Functional finance and intergenerational distribution in neoclassical and Keynesian OLG models

By

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Abstract

This paper examines the role of fiscal policy in a Keynesian OLG model. We show that (i) dynamic inefficiency in a neoclassical OLG model generates aggregate demand problems in a Keynesian version of the model, (ii) fiscal policy can be used to achieve full-employment growth, (iii) the required debt ratio is inversely related to both the growth rate and government consumption, and (iv) a simple and distributionally neutral tax scheme can maintain full employment in the face of variations in 'household confidence'.

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1 Introduction

A neoclassical OLG framework has important weaknesses. It assumes that desired household saving at full employment is automatically turned into investment; there are no aggregate demand problems. This paper presents an OLG model that includes Keynesian concerns. Households save but investment decisions are made by firms.

It is well known that neoclassical OLG models can produce dynamic inefficiency and that, if this happens, fiscal policy and public debt can be Pareto improving (Diamond 1965). Dynamic inefficiency is sometimes dismissed as empirically irrelevant (Abel et al. 1989), but the standard argument for irrelevance does not apply under imperfect competition (Skott and Ryoo 2014). In this paper we show that what appears as a problem of dynamic inefficiency in a neoclassical version of the model turns into a problem of aggregate demand and unemployment in a Keynesian version.

The existence of a link from dynamic inefficiency to aggregate demand does not exclude other sources of aggregate demand problems. Indeed, an OLG setting with an implied period length that greatly exceeds a normal business cycle cannot be used to analyze the short-run problems that dominate macroeconomic policy. Why then analyze a stylized OLG model?[1] Intergenerational fairness – the distribution of income across generations – has figured strongly in debates on public debt, and it is difficult to see how this issue can be addressed without some kind of OLG structure. The OLG framework also enriches the understanding of fiscal policy and aggregate demand in other ways. The link between dynamic inefficiency (in neoclassical models) and aggregate demand problems has not, to our knowledge, been noted in the literature. More generally, we strengthen the Keynesian case by showing the importance of aggregate demand in an OLG setting. Dominant macroeconomic models satisfy 'Ricardian equivalence' and imply that public debt becomes largely irrelevant. The irrelevance of debt in these models may

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[1] One reader suggested that we are using a sledgehammer to crack a nut. Not surprisingly, we disagree.

explain the prominence of purely empirical studies.[2] Our analysis contributes a theoretical perspective. The OLG models include optimization but households have a finite horizon, and public debt therefore matters. We demonstrate the need for policy intervention to overcome problems of aggregate demand and examine the long-run implications.

Following Lerner's (1943) principle of functional finance, we assume that policy makers aim for non-inflationary full employment and a desirable level of investment.[3] From a long-run perspective, desirable investment levels correspond, we shall argue, to a desirable choice of technique. This target is achieved through monetary policy: the rate of interest pins down the choice of technique, and the chosen technique can now be described by a Leontief production function. It is then left to fiscal policy to adjust aggregate demand to "eliminate both unemployment and inflation" (Lerner p. 41). In line with our focus on policies that achieve full employment without overheating and inflation, we take prices to be constant constant throughout the paper.

Our steady growth analysis shows a long-run relationship between the required debt ratio and the rate of growth, and the causal link unambiguously runs from growth to debt: a low growth rate generates a high steady-growth ratio of debt to income. The required debt, moreover, is inversely related to government consumption. Similar results have been found in other Keynesian models (e.g. Schlicht 2006, Ryoo and Skott 2013). Obtaining the results using a widely accepted OLG structure strengthens the argument.

Extending the analysis beyond steady growth, we examine the implications of fluctuations in saving rates associated with shifts in 'household confidence'. We show that a simple and distributionally

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[2] Reinhart and Rogoff's (2010) suggestion that debt-income levels above 90 percent tend to be associated with lower rates of economic growth has been discredited (Herndon et al. 2014), and the broader Reinhart and Rogoff analysis has been challenged by other studies on empirical grounds (e.g. Irons and Bivens (2010), Dube (2013), Basu (2013)).

[3] Functional finance

"prescribes, first, the adjustment of total spending (by everybody in the economy, including the government) in order to eliminate both unemployment and inflation...; second, the adjustment of public holdings of money and of government bonds, by government borrowing or debt repayment, in order to achieve the rate of interest which results in the most desirable level of investment; and, third, the printing, hoarding or destruction of money as needed for carrying out the first two parts of the program." (Lerner 1943, p. 41)

neutral tax scheme can maintain full employment in the face of shifts in confidence that would otherwise lead to problems of aggregate demand and secular stagnation. Moreover, in the special case where households correctly anticipate future taxes, no variations in taxes will be needed: the tax policy effectively functions as an insurance scheme. Concerns over the sustainability of the public debt trajectory, finally, find no support. A fiscal policy based on functional finance may lead to high levels of public debt, but no scenarios become explosive or otherwise unsustainable.

The Keynesian literature on functional finance has a long history.[4] We know of no other studies, however, that use a formal OLG structure to examine the long-run implications of functional finance.[5] OLG models have been used to analyze dynamic inefficiency and public debt dynamics, but not from the perspective of functional finance. Chalk (2000), for instance, assumes a constant primary deficit per worker. He finds that even if the economy is dynamically inefficient when public debt is zero, a constant primary deficit may be unsustainable. Moreover, in those cases where a primary deficit is sustainable, convergence is to a steady growth path that is dynamically inefficient. Chalk's analysis invites several objections. Why would a government want to pursue policies of this kind? Why focus on trajectories that keep a constant primary deficit? Economic analysis of monetary policy typically looks for 'optimal' policies (or policy rules), given some welfare function and a model of how the economy operates. The functional finance approach introduces elements that are usually absent in the analysis of monetary policy, but the search for appropriate policies is in a similar spirit.

Section 2 analyzes the choice of technique. Section 3 completes the Keynesian OLG model by introducing household behavior and firms' investment decisions. We add a public sector and derive the full-employment requirements for fiscal policy in section 4. Fluctuations in 'confidence' and their implications for fiscal policy are analyzed in section 5. These technical sections are followed in section 6

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[4] Pedersen (1937) articulated a similar principle of functional finance (Olesen (2001)). Recent contributions include Schlicht (2006), Godley and Lavoie (2007), Arestis and Sawyer (2010), Kregel (2010), and Ryoo and Skott (2013, 2015), Skott (2016).
[5] Skott and Ryoo's (2014) analysis of fiscal policy in an OLG model with imperfect competition includes no Keynesian elements and the focus is on steady states; there are no fluctuations in 'confidence', and the paper does not address questions of intergenerational fairness.

by a discussion which relates the analysis to recent policy debates. Section 7 presents a few concluding remarks.

2   Functional finance and the choice of technique

(Post-) Keynesian growth models typically assume a Leontief (fixed-coefficients) production function. The Leontief assumption is restrictive and this section provides a justification of the assumption. Readers who are happy to accept the Leontief assumption and an exogenously given interest rate may skip the section.

The motivation for the Leontief specification may derive in large part from the perceived lessons of the capital controversy. The controversy highlighted the difficulties of constructing an aggregate production function. It demonstrated, in particular, how reswitching and capital reversing may undermine theories – like the Solow model -- that rely on smooth and automatic adjustments in the output capital ratio.[6] Adjustments of this kind are questionable for a number of reasons. The scope for capital-labor substitution is limited in the short run; neighboring techniques in terms of capital intensity may differ widely in terms of the specific, disaggregated capital goods that they use; a fall in the cost of finance may lead to a 'perverse' reduction in the aggregate capital intensity (the famous case of capital reversing). But perhaps most importantly, when firms choose their capital intensity, the choice is guided by relative input prices. If these relative input prices fail to clear the labor market, the choice of technique will be determined by the 'wrong prices'.

These important lessons from the capital controversy do not imply that there is no choice of technique. The Leontief assumption therefore needs justification. Profit maximizing firms base their decisions on factor prices and demand conditions, and the fixed coefficients of the Leontief production function can be seen as the outcome of this profit maximizing choice of technique, given a

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[6] In Joan Robinson's words,
"The long wrangle about 'measuring capital' has been a great deal of fuss over a secondary question. The real source of trouble is the confusion between comparisons of equilibrium positions and the history of a process of accumulation." (Robinson,1974, p. 9)

policy-determined interest rate.

Monetary policy, Lerner argued, should be used to set interest rates at levels that induce a desirable amount of investment. If fiscal policy keeps output at full employment, this target can be expressed equivalently in terms of a desirable share of investment in output, and the investment share can be written

$$\frac{I_t}{Y_t} = \frac{I_t}{K_t} \frac{K_t}{Y_t} = (\widehat{K}_t + \delta) \frac{K_t}{Y_t} \tag{1}$$

where *I, Y, K* and δ denote investment, output, capital and the rate of depreciation; a hat over a variable is used to denote growth rates ($\hat{x}_t = (x_{t+1} - x_t)/x_t$). In steady growth with full employment, the accumulation rate is determined by the growth of the labor force which for present purposes we take as exogenously given. If the share of investment in output (*I/Y*) is at the desirable level, equation (1) therefore determines the output-capital ratio: in long-run growth with full employment, a desirable level of investment translates into a desirable output-capital ratio, that is, a desirable choice of technique.

Following Skott (1989, chapter 5), firms may be able to choose from a range of blueprints when they make an investment decision. But *ex post* – once an investment has been made in particular plant and machinery – the substitutability between 'capital' and 'labor' is limited. Assume, for simplicity, that the *ex ante* production function is Cobb-Douglas,[7]

$$Y_t = K_t^\alpha N_t^{1-\alpha}, \quad 0 < \alpha < 1 \tag{2}$$

where *N* denotes employment. Profit maximizing firms minimize cost. If W_t, P_t, i and δ denote the money wage rate, the price of capital goods, the cost of finance (the real rate of interest) and the rate of depreciation, the minimization problem can be written:

$$min_{L_t, K_t} \quad W_t N_t + (i + \delta) P_t K_t \tag{3}$$

$$s.t. \quad (u^* K_t)^\alpha N_t^{1-\alpha} = Y_t$$

Firms may want to maintain a certain amount of excess capacity on average; the reason for this include

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[7] The Cobb-Douglas assumption allows explicit functional expressions for the dependence of the choice of technique on the cost of finance. The general argument does not depend on this assumption (see footnote 9 below).

lumpiness in investment (a minimum scale of investment), short run volatility of demand at the firm level, and entry deterrence. Thus, the constraint in the minimization problem allows for the desired utilization rate of capital (u^*) to be less than one. The first order conditions imply that

$$\frac{Y_t}{N_t} = \lambda_t = \left(\frac{u^*}{i+\delta}\frac{\alpha}{1-\alpha}\frac{W_t}{P_t}\right)^{\alpha} \tag{4}$$

$$\frac{Y_t}{u^*K_t} = \sigma_t = \lambda_t^{-(1-\alpha)/\alpha} = \left(\frac{u^*}{i+\delta}\frac{\alpha}{1-\alpha}\frac{W_t}{P_t}\right)^{-(1-\alpha)} \tag{5}$$

The price of capital goods, P_t, is exogenous to the individual firm (and was treated as such in the minimization). In equilibrium, however, this price must be equal to the general price level in a one-good model. Assuming profit maximization, the pricing decision is based on marginal cost, and both the technical coefficients and the stock of capital are predetermined in the short run. Employment and output by contrast are taken to be variable. With excess capital capacity and constant labor productivity, this yields a markup on unit labor cost,[8]

$$P_t = (1+m)W_t\frac{1}{\lambda_t} \tag{6}$$

where the markup (m) is determined by the perceived elasticity of demand, which we take to be constant.

Combining equations (4)-(6), we have

$$\lambda_t = \lambda = \left[\left(\frac{\alpha}{1-\alpha}\right)\left(\frac{u^*}{i+\delta}\right)\left(\frac{1}{1+m}\right)\right]^{\alpha/(1-\alpha)} \tag{7}$$

$$\sigma_t = \sigma = \lambda^{-(1-\alpha)/\alpha} = \left(\frac{1-\alpha}{\alpha}\right)\left(\frac{i+\delta}{u^*}\right)(1+m) \tag{8}$$

Thus, the choice of technique is fully determined by i, u^* and m. Intuitively, cost minimization produces one relation between λ_t and W_t/P_t (for given i); pricing decisions give another relation. In equilibrium these two relations – equations (4) and (6) – must be mutually consistent. This consistency requirement fixes the real wage and the cost-minimizing input coefficients; for a given interest rate, cost minimization pins down the coefficients of a Leontief production function:[9]

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[8] The same qualitative outcome of the analysis – the determination of the choice of technique by the interest rate – could be derived by assuming a markup on total unit cost.
[9] The argument is quite general and does not depend on the existence of a smooth *ex ante* production function. For a given set of

$$Y = \min\{\lambda N, \sigma K\} \tag{9}$$

Using (6)-(8), the real wage and the rate of return on capital are determined by

$$w = W/P = \frac{1}{1+m}\lambda = \left[\left(\frac{\alpha}{1-\alpha}\right)\left(\frac{u^*}{i+\delta}\right)\right]^{\alpha/(1-\alpha)} (1+m)^{-1/(1-\alpha)} \tag{10}$$

$$R(i) = \pi u^* \sigma - \delta = m\left(\frac{1-\alpha}{\alpha}\right)(i+\delta) - \delta \tag{11}$$

where $\pi = m/(1+m)$ is the profit share. We assume that $R(i) \geq i$ or, equivalently, $m \geq \alpha/(1-\alpha)$. The failure of this condition to be met would imply negative net profits (after interest payments) and there would be no incentive for firms to invest.

Under functional finance interest rates are chosen by policy makers to achieve a desirable choice of technique, and low interest rates lead to dynamic inefficiency. In this example with an *ex ante* Cobb-Douglas production function, efficiency requires that $\partial Y/\partial K = \alpha Y/K > n + \delta$ or – using equations (8) and (11) – that $(1+m)(1-\alpha)(i+\delta)) = [\alpha(1+m)/m](R(i)+\delta) > n + \delta$. We assume that the interest rate is set to ensure dynamic efficiency, and the condition $m \geq \alpha/(1-\alpha)$ implies that $\frac{\alpha(1+m)}{m} \leq 1$. Thus, if $R(i) \geq i$, we also have $R(i) > n$.

3   OLG models

Following Diamond (1965), all agents live for two periods: they work in the first period and live off their savings in the second. The number of workers (L_t) grows at the constant rate $n \geq 0$,

$$L_{t+1} = (1+n)L_t \tag{12}$$

To keep the saving side simple, the utility function for a young agent in period t is taken to be logarithmic (Cobb-Douglas):

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input prices, firms will choose a particular technique,

$$\frac{Y}{N} = \phi\left(i, \frac{W}{P}\right)$$

Their pricing decisions, in turn, determines the real wage,

$$\frac{W}{P} = \psi\left(\frac{Y}{N}, i\right)$$

$$U = \log c_{1,t} + \frac{1}{1+\rho} \log c_{2,t+1} \qquad (13)$$

where $c_{1,t}$ and $c_{2,t+1}$ are consumption when the agent is young and old.[10] The labor supply is inelastic,

and normalizing the supply of an individual worker to one, the budget constraint is given by

$$c_{1,t} + \frac{1}{1+r_{t+1}} c_{2,t+1} = w_t \qquad (14)$$

where r_{t+1} is the rate of return on savings and w_t is the real wage.

Utility maximization implies that

$$c_{1,t} = (1-s)w_t \qquad (15)$$

where the young generation's saving rate s can be written

$$s = \frac{1}{2+\rho} \qquad (16)$$

A neoclassical version with Leontief technology and a fixed markup: dynamic inefficiency

Neoclassical OLG models assume full employment. Households save in the form of fixed capital, saving

decisions directly determine investment, and the total saving by the young determines the capital stock in

the following period:

$$K_{t+1} = S_t = sw_t N_t \qquad (17)$$

Using (16) and (17), and dividing through by K_t, the growth rate of the capital stock is given by

$$\hat{K}_t = \frac{K_{t+1}}{K_t} - 1 = s\frac{w_t N_t}{K_t} - 1 = \frac{(1-\pi)}{2+\rho}\frac{Y_t}{K_t} - 1 \qquad (18)$$

where π the is profit share. The output capital ratio is constant in steady growth, and full-employment

growth requires that $\hat{K}_t = n$. We take the production function to be Leontief (as given by equation

(9)), and the output capital ratio can be written $Y/K = u\sigma$. Thus, if the profit share π is determined by

an exogenous markup, equation (18) determines the steady-growth solution for utilization, u^{**}. There is

an upper bound on utilization, $u^{**} \leq 1;$[11] this restriction is satisfied if

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[10] The more general CIES specification complicates the analysis and does not add much, given the purposes of this paper.
[11] A fixed markup on marginal cost leaves the profit share indeterminate when capital is fully utilized. Thus, adjustments in the

$$\sigma \geq \frac{1}{1-\pi}(1+n)(2+\rho) \tag{19}$$

Assuming that (19) is met, adjustments in the utilization rate play the same role as movements along the production function in specifications with smooth substitution: the adjustments allow full employment growth. The dynamic inefficiency problem, however, is brought into stark focus by fixed coefficients. Firms may obtain a high profit rate, but the marginal product of capital is zero for utilization rates below one, and the presence of unused capital capacity is socially wasteful.[12] Consumption per worker is given by $C/L = (Y-I)/L = Y/L - (I/K)(K/Y)(Y/L) = \lambda - (n+\delta)\lambda/(\sigma u)$, where δ is the depreciation rate. A higher utilization rate (a lower ratio of capital to employment) would permit a permanent increase in consumption per worker.[13]

A Keynesian version: aggregate demand issues

In a Keynesian economy, firms make the investment and production decisions. Households do not participate directly in these decisions and typically do not own the physical capital; households' ownership of firms takes the form of financial assets. Thus, in place of (17) we have

$$\sum A_{i,t+1} = S_t = sw_t N_t \tag{20}$$

where $A_{i,t+1}$ represents the holdings of asset i at the beginning of period $t+1$, one type of assets being equity. Other assets may include corporate bonds and bank deposits. Equation (20) expresses an equilibrium condition for the financial markets: the value of the overall demand for financial assets (the saving of the young) must be equal to the value of the overall supply.

Dividing through by employment N_{t+1} in equation (20), we have

$$q_{t+1}k_{t+1} = sw\frac{N_t}{N_{t+1}} \tag{21}$$

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profit share can allow full employment growth with full utilization if $u^{**} \geq 1$. The full utilization solution is unstable, however; see Appendix A. Marglin (1984, chapter 2) highlights this instability in an OLG model with perfect competition.

[12] The analysis illustrates a more general point: having profit rates that exceed the rate of growth does not imply dynamic efficiency under imperfect competition (Skott and Ryoo 2014).

[13] Michl (2007) highlights another source of inefficiency in a related OLG model with Leontief technology. Assuming that income distribution adjusts to maintain full-employment growth and full utilization of capital, he shows that high saving rates lead to inefficient equilibria with $i > n$.

where $k = K/N$ and q is the ratio of the value of household financial wealth to the capital stock,[14] i.e.,

$$q = \frac{\sum A_i}{K} \qquad (22)$$

In steady growth with full employment we have $\frac{N_t}{N_{t+1}} = \frac{1}{1+n}$ and, using (7)-(8), the steady-growth value

of k is given by

$$k = \frac{u^* K}{Y} \frac{1}{u^*} \frac{Y}{N} = \frac{\lambda}{\sigma} \frac{1}{u^*} \qquad (23)$$

Thus, equation (21) implies that q must be constant in steady growth:

$$q = sw \frac{1}{1+n} \frac{1}{k} = s(1-\pi) \frac{1}{1+n} \frac{\lambda}{k} = s(1-\pi) \frac{1}{1+n} \sigma u^* \qquad (24)$$

Turning to the goods market, the equilibrium condition can be written

$$C_t^{young} + C_t^{old} + I_t = Y_t \qquad (25)$$

We have

$$C_t^{young} = (1-s)(1-\pi)Y_t \qquad (26)$$

$$C_t^{old} = (1+r_t)s(1-\pi)Y_{t-1} \qquad (27)$$

where r is the average rate of return on the financial assets owned by the old generation. Using (25)-(27)

and dividing by K, the equilibrium condition yields

$$(1-\pi)\frac{Y_t}{K_t} - s(1-\pi)\frac{Y_t}{K_t} + (1+r_t)s(1-\pi)\frac{Y_t}{K_t}\frac{Y_{t-1}}{Y_t} + \frac{I_t}{K_t} = \frac{Y_t}{K_t} \qquad (28)$$

In steady growth this equilibrium condition can be rewritten (using equation (24)) as

$$s(1-\pi)\left(\frac{1+r}{1+n} - 1\right)\sigma u^* + (n+\delta) = q(r-n) + (n+\delta) = \sigma u^* \pi \qquad (29)$$

or

$$r = \frac{\sigma u^* \pi - (n+\delta)}{q} + n = \frac{R(i)-n}{q} + n \qquad (30)$$

where the return on capital, $R = R(i)$, is given by (11).

Equations (24) and (30) would be mutually consistent if the rate of return (r) on the household

portfolio could be determined freely. This is not the case, however. Households' portfolio decisions are

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[14] The price level is taken to be constant (cf. above) and we set $P = 1$.

particularly simple in a benchmark case without risk and transaction costs. Thus, assume that all financial assets are safe and can be converted instantaneously and costlessly into the means of payment. With this assumption, the assets become perfect substitutes, and all financial markets will clear as long as the aggregate condition (24) is satisfied and all assets yield the same rate of return.

Following Skott (1989) we assume that private banks have no costs. If there is free entry into banking, there will be no profits in this sector either, and the same interest rate will apply to loans and deposits (these simplifying assumptions could be relaxed without affecting the qualitative conclusions). Monetary policy controls the interest rate, and if the banking system offers the interest rate i on deposits and loans, all financial assets in the household portfolio must earn this rate of return. Setting $r = i$, the two equations (24) and (30) have only one free variable, q, and – except by a fluke – full employment growth becomes incompatible with the conditions for equilibrium in the financial markets.

Full employment growth could be achieved by abandoning the requirement that utilization be at the desired rate, $u = u^*$. Equations (24) and (30) now contain two free variables, q and u:

$$q = s\frac{1-\pi}{1+n}u\sigma \tag{24'}$$

$$i = \frac{\sigma u\pi - (n+\delta)}{q} + n \tag{30'}$$

The two equations produce positive solutions, $q = \tilde{q} > 0$ and $u = \tilde{u} > 0$, if $(1 + n)\pi > (i - n)s(1 - \pi)$. Thus, full-employment growth may be possible through the adjustment of the utilization rate, as in the neoclassical version above. Unlike in the neoclassical version, however, a low utilization rate is not just socially wasteful (dynamically inefficient): the problem of dynamic inefficiency is transformed into one of aggregate demand if the level of investment is determined by profit-maximizing firms.

In general the solution $\tilde{u}$ will not coincide with the utilization rate that firms consider desirable, and the requirement that utilization be at the desired rate $(u_t = u^*)$ can be seen as the steady-growth implication of a Harrodian investment function

$$\frac{d}{dt}\hat{K} = \mu(u_t - u^*) \tag{31}$$

Underlying this stylized description of investment behavior lies a simple claim: profit maximizing firms will not maintain a constant rate of accumulation if they have persistent unwanted capacity. Using Harrod's terminology, $\widehat{K}^*$ – the steady growth solution associated with $u_t = u^*$ – defines the warranted growth rate. The warranted rate can be found directly from equations (24) and (30) by keeping $u = u^*$ and $r = i$, but allowing the growth rate to deviate from the 'natural rate' n. If θ denotes the warranted growth rate, the equations now determine the two variables, q and θ:

$$q = s\frac{1-\pi}{1+\theta}u^*\sigma \tag{24''}$$

$$i = \frac{\sigma u^*\pi-(\theta+\delta)}{q}+\theta \tag{30''}$$

There is a unique solution for θ with $-1 < \theta < i$; this solution is increasing in s.[15]   A low saving rate implies that the warranted rate is below the natural rate, $\widehat{K}^* = \theta < n$, and accumulation will be insufficient to keep up with the growth in the labor force. More interesting for present purposes is the case of high saving rates and $\widehat{K}^* > n$. In this situation labor constraints imply that output cannot grow at the warranted rate in the long-run. Excess capacity must emerge, and the dynamics depend on the full specification of investment behavior. The likely result from a Harrodian perspective is downward instability and secular stagnation. Nakatani and Skott (2007) discuss the Japanese stagnation after 1990 along these lines. But whatever the details, if $\widehat{K}^* \neq n$, there is no steady growth path with full employment and equilibrium in the product market.

This general conclusion does not depend on a Harrodian specification of investment. A simple

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[15] The solution for θ satisfies

$$s\frac{1-\pi}{1+\theta}u^*\sigma = \frac{\sigma u^*\pi - (\theta+\delta)}{i-\theta}$$

The left hand side of this equation is decreasing in θ for $\theta > -1$ and has a vertical asymptote at $\theta = -1$. By assumption, we have $R(i) = \sigma u^*\pi - \delta > i$ – otherwise profit maximizing firms would not want to invest – and for $\theta < i$ the right hand side is increasing in θ with a vertical asymptote at $\theta = i$. The existence of a unique solution for θ between -1 and i now follows. The positive effect on θ of a rise in s follows from the implicit function theorem.

The steady growth rate must satisfy the condition $i > \theta$ in this benchmark case. This implication is an artifact of the perfect substitutability between the financial assets. Perfect substitution implies that the average return on financial assets cannot exceed i. We have $\sigma u^*\pi - \delta > i$ and $\sigma u^*\pi - \delta > \theta$ (cf. section 2), and no positive value of q can reduce the average return on the financial assets to i if $i < \theta < \sigma u^*\pi - \delta$ (see equation (30'')). Without perfect substitution among the financial assets, the average return on financial assets can exceed i, and the growth rate can exceed the interest rate on safe assets.

Kaleckian investment function, for instance, assumes that the accumulation rate is positively related to utilization, $I/K = f(u)$. With this specification, full-employment growth requires $u = f^{-1}(n + \delta)$ and only by a fluke will $f^{-1}(n + \delta)$ be equal to $\tilde{u}$. This conclusion also applies to specifications that include additional variables (the valuation ratio, for instance). The saving side determines the solution $\tilde{u}$ and this value of the utilization rate need not be equal to the value determined from the investment side.

4 Public debt

In neoclassical OLG models, dynamic inefficiency problems can be overcome by introducing a public sector and public debt. Analogously, fiscal policy makes it possible to escape aggregate demand problems and achieve full-employment growth in our Keynesian OLG model.

Assume that the government consumes (G_t), levies lumpsum taxes on the young and old generations $(T_t^Y$ and $T_t^O)$, and has debt (B_t). The introduction of taxes modifies the household decision problem. A young (employed) agent in period t now maximizes (13) subject to the constraint,

$$c_{1,t} + \frac{1}{1+r_{t+1}} c_{2,t+1} = w_t - \tau_t - \frac{1+n}{1+r_{t+1}} \gamma_{t+1} \tag{14'}$$

where $\tau_t = T_t^Y/L_t$ and $\gamma_t = T_t^O/L_t$. Assuming full employment, the maximization gives the following solution for aggregate saving

$$S_t = \left[s(w_t - \tau_t) + (1-s) \frac{1+n}{1+r_{t+1}} \gamma_{t+1} \right] L_t \tag{32}$$

where s is given by (16). Alternatively, saving can be written

$$\sum A_{i,t+1} = S_t = \tilde{s}_t(w_t - \tau_t)L_t \tag{20'}$$

where the young generation's saving rate out of current disposable income $(\tilde{s}_t)$ is given by

$$\tilde{s}_t = \frac{s(w_t - \tau_t) + (1-s)\frac{1+n}{1+r_{t+1}} \gamma_{t+1}}{w_t - \tau_t} \tag{16'}$$

The expressions for consumption now become

$$C_t^{young} = (w_t - \tau_t)L_t - S_t \tag{26'}$$

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$$C_t^{old} = (1+i)S_{t-1} - \gamma_t L_t = \frac{1+i}{1+n}S_t - \gamma_t L_t \tag{27'}$$

As in section 3, we assume that the financial assets are perfect substitutes and have the same rate of return; thus, $r_t = i$. Equation (27') embodies this assumption.

Using the definitions of k, u and σ, the equilibrium condition for the goods market can be written

$$(1-\pi)\frac{Y_t}{K_t} - \frac{\tau_t L_t}{K_t} + \left(\frac{1+i}{1+n} - 1\right)\frac{S_t}{K_t} - \frac{\gamma_t L_t}{K_t} + \frac{I_t}{K_t} + \frac{G_t}{K_t} = \frac{Y_t}{K_t} \tag{28'}$$

or

$$(1-\pi)\sigma u^* - \frac{\tau_t}{k_t} + \frac{i-n}{1+n}\tilde{s}_t(w_t - \tau_t)\frac{1}{k_t} - \frac{\gamma_t}{k_t} + n + \delta + \frac{g_t}{k_t} = \sigma u^* \tag{28''}$$

where $g_t = G_t/L_t$. Three fiscal instruments – government consumption, taxes on the old or taxes on the young – could be used to achieve equilibrium. Taking the taxes on the young to be the active instrument, we assume that $g_t = g$ and $\gamma_t = \gamma$ are kept constant (the analysis would be analogous with g or γ as the active policy instrument). Steady growth requires that $u_t = u^*$ and, using equations (10) and (23) to substitute for w and k, equation (28'') can be solved for the long-run value of the tax rate τ:

$$\tau^* = \frac{(i-n)sw - (1+n)(\pi\sigma u^* - \delta - n)k}{1+n+s(i-n)} - \frac{1+n}{1+i}\gamma + \frac{1+n}{1+n+s(i-n)}g \tag{33}$$

The public sector budget constraint is given by

$$G_t + (1+i)B_t = B_{t+1} + T_t^Y + T_t^O \tag{34}$$

Dividing through by N_t and using $g_t = g$ and $\gamma_t = \gamma$, this dynamic equation for the public debt can be rewritten,

$$g + (1+i)b_t = (1+n)b_{t+1} + (\tau_t + \gamma) \tag{35}$$

where $b_t = B_t/L_t$. Substituting the solution for τ into equation (35), and rearranging, the stationary solution for b becomes

$$b^* = \frac{sw - (1+n)(\pi\sigma u^* - \delta - n)k/(i-n)}{1+n+s(i-n)} + \frac{1}{1+i}\gamma - \frac{s}{1+n+s(i-n)}g \tag{36}$$

Turning to financial markets, the model includes government bonds as an additional asset,

compared to section 3. Let F denote household financial wealth net of government bonds ($S_t = F_{t+1} + B_{t+1}$) and let $q_t = F_t/K_t$. With this definition, q still expresses firms' valuation ratio and equation (20') can be written

$$\frac{B_{t+1}+F_{t+1}}{L_t} = (1+n)(b_{t+1} + q_{t+1}k_{t+1}) = \tilde{s}_t(w_t - \tau_t) \qquad (20'')$$

Thus, in steady growth we have

$$(1+n)(b + qk) = \tilde{s}(w - \tau) \qquad (37)$$

The solution for the valuation ratio q can now be found by combining equations (16'), (33) and (37):

$$q = \frac{\pi\sigma u^* - \delta - n}{i - n} \qquad (38)$$

Intuitively, firms have a net profit rate of $\pi\sigma u^* - \delta$, leaving $(\pi\sigma u^* - \delta - n)K$ for distribution to households after financing net investment, but the financial return on equity also includes capital gains: if one unit of fixed capital is valued at q by the financial market, the financial valuation of the firms increases by qnK. [16] The value of q has to make the financial rate of return equal to i, that is:

$iq = \pi\sigma u^* - \delta - n + qn$ or $q = \frac{\pi\sigma u^* - \delta - n}{i - n}$.

Equations (33) and (36) describe the long-run implications of a full-employment policy for taxes and the debt ratio. The equations have several interesting implications. From (36) it follows that the required debt ratio depends *inversely* on public consumption (g) and *directly* on the level of taxes on the old generation (γ).[17] An increase in g implies that private consumption has to contract in order to maintain equilibrium in the product market. This is achieved by increasing taxes on the young. As a result the desired saving decreases and this, in turn, reduces the need for government debt as an outlet for private saving. Analogously, with a given value of g, an increase in γ must be accompanied by a reduction in τ in order to maintain the level of consumption and ensure equilibrium in the goods market; the disposable income of the young increases, and the amount of public debt must also increase to meet

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[16] The choice of financing – retained earnings, new equity or corporate bonds – is of no importance when all assets must earn the same rate of return.

[17] An inverse relation between debt and government consumption is obtained in a non-OLG setting by Schlicht (2006) and Ryoo and Skott (2013).

the rise in private saving.

Equation (36) also implies a relation between economic growth and public debt: the required debt is inversely related to the growth rate n for empirically relevant values of the parameters; the inequality $(w - g) > 0$ is a sufficient condition for the partial $\partial b / \partial n$ to be negative, and empirically the wage share greatly exceeds the share of government consumption.[18] Intuitively, debt is required because the young generation wants to save in excess of what is needed to provide fixed capital for the next generation. A higher growth rate raises the need for fixed capital and therefore reduces the need for public debt.

The tax rate also depends on g, γ and n (equation (33)). It should be noted, however, that the reduced-form correlation between b and τ is ambiguous. An increase in g, for instance, raises τ^* and reduces b^*, and variations in g produce a negative correlation between the steady-growth values of τ and b; high debt in these cases is associated with low tax rates. Other parameter shifts yield a positive correlation between τ and b^*; a shift in the profit share, for instance, will change b^* and τ^* in the same direction if $i > n$.[19]

5   Fluctuations in 'confidence' and intergenerational fairness

The saving propensity may fluctuate across generations either as a result of variations in the discount rate across generations or because of variations in 'confidence'. Suppose, for instance, that young agents believe that in addition to the returns on their saving, they will have an after-tax income of ε. By assumption, the actual after-tax income will be the net tax on the old, that is, the value of ε_{t+1} is given by $-(1 + n)\gamma_{t+1}$. Agents may not have perfect foresight, however, and for present purposes it

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[18] The partial $\partial b^* / \partial n$ can be written

$$\frac{\partial b^*}{\partial n} = \frac{-1}{[1 + n + s(i - n)]^2} \left\{ (1 - s)s(w - g) + s(1 + i)qk + [1 + n + s(i - n)]k(1 + n)\frac{\pi \sigma u^* - \delta - i}{(i - n)^2} \right\}$$

[19] From equation (35) it follows that in steady growth $(i - n)b = \tau + \gamma - g$. Thus, b and τ must move in the same direction if i, n, γ and g are kept constant.

does not matter whether a high ε reflects a mistaken belief about future taxes or an expectation that some other source of income will be available (e.g. an expectation of being able and willing to work in the second period). The state of confidence – the beliefs about future income – may be wrong, but the beliefs alter the perceived budget constraint and affect the saving decisions. The budget constraint now reads:

$$c_{1,t} + \frac{1}{1+i} c_{2,t+1} = w_t - \tau_t + \frac{1}{1+i} \varepsilon_{t+1} \tag{39}$$

Assuming, for simplicity, that there is no subjective uncertainty, the maximization of (13) subject to (39) implies that

$$S_t = \left[s(w_t - \tau_t) - (1-s) \frac{1}{1+i} \varepsilon_{t+1} \right] N_t = \tilde{s}(\varepsilon)(w_t - \tau_t) N_t \tag{40}$$

Distributionally neutral intervention

A distributionally neutral policy intervention can be achieved by instituting a transfer to those young generations that are unduly pessimistic (tend to consume too little) and finance the transfer by taxing the same generations when they get old.[20] Conversely, an overly optimistic generation can be taxed in the first period and compensated by a transfer in the second.

Substituting (40) into (20'') and (35), full-employment growth requires that

$$\tau_t = \frac{(1+n)qk^* + g + (1+i)b_t - \gamma_t - sw}{1-s} + \frac{1}{1+i} \varepsilon_{t+1} \tag{41}$$

The tax on the old generation (γ_t) and the public debt (b_t) appear on the right hand side of equation (41). These variables are pinned down by the neutrality requirement.

Distributional neutrality implies that a generation should not be favored (or punished) because of a shift in the confidence of the succeeding generation. If b^* and γ^* denote the steady-growth values of b and γ when there are no variations in confidence, this condition can be stated formally as

$$(1+i)(qk^* + b_t) - \gamma_t = (1+i)(qk^* + b^*) - \gamma^* \tag{42}$$

The expression on the left hand side of equation (42) gives the income available to the old generation in

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[20] The transfer stimulates the young generation's consumption but part of the transfer will be saved. The additional saving will be absorbed by the issue of government bonds.

period t. Neutrality requires that this income be equal to the level that characterizes the steady growth path. Output follows the full-employment path; the stabilization of the consumption of the old generation therefore implies that the consumption of the young will also be at its steady-growth value.

Using (41) and (42), the equation for the tax on the young at time t can now be written

$$\tau_t = \frac{(1+n)qk^*+g+(1+i)b^*-\gamma^*-sw}{1-s} + \frac{1}{1+i}\varepsilon_{t+1}$$

$$= \tau^* + \frac{1}{1+i}[\varepsilon_{t+1} + (1+n)\gamma^*] \tag{43}$$

where τ^* is the steady-growth value of τ in the absence of variations in confidence.

Using (35), (42) and (43), we have

$$(1+n)b_{t+1} = g + (1+i)b^* - \gamma^* - \tau^* - \frac{1}{1+i}[\varepsilon_{t+1} + (1+n)\gamma^*]$$

$$= (1+n)b^* - \frac{1}{1+i}[\varepsilon_{t+1} + (1+n)\gamma^*] \tag{44}$$

$$\gamma_{t+1} = \gamma^* + (1+i)(b_{t+1} - b^*)$$

$$= \gamma^* - \frac{1}{1+n}[\varepsilon_{t+1} + (1+n)\gamma^*]$$

$$= -\frac{1}{1+n}\varepsilon_{t+1} \tag{45}$$

Hence,

$$\frac{\partial \tau_t}{\partial \varepsilon_{t+1}} = \frac{1}{1+i}, \ \frac{\partial b_{t+1}}{\partial \varepsilon_{t+1}} = -\frac{1}{(1+i)(1+n)}, \ \frac{\partial \gamma_{t+1}}{\partial \varepsilon_{t+1}} = -\frac{1}{1+n} \tag{46}$$

$$\frac{\partial \tau_{t+k}}{\partial \varepsilon_{t+1}} = \frac{\partial b_{t+1+k}}{\partial \varepsilon_{t+1}} = \frac{\partial \gamma_{t+1+k}}{\partial \varepsilon_{t+1}} = 0 \ \text{for} \ k \geq 1 \tag{47}$$

A shock to a generation's confidence is fully absorbed by adjustments in the taxes for that same generation; there are no persistent effects on the debt ratio.

Tax expectations

The above analysis uses systematic variations in τ_t and γ_{t+1} to get distributional neutrality across generations. The analysis took the expected after-tax, non-capital income as exogenous, and this exogeneity assumption may seem unreasonable: systematic variations in taxes may be anticipated. The

private sector's anticipation of future taxes does not, however, negate the possibility of distributionally neutral stabilization.

Consider an extreme case where taxes are perfectly foreseen and confidence is characterized by the value of the expected pre-tax, non-capital income, $z_{t+1} = \varepsilon_{t+1} + (1+n)\gamma_{t+1}$. Taxes can now be used as an insurance mechanism. Formally, let γ_{t+1} be determined by

$$\gamma_{t+1} = \gamma^* + \frac{\bar{z}_{t+1}}{1+n} \tag{48}$$

where $\bar{z}_{t+1}$ is the actual average non-capital income when the generation is old. By assumption there is symmetry across agents within a generation and the individual agent's own income z_{t+1} will be equal to the average income $\bar{z}_{t+1}$, but the specification of taxes in terms of average income preserves the lump-sum character of the tax.

The tax scheme in (48) implies that the budget constraint (39) can be rewritten

$$c_{2,t+1} = (1+i)\big(w_t - \tau_t - c_{1,t}\big) + (1+n)[z_{t+1} - (1+n)\gamma_{t+1}]$$

$$= (1+i)\big(w_t - \tau_t - c_{1,t}\big) - (1+n)\gamma^* \tag{49}$$

Equation (49) implies that the budget constraint becomes independent of 'confidence': the conditional tax scheme provides insurance and effectively guarantees that the after-tax, non-capital income will be equal to $-(1+n)\gamma^*$. Consequently, the tax rate on the young can be set at the steady-growth level, $\tau_t = \tau^*$, no variations in τ are required.

The combination in this example of confidence effects and perfect anticipation of future taxes may seem even more questionable than the more common Ricardian assumptions of perfect foresight with respect to both taxes and future returns. In response to this objection, one can take one of two routes: assume that there are no variations in confidence or, alternatively, accept that variations in confidence do occur and that households do not fully anticipate future taxation. The first route we will leave to others; the second can be approached by examining – as in equation (43) – how variations in expected after-tax, non-capital income can be neutralized by taxation.

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Non-neutral intervention

The analysis may be subject to another objection. We have assumed that the private sector is subject to swings in confidence; the government, by contrast, correctly infers the private sector's expectations, correctly anticipates the future incomes, and has the ability to implement sophisticated tax schemes. These assumptions may impose policy demands that no government can meet. Intergenerational neutrality and perfect government foresight are not required, however, for full-employment growth.

To see this, consider the simple case in which capital income is taxed at a constant rate β,

$$\gamma_t = \beta(qk_t + b_t)(1 + i) \tag{50}$$

Returning to the case without private sector anticipation of future taxes, we take the expected future after-tax, non-capital income as exogenous; thus, the saving rate by the young generation is given by (40). Combining these assumptions with equations (20'') and (35) – still assuming that τ_t is used as the active instrument to ensure full-employment growth – the debt dynamics can be written

$$b_{t+1} = A - Bb_t + \frac{1}{(1+n)(1+i)(1-s)}\varepsilon_{t+1} \tag{51}$$

where

$$A = \frac{s[w - g + \beta(1+i)qk^*] - qk^*(1+n)}{(1+n)(1-s)} \tag{52}$$

$$B = (1 - \beta)\frac{1+i}{1+n}\frac{s}{1-s} \tag{53}$$

If $\varepsilon_t = 0$ for all t and the tax rate β is sufficiently large, the difference equation (51) has a unique, stable stationary point,

$$b^{**} = \frac{A}{1+B} \tag{54}$$

Random fluctuations in ε generate fluctuations in b_t. But if the fluctuations in ε are bounded then so are the fluctuations in b_t[21]

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[21] Other non-neutral schemes could be used, including one with a balanced government budget at all times: tax the pessimistic young and transfer the tax revenue to the currently old generation.

6   Discussion

Public debt, interest rates and economic growth

In OLG models an exogenous rise in debt will be associated with a fall in the capital stock and an increase in the return on capital. A functional finance approach to fiscal policy makes this result irrelevant: debt is allowed to increase if an increase is necessary to maintain both full employment and the optimal capital intensity. A perfectly executed fiscal policy of this kind may show fluctuations in debt (as in section 5), but the capital intensity and the return on capital are kept constant.

Fiscal policy is not always conducted in accordance with the principles of functional finance – the current obsession with austerity testifies to that – but the result carries important implications. Under pure functional finance interest rates are independent of debt. This result does not hold without pure functional finance, but observed correlations between interest rates and debt depend on the interaction between policy regimes and private sector behavior. Without knowledge of the sources of changes in the public debt, there is no way to predict the empirical correlation between debt and interest rates. Thus, it is not surprising that the results of empirical studies are weak and inconclusive.[22]

Disregarding this inconclusiveness, the standard OLG link is between the level of debt and the levels of capital and income. This link is different from the long-run relation between the debt ratio and the rate of economic growth suggested in some empirical studies by Reinhart and Rogoff (2010) and Kumar and Woo (2010). The theoretical story behind the relation between debt and growth is unclear, and theoretical ambiguities accentuate the difficulty of interpreting empirical results.[23] Accepting, for the sake of the argument, that a negative correlation can be found between debt and economic growth, the

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[22] In the words of Engen and Hubbard (2005, p.83), there is "little empirical consensus about the magnitude of the effect ... some economists believe there is a significant, large, positive effect of government debt on interest rates, others interpret the evidence as suggesting that there is no effect on interest rates" . Bohn (2010, p.14) makes a similar statement about the difficulty of finding significant interest effects of debt. He goes on to suggest that a "leading explanation is Ricardian neutrality" . There is no need for Ricardian neutrality to explain the results, however; our OLG model does not display neutrality.

[23] Kumar and Woo mention a number of possible channels, including the effect of higher interest rates on capital accumulation, and the potential effects of debt induced increases in "uncertainty about prospects and policies". As discussed above, the evidence on a debt - interest rate link is tenuous, at best. The latter effect seems to be a close cousin of what Krugman has been referring to as the 'confidence fairy', and it is hard to see how contractionary fiscal policies will enhance confidence in a recession.

key question concerns causation. This question has two parts. The first part asks whether past episodes of high debt did in fact *cause* low growth, as opposed to a reverse causal link between the two variables or an explanation in which a third factor accounts for the changes in both debt and growth. Empirical studies by Irons and Bivens (2010), Basu (2013) and Dube (2013) conclude that causation has run from growth to debt. These empirical results could be driven by short and medium term effects of a slowdown in growth on deficits and debt, but the analysis in this paper lends theoretical support to the conclusions, also for the long run. As shown in section 4, functional finance produces a causal link between growth rates and debt: a reduction in the long-run rate of growth raises the long-run debt ratio.

The second part of the question is more radical. One may ask whether it is at all meaningful to look for a general answer to a reduced-form question about the growth effects of public debt. According to Rogoff and Reinhart (2010, p. 6),

> . . .war debts are arguably less problematic for future growth and inflation than large debts that are accumulated in peace time. Postwar growth tends to be high as war-time allocation of man-power and resources funnels to the civilian economy. Moreover, high war-time government spending, typically the cause of the debt buildup, comes to a natural close as peace returns. In contrast, a peacetime debt explosion often reflects unstable underlying political economy dynamics that can persist for very long periods.

As pointed out by Michl (2013):

> To a Keynesian, the quote above would very sensibly read 'high recession-time government spending, typically the cause of the debt buildup, comes to a natural close as growth returns.' In fact, Keynes (1972, p. 144) once aptly described government borrowing as "nature's remedy" for preventing a recession from deteriorating into a total collapse in production. As for the rest of the quote, who would deny that 'unstable political dynamics' can be an obstacle to growth?

A fiscal expansion is intrinsically neither good nor bad. A reckless fiscal expansion can cause overheating, inflation and macroeconomic instability. Sensible fiscal policies are adjusted in the light of prevailing economic circumstances, and the effects of bad policy say little about the growth effects of a

fiscal expansion in a deep recession. The general point is simple: reduced-form correlations between debt and growth depend on the underlying sources of the movements in debt.

Public debt and intergenerational distribution

Claims that high public debt hurts future generations have figured prominently in popular debates and also appear in the academic literature. Having found that public debt has at most small effects on interest rates, Engen and Hubbard (2005), go on to caution that public deficits and debt still matter because large levels of government debt "can represent a large transfer of wealth to finance current generations' consumption from future generations which much eventually pay down federal debt to a sustainable level." (p. 132)

The *possibility* that fiscal policy can hurt future generations is not controversial; inappropriate fiscal policy can have negative effects for future as well as for current generations. But our analysis of an OLG model without bequests – the setting that is most favorable to the case for adverse future effects of public debt – shows that debt need not be a burden on future generations. On the contrary, it can serve to remove dynamic inefficiencies and maintain full employment. Fluctuations in 'confidence' can be addressed through policies that are neutral in their effects on the intergenerational distribution. Even when a policy is not fully neutral in this sense, future generations may be better off than without the policy. With a fixed tax rate on capital income, for instance, the required variations in the tax on the young generation will have distributional effects: a pessimistic generation will be favored by a reduction in its taxes (section 5). This result does not imply that future generations would be better off without the reduction. In the absence of fiscal expansion, a lack of demand would affect capacity utilization, reduce investment and the future capital stock, and jeopardize both current and future employment.

Austerity and long term consolidation

Entitlement programs like social security or medicare are prime targets of most austerity programs.

Reductions in these programs have adverse intra-generational effects on distribution (which our model with identical agents within each generation cannot capture). More surprisingly, our analysis demonstrates that these reductions may also be counterproductive on their own terms, assuming that the aim is to reduce public debt: reductions in social security and medicare correspond to a rise in the tax on the older generation, and as shown in section 4, an increase in the taxation of the old generation will raise the required debt. A reduction in government consumption (g), likewise, requires an increase in the long-run debt. The general point, once again, is that the desirable level of public debt depends on a range of behavioral and policy variables.

These results suggest that some critiques of austerity may not go far enough. Krugman's insistence that the slump is not the time to cut the debt is fully in line with functional finance, but he also suggests that the US has long-run budget problems that must be addressed once we are out of recession.[24] The nature of the long-run debt problem is not made clear, however. This is not to say that there can be no adverse consequences of high public debt. But these consequences have to be clearly specified and balanced against the benefits.

7 Conclusions

Are the current debt levels and fiscal deficits sustainable? It is not always clear what is meant by sustainability, but the analysis in this paper shows that fiscal policy and public debt may be needed to maintain full employment. The required fiscal policy, moreover, need not – and in our OLG model does not – lead to unsustainability in the form of an ever-increasing debt-GDP ratio.[25]

The equilibrium debt ratio depends on the parameters of the model. Some parameters are of

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[24] "Yes, the United States has a long-run budget problem. Dealing with that problem is going to require, first of all, sharply bending the curve on Medicare costs; without that, nothing works. And second, it's going to require some combination of spending cuts and revenue increases, amounting to at least 3 percent of GDP and probably more, on a permanent basis." Krugman, http://krugman.blogs.nytimes.com/2010/07/21/notes-on-rogoff-wonkish/

[25] As shown by Ryoo and Skott (2013), functional finance can produce unstable debt-income dynamics in settings with intra-generational heterogeneity. These unstable scenarios are closely linked to (intra-generational) distribution effects and can be avoided by changes in the structure of taxation.

particular interest. Austerity policies, which tend to reduce government consumption and raise net taxes on the old, will raise the debt ratio. Negative correlations between growth rates and debt ratios, moreover, are consistent with the model, but the causation runs from growth to debt: low growth requires a high debt ratio if full employment is to be maintained.

In steady growth all generations do equally well, but questions of inter-generational distribution may arise away from steady growth. We address this issue by introducing fluctuations in household 'confidence'. A failure to adjust fiscal policy in response to a decline in confidence leads to aggregate demand problems and secular stagnation. Distributionally neutral policies can prevent this outcome and maintain full employment.

The analysis has many limitations. We have focused on a closed economy, and the paper says nothing about the problems of open economies with public debt in a foreign currency.[26] The neglect of heterogeneity within generations represents a second limitation. Public debt may have regressive distributional effects if taxes on wage income are used to finance interest payments to the rich. The incentive effects of taxes, third, have been ignored throughout. As shown in section 4, a higher level of debt need not be associated with higher tax rates but even if it is, the structure of government consumption and the form of taxation may be more important than the level of debt for the public sector's incentive effects.[27] Fourth, we took the price level to be constant, and the model only indirectly addresses inflationary concerns. Engen and Hubbard (2005) suggest that "federal government debt may also pose the temptation to monetize the debt, causing inflation" but point out that "this concern has not been a problem in the United States over the past fifty years" (p. 98); Reinhart and Rogoff (2010) also find no evidence for a link between debt and inflation in advanced economies. The inflation fear essentially boils down to a concern that policy may not in the future be governed by a functional finance criterion:

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[26] Chalk (2000, p. 319) argues that some OECD countries "have seen an explosion in their indebtedness to such an extent that the solvency of the public sector is brought into question." Solvency questions of this kind may be relevant for countries with debt in foreign currency. But it is unclear how a sovereign state could ever become insolvent if its debt obligations are denominated in a currency that it can print at will.

[27] The importance of incentives for growth is questionable. Fast growth during the 'golden age' was associated with high marginal tax rates in the US, and the Nordic welfare states have low unemployment and labor force participation rates that exceed those of the US.

"eliminate both unemployment and inflation" (Lerner 1943, p. 41). Functional finance, fifth, may imply that interest rates should be set to achieve a desired capital intensity. This objective need not exclude short-run variations in interest rates around the level associated with the chosen capital intensity. The level of public debt influences the effectiveness of short-run monetary policy, however. A contractionary monetary policy raises interest rates and generates an automatic fiscal expansion unless it is matched by an increase in tax rates. Thus, monetary policy is blunted when debt is high, and this may complicate short-run economic policy.[28] The simple OLG structure, sixth, may be appealing for an analysis of public debt, but it has peculiar properties that find no support in data. The model implies that the saving rate is inversely related to the profit share: only the young save, and the young get their income as wage income. Empirically, by contrast, saving rates are higher out of profits than wages. Thus, the saving assumptions that are at the center of the analysis in OLG models can be questioned.[29]

Our analysis, finally, has taken as given the level of government spending. Public investment in infrastructure, education, health, and the environment clearly contribute to future welfare, and public consumption and social spending can also have a high payoff, even in narrow economic terms (by reducing crime or raising future earnings, for instance). The benefits and distributional effects of public spending could justifiably be ignored in a discussion of public debt if this spending were already at an agreed-upon, optimal level. A good deal of the debate over public debt, however, may reflect underlying controversies over the desirable level of public spending. These issues are beyond the scope of this paper.

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[28] Ryoo and Skott (2015) analyze short-run stabilization in an economy characterized by Harrodian instability; see also Franke (2015).
[29] We abandon these assumptions in Ryoo and Skott (2013, 2015) which build on the framework in Skott (1989) and Skott and Ryoo (2008).

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Appendix A: A neoclassical OLG model with Leontief technology

Let the production function be

$$Y_t = \min\{\lambda L_t, \sigma K_t\} \tag{A1}$$

Assuming an inelastic labor supply and markup pricing ($P = (1 + m)c$, where c is marginal cost), we have

$$w_t = \begin{cases} 0 & \text{if} \quad \lambda L_t > \sigma K_t \\ \frac{\lambda}{1+m} & \text{if} \quad \lambda L_t < \sigma K_t \end{cases} \tag{A2}$$

$$r_t + \delta = \begin{cases} \sigma & \text{if} \quad \lambda L_t > \sigma K_t \\ \frac{m}{1+m}\sigma u & \text{if} \quad \lambda L_t < \sigma K_t \end{cases} \tag{A3}$$

The economy has two (non-trivial) steady growth paths, as well as a trivial steady-growth solution with $K_t = Y_t = 0$. There is a full-utilization path with $\lambda L_t = \sigma K_t$ and[30]

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[30] The inequalities (A4)-(A5) follow from condition (19).

$$w = (2 + \rho)(1 + n)\frac{\lambda}{\sigma} < \lambda \tag{A4}$$

$$r + \delta = \sigma - (2 + \rho)(1 + n) > 0 \tag{A5}$$

The steady growth path described by equations (A4)-(A5) is dynamically efficient but unstable: a negative shock to w_t reduces S_t (equation (17) and implies that $K/L < \lambda/\sigma$ in the next period; as a result, w_t drops to 0, there is no saving, and the capital stock drops to 0.

In addition to the efficient steady growth path and the trivial path with $K_t = 0$, there is a locally stable steady growth path with less than full utilization of capital. Starting from the efficient path, a positive shock to w raises saving, and capital intensity increases in the next period to give $K/L > \lambda/\sigma$. The wage rate then rises to $w_t = \lambda/(1 + m)$ in subsequent periods, and the economy will be following a steady growth path with excess capacity:

$$k = \frac{\lambda}{(2+\rho)(1+n)} > \frac{\lambda}{\sigma} \tag{A6}$$