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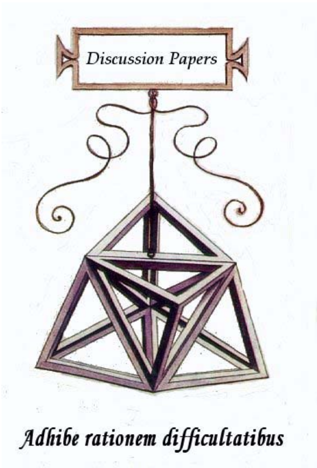

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DYNAMIC INEFFICIENCY, PUBLIC DEBT AND ENDOGENOUS FERTILITY

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Abstract

In this paper we show that, when endogenous fertility is considered via Cobb-Douglas preferences, public debt plays a clear-cut role on dynamic inefficiency (DI) of an OLG economy: in fact, for correcting the DI problem, debt must be increased (decreased) when the economy is overaccumulating (underaccumulating). The occurrence of overaccumulation, and, thus, the necessity of a positive level of debt, is favoured by a small capital income share, on the technological side, and a sufficiently high degree of patience and a low preference for children on preferences grounds. As for the optimal level of debt, our analysis shows that a high level of debt is more likely to be optimal for countries with a relatively low share of capital, with high costs for rearing children, with high individuals' degree of patience; as for individuals' preference for children, as expected, the preference for a numerous family reduces the risk of overaccumulation and, thus, the optimal level of national debt. Moreover, interestingly, although in our model the occurrence of dynamic inefficiency (DI) does not depend on the level of the child rearing cost, such cost magnifies the degree of inefficiency and, therefore, a higher public debt is required for correcting DI. Finally, it is argued that such findings can provide useful criteria for assessing the optimality of public debt-cutting policies undertaken by several Europen countries.

J.E.L. classification: D91, E62, H63, J13.

Keywords: Overlapping Generations, endogenous fertility, dynamic inefficiency, debt.

1 Introduction

As fairly known, one of the most interesting features of OLG economies is the possibility of dynamic inefficiency (DI) occurrence, that is the overaccumulation of physical capital relative to the level which would maximize the steady state

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consumption (see Samuelson (1958) and Diamond (1965))[1]. This possibility is likely to happen even in the simplest OLG framework, in which only savings are endogenous and government is absent. The introduction of public debt, as pioneered by Diamond (1965), can correct such situation by crowding out the steady state level of savings and, thus, of capital.

So far, in Diamond's model and its subsequent extensions, the rate of population growth has been usually assumed as exogenous[2]; however, this variable is crucial in determining dynamic inefficiency. Hence, in this work we relax this assumption by endogeneizing the fertility rate and address the following questions: 1) What are the determinants of the steady state capital stock resulting from the decentralized allocation and of the capital stock prescribed by the (Modified) Golden rule? 2) What is the role of public debt in the presence of dynamic inefficiency? 3) Under which conditions an "optimal" level of debt (that is correcting DI) does exist and what are the determinants of such optimal level?

We show that, when preferences are assumed, for simplicity, of the Cobb-Douglas type and the rearing cost for each child is constant: 1) the steady state level of capital emerging from the market equilibrium depends only on the preferences side but neither on the technological one nor on the supply side conditions, which is in contrast with the traditional features of OLG frameworks; 2) the introduction of public debt does fully crowd out the steady state level of capital, thus being able to correct dynamic inefficiency; 3) the existence of an optimal positive amount of public debt is favoured by a small capital income share, on the technological side, a sufficiently high degree of patience and a sufficiently low preference for children, on preferences grounds. Moreover, we argue that such level is higher the bigger the child rearing cost, the lower the capital share, the higher the individuals' degree of patience and the lower the preference for children.

It is argued that such findings can provide useful criteria for assessing the optimality of public debt-cutting policies undertaken by several Europen countries.

The paper is organized as follows: in the section 2 we lay out the basic framework and then we look at the effect of the introduction of debt upon the steady state level of capital. Next, after characterizing the allocation of resources, and in particular of capital, stemming from the Golden Rule, in section 4 we analyze the existence and the determinants of the optimal level of debt.

[1]As for the most recent empirical evidence on such issue, see the contributions by Abel et al. (1989) and Anderson (1993): in fact, while the first work confirms that dynamic efficiency has been satisfied by the U.S. economy and other six developed countries, the second study casts doubt on such conclusion as for the U.S., Canada and Great Britain.

[2]Rather, endogenous fertility have been largely investigated with particular focus on the (optimality of) Social Security systems. On this point see, among others, Zang and Nishimura (1992 and 1993), Cigno (1995), Rosati (1996) and Lagerlöf (1997). Another ample field of investigation of the endogenous fertility in a OLG framework is that focusing upon the so-called demographic transition (e.g. Galor and Weil (1996)), but also in such a field the issue of the public debt has been neglected.

2 The model set up

Following a standard way to endogeneize fertility in an OLG framework (e.g. Strulik(1999) and (2003)) life is separated into three periods: childhood, young adulthood, and old–age. During childhood, individuals do not make any decisions. Young adult individuals belonging to generation, say, $t-1$, have an utility function U, defined over c_{1t}, c_{2t+1}, n_t, that is consumption in the first and second period of adulthood and number of children, respectively: thus, in such a period of life agents, who receive a working income w_t, choose their optimal intertemporal allocations of consumption/savings and fertility. By assuming for simplicity that every single young adult can have children, the population at the steady state will be stationary or increasing if n is equal of bigger than 1 respectively (with $n-1$ being the long run growth rate of the economy as well). Moreover, rearing a child requires a fixed cost, e[3]. At each date t, young adults (who are identically equal to the workers of the economy) solve the following maximization problem[4], by choosing the savings s_t and the number of children n_t:

$$\max U(c_{1t}, c_{2t+1}, n) = b_1 \log(c_{1t}) + b_2 \log(c_{2t+1}) + b_3 \log(n_t)$$

where

$$c_{1t} = w_t - en_t - s_t$$

$$c_{2t} = (1 + r_{t+1})s_t.$$

The steady state solutions of this simple maximization problem are[5]

$$s^M = \frac{b_2 w}{\beta} \tag{1}$$

where $\quad \beta = b_1 + b_2 + b_3$

$$n^M = \frac{b_3 w}{e\beta}. \tag{2}$$

Finally, the capital market clearing condition for period t is: $s_t N_{t-1} = K_{t+1}$, where N_{t-1} is the size of the young adults of period t, born at the beginning of period $t-1$; now, by recalling that these individuals are also the workers of the economy (L_t) we get, in per worker terms:

$$s_t = (k_{t+1})\, n_t. \tag{3}$$

[3]This assumption departs from Strulik ((1999) and (2003)) who assumes the rearing cost as a fixed fraction of w.

[4]In the utility function of individuals only the number of children, but not their quality, matters. We leave the analysis of the implications of relaxing this hypothesis for future research.

[5]The superscript M stands for “market solution”

It is straightforward to ascertain existence, unicity and stability of the positive[6] long run equilibrium k^M, which is:

$$k^M = \frac{eb_2}{b_3}.$$

Remark 1 *As expected, the long run per worker capital is inversely linked with the factors increasing the population growth and, thus, depends positively on the rearing cost (*e*) and the preferences for children (*b_3*) and positively linked with the factor increasing accumulation, that is with the degree of patience (*b_2*).*

Remark 2 *Rather interestingly, the long run per worker capital is independent of technology: for whatever technology (CD, CES, Leontief and so on) the long run per worker capital is the same. But this also means that it is independent of all the usual assumptions on the side of firms, typical of the OLG framework: i.e. the constant returns to scale and competitive market.*

In other words, when fertility is endogenously chosen by individuals with CD preferences and constant rearing costs, the steady-state capital and the rate of growth of the economy depends only on the preferences and not on the technology.

3 The case with public debt

Following Diamond (1965), suppose that the government at each date t issues debt B_t and levies lump sum taxes upon the young adults, according to the ordinary dynamic equation: $B_{t+1} = B_t (1 + r_t) - \tau_{1t} N_{t-1}$ (where τ_{1t} is the lump sum tax) which, in per worker terms, is: $b_{t+1} n_t = b_t (1 + r_t) - \tau_{1t}$.

Next, the debt accumulation equation in per worker terms can be written as follows:

$$b_{t+1} n_t = b_t (1 + r_t) - \tau_{1t}; \tag{4}$$

The young adults now solve

$$\max U(c_{1t}, c_{2t+1}, n_t) = b_1 \log(c_{1t}) + b_2 \log(c_{2t+1}) + b_3 \log(n_t)$$

where

$$c_{1t} = w_t - \tau_{1t} - en_t - s_t$$

$$c_{2t+1} = (1 + r_{t+1}) s_t.$$

Again by following Diamond (1965), we make the assumption that the debt in per worker terms be constant, so that the level of taxes, τ_{1t}, is equal to $b (1 + r_t - n_t)$.

[6] Of course, also a zero equilibrium does exist. Although a zero equilibrium could be considered as a special case of "poverty trap", we focus only on the positive steady state.

Hence, the aim of this analysis is to investigate the effects of the public debt: 1) on the long run per worker capital; 2) on the situation of dynamic inefficiency (or efficiency); finally, we characterize the "optimal" level of debt, that is the level which allows to achieve the Golden Rule accumulation path.

Now two assumptions can be made as for the individuals' behavior with respect to the choice of the number of children: 1) they have ultra-perfect foresight, so that they account for the effect of their choice of children on the level of taxes; 2) they are atomistic and because the individual choice cannot influence the aggregate rate of growth of population, they take n_t as exogenously given in the term $b\,(1 + r_t - n_t)$ while solving their maximization problem with respect to n_t. The difference between the two assumptions mirrors also the difference between the choice of a benevolent planner and the decentralized solutions: in fact, typically the "social" optimal choice of savings and population is different from the decentralized optimal choice. For simplicity, in this paper we focus only on the second case.

In this case the steady state solutions are:

$$s^* = \frac{b_2 e(w - b(1+r))}{e\beta - bb_3} \tag{5}$$

$$n^* = \frac{b_3(w - b(1+r))}{e\beta - bb_3}; \tag{6}$$

necessary and sufficient conditions for $s, n > 0$ are alternatively: i) $b > max\left[\frac{w}{1+r}, F\right]$; ii) $b < min\left[\frac{w}{1+r}, F\right]$, where $F = \frac{eb_2}{b_3}$. Given the market clearing condition: $s_t N_{t-1} = K_{t+1} + B_{t+1}$, that is:

$$s_t = (k_{t+1} + b)\, n_t. \tag{7}$$

and the solutions for s, n above, the market clearing condition boils down to the following long run per worker capital[7]:

$$k^* = \frac{eb_2}{b_3} - b. \tag{8}$$

It is interesting to note that at the equilibrium there is a complete "crowding out" effect of the public debt on the capital, that is a one-to-one correspondence between them. Moreover, also in this case remarks 1 and 2 presented above continue to hold. Therefore the condition for a positive long run capital stock is that public debt is lower than the following constant

$$b < F.$$

[7] Also in this case a zero equilibirum exists (see note 5).

As mentioned above, although the steady state capital is independent of the assumptions on the production side, in order to analyze more deeply the effects of the public debt we specify the usual condition with respect to production: firms own a constant returns to scale production technology $F(K_t, L_t)$ by which they transform physical capital (K_t) and labor (L_t), with $L_t = N_{t-1}$, into the consumption good. We assume a perfect competitive market: thus, firms hire capital and labor by remunerating them according to their marginal productivity. Moreover, due to the homogeneity of degree one of F, it follows that $w_t = f(k_t) - f_k'(k_t)\, k_t$ and $r_t = f_k'(k_t)$ (in the case of absence of depreciation) or $r_t = f_k'(k_t) - 1$ (in the case of full depreciation), where low letters (apart from factor prices) indicate variables expressed in per worker terms and the subscript of the derivative function f' indicates the derivation variable.

In particular, by assuming the usual CD production function in per worker terms

$$y = Bk^a$$

and full depreciation of capital (that is $aBk^{a-1} = 1+r$), necessary and sufficient conditions for $s, n > 0$ are alternatively: i) $b > max\left[(1-a)F, F\right]$; *ii)* $b < min\left[(1-a)F, F\right]$. Hence, the overall conditions for the positivity of the long run values of s, n, k simply boil down to the ii) above mentioned, which, recalling that $a < 1$, is $b < (1-a)\,F$. In other words public debt must be sufficiently low, especially when rearing costs and the degree of patience are low and preference for children and capital share are high.

4 The Golden Rule with endogenous fertility choices and the optimal level of debt

The Golden Rule provides the first best allocations, that is the level of consumption, fertility and capital which maximize a social welfare function[8]. Thus, suppose that the benevolent policymaker solves the following problem:

$$\max U(c_{1t+s}, c_{2t+s}, n) = b_1 \log(c_{1t+s}) + b_2 \log(c_{2t+s}) + b_3 \log(n_{t+s})$$

$$sub \;\; c_{1t+s} + \frac{c_{2t+s}}{n_{t+s-1}} + e n_{t+s} = f(k_{t+s}) - k_{t+1+s} n_{t+s} + k_{t+s}(1-\delta), \forall s > 0. \quad (9)$$

where eq. (9) is the time $t+s$ resource constraint. The FOCs conditions are the following[9]:

[8]More precisely, when the maximization problem deals with a "Social Welfare function", rather than the steady state consumption, the solutions are referred to as the "Modified Golden Rule" allocations.

[9]For the sake of notational simplicity we omit the s indicator.

$$c_{1t}:\ U_1^t - \lambda_t = 0 \tag{10}$$

$$c_{2t}:\ U_2^t - \frac{\lambda_t}{n_{t-1}} = 0 \tag{11}$$

$$n_t:\ U_3^t - \lambda_t\left(e + k_{t+1}\right) + \lambda_{t+1}\frac{c_{2t+1}}{n_t^2} = 0 \tag{12}$$

$$k_{t+1}: -\lambda_t n_t + \lambda_{t+1}\left(f'_{k_{t+1}} + 1 - \delta\right) = 0 \tag{13}$$

where λ_t is the Lagrangian multiplier associated to the time $t+s$ resource constraint. Then, by substituting for λ_{t+1} from equation (13) and dividing equations (12) and (11) by the (10) we get:

$$\frac{\lambda_{t+1}}{\lambda_t} = \frac{n_t}{\left(f'_{k_{t+1}} + 1 - \delta\right)} \tag{14}$$

$$\frac{U_2^t}{U_1^t} = \frac{1}{(n_{t-1})} \tag{15}$$

$$\frac{U_3^t}{U_1^t} = e + k_{t+1} - \frac{n_t}{\left(f'_{k_{t+1}} + 1 - \delta\right)}\frac{c_{2t+1}}{n_t^2} \tag{16}$$

Finally, supposing for simplicity that $\delta = 1$ and exploiting the resource constraint, it follows that, at the steady state:

$$\frac{U_2}{U_1} = \frac{1}{n} \tag{17}$$

$$f'_k = n \tag{18}$$

$$\frac{U_3}{U_1} = e + k - \frac{c_2}{n^2}. \tag{19}$$

Note that eqs. (17) and (18) replicate the well known Golden Rule conditions; precisely, the first expression says that the social marginal rate of substitution between consumption in the two periods of life must equal the marginal rate of transformation (n),whereas the second one prescribes that, in order to achieve Pareto efficiency, the marginal productivity of capital must equal the gross growth rate of the population (and of the economy). As for eq. (19), it is a further condition directly stemming from the assumption of fertility choice endogeneity: it states that, along the optimal steady state path, the marginal rate of substitution between fertility and consumption must be equal to its social cost.

In our case, with Cobb-Douglas preferences and by exploiting eqs. (17) to (19) and eq. (9), we get:

$$k^{GR} = \frac{ae\gamma}{(b_2 + b_3) - a\gamma} \tag{20}$$

where $\gamma = b_1 + 2b_2 + b_3$. The positivity of the Golden Rule capital requires as necessary condition that $a < \frac{(b_2+b_3)}{\gamma}$.

In the light of these results, we can now focus on the national debt, starting from its role in correcting DI:

Proposition 1 *Public debt must be increased (decreased) when the economy is overaccumulating (underaccumulating).*

Proof. The proof obtains by calling $D = k^M - k^{GR}$ and by observing that $\frac{dD}{db} = -1$. ■

As for the optimal steady state level of debt, the following proposition holds

Proposition 2 *The optimal level of debt is:*

$$b^{GR} = \frac{eb_2}{b_3} - \frac{ae\gamma}{b_2 + b_3 - a\gamma}. \tag{21}$$

Proof. The proof is straightforward by substracting eq. (8) from eq. (20) and by solving for b. ■

A positive level of debt is needed for correcting overaccumulation, or, in other words, in the case of DI; conversely, in the case of dynamic efficiency, the Golden Rule accumulation path would require a negative level of debt (in this case the government should buy bonds issued by private agents). We disregard here the case of negative debt and focus on that of dynamic inefficiency, aiming to investigate the properties of the corrective level of debt.

Hence, in order for the economy to be in the DI case, in the absence of debt, and thus to need a positive level of debt for correcting DI, the necessary and sufficient condition is $a < \frac{b_2}{\gamma}$[10]. In fact, it is easy to verify that, when a happens to be equal to $\frac{b_2}{\gamma}$ the decentralized solution is Pareto optimal, since $k^M = k^{GR}$.

As a consequence, we remark that the existence of a positive level of debt is favoured by a small capital income share (a) and a sufficiently high degree of patience (b_2) and a sufficiently low preference for children (b_3). Such an existence, instead, does not depend on the cost of rearing children.

Remark 3 *For given technology and thriftiness, the higher the preference for children is, the more likely is the occurence of DI.*

[10] Moreover, in order to ensure the positivity of s, n, k, another inequality must hold: $a > \frac{b_2}{\gamma} - \frac{b_3}{b_2\gamma}(\gamma - b_2)$. Simple realistic numerical examples show that only the upper bound for a is binding, since the lower bound $\frac{b_2}{\gamma} - \frac{b_3}{b_2\gamma}(\gamma - b_2)$ is likely to be negative as long as the preference for children is sufficiently positive.

The following proposition contains some comparative-statics results relating the optimal debt level to preference and technological parameters and to the rearing cost:

Proposition 3 *a) The higher the elasticity of physical capital is, the lower the optimal level of debt; b) the higher the rearing cost is, the higher optimal level of debt; c) the higher the degree of patience of individuals is, the higher optimal level of debt; d) the higher the preference for children is, the lower the optimal level of debt.*

Proof. Part a) of the proposition simply follows from the sign of $\frac{db^{GR}}{da} < 0$. As for part b), we note that both $\frac{\partial k^M}{\partial e} > 0$ and $\frac{\partial k^{GR}}{\partial e} > 0$. Since we are in the DI case, in absence of debt, the economy is overaccumulating, so that $b^{GR} = k^M - k^{GR} > 0$; moreover, by reckoning that $b^{GR} = e\left(\frac{\partial k^M}{\partial e} - \frac{\partial k^{GR}}{\partial e}\right) > 0$, then $\frac{\partial k^M}{\partial e} > \frac{\partial k^{GR}}{\partial e}$, and, hence, $\frac{db^{GR}}{de} = \left(\frac{\partial k^M}{\partial e} - \frac{\partial k^{GR}}{\partial e}\right) > 0$.As for part c), the following derivative $\frac{db^{GR}}{db_2} = \frac{e}{b_3} + \frac{ae(b_1-b_3)}{(b_2+b_3-a\gamma)^2}$ shows that the effect of b_2 could be, at first sight, ambiguous; however, by exploiting condition $a < \frac{b_2}{\gamma}$, and writing $a = \frac{b_2}{\gamma} - \varepsilon$, where $0 < \varepsilon < b_2$ is an arbitrarily small constant, which ensure us to deal with the DI case, we get that: $\frac{db^{GR}}{db_2} = \frac{1}{\gamma(\varepsilon\gamma+b_3)^2 b_3}\left[\varepsilon^2(\gamma)^3 + \varepsilon\gamma b_3(\gamma + 2(b_2+b_3)) + b_3(b_1+b_3)(b_2+b_3)\right]e$, which is unambiguosly positive. Finally, as for part d), by adopting the same strategy of part c), it can be shown that

$$\frac{db^{GR}}{db_3} = -\frac{\left[\varepsilon^2 b_2(\gamma)^3 + \varepsilon b_3\left(b_1b_3 + 2b_1b_2 + 3b_2b_3 + 4b_2^2\right)(\gamma) + b_3^2 b_2(b_2+b_3)\right]e}{(b_3+\varepsilon\gamma)^2(\gamma)b_3^2} < 0. \blacksquare$$

As for the role of the elasticity of the physical capital a, its economic meaning is straightforward: since the Golden Rule level of capital depends positively on such parameter (whereas the steady state capital emerging from the market solution does not depend on it) the higher a is, the more likely is that the economy undergoes the risk of overaccumulation and, thus, the bigger is the debt the government has to issue in order to correct the DI of the market allocation. As far as the role played by the cost of rearing children e is concerned, it is firstly worth noting that the decentralized-economy level of capital is positively related with it. In particular, this relationship descends from eq. (5) and (6), in that $\frac{\partial s}{\partial e} > 0$ and $\frac{\partial n}{\partial e} < 0$ imply a lower level of per-worker capital when e decreases $\left(\frac{\partial k^M}{\partial e} > 0\right)$; however, also the Golden Rule capital increases if e gets bigger $\left(\frac{\partial k^{GR}}{\partial e} > 0\right)$; however, in the DI case an increase of the children rearing cost increases the market capital stock more that the capital stock optimally chosen by the benevolent policymaker.

Hence the following remark holds:

Remark 4: *In our economy the children rearing cost plays solely a "factor scale role", as for the DI issue: in fact, while being irrelevant for the occurence of DI, higher levels of such cost increase the optimal level of debt.*

Finally, as expected, a higher thriftiness of the individuals increases overaccumulation, consequently requiring a higher level of debt.

In the light of our analysis we can say that a high (low) level of debt is more likely to be optimal for countries with a relatively low (high) share of capital, with high (low) costs for rearing children, with low (high) preference for children and with high (low) degree of patience.

5 Conclusions

This paper extends Diamond's (1965) OLG framework by allowing for endogenous fertility choices. We show that, when such feature is accounted for via Cobb-Douglas preferences, public debt plays a clear-cut role on the dynamic inefficiency: in particular, in order to correct such suboptimality, debt must be increased (decreased) when the economy is overaccumulating (underaccumulating). We show that a positive level of debt may be optimal depending on the other economic parameters: in fact, the occurence of overaccumulation is favoured by a small capital income share, a sufficiently high degree of patience and a sufficiently low preference for children. As for the optimal level of debt, we argue that it is higher the bigger the child rearing cost, the lower the capital share, the higher the degree of patience and the lower the preference for children. As for the latter, the analysis has shown that, as intuition would suggest, a high interest for children makes the DI risk less worrying, in that in this case savings (and the per worker level of capital) tend to be relatively low. Finally, in our model DI occurence does not depend on the level of the child rearing cost; however, interestingly, when a country is dynamically inefficient, such rearing cost magnifies the degree of inefficiency and, therefore, a higher public debt is required for correction. On policy grounds, it is argued that for those Europen countries (such as Italy) that have experienced in the last three decades one the one side an increase of capital share and, on the other side, a decrease of the propensity to save, policies of public debt reduction would go in the right direction; however, for the optimality of such policy to hold, it is also necessary that the cost of rearing children does not increase; unfortunately, in such countries, such as, again, Italy, the rearing cost has been increasing, which could weaken the optimality of current cutting-debt policy. Finally, similarly to Diamond's model, also in the present work the use of the public deficit is completely unspecified; whether the use of the public debt to finance a policy for reducing the child rearing cost reduces or not the optimal level of debt is left for future research.

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