Schumpeterian Growth with Productive Public Spending and Distortionary Taxation

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Abstract

Schumpeterian growth theory eliminates the scale effect by positing a process of development of new product lines that fragments the aggregate market in submarkets whose size does not increase with population or the size of the workforce. This entails the sterilization of the growth effects of selected fiscal variables. This insight is applied to shed new light on the role of distortionary taxes on consumption, household labor and assets income, corporate income, and of productive public spending. The framework allows the identification of which of these fiscal variables have permanent (steady-state) growth effects, and which ones have only transitory effects. It also allows the transitional dynamics to be solved analytically and thus the analysis of the welfare effects of revenue-neutral changes in tax structure. It is found that replacing taxes that distort labor supply with taxes that distort saving/investment choices raises welfare, and the intuition behind this surprising result is discussed.

1. Introduction

The latest vintage of Schumpeterian growth models exhibits a sharp distinction between factors that affect the steady-state growth rate and factors that affect the steady-state level of income per capita. As discussed in several recent contributions,[1] eliminating the scale effect of population size on endogenous growth requires sterilization of the effect of the size of the market on firms' incentives to undertake R&D targeted at a given product line. One way of doing this is to posit a process of development of new product lines that effectively fragments the aggregate market in submarkets whose size does not increase with population. The consequence of this process of market fragmentation is that fundamentals and policy variables that work through the size of the aggregate market do not affect steady-state growth; only fundamentals and policy variables that work through the interest rate do. Variables that work through the size of the aggregate market, nevertheless, have transitory effects that are important determinants of welfare.

In this paper I argue that this insight sheds new light on the workings of fiscal policy.[2] In particular, it identifies the main channel linking distortionary taxes and public spending to growth and thereby identifies which fiscal variables have permanent (i.e. steady-state), as opposed to only transitory, effects. The relevant features of the analysis are as follows.

- The model has no scale effect on the growth rate of income per capita because of the endogenous product proliferation mechanism.
- The set-up allows one to solve the transitional dynamics analytically, and thus to analyze the welfare effects of tax rates and public spending and of revenue-neutral changes in tax structure.

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I provide two classes of results. First, I study equilibrium dynamics under the assumption that (flat) tax rates are constant over time while public spending is endogenous. This analysis characterizes the direct effects of tax rates on the relevant macroeconomic variables. In particular:

- Labor and consumption taxes do not affect long-run growth; taxes on household asset income or corporate income do. The intuition for this property has been discussed previously by Zeng and Zhang (2002) and Peretto (2003) in more restrictive environments.[3] Their analysis shows that tax instruments that work through the size of the aggregate market do not affect steady-state growth in the new vintage of models that do not exhibit the scale effect. In contrast, taxes on asset or corporate income operate through the interest rate and thus have long-run growth effects. The present analysis generalizes this property in several dimensions and studies its welfare implications.
- Since public spending is endogenous, one does not have an explicit comparative statics result establishing the lack of growth effect of this instrument. However, the characterization of the steady state features no feedback running from the government's budget constraint—which determines public spending given tax rates and private agents' decisions—and the equations determining steady-state growth. In this indirect fashion one can see that public spending does not affect steady-state growth.

The next set of results concerns equilibrium dynamics under the assumption that the government holds constant the fraction of GDP allocated to public spending while at least one of the tax rates is endogenous. In line with the previous analysis, this exercise shows that public spending does not have a direct effect on growth. It can have indirect effects, however, due to the choice of financing instrument. In particular, financing public spending with labor income taxes or consumption taxes does not entail a link from spending to growth; financing public spending through taxes on household asset or corporate income entails a link between public spending and growth.

The set-up allows me to investigate revenue-neutral changes in taxation. Comparing taxes pairwise I show that:

- a revenue-neutral replacement of the asset income tax with a corporate income tax is welfare improving;
- a revenue-neutral replacement of the consumption tax or of the labor income tax with a corporate income tax is welfare improving;
- in an economy where firms face high fixed operating and sunk entry costs, a revenue-neutral replacement of the consumption tax or of the labor income tax with an asset income tax is welfare improving.

The intuition for these results follows from the different effects that distortionary taxes have according to whether they apply to households or firms. The first two experiments posit the replacement of a tax that distorts the choices of households —their intratemporal consumption/labor/leisure choice or their intertemporal consumption/saving choice—with a tax that distorts the production/investment/entry choices of firms. The third experiment posits the replacement of a tax that affects the intratemporal choices of households with a tax that affects their intertemporal choices. In all three cases, removing the taxes that distort consumption and labor supply decisions raises welfare through level effects, that is, higher steady-state consumption and leisure. The introduction of a tax that distorts intertemporal choices of firms or households produces growth effects that might reinforce or offset the level effects. In the case

of the corporate income tax the growth effect is unambiguously positive; in the case of the asset income tax it depends on structural parameters that regulate firm size.

But how can taxes that affect intertemporal choices have a positive effect on growth? The role played by fixed operating and sunk entry costs provides a hint to the answer.

In the experiments above the posited tax changes require that firms generate a higher *profit rate* in order to keep delivering to shareholders their reservation after-tax rate of return.[4] For this to happen in equilibrium, the market must converge to a situation where the number of firms per capita is smaller so that the typical firm controls a larger share of the aggregate market. But larger, more profitable firms exploit internal increasing returns more aggressively and thereby grow faster.

In focussing attention on the link between profitability and growth incentives as the driver of the effects of changes in taxation, this paper does not differ from standard endogenous growth theory. Where it does differ is in highlighting that this profitability–incentives link is in essence a market structure story. Specifically, what matters for growth and welfare is how distortionary taxes and public spending affect the aggregate size of the market and, crucially, how the aggregate market is divided across firms through a process of entry and market shares determination that "dilutes" aggregate impulses at the firm level. A crucial aspect of this story is that the margin that absorbs the negative effect of taxation on the incentives to accumulate is the number of firms, not the economy's growth rate.

2. The Model

2.1 Final Sector

A competitive representative firm produces a final good Y that can be consumed, used to produce intermediate goods, invested in R&D that improves the quality of existing intermediate goods, or invested in the creation of new intermediate goods. The price of this final good is the *numéraire*, $P_Y \equiv 1$. The production technology is

$$Y = \int_0^N X_i^\theta \left[Z_i^\alpha \left(\frac{G}{e^{\lambda t}} \right)^{1-\alpha} L_i \right]^{1-\theta} di, \quad 0 < \alpha, \theta < 1 \tag{1}$$

where N is the mass of non-durable intermediate goods. These goods are vertically differentiated according to their quality. The productivity of L_i workers using X_i units of good i depends on good i's quality, Z_i, and on the contribution of government expenditures, G, on public goods that are essential, augment labor in a manner that complements technology,[5] and are subject to congestion on a per capita basis. Initial population is normalized to 1 so that at time t population size is $e^{\lambda t}$, where λ is the rate of population growth.

The final producer sets the value marginal product of intermediate good i equal to its price, P_i, and the value marginal product of labor equal to the wage rate, W. This determines the demand curves:

$$X_i = \left(\frac{\theta}{P_i} \right)^{\frac{1}{1-\theta}} Z_i^\alpha \left(\frac{G}{e^{\lambda t}} \right)^{1-\alpha} L_i; \tag{2}$$

$$L_i = \left(\frac{1-\theta}{W} \right)^{\frac{1}{\theta}} X_i \left[Z_i^\alpha \left(\frac{G}{e^{\lambda t}} \right)^{1-\alpha} \right]^{\frac{1-\theta}{\theta}}. \tag{3}$$

The competitive final producer pays total compensation θY and $(1-\theta)Y$ to intermediate producers and labor, respectively.

2.2 Intermediate Sector

The typical intermediate firm produces its differentiated good with a technology that requires one unit of final output per unit of intermediate good and a fixed management cost ϕZ, where $Z = \int_0^N (1/N) Z_i di$ is average knowledge. The idea here is that fixed management costs depend on the overall state of technology. The firm can invest units of final output to increase quality according to the technology $\dot{Z}_i = R_i$. The firm's pre-tax profit is

$$\Pi_i = X_i(P_i - 1) - \phi Z - R_i,$$

where X_i is output and R_i is R&D investment. R&D is expensible (as in the US tax code) in the sense that the corporate income tax τ_Π applies to the firm's cash flow net of R&D expenditure.

The firm maximizes

$$V_i(t) = \int_t^\infty e^{-\bar{r}(t,s)}(1-\tau_\Pi)\Pi_i(s)\,ds,$$

where $\bar{r}(t,s)$ is the average interest rate between t and s, subject to the demand schedule (2) and the technology constraints discussed above. The firm is willing to undertake R&D if the shadow value of the innovation, q_i, is equal to its cost,

$$q_i = 1 - \tau_\Pi \Leftrightarrow R_i > 0. \tag{4}$$

Since the innovation is implemented in-house, its benefits are determined by the marginal after-tax profit it generates. Thus, the return to the innovation must satisfy the arbitrage condition[6]

$$r = (1-\tau_\Pi)\frac{\partial \Pi_i}{\partial Z_i}\frac{1}{q_i} + \frac{\dot{q}_i}{q_i}. \tag{5}$$

The assumption that R&D is expensible implies that the corporate income tax cancels out; combine (4) and (5) to see this. To calculate the marginal profit, observe that the firm's problem is separable in the price and investment decisions. With demand (2) and marginal cost of production equal to one, the intermediate producer sets a price $P_i = 1/\theta$. Pre-tax profit then is

$$\Pi_i = \frac{1-\theta}{\theta}\theta^{\frac{2}{1-\theta}} Z_i^\alpha \left(\frac{G}{e^{\lambda t}}\right)^{1-\alpha} L_i - \phi Z - R_i.$$

Differentiating with respect to Z_i, substituting the resulting expression into (5), using (2) and imposing symmetry yields

$$r = \frac{\alpha(1-\theta)}{\theta}\frac{X}{Z}. \tag{6}$$

As discussed, the tax rate τ_Π does not appear in this expression because R&D is fully expensible so that the after-tax cost of R&D is $1 - \tau_\Pi$.

Entrepreneurs create new firms. The associated sunk cost of entry at time t is $\beta X_i(t)$ in units of final output. Set-up costs are linear in the firm's initial output to capture in

a simple way the idea that they depend on the productive assets that need to be put in place to start operations (structures and equipment). This assumption captures the fact that entry costs are sunk albeit not necessarily independent of the initial choice of productive capacity. It has the additional benefit that it delivers remarkably simple dynamics.[7]

Suppose that start-up firms finance entry by issuing interest-bearing securities (e.g. corporate debt). Entry is positive if the value of the firm is equal to its after-tax start-up cost,

$$V_i = \beta X_i \Leftrightarrow \dot{N} > 0. \tag{7}$$

The profit that accrues to an entrant is given by the expression derived for incumbents. Hence, the value of the firm satisfies the arbitrage condition

$$r = (1 - \tau_\Pi) \frac{\Pi_i}{V_i} + \frac{\dot{V}_i}{V_i}. \tag{8}$$

Taking logs and time derivatives of (7) and imposing symmetry, that is, $\Pi_i = \Pi$, $X_i = X$, $R_i = R$, yields

$$r = (1 - \tau_\Pi) \frac{\Pi}{\beta X} + \frac{\dot{X}}{X}. \tag{9}$$

Observe how the corporate income tax depresses the return to entry and thus distorts incentives in favor of allocating funds to R&D internal to the firm. The reason is that full expensibility implies a subsidy at rate τ_Π for the firm's R&D, while the implicit subsidy to entry is zero.[8]

2.3 Households

The economy is closed and populated by identical individuals who supply labor services and consumption loans in competitive labor and asset markets. Each individual is endowed with one unit of time. The typical individual maximizes

$$U(t) = \int_t^\infty e^{-(\rho - \lambda)(s - t)} [\log C(s) + \gamma \log(1 - l(s))]ds, \quad \rho > \lambda \geq 0, \gamma > 0$$

where ρ is the individual discount rate. Instantaneous utility is defined over consumption per capita C and leisure $1 - l$, where l is the fraction of time allocated to work. γ measures preference for leisure. Individuals face the flow budget constraint

$$\dot{A} = [r(1 - \tau_A) - \lambda]A + (1 - \tau_L)Wl - (1 + \tau_C)C,$$

where A is asset holding[9] and W is the wage rate. The government taxes asset income at rate τ_A, labor income at rate τ_L and consumption at rate τ_C.

The optimal plan for this set-up is well known. Individuals save and supply labor according to:[10]

$$\frac{\dot{C}}{C} = (1 - \tau_A)r - \rho; \tag{10}$$

$$l = 1 - \frac{(1 + \tau_C)\gamma C}{(1 - \tau_L)W}. \tag{11}$$

Aggregate labor supply is $L = le^{\lambda t}$. Since the labor market is competitive and clears instantaneously, this is also aggregate employment.

2.4 Government

The government cannot borrow and thus satisfies the budget constraint

$$G = \tau_L WL + \tau_C Ce^{\lambda t} + \tau_\Pi \Pi N + \tau_A rAe^{\lambda t}. \tag{12}$$

Production of one unit of public goods requires one unit of final output. This is equivalent to assuming that the government purchases final goods. It is useful to characterize fiscal policy as

$$G = gY, \quad g < 1 \tag{13}$$

where g can be either endogenous, given a vector of fixed tax rates, or fixed, in which case one of the tax rates is endogenous.

3. Equilibrium Dynamics with Fixed Tax Rates

This section specifies fiscal policy as a vector of constant tax rates. Public spending adjusts endogenously to balance the government's budget. There are two reasons for carrying out this exercise: it is interesting per se, in that it allows one to understand how the different tax rates work through the economy, and it provides a useful benchmark for the analysis of revenue-neutral changes in tax structure.

Define the consumption ratio $c \equiv Ce^{\lambda t}/Y$, the profit ratio $\pi \equiv \Pi N/Y$, the growth rate of quality $z \equiv \hat{Z} = R/Z$, and the number of firms per capita $n \equiv Ne^{-\lambda t}$. (A hat on top of a variable denotes a proportional growth rate.) Recalling that the labor share of GDP is $WL/Y = 1 - \theta$ and that aggregate employment is $L = e^{\lambda t}l$, the labor supply equation (11) can be rewritten

$$l = \frac{1}{1 + \dfrac{(1 + \tau_C)\gamma}{(1 + \tau_L)(1 - \theta)}c}.$$

In symmetric equilibrium (1), (2) evaluated at price $P_i = 1/\theta$, and the relation $G = gY$ allow one to write

$$Y = \Omega(g, l)e^{\lambda t}Z, \tag{14}$$

where $\Omega(g, l) \equiv \theta^{\frac{2\theta}{\alpha(1-\theta)}} g^{\frac{1-a}{\alpha}} l^{\frac{1}{\alpha}}$. This expression says that aggregate output is proportional to population. The factor of proportionality is given by the average quality of intermediate goods, Z, and the function $\Omega(g, l)$, which is increasing in the government-provided quality of the workforce, g, and individual work effort, l. This is the supply side of the output market. Equilibrium requires

$$Y = G + Ce^{\lambda t} + N(X + \phi Z + R) + \beta X\dot{N},$$

where G is given by the government's budget constraint (12).

With labor and output markets taken care of, I now need to characterize the assets market. In equilibrium, the total value of interest-bearing securities issued by firms has to equal the total value of household assets. Recall that the total compensation to intermediate producers yields

$$NX = \theta^2 Y. \tag{15}$$

The asset market equilibrium condition then reads

$$Ae^{\lambda t} = NV = N\beta X = \beta\theta^2 Y. \tag{16}$$

Using this fact and dividing through by A, the household's budget constraint becomes[11]

$$\frac{\dot{Y}}{Y} = r(1-\tau_A) + (1-\tau_L)\frac{1-\theta}{\beta\theta^2} - (1+\tau_C)\frac{Ce^{\lambda t}}{\beta\theta^2 Y}.$$

The Euler equation (10) and the definition $c \equiv Ce^{\lambda t}/Y$ allow one to rewrite this expression as

$$\frac{\dot{c}}{c} = (1+\tau_C)\frac{1}{\beta\theta^2}c - (\rho-\lambda) - (1-\tau_L)\frac{1-\theta}{\beta\theta^2}. \tag{17}$$

Since the tax rates τ_C and τ_L are constant, c jumps to

$$c* = \frac{(\rho-\lambda)\beta\theta^2 + (1-\tau_L)(1-\theta)}{1+\tau_C}.$$

Hence, labor supply jumps to

$$l* = \frac{1}{1+\gamma\dfrac{(1+\tau_C)c*}{(1-\tau_L)(1-\theta)}} = \frac{1}{1+\dfrac{(\rho-\lambda)\beta\theta^2 + (1-\tau_L)(1-\theta)(1+\tau_C)}{(1-\tau_L)(1-\theta)}}.$$

A useful property of this model therefore is that the consumption ratio c and the employment ratio l jump to their steady-state values.

   To understand this property, observe that the assumption that the entry cost is proportional to initial output yields that the aggregate value of the securities issued by firms is proportional to GDP. The asset market equilibrium condition then says that the total value of the household's portfolio is proportional to GDP. Given logarithmic utility, which implies that the income and substitution effects of changes in the interest rate cancel out, the condition that the rate of return to stocks must equal the reservation interest rate demanded by savers implies that the household's budget constraint reduces to an unstable differential equation relating the rate of growth of the consumption ratio to its level. It follows that the unique equilibrium trajectory that satisfies boundary conditions is for the consumption ratio to jump to its steady-state value. Accordingly, the employment ratio jumps to its steady-state value.[12]

   These results allow me to characterize dynamics in a simple way. Using (15) and the definition $n \equiv Ne^{-\lambda t}$, equations (6) and (14) yield

$$r = \frac{\alpha\theta(1-\theta)\Omega(g, l*)}{n}. \tag{18}$$

The reduced-form production function (14) yields

$$\hat{Y} = \hat{Z} + \lambda + \frac{1-\alpha}{\alpha}\hat{g}.$$

Observe also that the result that the consumption ratio is constant implies $\hat{C} + \lambda = \hat{Y}$. Hence, one can use the Euler equation (10) to write the reservation interest rate demanded by savers as

$$r = \frac{\rho + z + \dfrac{1-\alpha}{\alpha}\hat{g}}{1 - \tau_A}.$$

(19)

This relation and equation (18) allow me to write

$$z = \frac{(1-\tau_A)\alpha\theta(1-\theta)\Omega(g, l^*)}{n} - \rho - \frac{1-\alpha}{\alpha}\hat{g}.$$

(20)

This expression plays an important role in the analysis below. It shows how incentives to invest in existing products depend positively on the public spending ratio, g, and on the employment ratio, l. The first effect is due to the fact that higher public spending increases labor productivity so that the conditional demand for each intermediate good shifts out. Similarly, a higher employment ratio shifts out the conditional demand for each intermediate good. Both forces kick in a cost-spreading effect at the firm level whereby the cost of quality-improving innovation is spread over more units of the good that the firm sells so that the unit cost of innovation is lower. In contrast, the return to innovation, and thus the rate of growth of quality, decreases with the number of goods per capita because of the market share effect: the more goods there are, the more total demand for intermediates is spread thin across goods, and this dampens the cost-spreading effect just discussed.

Another important relation concerns the economy's profit ratio. For the purposes of this discussion, I focus on situations where R&D is positive. Thus, recalling $z = R/Z$, the mark-up rule $P_i = 1/\theta$, the definition of the firm's profit Π_i, and the result in (15) above, I have

$$\begin{aligned}\pi &= \frac{NX}{Y}\frac{1-\theta}{\theta} - \frac{NZ}{Y}\left(\phi + \frac{R}{Z}\right)\\ &= \theta(1-\theta) - \theta^2\frac{Z}{X}(\phi + z).\end{aligned}$$

This expression highlights two important forces. First, the profit ratio is negatively related to quality growth because R&D is an endogenous fixed, sunk cost that the firm pays at any moment in time. Second, the profit ratio is increasing in the firm's sales to quality ratio $X/\theta Z$, reflecting the cost-spreading argument discussed above: the higher the sales-to-quality ratio, the lower the unit cost of innovation for the firm. One can now manipulate further this expression by using equation (6) and equation (19) to write

$$\pi = \theta(1-\theta)\left[1 - (1-\tau_A)\alpha\frac{\phi + z}{\rho + z + \dfrac{1-\alpha}{\alpha}\hat{g}}\right].$$

(21)

A feature of this relation that plays a crucial role in the analysis below is that the profit ratio π is increasing in z and τ_A.[13] The reason is that the profit ratio is increasing in the sales-to-quality ratio, which is positively related to the return to innovation. Since in equilibrium the return to innovation must equal the reservation interest rate of savers,

the profit ratio generated by firms must rise when faster growth or a higher tax rate on asset income raise the reservation interest rate.

Observe now that using (15) the expression for the rate of return to entry in (9) can be rewritten

$$\pi = \frac{\beta\theta^2}{1-\tau_\Pi}\left(r - \frac{\dot{Y}}{Y} + \frac{\dot{N}}{N}\right).$$

Observe also that the relation $\hat{C} + \lambda = \hat{Y}$ and the Euler equation (10) yield that the growth rate of GDP is $\hat{Y} = (1 - \tau_A)r - \rho + \lambda$. Substituting into the expression above and recalling that $n = Ne^{-\lambda t}$, I can write

$$\pi = \frac{1}{1-\tau_\Pi}(\rho + \hat{n} + \tau_A r)\beta\theta^2. \tag{22}$$

The previous equation characterizes how firms' decisions produce the profit ratio π. This equation defines the profit ratio needed to generate the required after-tax rate of return to saving for the households. Together, the two characterize equilibrium of the assets market.

Recall now that given public spending $G = gY$, the government's budget constraint (12) reads

$$g = \tau_L(1-\theta) + \tau_C c^* + \tau_\Pi\pi + \tau_A\beta\theta^2 r. \tag{23}$$

A technical appendix available on request shows that equations (18)–(23) define a dynamic system in (n, g) space that is stable and converges to the steady state (n^*, g^*).

To characterize the steady state, observe that setting $\hat{g} = 0$ in (19) yields $r(1 - \tau_A) = \rho + z$. This and $\hat{n} = 0$ allow me to rewrite the asset market equilibrium equations (21) and (22) as:

$$\pi = \theta(1-\theta)\left[1 - \alpha(1-\tau_A)\frac{\phi+z}{\rho+z}\right]; \tag{24}$$

$$\pi = \frac{1}{1-\tau_\Pi}\left[\rho + \frac{\tau_A}{1-\tau_A}(\rho+z)\right]\beta\theta^2. \tag{25}$$

The first equation is the "profits" locus, how firms decisions about their internal growth z generate the profit ratio π; the second equation is the "returns" locus, the profit ratio π required to deliver to savers their reservation rate of return $\rho + z$. The joint solution of these two equations yields a pair (z^*, π^*) that depends only on τ_A and τ_Π; the upper panel of Figure 1 illustrates. An important feature of this asset market equilibrium, therefore, is that it pins down growth independently of the scale factor $\Omega(g, l)$ and thus of g, τ_L, τ_C. Associated to this pair, there is the public spending ratio

$$g^* = \tau_L(1-\theta) + \tau_C c^* + \tau_\Pi\pi^* + \frac{\tau_A\beta\theta^2(\rho+z^*)}{1-\tau_A}. \tag{26}$$

To gain intuition, consider the lower panel of Figure 1, which represents the steady state in (n, z) space.[14] Equation (20) now reads

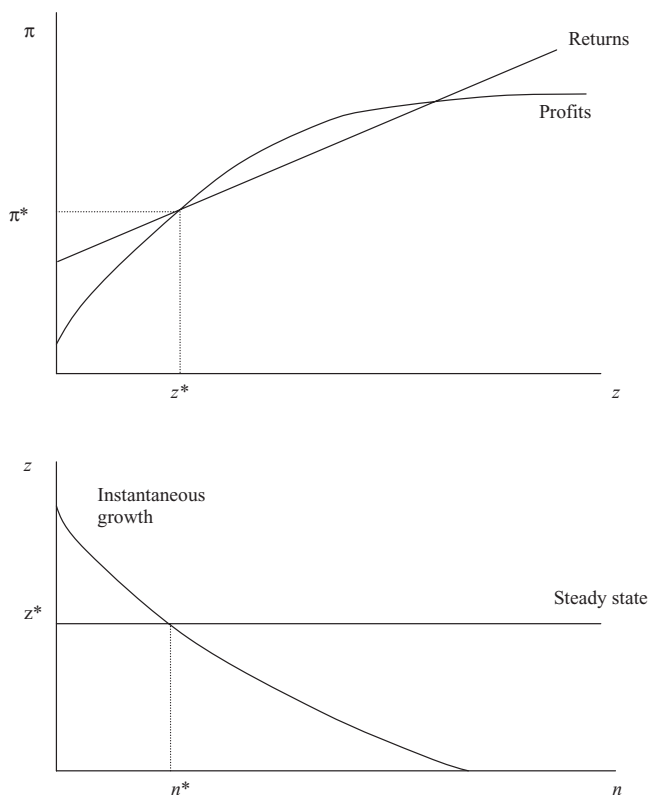$$z = \frac{(1-\tau_A)\alpha\theta(1-\theta)\Omega(g^*, l^*)}{n} - \rho. \tag{27}$$

Figure 1. *Equilibrium with Fixed Tax Rates*

The steady state is the intersection of this downward sloping relation with the value z^* obtained above. It is then clear that changes in fiscal variables that affect the factor $\Omega(g^*, l^*)$ are fully absorbed by the number of firms per capita so that the growth rate of quality remains unchanged. This result reflects the property that the model does not exhibit the scale effect because endogenous product variety sterilizes the effects of aggregate market size on the individual firm's incentives to innovate. Comparative statics are as follows.

Taxation of wages or consumption reduces both the consumption and employment ratios and has no effect on growth.

The tax on profits does not affect the consumption and employment ratios while it has a *positive* effect on growth. This apparently surprising result is in fact quite intuitive: expensibility of incumbents' R&D costs implies an implicit subsidy at rate τ_Π that offsets the standard distortionary effect on investment incentives of taxation of profits. To see this, observe that the return to in-house innovation in (6) does not contain τ_Π so that the profits locus (24) does not shift with changes in τ_Π. In contrast, the returns locus (25) shifts up with τ_Π reflecting the fact that taxation of profits requires higher pre-tax profits in order to deliver to shareholders their required rate of return on saving. The latter part of the story is the consequence of the assumption that entry costs are not expensible so that the implicit subsidy to R&D does not apply to entrants. In other words, the corporate income tax discriminates in favor of incumbents in the sense that while it does not distort their internal R&D choices, it does distort the return to entry.

The tax on asset income does not affect the consumption and employment ratios while it has two effects on growth.[15] First, because it raises the reservation interest rate of savers, it reduces growth. This effect is captured by the upward shift of the profits locus (24). However, precisely because it reduces growth, it reduces the firm's incumbency costs and thus raises its profit. This effect is captured by the upward shift of the returns locus (25). There is thus a tension between the direct and indirect effects of this tax. As a result, an increase in the tax on asset income *may* have a *positive* effect on growth.

It is important to notice that the steady state number of firms per capita n^* decreases with both τ_Π and τ_A so that, in line with conventional wisdom, taxation of profits and savings *reduces* the incentives to accumulation. The key is that the bulk of the adjustment is borne by product proliferation, not necessarily by growth of existing product lines.

4. Fixed Public Spending Ratio

This section considers the case of endogenous tax rates. It is useful to start by comparing the performance of different taxes by solving the model for each tax while setting all other taxes to zero. Since the model allows one to distinguish between the level and growth effects of each tax, it is useful to present the results separately.

4.1 Level Effects

Equation (17) determines the dynamics of consumption. If the government uses τ_L or τ_C, the government's budget constraint yields the endogenous tax rates $\tau_L = g/(1 - \theta)$ or $\tau_C = g/c$. In the first case consumption follows

$$\hat{c} = \frac{1}{\beta\theta^2}c - (\rho - \lambda) - \frac{1-\theta}{\beta\theta^2} + \frac{g}{\beta\theta^2};$$

in the second case it follows (see the technical appendix for a derivation of this equation)

$$\hat{c} = \frac{c+g}{c}\left[\frac{1}{\beta\theta^2}c - (\rho - \lambda) - \frac{1-\theta}{\beta\theta^2} + \frac{g}{\beta\theta^2}\right].$$

In both cases, consumption jumps to

$$c^*_{L,C} = (\rho - \lambda)\beta\theta^2 + 1 - \theta - g.$$

The expression for l^* derived in the previous section yields the solutions for the employment ratio in the two cases:

$$l^*_L = \frac{1}{1 + \gamma\dfrac{(\rho - \lambda)\beta\theta^2 + 1 - \theta - g}{1 - \theta - g}};$$

$$l^*_C = \frac{1}{1 + \gamma\dfrac{(\rho - \lambda)\beta\theta^2 + 1 - \theta}{1 - \theta}}.$$

If the government uses τ_Π or τ_A, the government's budget constraint yields the endogenous tax rates $\tau_\Pi = g/\pi$ or $\tau_A = g/\beta\theta^2 r$. Consumption follows

$$\hat{c} = \frac{1}{\beta\theta^2} c - (\rho - \lambda) - \frac{1-\theta}{\beta\theta^2}$$

and jumps to

$$c^*_{\Pi,A} = (\rho - \lambda)\beta\theta^2 + 1 - \theta.$$

Accordingly, the employment ratio jumps to

$$l^*_{\Pi,A} = \frac{1}{1 + \gamma \dfrac{(\rho - \lambda)\beta\theta^2 + 1 - \theta}{1 - \theta}}.$$

Comparison of these solutions establishes the following ranking:

$$c^*_{\Pi,A} > c^*_{L,C}, \quad l^*_{\Pi,A} = l^*_C > l^*_L.$$

These results are intuitive: taxes on wages distort the labor/leisure choice and reduce the employment ratio; taxes on consumption distort the consumption/leisure choice and raise the employment ratio; taxes on asset income or corporate income do not distort intratemporal household choices. Observe that taxes on wages and consumption yield the same consumption ratio. This is because in each case the distortion of the consumption/labor/leisure choice is fully captured by the amount of tax revenue that one must subtract from the right-hand side of the household's budget constraint (17) that yields the steady-state solution for c. This explains why the consumption tax does not distort the employment ratio.

4.2 Dynamics and Growth Effects

Substitution of the government budget constraint (23) into the expression for the rate of return to entry, equation (22), yields

$$(\hat{n} + \rho)\beta\theta^2 = \pi + \tau_L(1 - \theta) + \tau_C c - g. \tag{28}$$

Since g is constant, equation (20) reads

$$z = \begin{cases} (1 - \tau_A)\alpha\theta(1 - \theta)\Omega(g, l^*)\dfrac{1}{n} - \rho & n < \bar{n} \\ 0 & n \geq \bar{n} \end{cases}, \tag{29}$$

where

$$\bar{n} \equiv (1 - \tau_A)\alpha\theta(1 - \theta)\Omega(g, l^*)\frac{1}{\rho}.$$

This relation says that there exist equilibria with no R&D, a fact that I must take into account in order to do dynamics. Accordingly, the expression for profit becomes

$$\pi = \begin{cases} \theta(1 - \theta)(1 - \alpha + \alpha\tau_A) - \dfrac{\phi - \rho}{\Omega(g, l^*)}n & n < \bar{n} \\ \theta(1 - \theta) - \dfrac{\phi}{\Omega(g, l^*)}n & n \geq \bar{n} \end{cases}. \tag{30}$$
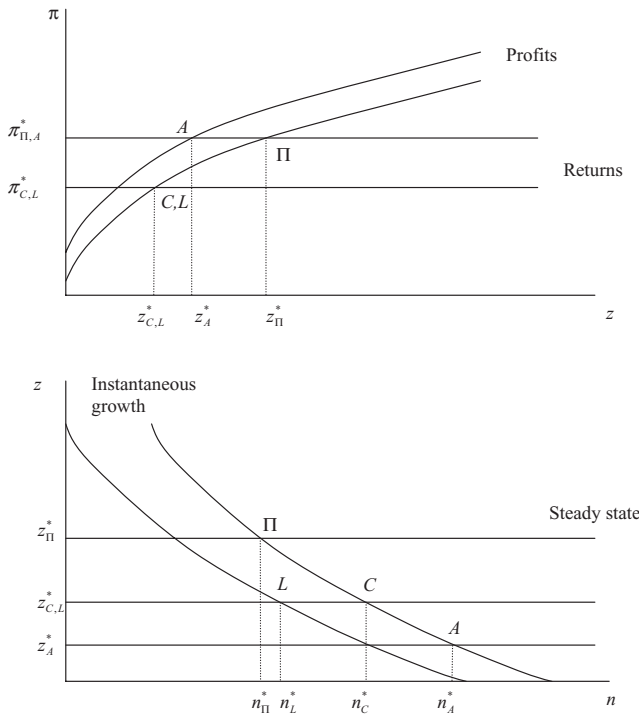
Figure 2. Equilibrium with Fixed Public Spending Ratio

This is constructed as follows. Recall that in general profit can be written

$$\pi = \theta(1-\theta) - \theta^2 \frac{Z}{X}(\phi + z).$$

If R&D is positive, this expression yields equation (24) derived above. The top line of (30) then follows from inserting (29) into (24). If R&D is zero, instead, equation (6) does not hold and hence (24) does not hold. Accordingly, I use only (14) and (15) to obtain the bottom line of (30).

Equation (30) allows one to characterize dynamics in a simple way since it says that π is a decreasing function of n only. The technical appendix provides a detailed analysis of this system. In the following I focus on a more insightful characterization. Consider Figure 2. The upper panel illustrates the determination of the steady-state growth rate z^* and profit ratio π^* as the intersection of equation (24), the profits locus, with equation (28) evaluated at $\hat{n} = 0$, the returns locus. The lower panel illustrates dynamics. The economy is at all times on the instantaneous growth line (29). On the branch of (29) that lies above the steady-state locus z^*, the economy experiences a rate of entry that is less than the rate of population growth so that the number of firms per capita shrinks. The reverse happens on the branch of (29) that lies below the steady state locus. The steady state (n^*, z^*) is thus stable. This general procedure will allow me to undertake a straightforward analysis of welfare in the next section. I now look at the specific cases.

If the government uses τ_L or τ_C, equation (28) evaluated at $\hat{n} = 0$ yields the returns locus

$$\pi^*_{L,C} = \rho\beta\theta^2.$$

Substituting into (24) yields the undistorted growth rate

$$z^*_{L,C} = \frac{\phi - \rho\Gamma}{\Gamma - 1}, \quad \Gamma \equiv \frac{1 - \theta - \rho\beta\theta}{\alpha(1-\theta)}, \quad \frac{\phi}{\rho} > \Gamma > 1.$$

Substituting this expression into (30) yields

$$n^*_j = \left[\theta(1-\theta)(1-\alpha) - \rho\beta\theta^2\right]\frac{\Omega(g, l^*_j)}{\phi - \rho}, \quad j = L, C.$$

As one can see, the growth rate is equal across these taxes. As anticipated in the previous section, moreover, it does not contain g. In other words, financing public expenditure through taxes on wages or consumption has no steady-state effect on growth. The intuition is straightforward: since the model has no scale effect, neither g nor τ_L or τ_C have growth effects. Hence, accounting for the feedback due to the endogeneity of each of these tax rates does not establish a link between growth and public spending since their effects on market size are absorbed by the number of firms.

Tax instruments that distort the consumption/saving choice or the production/investment/entry choice, in contrast, have direct growth effects and thus establish a link between growth and public spending. To see this, recall that equation (28) evaluated at $\hat{n} = 0$ yields the returns locus, and observe that both τ_Π and τ_A yield the following "distorted" version of the locus

$$\pi^*_{\Pi,A} = \rho\beta\theta^2 + g.$$

The difference between taxing profits and taxing household asset income arises because the relation between the profit ratio and the growth rate, equation (24), now reads

$$\pi = \begin{cases} \theta(1-\theta)\left[1 - \alpha\dfrac{\phi + z}{\rho + z}\right] & \text{if } \tau_\Pi = \dfrac{\pi}{g} \\[3em] \theta(1-\theta)\left[1 - \alpha\dfrac{\phi + z}{\rho + z + \dfrac{g}{\beta\theta^2}}\right] & \text{if } \tau_A = \dfrac{g}{r\beta\theta^2} \end{cases}.$$

The second line follows from the fact that $\tau_A r\beta\theta^2 = g$ and $r(1 - \tau_A) = \rho + z$ yield $1 - \tau_A = (\rho + z)/(\rho + z + g/\rho\beta\theta^2)$. The difference then is intuitive: taxation of asset income distorts the consumption/saving choice and raises the reservation interest rate demanded by savers. As a consequence, it raises the equilibrium profit ratio that the market must generate. Taxation of profits, in contrast, does not distort the consumption/saving choice of households or the production/investment choice of incumbent firms.

I can again solve in closed-form for the growth rate in the two cases:

$$z^*_\Pi = \frac{\phi - \rho\left(\Gamma - \dfrac{g}{\alpha\theta(1-\theta)}\right)}{\Gamma - \dfrac{g}{\alpha\theta(1-\theta)} - 1}, \quad \frac{\phi}{\rho} > \Gamma - \frac{g}{\alpha\theta(1-\theta)} > 1;$$

$$z_A^* = \frac{\phi - \left(\rho + \dfrac{g}{\beta\theta^2}\right)\left(\Gamma - \dfrac{g}{\alpha\theta(1-\theta)}\right)}{\Gamma - 1 - \dfrac{g}{\alpha\theta(1-\theta)}}, \qquad \frac{\phi}{\rho + \dfrac{g}{\beta\theta^2}} > \Gamma - \frac{g}{\alpha\theta(1-\theta)} > 1.$$

Using these expressions, I can calculate:

$$n_\Pi^* = \left[\theta(1-\theta)(1-\alpha) - g - \rho\beta\theta^2\right]\frac{\Omega(g, l_\Pi^*)}{\phi - \rho};$$

$$n_A^* = \left[\theta(1-\theta)(1-\alpha) - g - \rho\beta\theta^2\right]\frac{\Omega(g, l_A^*)}{\phi - \rho - \dfrac{g}{\beta\theta^2}}.$$

Notice how financing public spending through these taxes produces a growth effect despite the fact that g per se does not affect growth. This is the indirect effect of g due to the endogeneity of the tax rates.

Comparison of the solutions yields:

$$z_\Pi^* > z_A^* \geq z_{L,C}^* \quad \text{for} \quad \phi \geq \rho + (\Gamma - 1)\left(\Gamma - \frac{g}{\alpha\theta(1-\theta)}\right)\frac{\alpha(1-\theta)}{\beta\theta};$$

$$z_\Pi^* > z_{L,C}^* \geq z_A^* \quad \text{for} \quad \phi \leq \rho + (\Gamma - 1)\left(\Gamma - \frac{g}{\alpha\theta(1-\theta)}\right)\frac{\alpha(1-\theta)}{\beta\theta}.$$

Thus, use of the corporate income tax yields higher growth than taxes on wages, consumption or asset income. Moreover, taxation of asset income *may* generate *faster* growth than taxation of wages or consumption.

Figure 2 builds some intuition by displaying the four solutions in (z, π) and (n, z) space. (Notice that for simplicity I focus only on the case $z_A^* > z_{C,L}^*$; it should be obvious how to modify the figure to obtain the other case.) The solutions are marked as points C, L, Π and A. Consider the upper panel. The choice of tax instrument affects two things: the location of the returns locus, equation (28) evaluated at $\hat{n} = 0$, and the location of the profits locus describing the relation between the profit ratio and the growth rate due to the endogeneity of R&D choices, equation (24). Now recall that taxation of profits or asset income does not distort intratemporal household choices. Thus, their effects are governed by the distortion of the consumption/saving choice of households and the production/investment/entry choice of firms.

Two assumptions concerning the structure of taxation govern the distortion due to taxation of profits. First, full expensibility of R&D costs sterilizes the potential distortion of the production/investment choice of incumbents because it implies that the shadow value of innovation is $1 - \tau_\Pi$ so that the tax cancels out of the expression for the rate of return to innovation. As discussed, full expensibility is equivalent to subsidization at rate τ_Π of investment by incumbents. Second, the assumption that entry costs are not expensible implies that the tax code discriminates in favor of incumbents since entry is not implicitly subsidized at rate τ_Π. As a result of these features the tax on profit has a positive effect on growth. This property explains why the distorted growth rate z_Π^* is higher than $z_{C,L}^*$.

Taxation of asset income distorts the consumption/saving choice of households and thus raises the required rate of return to saving. In equilibrium this means that the profit ratio generated by the market must rise. This shows up as the upward shift of the returns locus with respect to the undistorted case. Inspection of Figure 2 shows that the location of point A with respect to points C, L depends on the vertical distance between the returns loci π_A^* and $\pi_{C,L}^*$ and on the upward shift of the profits locus. The first shift reflects the fact that the tax on asset income τ_A must generate total revenue g. The second is due to the endogeneity of the tax rate τ_A and its feedback on the consumption/saving choice. As one can see, the upward shift of the profits locus depends on the presence of the term $g/\beta\theta^2$ and is regulated by the parameters ϕ and ρ. To understand how, consider the condition for $z_A^* \gtrless z_{C,L}^*$ stated above and recall that the parameters ϕ and β describe, respectively, the instantaneous fixed operating costs and the sunk entry costs of firms. An economy with high ϕ, β is an economy populated by few, large firms that generate a high pre-tax rate of return r. It follows that the tax base for the asset income tax, $r\beta\theta^2$, is large so that the equilibrium tax rate is small. This implies that the distortion of the consumption/saving choice is small and that the upward shift of the equity locus is small. This yields $z_A^* > z_{C,L}^*$. In contrast, an economy with low ϕ, β is an economy populated by many small firms that generate a low r and thus a small tax base $r\beta\theta^2$. In such an economy, relying on the asset income tax produces a high tax rate and a large distortion of consumption/saving choices. As a result, $z_A^* < z_{C,L}^*$.

4.3 Feasibility

One question that arises naturally from the analysis above is whether the posited policies are feasible, meaning: is the endogenous tax rate sustainable, that is, less than 1? The answer is straightforward for τ_L and τ_C since the government's budget constraint yields the three parametric conditions: $g < 1 - \theta$ and $g < c_C^* \Rightarrow 2g < (\rho - \lambda)\beta\theta^2 + 1 - \theta$. In the case of τ_Π and τ_A the answer is not straightforward because the tax base evolves along the transition. For this reason, it is more productive to relegate a discussion of feasibility to the specific examples analyzed in the next section.

5. Welfare

I now investigate the welfare implications of the results discussed above. To highlight the insight provided by this model, I focus on revenue-neutral changes that shift the distortionary effects of taxation from the intratemporal choices of households to the intertemporal choices of households or firms.

Let 0 be an arbitrary date. Taking into account that in all cases the consumption and employment ratios jump to their steady-state values, equation (14) allows me to write income per capita, $y \equiv Ye^{-\lambda t}$, at time $t > 0$ as

$$\log y(t) = \log \Omega(g, l^*) + \int_0^t z(s)ds + \log Z(0).$$

Without loss of generality I can normalize $Z(0) \equiv 1$. Moreover, the definition $c \equiv Ce^{\lambda t}/Y$ allows me to write

$$\log u(t) = \log \Omega(g, l^*) + \log c^* + \gamma \log(1 - l^*) + \int_0^t z(s)ds.$$

As one can see, the number of firms per capita does not have a direct effect on income per capita, the consumption ratio, or the employment ratio. The reason why it matters

is that given aggregate variables it determines firm-level variables and thus drives the dynamics of the interest rate and growth. Flow utility features a tension between work and leisure. The following result allows one to resolve this tension.

LEMMA 1. *Holding constant the consumption ratio c, flow utility is increasing in the employment ratio l.*

PROOF. Holding constant c, flow utility is increasing in l if $l < 1/(1 + \gamma\alpha)$. Observing that l_Π^* is the largest possible value of the employment ratio, a sufficient condition for utility to be increasing in l in all cases is

$$l_\Pi^* = \frac{1}{1 + \gamma \dfrac{(\rho - \lambda)\beta\theta^2 + 1 - \theta}{1 - \theta}} < \frac{1}{1 + \gamma} < \frac{1}{1 + \gamma\alpha},$$

which implies

$$(\rho - \lambda)\beta\theta^2 + 1 - \theta > 0.$$

This inequality holds because $\rho > \lambda$ is necessary to have bounded utility. It follows that the steady states occur on the upward sloping portion of the flow utility function with respect to the employment rate.   □

With this result in hand, I can establish the following propositions. All proofs refer to Figure 2. For each proposition, a discussion of feasibility is available in the technical appendix.

PROPOSITION 1. *A revenue-neutral replacement of taxation of household asset income with taxation of corporate income is welfare improving.*

PROOF. This experiment amounts to traveling from point A to point Π. When the change is implemented, the consumption and employment ratios remain at $c_\Pi^* = c_A^*$ and $l_\Pi^* = l_A^*$. Given the initial condition n_A^*, transition dynamics feature a gradual decline of n toward n_Π^*. Quality growth exhibits an initial jump up due to the elimination of the distortion of the consumption/saving choice (as the economy jumps on the higher instantaneous growth line), followed by a gradual increase to $z_\Pi^* > z_A^*$ (a movement along the new growth line). This policy raises welfare because it has no level effects while it raises growth permanently. Formally,

$$\log \frac{u_\Pi(t)}{u_A^*} = \int_0^t [z_\Pi(s) - z_A^*]ds.$$

Integration yields the change in welfare.   □

PROPOSITION 2. *A revenue-neutral replacement of taxation of consumption or of labor with taxation of corporate income is welfare improving.*

PROOF. In this case the economy travels from point C or L to point Π. I prove first the result for the replacement of the consumption tax. When the change in taxation is

implemented, c jumps from c_C^* to c_Π^* while l stays at $l_C^* = l_\Pi^*$. Given the initial condition n_C^*, transition dynamics feature a gradual fall toward n_Π^*. Accordingly, the growth rate rises gradually to the long-run value $z_\Pi^* > z_C^*$ (since the economy is already on the relevant growth line there is no initial jump in z and only movement along the line). This change in tax instrument raises welfare because it raises the consumption ratio, it keeps the employment ratio constant, and it raises productivity growth permanently. Formally, at all times utility follows

$$\log \frac{u_\Pi(t)}{u_C^*} = \log \frac{c_\Pi^*}{c_C^*} + \int_0^t [z_\Pi(s) - z_C^*] ds.$$

Integration yields the change in welfare. Consider now the replacement of the tax on labor. When the change in taxation is implemented, c jumps to $c_\Pi^* > c_L^*$ while l jumps to $l_\Pi^* > l_L^*$. Given the initial condition n_L^*, transition dynamics feature either a gradual fall or a gradual rise toward n_Π^* depending on $n_\Pi^* \gtrless n_L^*$. Accordingly, the growth rate jumps up initially (when the economy moves onto the new, higher growth line) and thereafter either rises or falls gradually to the long-run value $z_\Pi^* > z_L^*$ (a movement along the growth line). This change in tax instrument raises welfare because it raises the consumption and employment ratios and long-run productivity growth. Formally, at all times utility follows

$$\log \frac{u_\Pi(t)}{u_L^*} = \log \frac{c_\Pi^*}{c_L^*} + \log \frac{l_\Pi^*}{l_L^*} + \gamma \log \frac{1 - l_\Pi^*}{1 - l_L^*} + \int_0^t [z_\Pi(s) - z_L^*] ds.$$

Integration yields the change in welfare.   □

PROPOSITION 3. *A revenue-neutral replacement of taxation of consumption or of labor with taxation of household asset income is welfare improving if $z_A^* \geq z_{C,L}^*$, while it has an ambiguous welfare effect if $z_A^* < z_{C,L}^*$.*

PROOF. In this case the economy travels from point C or L to point A. The transition path is qualitatively identical to the one discussed in the previous proposition for the replacement of the labor tax so that the proof is qualitatively the same. If $z_A^* \geq z_C^*$ this change in tax instrument raises welfare because it raises the consumption ratio, it keeps the employment ratio constant, and it raises productivity growth permanently, or at least it does not reduce it. In contrast, for $z_A^* < z_C^*$ there is a trade-off between the level and growth effects of the policy. Formally, at all times utility follows

$$\log \frac{u_A(t)}{u_C^*} = \log \frac{c_A^*}{c_C^*} + \int_0^t [z_A(s) - z_C^*] ds.$$

Integration yields the change in welfare.   □

These examples suggest the following insight. Firm-level quality growth is increasing in the firm's scale of operations through the cost-spreading effect. Tax changes that raise aggregate market size, therefore, have temporary positive effects on R&D effort and thereby yield temporarily faster growth. Quality growth ultimately returns to the previous trend but the gain is permanent and shows up as higher quality *level* at the end of the transition.

In terms of welfare, the key property is that equilibrium occurs on the upward sloping portion of utility as a function of the employment rate so that flow utility is

increasing in economic activity. In other words, the utility loss due to lower leisure is more than compensated by the gain due to higher consumption. In these circumstances, changes in taxation that eliminate distortions of the labor/leisure and consumption/leisure choices of households can be beneficial even if they introduce distortions of the consumption/saving choice of households or the production/investment/entry choice of firms. The key is *how* the tax instrument affects those choices. If the net effect is to raise growth, then the change in taxation raises welfare. The analysis in section 4 has provided some insight about the conditions under which this happens. The next section investigates further the mechanism by considering some plausible modifications of the basic model.

6. Robustness Checks

6.1 Partially Expensible R&D Costs

Suppose that R&D is partially expensible. (Entry costs are still not expensible.) Specifically, rewrite instantaneous after-tax profit as

$$(1 - \tau_\Pi)[X_i(P_i - 1) - \phi Z - \sigma R_i] - (1 - \sigma) R_i,$$

where σ is the fraction of R&D expenditures that the firm is allowed to subtract from its cash flow to determine taxable income. It is useful to rewrite this expression as

$$(1 - \tau_\Pi)[X_i(P_i - 1) - \phi Z - R_i] - \tau_\Pi (1 - \sigma) R_i,$$

where, as in the previous cases,

$$\Pi_i = X_i(P_i - 1) - \phi Z - R_i.$$

This formulation makes clear that partial expensibility can be interpreted as taxation at rate τ_Π of fraction $(1 - \sigma)$ of the R&D undertaken by the firm or, equivalently, as subsidization at rate $\sigma \tau_\Pi$ of R&D. Accordingly, the government's budget constraint now reads

$$G = \tau_L W L + \tau_C C e^{\lambda t} + \tau_\Pi \Pi N + \tau_A r A e^{\lambda t} + (1 - \sigma) \tau_\Pi N R.$$

Following the same procedure as in section 2, one obtains the following rates of return to R&D and entry for a symmetric equilibrium:

$$r = \frac{1 - \tau_\Pi}{1 - \sigma \tau_\Pi} \frac{\alpha(1 - \theta)}{\theta} \frac{X}{Z};$$

$$r = \frac{1 - \tau_\Pi}{\beta X} \Pi - \frac{(1 - \sigma) \tau_\Pi}{X} R + \frac{\dot{X}}{X}.$$

Observe how taxation of R&D affects the return to entry negatively because now firms get a smaller break on their (endogenous) fixed costs. More importantly, observe how it distorts the internal decision of firms by depressing the return to innovation.

One can now proceed as in the body of the paper and show that, because corporate income taxation does not affect household choices directly, consumption and labor supply jump to the same levels as before. Therefore, one can anticipate that the implicit taxation of R&D due to $\sigma < 1$ operates only on the production/investment/entry

choices of firms. The main result that one can prove is that there exists a threshold value of σ above which a revenue-neutral replacement of taxation of wages, consumption or asset income with taxation of corporate income is growth enhancing. It is then immediate to see that Propositions 1–3 apply since the only effect of partial expensibility of R&D costs is to reduce the return to innovation leaving the level effects of the corporate income tax unchanged. Thus, a revenue-neutral replacement of the tax on consumption, wages, or asset income with a tax on profits is welfare improving.

The important message of this exercise is twofold. First, if R&D is not expensible ($\sigma = 0$) the corporate income tax has the qualitative effects of the asset income tax, that is, there is a trade-off between the positive level effects of eliminating taxes on wages or consumption and the possibly negative growth effect of introducing taxation of profits. Second, Propositions 1–2 must be amended with the additional clause that the corporate income tax is introduced together with full expensibility of R&D.

6.2 Symmetric Treatment of Incumbents and Entrants

One can generalize these results further by considering what happens if entry costs are expensible. For simplicity, consider the case in which R&D and entry costs receive symmetric treatment. Specifically, suppose that entry costs are subsidized at rate $\sigma\tau_\Pi$ so that in symmetric equilibrium the value of the firm is $V = \beta X(1 - \sigma\tau_\Pi)$. The expression for the rate of return to equity is then

$$r = \frac{1-\tau_\Pi}{\beta X(1-\sigma\tau_\Pi)}\Pi - (1-\sigma)\,\tau_\Pi\,\frac{R}{\beta X(1-\sigma\tau_\Pi)} + \frac{\dot{X}}{X}.$$

In steady state this becomes

$$\rho\beta\theta^2 = \frac{1-\tau_\Pi}{1-\sigma\tau_\Pi}\left[\frac{\Pi N}{Y} - \frac{(1-\sigma)\,\tau_\Pi}{1-\tau_\Pi}\frac{RN}{Y}\right].$$

The government's budget constraint now reads

$$g = \tau_\Pi\frac{\Pi N}{Y} + \tau_\Pi(1-\sigma)\frac{RN}{Y} - \sigma\tau_\Pi\beta\theta^2\hat{N},$$

where the last term is the subsidy to entrants. Using these expressions one can show that the equilibrium changes as follows. The steady state solutions $z_\Pi^*(\sigma)$ and $\tau_\Pi^*(\sigma)$ are, respectively, smaller and larger for all σ than in the case of zero subsidy to entrants. This is intuitive: the subsidy to entrants reduces (after-tax) entry costs and thus raises the rate of return to equity. Because of this, it diverts resources from incumbents' R&D activity to entry activity and reduces growth. Moreover, because the government must pay for the subsidy, the tax rate on corporate income must be higher and this implies a larger distortion of the production/investment choice of incumbents. This explains the second important way in which results change. Namely, Propositions 1–2 still hold but the threshold for σ above which taxation of profits is welfare improving is now higher.

6.3 Social Returns to Variety

One might think that the welfare results above depend crucially on the assumption that there are zero social returns to product variety in the technology (14). I now argue that this is not the case. There are two ways to make the point. The first is to modify the basic technology of the model to

$$y = n^{\eta}\Omega(g,l)Z, \quad 0 \le \eta < 1 \tag{31}$$

so that output per capita depends positively on the number of firms per capita.[16] These social returns to variety are external to all agents so that their behavior does not change with respect to the characterization above. One can then repeat the analysis of the previous sections and show that the qualitative results do not change.

A second, and more intuitive, way of making the point is to observe that the results discussed above do *not* hinge on the number of firms per capita falling. In fact, in all cases it is quite possible that the number of firms per capita rises, and I have shown that this drives feasibility of the policies in Propositions 1–3. More specifically, as long as the market size effect dominates, so that the number of firms rises, positive social returns to variety would *reinforce* the welfare results discussed above.

7. Conclusion

The latest vintage of Schumpeterian growth models eliminate the scale effect of population size on endogenous growth by positing a process of development of new product lines that fragments the aggregate market in submarkets whose size does not increase with population. An important consequence of this mechanism is that fundamentals and policy variables that work through the size of the aggregate market do not affect steady-state growth, while fundamentals and policy variables that work through the interest rate do.

In this paper I have applied this insight to shed new light on the role of distortionary taxes on consumption, household labor and assets income, corporate income, and of public spending. I have shown which of these have permanent (steady-state) growth effects, and which have only transitory effects. I have also carried out a series of pairwise, revenue-neutral comparisons of tax instruments to assess which ones deliver higher welfare.

These revenue-neutral exercises reveal quite vividly the importance of the interaction between the two margins of technological advance—variety and quality/cost—at the heart of the latest Schumpeterian growth models. In one set of experiments I have posited the replacement of a tax that distorts the choices of households—intratemporal consumption/labor/leisure choices or intertemporal consumption/saving choices—with a tax that distorts the production/investment/entry choices of firms. In another, I have posited the replacement of a tax that affects the intratemporal choices of households with a tax that affects their intertemporal choices. In all three cases, removing the taxes that distort consumption and labor supply decisions raises welfare through level effects, that is, higher steady-state consumption and leisure. The introduction of a tax that distorts intertemporal choices of firms or households produces growth effects that might reinforce or offset the level effects. In the case of the corporate income tax the growth effect is unambiguously positive; in the case of the asset income tax, it depends on structural parameters that regulate firm size. This immediately begs the question of how it is possible that distortionary taxation of corporate profits or household assets income raises growth.

The answer is straightforward once one takes into account the fundamental property of these models. In all the experiments above, the distortion relevant for growth typically takes the form of a wedge between the pre- and after-tax returns generated by firms. Specifically, the posited tax changes require firms to generate a *higher* pre-tax rate of return in order to keep delivering to shareholders their reservation after-tax rate of return. This happens in equilibrium because the market converges to a configuration

where the number of firms per capita is smaller so that the typical firm is larger. The key mechanism driving the results then is that larger firms exploit internal increasing returns more aggressively and grow faster. At the heart of this mechanism there is the very intuitive fact that to deliver to their shareholders higher pre-tax returns firms must generate a higher profit rate. It is their higher profitability that drives up the incentive to invest in their own growth. Hence, in line with standard intuition my analysis emphasizes the role of the link between profitability and investment incentives in driving the effects of changes in taxation.

My approach differs, however, in focussing on the particular role played by the two-dimensional representation of technology that characterizes the latest Schumpeterian growth models. The profitability–incentive link is in essence a market structure story: what matters for growth and welfare is how distortionary taxes and public spending affect the aggregate size of the market and, crucially, how the aggregate market is divided across firms through a process of entry and market share determination that "dilutes" aggregate impulses at the firm level. Because two endogenous variables are involved in the adjustment, a key insight of the market structure story is that the margin that absorbs the negative effect of distortionary taxation on the incentives to accumulate is the number of firms, while what happens to the economy's growth rate depends on what happens at the level of the individual firm. This means that—in line with standard intuition—taxation of savings and profits *does* reduce the incentives to accumulate, but that—in contrast to standard intuition—this *does not* require slower growth. In fact, it might well deliver faster growth if the reduction of the number of firms per capita ultimately results in larger firm size.

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Notes

1. See Peretto (1998, 1999), Dinopoulos and Thompson (1998), Young (1998), and Howitt (1999) for the original contributions. See also Jones (1999), Aghion and Howitt (1998, 2005), Dinopoulos and Thompson (1999), Peretto and Smulders (2002), and Laincz and Peretto (2006) for reviews of the various approaches and of the empirical evidence.

2. Several studies have tried to assess the theoretical and empirical contribution to growth of variables like distortionary and non-distortionary taxation, productive and non-productive public expenditure, and public debt. For theoretical contributions, see Barro (1990), Barro and Sala-i-Martin (1992), and Turnovsky (2000). None of these contributions is based on the Schumpeterian approach that characterizes this paper. Notable empirical contributions are: Easterly and Rebelo (1993), Stokey and Rebelo (1995), Cooley et al. (1997), Kocherlakota and Yi (1997), Mendoza et al. (1997), and Kneller et al. (1999).

3. Specifically, Zeng and Zhang (2002) do not consider public expenditure while Peretto (2003) studies a model where public spending enters the utility function of households and thus does not affect total factor production (TFP). In addition, both papers study steady states only, with no attention to transitional dynamics and thus to welfare.

4. In this paper I use a "creative accumulation" model, whereby R&D targeted to a given product line is undertaken by an incumbent that controls that product line. Thus all the statements below apply to the firm as well as to the product line. If instead I used a model of "creative destruction", whereby R&D is undertaken by outsiders that challenge the dominant position of the current incumbent, I would obtain the same qualitative results but the terminology would have to highlight the product line, as opposed to the firm, as the main locus where increasing returns apply.

5. Specifically, endogenous growth is not possible if government services do not keep up with the pace of technology—think of education.

6. The usual method of obtaining this condition is to write the Hamiltonian for the optimal control problem of the firm. The derivation in the text highlights the intuition.

7. This paper assumes that firms' and entrepreneurs' investments consist of final output. The results are essentially the same if they consist of labor (or both labor and final output). For an example of a model constructed along these lines, see Peretto (2003).

8. This derivation assumes that entry costs are not expensible. Section 6 shows that things do not change if this assumption is relaxed.

9. Since there is no physical capital (and no government debt), the household's portfolio contains only securities (e.g. corporate bonds) issued by firms. These are backed up by intangible productive assets accumulated through R&D. Thus, in this environment the asset income earned by households stems from product differentiation and (static and dynamic) increasing returns at the firm level.

10. If the tax rate on consumption is endogenous, it is time-variant along the transition and thus distorts the consumption/saving choice. This effect is taken into account in the analysis below.

11. Recall that substitution of the government's budget constraint into the economy's resources constraint (the output market equilibrium condition) yields the household's budget constraint. Hence, working directly with the household's budget constraint is just a short-cut.

12. One can relax the assumption of log utility and use preferences that feature (constant) intertemporal elasticity of substitution different from 1, provided one preserves unitary elasticity of substitution between consumption and leisure. The steady-state qualitative results remain the same. The cost is that the analysis of transitional dynamics, and thus of welfare, becomes more complicated because one loses the property that the saving ratio of the economy is constant throughout the transition.

13. I show below that a necessary condition for the equilibrium with positive growth to occur is $\phi > \rho$.

14. Notice that there are two solutions for (z^*, π^*), and thus two solutions for g^*. Substituting either one of equations (24)–(25) into the steady-state government budget constraint (26) provides a positive relation between z^* and g^*. The analysis of dynamics in the technical appendix (available on request) shows that the steady state with larger g is unstable, while the one with smaller g is stable. It follows that the solution with the smaller value of z^* (and π^*) is stable, while the other one is unstable and can be ruled out.

15. This property stems from log-utility which yields that the income and substitution effects of changes in the returns to savings cancel out. As mentioned above, the basic results of the paper survive more general preferences.

16. See Aghion and Howitt (1998, pp. 407–8, in particular footnote 6) for arguments that justify introducing social returns to variety in this fashion.