1)$ are middle-age consumption and old-age consumption, respectively. Also, the utility of an agent is of the form:

$$V_t = \ln c_1(t) + \rho_1 \ln c_2(t+1) + \rho_2 \ln n_t + \alpha V_{t+1}.$$

Accordingly, the capital market clears when:

(19) $K_t = L_{t-1} s_{t-1}$.

It can be shown that if bequests are positive, the solutions for saving rates, investments in human capital per child as a fraction of family income, and the growth rate are of the same forms as in (10), (14), and (15), and fertility depends negatively on the debt income ratio. Therefore, Propositions 1 and 2 hold in this extended model as long as bequests are positive.

Welfare implications

In the present model with changing population and growing income and with two types of capital, there are no analytic solutions for the dynamic transitional process corresponding to different debt income ratios. Without the transitional analysis, we cannot have a complete welfare analysis. Lapan and Enders (1990) investigated the transitional process by linearizing the difference equations and examined the welfare implication of public debt with some simplifying assumptions such as a constant interest rate. Also, in their model with one capital the economy jumps to a new steady-state in one period, which enables them to study initial welfare changes. In the present model with two types of capital, the transition can take many periods and it is unclear analytically how initial welfare responds to the change in the debt income ratio. But qualitatively, we can discuss the welfare effect as in their model.

Owing to the distortionary effects on fertility and investments in human capital, increasing the debt income ratio reduces initial welfare. But the rises in human capital investments and in the per capita growth rate caused by public debt raise future generations' utility after a certain number of periods. In Lapan and Enders (1990), the gain in future generations' utility is from the rise in the level (not the growth rate) of per capita income brought about by public debt. For a given rise in the debt income ratio, the gain in future generations' welfare should be relatively small and limited in their model compared to the gain in this model that is unlimited from faster growing per capita income and human capital. On the other hand, public debt reduces fertility only through increasing bequests in both their model and this model and has no direct impact on investments in human capital. The fall in fertility has positive impacts on human capital per child and hence on children's welfare, offsetting partly the welfare loss. Thus, the net decline in initial welfare caused by the rise in the debt income ratio seems to be smaller in this model than in their model.

Moreover, if there are externalities in producing human capital (or goods) then the rise in the debt income ratio may be welfare improving because it corrects the under-investment in human capital caused by such externalities. (Note that with externalities public debt creates additional returns to investments in human capital that cannot be internalized by each individual.) Thus, this model can produce the same welfare implication as that in Drazen (1978) by considering externalities.

Limitations on the debt income ratios

Even if public debt may raise welfare, this model does not lead to the conclusion that governments should set high debt income ratios. As pointed out in section II, fertility falls with the debt income ratio. When fertility falls below its replacement level (many developed countries have observed fertility rates below this level for decades), population shrinks over time and no steady-state equilibrium is infinitely sustainable. To maintain a steady-state equilibrium, governments cannot raise debt income ratios above the critical ratio corresponding to $n = 1$ by (13).

Also, $\gamma_\tau = [(1-\alpha)/\alpha]\gamma_b$ implies that governments may face difficulties in increasing tax income ratios (γ_τ) when they raise debt income ratios. When α is close to unity, the tax income ratio is very small relative to the debt income ratio. But if α is close to $1/2$, then these two ratios are nearly the same. A simple way to determine α is using (10) because the saving rate (which has a fixed relationship with γ_k as argued in Note 4), and share parameters, θ and $1-\theta$, are observable. Since $\gamma_k = \alpha\theta/(1-\theta)$ is the ratio of savings to labor income, the ratio of savings to total income equals $\alpha\theta$. Suppose that the saving rate is 0.2 and that $\theta = 0.25$. Then $\alpha = 0.8$ and $\gamma_\tau/\gamma_b = 0.25$. In other words, if the debt income ratio is 4% then the corresponding tax income ratio is 1%. In countries where governments are deep in debt with, for example, a 100% debt income ratio like in Canada, the tax income ratio will be around 25% to sustain that debt income ratio. These governments will certainly have difficulties in keeping such a high tax income ratio to retire bonds and to pay the interest bills.

IV. Conclusions

This paper has shown that Ricardian equivalence holds in an endogenous growth model when fertility is exogenous. When fertility is endogenous, a rise in the debt income ratio raises the cost of raising a child by increasing bequests to children, and hence reduces fertility, which leads to declines in welfare. Investments in human capital per child as a fraction of family income rise due to the fall in fertility. Consequently, per capita growth speeds up, which can substantially offset the decline in initial welfare and which raises future generations' welfare. As a result, public debt may cause a small net loss in initial welfare without any externality, and may be welfare improving with externalities in producing human capital or goods.

Moreover, this paper found that the debt income ratio is related closely with the tax rate and their relationship is determined by both the saving rate and the share parameter in the production function. Given plausible values of the saving rate and the share parameter, the tax income ratio needed to service government debt is approximately one-fourth of the debt income ratio. This quantitative relation between debt and taxes may help governments to target a sustainable debt income ratio.

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NOTES

1. Kotlikoff and Summers (1981) found that intergenerational transfers are important elements in accounting for aggregate capital in the United States.

2. The present model achieves the neutrality with the entry of new generations and the neutrality holds infinitely. In contrast, with finitely-lived agents and without the entry of new generations, the neutrality in van der Ploeg and Alogoskoufis (1994) cannot hold infinitely.

3. From (12) and (13), $\rho > \alpha\{\theta[1-\alpha(1-\delta)]+\delta(1-\theta)\}/\{(1-\alpha)[1-\alpha\theta(1-\delta)]\}$ implies $n_t > 0$ without public debt (i.e., $\gamma_b = 0$). Since the right side rises with α, this restriction says that there is a unique interior solution if the taste for the number of children ρ is sufficiently strong relative to the taste for the welfare of children α. In other words, given ρ, we have a unique interior solution if the discount factor on children's utility α is sufficiently small. Lapan and Enders (1990, p. 234) derived a similar condition for a unique interior solution in the example with a Cobb-Douglas utility function.

4. With the Cobb-Douglas production function, the relationship between the capital labor income ratio and the capital income ratio is fixed. Moreover, under the assumption that capital depreciates entirely in one period, the capital income ratio must equal the saving rate. Therefore, the capital labor income ratio and the saving rate have a constant relation.

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