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DO TAXES MATTER FOR LONG-RUN GROWTH?: HARBERGER'S SUPERNEUTRALITY CONJECTURE

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ABSTRACT

Harberger's superneutrality conjecture contends that, although in theory the mix of direct and indirect taxes affects investment and growth, in practice growth effects of taxation are negligible. This paper provides evidence in support of this view by testing the predictions of endogenous growth models driven by human capital accumulation. Theoretical analysis highlights implications of different taxes for growth and investment in these models. The empirical work is based on cross-country regressions and numerical simulations, using a new methodology for estimating aggregate effective tax rates. Results show significant investment effects from income and consumption taxes that are consistent with small growth effects. The results are robust to the introduction of other growth determinants.

Do Taxes Matter for Long-Run Growth?: Harberger's Superneutrality Conjecture

Enrique G. Mendoza, Gian Maria Milesi-Ferretti and Patrick Asea[1]

"In today's environment it is quite natural to inquire into the likely effects of alternative policies upon the rate of growth...this boils down to the question of how significantly the rate of growth could be influenced by plausible changes in the mix of direct and indirect taxation. I think that the answer is not very much." [A. C. Harberger (1964b), pp.62-63]

1. Introduction

How do changes in tax policy affect economic activity and welfare? Arnold Harberger has devoted much of his influential work to answering this paramount question and in doing so he has made major contributions. In classic articles ranging from theoretical expositions on the normative and positive effects of tax policy, to empirical studies aimed at quantifying those effects, Harberger reoriented the macroeconomic study of tax policy from the design of second-best hypothetical tax systems to the social philosophy of studying what he called "the Economics of the nth-best." Nth-best economics, as defined in his pioneering 1964 article on "The Measurement of Waste," has to do with assessing the state of the economy in its actual tax-distorted equilibrium and quantifying the effects of altering the tax structure in a particular direction. This pragmatic approach promoted the dissemination of his views in policy-making circles world wide, where the focus of attention is on assessing the current situation and its viable alternatives, rather than on the elegance of optimal tax design. Still, while pragmatic in orientation, Harberger's work has had enduring academic influence because of its sound neoclassical foundations, as brilliantly illustrated in the "Harberger Triangle."

This paper focuses on one aspect of nth-best economics, namely the implications of variations in the mix of direct and indirect taxes, or the tax structure, for growth and investment. Tax structure issues

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play a crucial role in Harberger's writings. In theoretical work he examined efficiency and incidence implications of direct vs. indirect taxes, and how they depend critically on the elasticity of labor supply (Harberger (1964b) and (1966)), and in empirical research he emphasized the need to construct accurate measures of the various tax rates, and to isolate indirect effects of taxes on dependent variables of interest via indirect effects on other variables (Harberger et al. (1967)). From a broader perspective, tax structure issues are repeatedly discussed in his work on the welfare effects of taxation, and on the empirical relevance of neoclassical tax analysis.

With regard to the growth and investment effects of taxation, however, Harberger's articles show marked skepticism. In Harberger (1964a), he argued that, while scientifically the most satisfying approach to understand the macroeconomic effects of taxation is to extend static models into intertemporal models, the level of the capital stock "is reasonably independent of tax rate changes (at least of the sorts of tax rate changes that we have observed)." He based this argument on the observation that the U.S. saving rate has been invariant to large changes in the tax structure. Harberger (1964b) went a step further and, in examining how taxation affects capital and labor inputs within a growth-accounting framework, argued that: (a) changes in the mix of direct and indirect taxation are unlikely to have significant effects on the growth of labor supply or on labor's income share, and hence may have negligible effects on the "normal", or long-run, rate of output growth, and (b) plausible tax changes, such as a shift from income to expenditures as the main tax base, are unlikely to have the large effects on savings and investment rates needed to be reflected in faster output growth. He estimated that "tax changes are unlikely to increase the rate of growth of national income by more than .10 or .20 of a percentage point." Thus, in Harberger's view, feasible changes in tax policy around the actual nth-best tax structure may affect investment rates and improve social welfare, but do not have a significant effect on economic growth, that is, tax policy would seem to be "superneutral."

The objective of this paper is to examine Harberger's conjecture on the superneutrality of tax policy in the light of modern endogenous growth theory. In particular, we aim to answer two questions: (a) does endogenous growth theory support the view that changes in the tax structure can affect investment significantly without changing much the rate of economic growth, and (b) is there evidence in the data supporting both the predictions of the theory and Harberger's superneutrality conjecture?.

Despite Harberger's views, a large literature aimed at studying the growth effects of taxation emerged in tandem with the development of modern endogenous growth theory (see the survey by Rebelo (1994)). Some of this literature reflects Harberger's influence in its concern for developing dynamic models that can shed some light on the transmission mechanisms by which taxes affect growth. For instance, in his seminal lecture on supply-side economics, Lucas (1990) acknowledges Harberger's comments as well as his influence as the professor from which he originally learned tax analysis. At the same time, the ambiguous evidence on growth effects of taxation provided by some empirical studies, like Easterly and Rebelo (1993a), seems to support Harberger's conjecture. There are, however, two aspects of this literature on which further progress can be made. One is that theoretical studies cover a variety of transmission mechanisms linking taxation to growth, but most of them do not examine the predictions the models produce for the growth effects of different combinations of direct and indirect taxes.[2] The second is that, while the empirical literature on cross-country growth regressions initiated by Barro (1991) has examined the growth implications of aggregate tax measures, it has not studied explicitly the growth effects of the tax structure, nor has it followed Harberger's demanding criteria for definition of tax variables. Thus, Harberger's superneutrality conjecture remains open for debate.

This paper highlights the predictions of one class of endogenous growth models for the growth and investment effects of taxes on labor income, capital income, and consumption, and undertakes an

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[2]Two exceptions are Stokey and Rebelo (1993) and Milesi-Ferretti and Roubini (1995).

econometric investigation of those effects using a state-of-the-art methodology for estimating actual effective tax rates. We provide a systematic presentation of the transmission mechanisms by which taxes affect growth within the class of growth models driven by the existence of multiple accumulable factors (human and physical capital) and constant-returns accumulation technologies. The analysis examines how the growth effects of direct and indirect taxes vary depending on assumptions with regard to the households' subjective valuation of their time, the technologies available for accumulation of physical and human capital, and the incidence of income taxes.[3] In general, income taxes on human and physical capital are growth-reducing, while growth effects of consumption taxes are ambiguous and depend in particular on the elasticity of labor supply--a result clearly anticipated in Harberger (1964b). Numerical simulations show that, given reasonable characterizations of preferences and technology, Harberger's superneutrality conjecture is consistent with the predictions of the class of growth models we study. Changes of 10 percentage points in direct and indirect tax rates, around the values that reflect actual tax policies, induce changes in the investment rate of 1 to 2 percentage points, while changes in the rate of output growth are only about 2/10s of a percentage point.

The second contribution of the paper is in its empirical analysis. There have been several panel data studies looking for evidence on the growth effects of tax policy (Easterly and Rebelo (1993a), Engen and Skinner (1992), Koester and Kormendi (1989), and Plosser (1992)), or of economic policy in general (see the December 1993 special issue of the *Journal of Monetary Economics)*, but to date two key issues remain unresolved. First, the indicators of tax policy commonly used are too general to constitute good proxies for the true measures of factor income and consumption tax rates referred to in the models, and hence it has not been possible to separate the effects of direct and indirect taxes, and

[3]We limit the analysis to effects of human and physical capital accumulation, although the growth literature has also studied population growth (Razin and Yuen (1993)), technological innovation (Grossman and Helpman (1991)), and government expenditures (Barro and Sala-i-Martin (1995)).

different types of direct taxes. It is common practice to use an aggregate measure of tax burden, such as the ratio of total tax revenue to GDP, or to use estimates of aggregate marginal tax rates, such as those produced by Barro and Sahasakul (1986) for the United States, without separating different factor income taxes and indirect taxes. Second, several empirical studies fail sensitivity and robustness tests. Tax rates are significant in simple bivariate analysis, but multivariate regressions usually render tax rates measures redundant. More precise tax measures might yield more favorable results.

Because we focus on the effects of the tax structure and use cross-country panel data methods, our empirical analysis requires accurate measures of the effective tax rates on labor income, capital income, and consumption relevant for macroeconomic analysis for several countries over the longest possible sample. Mendoza, Razin, and Tesar (1994) developed a method for computing time series of tax rates and provided the data for G-7 countries. We extend their results to 18 OECD economies for the period 1965-1991. Our regression analysis also follows Harberger et al. (1967) in attempting to avoid spurious correlations both by correcting for the indirect growth effects of taxation via the effects of tax rates on growth determinants, such as the investment rate and government expenditures, and by including variables that explain growth independently of tax rates, such as the terms of trade or initial income. This is done by expanding the panel to add the "robust" determinants of growth emphasized in recent empirical work (see Barro and Lee (1993) and Barro and Sala-i-Martin (1995)). In the models we examine, the long-run equilibria of growth and private investment are simultaneously determined by the tax rates and the other "robust" growth determinants, and fiscal revenue and expenditure policies are linked by the government's budget constraint. Thus, the statistical analysis begins with a separate examination of the determinants of private investment, proceeding in a second stage to study "reduced form" growth equations.

The results of the econometric analysis provide evidence in support of Harberger's (1964b) view that "nth-best" tax policy is superneutral, and generally lend support to the quantitative predictions of the theory. Cross-section and full panel regressions show that the effects of changes in the tax structure on private investment are economically and statistically significant, but these effects are not sufficiently strong to produce large growth effects. Moreover, both our regression estimates and model simulations are close to Harberger's estimate that feasible changes to the tax structure would affect the investment rate by about 1 to 2 percentage points, with negligible growth effects--even though our approach is quite different from his. Taxes are generally insignificant for explaining growth in cross-section regressions based on five-year averages, but they are significant, albeit with small coefficient estimates, in the time-series panel regressions.

Our empirical results are also broadly in line with results of existing empirical studies, except that we find that in the "reduced form," full panel models, taxes are robust determinants of growth--even after other explanatory variables are considered and adjustments are made to account for the simultaneity linking investment and taxes, government expenditures and taxes, and taxes and initial income. The fact that growth effects of taxes are identified more precisely in full panel regressions, maximizing the use of time-series information, is consistent with Fischer's (1993) finding that time-series variability of growth determinants is important to consider, and with stochastic growth models based on Phelps' (1962) savings-under-uncertainty framework, in which the variance of growth determinants affects growth. The results are also consistent with the theoretical models we consider, since these models predict that transitional growth effects of taxes are larger than long-run growth effects (see King and Rebelo (1990)) and it can be argued that growth effects identified in time-series panel regressions reflect transitional growth, instead of long-run growth.

The paper is organized as follows. Section 2 examines endogenous growth models highlighting the main results for growth and investment effects of taxation, along with a discussion of numerical simulations that provide rough estimates of the likely magnitude of long-run growth effects of tax policy. Section 3 discusses the method used for measuring tax rates and presents some general empirical regularities linking tax rates, investment, and growth. Section 4 presents the results of econometric analysis testing the hypothesis that the structure of the tax system affects investment and growth. Section 5 concludes.

2. Tax Structure and Economic Growth: Theoretical Predictions

This section derives the predictions for the growth effects of changes in the mix of direct and indirect taxes that follow from the class of endogenous growth models in which the engine of growth is the presence of multiple accumulable factors, typically, human and physical capital. In order to sustain endogenous long-run growth, accumulation technologies exhibit constant returns to scale. We focus the presentation on a benchmark two-sector growth model, with a market sector producing goods and physical capital, and a non-market sector producing human capital. This benchmark model is then altered to study the predictions that follow for the link between taxes and growth under alternative assumptions regarding the nature of leisure time, the accumulation technologies, and the taxation of human vis-a-vis physical capital.[4]

Firms, Households, and the Public Sector

Physical output is produced with a constant returns to scale (CRS) technology that uses human capital H and physical capital K as inputs. The technology takes the Cobb-Douglas form:

$$Y_t = A(v_t K_t)^{\alpha}(u_t H_t)^{1-\alpha} \tag{1}$$

where v (u) is the fraction of K (H) devoted to the production of goods. K and H depreciate at the rate δ.

Human capital creation is a non-market activity., and H is produced with a CRS technology that uses both human and physical capital as inputs, as in Rebelo (1991). The production function is Cobb-Douglas:[5]

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[4] The model is similar to the ones presented by Rebelo (1991) and Stokey and Rebelo (1993).

$$\dot{H}_t = B[(1-v_t)K_t]^{\beta}(z_t H_t)^{1-\beta} - \delta H_t \tag{2}$$

where 1 - v (z) is the fraction of K (H) devoted to the accumulation of human capital. Equations (1) and (2) assume implicitly that "point-in-time technologies" are linear: if a fraction v of the capital stock is employed in the production of final goods, the "effective capital" is vK.[6]

The government finances exogenous paths of public expenditures and lump-sum transfers by levying taxes on factor incomes and consumption. For simplicity, we impose a balanced-budget condition:

$$G_t + S_t = T_t \tag{3}$$

where G_t is government expenditure, S_t are transfers and T_t is total tax revenue. In every period, the resource constraint of the economy is given by:

$$\dot{K}_t = Y_t - \delta K_t - C_t - G_t \tag{4}$$

where C is private consumption.

The economy is inhabited by identical atomistic agents, who own the factors of production. They accumulate human capital, rent physical and human capital to firms, and choose consumption, investment and the allocation of human and physical capital so as to maximize an intertemporal utility function:[7]

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[5] Our results generalize to the case in which the technologies are CRS with positive cross-derivatives. See Rebelo (1991) and Jones, Manuelli and Rossi (1993b).

[6] Mulligan and Sala-i-Martin (1993) discuss in detail the role of the point-in-time technologies.

[7] Alternatively, we could assume that human capital is a "market good" produced by firms as well, whose returns are taxed. In this case the number of possible taxes increases, since physical and human capital can be taxed differently in different sectors. See, for example, Stokey and Rebelo (1993).

$$U = \int_0^\infty e^{-\rho t} u(C_t, l_t)\, dt \tag{5}$$

where ρ is the rate of time preference and l is leisure time. The instantaneous utility function u (.) takes a Constant Intertemporal Elasticity of Substitution (CIES) form:

$$\begin{aligned} u(C_t, l_t) &= \frac{(C_t l_t^{\eta})^{1-\theta}}{1-\theta} - 1 \qquad \theta \neq 1 \\ u(C_t, l_t) &= \log C_t + \eta \log l_t \qquad \theta = 1 \end{aligned} \tag{6}$$

where θ is the inverse of the intertemporal elasticity of substitution. This functional form is consistent with a balanced growth path, as shown by King et al. (1988). Households take the paths of factor returns, transfers and tax rates as given and choose the paths of C, K, H, u, v, z to maximize (5) subject to the constraint on human capital accumulation given by (2) and to the following budget constraint:

$$R_t^K (1 - \tau_t^K) v_t K_t + R_t^H (1 - \tau_t^H) u_t H_t + S_t - C_t (1 + \tau_t^C) - \dot{K}_t - \delta K_t \geq 0 \tag{7}$$

where R^K, R^H, τ^K and τ^H are the rates of return and the tax rates on capital and labor income, respectively, and τ^C is a consumption tax. Total tax revenues T are equal to $\tau^K R^K vK + \tau^H R^H uH + \tau^C C$. Each individual's time endowment is normalized to one:

$$l_t + u_t + z_t = 1 \tag{8}$$

Firms rent capital from households at the rate of interest R^K, hire labor at the wage rate R^H and use these inputs to produce output with the technology defined in (1). They hire labor and capital up to the point at which their marginal products equate marginal costs:

$$R_t^K = \alpha A \left(\frac{v_t K_t}{u_t H_t} \right)^{\alpha - 1} \tag{9}$$

$$R_t^H = (1-\alpha)A\left(\frac{v_t K_t}{u_t H_t}\right)^{\alpha} \tag{10}$$

Balanced Growth Competitive Equilibrium

We focus on competitive equilibria in which the economy exhibits a balanced growth path, along which consumption, physical capital and human capital grow at the common rate γ, while factor allocations (*u, v* and *z*) remain constant. Let *r* be the after-tax net rate of return on physical capital, $r = R^K(1-\tau)-\delta$. The following equilibrium conditions describe the behavior of the economy along the balanced growth path:[8]

$$\gamma = \frac{1}{\theta}(r-\rho) \tag{11}$$

$$r = (1-\tau^K)\alpha A\left(\frac{vK}{uH}\right)^{\alpha-1} - \delta \tag{12}$$

$$r = (1-\beta)B\left(\frac{(1-v)K}{zH}\right)^{\beta}(u+z) - \delta \tag{13}$$

$$\frac{v}{u} = \frac{\alpha}{1-\alpha}\,\frac{1-\beta}{\beta}\,\frac{1-\tau^K}{1-\tau^H}\,\frac{1-v}{z} \tag{14}$$

$$\gamma = Bz\left[\frac{(1-v)K}{zH}\right]^{\beta} - \delta \tag{15}$$

$$\frac{C}{H} = \frac{1-\tau^H}{1+\tau^C}\eta^{-1}(1-u-z)(1-\alpha)A\left(\frac{vK}{uH}\right)^{\alpha} \tag{16}$$

$$\frac{1}{v}A\left(\frac{vK}{uH}\right)^{\alpha-1} - \frac{C}{H}\frac{H}{K} - \frac{G}{K} = \gamma + \delta \tag{17}$$

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[8]An Appendix available from the authors on request describes the derivation of these conditions.

Equation (11) is the usual condition linking the growth rate to the difference between the return on capital and the rate of time preference, adjusted for intertemporal substitution. Equation (12) determines the net, after-tax marginal product of physical capital r. Equation (13) and (14) reflect arbitrage conditions: (13) equates rates of return between sectors producing goods and human capital, and (14) equates rates of return on physical and human capital in the two sectors. Equation (15) describes equilibrium in the human capital accumulation process--human capital grows at the same rate as consumption and physical capital. Equation (16) reflects the equality between the marginal rate of substitution in consumption and leisure and the real rate of return on human capital. Equation (17) is the aggregate resource constraint.

Effects of Taxation on Long-Run Growth and Transmission Channels

The system (11)-(17) determines the values of γ, r, K/H, C/H, u, v and z as functions of technology parameters and of the exogenous fiscal variables τ^C, τ^H, τ^K and G/K. The following semi-reduced form expression for the growth rate follows from (11)-(14):

$$\gamma = \frac{1}{\theta}\left(\left[D(1-\tau^K)^{\alpha\beta}(1-\tau^H)^{\beta(1-\alpha)}(u+z)^{1-\alpha}\right]^{\frac{1}{1-\alpha\cdot\beta}} - \rho - \delta\right) \tag{18}$$

where $D = (\alpha A)^\beta\,[B(1-\beta)]^{1-\alpha}\,[(1-\alpha)\beta/\alpha(1-\beta)]^{\beta(1-\alpha)}$ is a function of the technology parameters α, β, A and B.

Inspection of (11)-(17) and (18) reveals that in general all three tax rates affect long-run growth in the benchmark model. The channels through which taxes affect growth are the following:

<u>Tax on Physical Capital</u>

K.1) τ^K reduces the net-of-tax real interest rate r, for a given capital/labor ratio in production (vK/uH). This has a negative effect on growth.

K.2) τ^K reduces the capital/labor ratio in production (vK/uH), given a time allocation between work/education and leisure, thus increasing the gross-of-tax return on capital. This effect on growth is positive.

K.3) τ^K affects the labor/education-leisure decision ($u + z$), which in turn affects the capital/labor ratio in production. The growth effect is negative if the elasticity of intertemporal substitution is sufficiently high, as shown by Devereux and Love (1994).

Tax on Human Capital:[9]

H.1) τ^H raises the capital/labor ratio in production (vK/uH), given a time allocation between work/education and leisure, thus reducing the gross-of-tax return on capital. This has a negative growth effect.

H.2) τ^H affects the labor/education - leisure decision ($u + z$), which in turn affects the capital/labor ratio in production. The growth effect is negative if the elasticity of intertemporal substitution is sufficiently high.

Tax on Consumption:

C.1) τ^C affects the labor/education - leisure decision ($u + z$), which in turn affects the capital/labor ratio in production. The effect on growth is negative.

Following Devereux and Love (1994), one can prove that the overall growth effects of physical and human capital income taxes and consumption taxes in the benchmark model are always negative. Modifications of the model affect some or all of the transmission channels listed above and hence yield different effects for a particular tax change on growth. Consider in particular the following modifications:[10]

Case A: Physical capital does not enter in the production of H ($\beta = 0$), as in Lucas (1990). Here channel H.1 is neutralized and a tax on human capital affects growth only through its impact on the work/leisure decision, thus becoming analogous to a consumption tax.

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[9] τ^H has no direct effect on the rate of return on human capital because H is modelled as a non-market, tax-free activity. Thus there is no effect equivalent to K.1 in the human capital sector.

[10] Milesi-Ferretti and Roubini (1995) discuss alternative model specifications in greater detail.

Case B: Human capital is a market good and its factor income returns are taxed at the same rates as in the final goods sector (Pecorino, 1993 and Stokey and Rebelo, 1993). The semi-reduced form expression for growth becomes:

$$\gamma = \frac{1}{\theta}\left([D(1-\tau^K)^{\beta}(1-\tau^H)^{1-\alpha}(u+z)^{1-\alpha}]^{\frac{1}{1-\alpha+\beta}} - \rho - \delta\right) \tag{19}$$

In this case all the transmission channels are operative and the overall impact of income taxes on growth is enhanced through the addition of direct effects of taxation on the returns paid on H. When H is a tax-free sector, these adverse growth effects of higher taxes are mitigated by the fact that higher taxes reduce the opportunity cost of education, and not only its future returns. This is no longer true when factor incomes on H are taxed. A comparison of (19) with (18) shows that the exponents on $(1 - \tau^K)$ and $(1 - \tau^H)$ are larger in (19). Note that if factor incomes in the H sector are taxed, but they are given preferential tax treatment relative to other factor incomes, these additional negative growth effects of taxation are less severe.

Case C: Leisure is quality time/home production (CRS in H and/or K). In this case the term $u + z$ does not appear in equation (13), and the system can be solved recursively with equations (11)-(14) determining γ, r, vK/uH and $(1 - v)K/zH$ (as in Rebelo (1991) and Milesi-Ferretti and Roubini (1994)). Because now the accumulation of human capital increases the utility of leisure, channels K.3, H.2, and C.1 are neutralized and hence the consumption tax has no growth effects. If, in addition, $\beta = 0$, K.1 and K.2 exactly offset each other and H.1 is neutralized, so that all taxes have no growth effects. This is because higher income taxes reduce the returns on education and its opportunity cost by the same amount, leaving the choice to invest time in education unaffected.

Case D: No leisure ($\eta = 0$). In this case $u + z = 1$ in equation (13) and the system can be solved recursively as in Case C. This also implies that channels K.3, H.2 and C.1 are neutralized. As above, a consumption tax has no growth effects. The intuition for these results is as follows. Since leisure does not bring utility, total labor supply (in the production and education sectors) is inelastic, and therefore a consumption tax is non-distortionary in the long run. Furthermore, if physical capital does not enter in the production of human capital ($\beta = 0$), income taxes do not affect growth for the same reasons as in Case C.

The above discussion shows that, in general, taxes on human and physical capital reduce growth, while the effects of a consumption tax are more ambiguous, and depend in particular on the elasticity of labor supply (i.e. on the specification of the leisure activity). Two other factors also play an important role in determining the quantitative impact of taxes on economic growth: the technology and the tax treatment in the human capital accumulation sector. In particular, the growth effect of taxes on human and physical capital when factor incomes in the H sector are untaxed are proportional to β, the share of physical capital in the production of human capital (the limiting case being no effects on growth if $\beta = 0$). Alternatively, when human capital is a "market" sector whose factor income returns are taxed, the growth-reducing effects of capital and labor income taxes are enhanced.

It is also worth noting that most of the channels of transmission that explain the growth effects of taxation affect the ratio of investment on physical capital relative to output. This is important to note because of the important role that the investment rate plays as an explanatory variable in some empirical growth studies. In contrast, in the class of models reviewed here, both investment and growth rates are simultaneously determined by the values of the tax rates and other parameters. In the benchmark model, an increase in τ^K generally reduces the physical investment rate, while an increase in τ^H reduces the investment rate in education. The effect of a higher τ^H on the physical investment rate is, however, ambiguous, as we show in the simulations that follow. Moreover, intuition suggests that rising τ^C reduces the consumption-output share, and thus should increase the investment rate.[11] Thus, it is

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[11]This result depends on whether K and C are assumed to be perfect substitutes or not. Pecorino (1993) and Stokey and Rebelo (1993) discuss cases in which this assumption does not hold.

important that empirical analysis takes into account the endogeneity of the investment rate with respect to tax policy.

We conduct next some numerical simulations to illustrate how the quantitative effects of taxes on growth and investment depend on model specification. The simulations are based on parameters calibrated to approximate the "normal" growth rate of large industrial countries, at about 3 percent, and their shares of investment and tax revenue in GDP for the benchmark model in which H is a non-market sector. Tax rates and the share of g in GDP were set to match values for the U.S. economy reported in Mendoza and Tesar (1995). For model specifications other than the benchmark, we adjust the productivity constant of the H sector (B) so as to maintain initial growth at 3 percent in all experiments. We examine the implications for the growth rate and the physical investment rate that follow from reducing τ^K and τ^H, and rising τ^C, one at a time by 10 percentage points and from increasing the share of g in GDP by 5 percentage points.

The results of the simulations are reported in Table 1. For all model specifications, except model v, the largest growth effects follow from a reduction in τ^H, relative to the other taxes. This is because the shares of human capital in both sectors are higher than the shares of physical capital--the latter are $\alpha=\beta=1/3$--and hence the exponents on the terms including τ^H in (18) and (19) are higher than those on the terms including τ^K. Across model specifications, the largest increases in growth induced by income tax cuts are obtained, as expected, in the case that H is a market sector subject to taxation (model iii). In this case cutting τ^H by 10 percentage points increases growth by about 1.5 percentage points. But this case is by far the exception: growth-enhancing effects of income tax cuts are modest in all other models and particularly when leisure is quality time (model iv) and when labor supply is inelastic (model vi). With regard to τ^C, a rise in this tax of 10 percentage points reduces growth by 0.2-0.3 percentage points in models i-iii, and it has no growth effects in models iv-vi, as argued above. Keeping taxes constant, a higher GDP share of government purchases increases growth.[12]

With respect to investment effects of tax changes, Table 1 shows that a 10-percent cut in τ^K increases the investment rate in all model specifications. In contrast, a cut in τ^H has an ambiguous effect on physical investment, although it would increase overall investment if one included investment in human capital.[13] As argued earlier, a rise in τ^C reduces the consumption-GDP share and hence rises the investment rate.

The results of the numerical analysis are consistent with Harberger's view that tax changes around the current tax structure are likely to affect investment more than growth. Only in the case that human capital accumulation is a taxed market activity, we find that changes in factor income taxes generate growth effects that substantially exceed the 1/10 to 2/10 of a percentage point range predicted by Harberger (1964b). Even then, the simulations assume cuts of 10 percentage points in income tax rates, which arguably may be in the extreme of viable changes around the current tax structure. Furthermore, the simulations are also suggestive of the difficulties that one may find in conducting empirical tests of the link between taxation and long-run growth. First, except for the case in which H is a taxed market activity, the growth effects of even large tax changes are small, so identifying precisely the small contribution of tax rates to the widely variant cross-country growth experience is likely to be difficult, even if tax structure data is properly constructed. Second, there is a potentially serious identification problem to the extent that the magnitude, and in some cases even the direction, of the effects of tax changes on growth may vary across countries because of differences in key parameters (such as the share of physical capital in the production of human capital), the nature of leisure time, and

[12]Devereux and Love (1995) examine growth effects of government purchases.

[13]Further numerical analysis shows that the direction of the effect of higher τ^H on the physical investment rate depends critically on the elasticities of intertemporal substitution and of labor supply. As these elasticities rise, a higher τ^H has a stronger negative effect on I/Y.

details of the tax codes pertaining to differential tax treatment to the returns on human and physical capital. Thus, theory provides no argument for expecting cross-sectional regressions of growth on tax rates to provide robust results.

3. Tax Structures, Investment and Growth: Measurement Issues and International Regularities

The main obstacle that empirical research on growth implications of tax policy faces is the difficulty in constructing accurate tax measures that correspond to tax rates in theoretical models. The class of endogenous growth models reviewed in the previous section focuses on ad-valorem tax rates on the income derived from capital and labor services and on consumption expenditures as they apply to a hypothetical representative household. In contrast, the extensive empirical literature on measurement of tax rates for macroeconomic models has focused on either aggregate measures of the tax burden, like the ratio of tax revenue to GDP, as a proxy for average effective tax rates, or on sums of statutory income tax rates or income tax returns weighted using income distribution data, as a proxy for aggregate marginal tax rates. These conventional tax measures are rough approximations to the tax variables defined in the models, and until recently there had been no attempts at providing other measures and comparing their performance in empirical tests.[14] Conventional tax measures are also impractical for international analysis given limitations imposed by data availability and difficulties in dealing with the complexity of actual tax systems. In light of these limitations, we chose not to use the conventional tax measures and adopted a new strategy.

In a recent study, Mendoza et al. (1994) proposed a new method for computing aggregate effective tax rates on consumption, labor income, and capital income based on data from revenue statistics and national accounts. Their estimates of ad-valorem tax rates represent the wedges distorting optimal plans in a macroeconomic, representative agent setting constructed by comparing measures of

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[14]See Easterly and Rebelo (1993a) and (1993b) and Mendoza et al. (1994) for reviews of the different methods available for estimating tax rates.

aggregate post- and pre-tax incomes and prices. Mendoza et al. constructed estimates of the three tax rates for G-7 countries covering the period 1965-1988. These tax rates share the key features of the most recent average and marginal tax rate estimates obtained with conventional methods, with the advantage that tax rates on different factor incomes and consumption are separated and the development of a cross-country, time-series data base is straightforward. Moreover, the authors showed that income-weighted aggregate marginal tax rates do not differ substantially from their estimates. With this evidence in mind we decided to apply here this new strategy for measuring tax rates.

Computing Macroeconomic Measures of Effective Tax Rates

Computing effective marginal tax rates useful for empirical analysis at a national or international level is a complex task because (a) the myriad of tax exemptions, deductions, and credits that make it difficult to extrapolate the actual tax burden from statutory tax rates, (b) different taxes have equivalent effects on observable variables that could be used to construct tax rate estimates (see Frenkel, Razin, and Sadka 1991), (c) the progressivity and nonlinearity of income tax schedules, which imply that aggregate marginal tax rates estimates require data on the distribution of income consistent with those schedules, and (d) tax systems often include different forms of taxation affecting the same tax base--like individual income taxes levied on wages and social security taxes, both of which are labor income taxes. For cross-country analysis, the situation is complicated even further by differences in the structure of tax systems and limitations of the information available on tax revenues and income distribution.

A strategy for resolving completely all of the above problems is not available, but the method proposed by Mendoza et al. (1994) offers a second-best approach. The intuition of the method is the following. Consider an economy with three goods, consumption (c), labor (l), and capital (k). Household consumption is represented by the vector $h=(h_c,h_l,h_k)$, and government expenditures are denoted by the vector $g=(g_c,g_l,g_k)$. Firms produce c using k and l, and government finances g by levying taxes on consumption and factor incomes. The post-tax price vector facing households is $p=(p_c,p_l,p_k)$ and the producer pre-tax price vector is $q=(q_c,q_l,q_k)$. Tax policy is given by specific tax rates $t=(t_c,t_l,t_k)$ per unit of the respective good. Thus, $t=p-q$ and the vector of ad-valorem tax rates is $\tau=(\tau_c,\tau_l,\tau_k)$, where $\tau_i=t_i/q_i$ for $i=c,l,k$. Since price vectors p and q are not readily available in the data, the tax rates estimates are constructed by multiplying t_i and q_i times an appropriate quantity so as to use data on tax revenues and tax bases rather than price data. The appropriate quantity measures are constructed using OECD data from Revenue Statistics (OECD, 1992) and National Accounts: Volume II, Detailed Tables (OECD, 1991a). Revenue Statistics contains tax revenue data on a cash-receipt basis at the general government level organized under a uniform format. Other sources, such as the IMF's Government Finance Statistics report for several countries central government figures only, thus ignoring state and local taxes, or list budget estimates rather than cash receipts. The detailed tables of the OECD National Accounts are consistent with the Revenue Statistics data and hence help construct tax-base measures. Of particular importance is the data at the disaggregated level on the "balance sheets" of households, corporate enterprises, and government.

Effective Consumption Tax Rate: The consumption tax rate is the percentage difference between post-tax consumer prices and the pre-tax prices at which firms supply consumer goods. The tax rate is measured as the ratio of the revenue derived from all indirect taxation to the pre-tax value of aggregate consumption. The latter is measured as post-tax consumption expenditures from national accounts minus the revenue from indirect taxation, correcting for the fact that indirect tax revenue data include taxes paid by government in its purchases of goods and non-factor services.

Effective Labor Income Tax Rate: The effective ad-valorem tax on labor income corresponds to the percentage difference between post- and pre-tax labor income. Computing this tax rate is difficult because individual income tax revenue data do not provide a breakdown of revenue in terms of labor and capital income taxes (since tax returns and tax schedules apply to all of a tax-payer's income), and there are other major taxes on labor income in addition to individual income taxes on wages (mainly social security and payroll taxes) that need to be considered. To deal with these problems, Mendoza et al. (1994) compute the labor tax in two steps. First, assuming that all sources of household income are taxed at the same rate (based on evidence from OECD (1991b)), the households' average tax rate on total income τ^Y is computed as the ratio of individual income tax revenue to pre-tax household income. The latter is the sum of wage and non-wage individual income (wages and salaries, property and entrepreneurial income, and the operating surplus of private unincorporated enterprises). The fraction of individual income tax revenue that represents labor tax revenue is then measured as $\tau^Y W$, where W represents wages and salaries. In the second step, the effective tax rate on labor income τ^H is computed by adding to $\tau^Y W$ social security contributions and payroll taxes, and dividing over an expanded tax base that adds to W the employers' social security contributions.

Effective Capital Income Tax Rate: Continuing under the assumption that all sources of household income are taxed uniformly, the tax rate on capital is also constructed in two steps. First, the fraction of individual income tax revenue that represents a levy on capital income is computed by applying τ^Y to the operating surplus of unincorporated firms and property and entrepreneurial income, which includes dividends, rents, interest, and royalties.[15] In the second stage, the effective capital income tax rate τ^K is computed as the difference between post-tax and pre-tax capital income divided over pre-tax capital income. The difference between post- and pre-tax capital income includes, in addition to households' capital income taxes, payments of capital income taxes by corporations, all recurrent taxes on immovable property paid by households and others, and the revenue from specific taxes on financial and capital transactions. The pre-tax capital income used as the base of the tax is the total operating surplus of the economy (gross output at producers' values less intermediate consumption, compensation of employees--

[15]The operating surplus of private unincorporated firms does not reflect only capital income for some countries in which it includes small business owners' salaries.

which is wages and salaries plus employers' contributions to social security--, consumption of fixed capital, and indirect taxes reduced by subsidies).[16]

Effective Tax Rates and Economic Growth: International Empirical Regularities

We constructed time-series of tax rates extending the computations of Mendoza et al. (1994) for the G-7 by adding three years (to cover the sample 1965-1991) and 11 countries (Australia, Austria, Belgium, Denmark, Finland, the Netherlands, New Zealand, Norway, Spain, Sweden, and Switzerland). Tax rates for other OECD countries could not be computed because some of the variables were not available in OECD sources. The missing tax rates could be approximated with rough estimates, as has been done in other cross-sectional studies (see Easterly and Rebelo 1993a) and (1993b)), but we opted to maintain a high degree of accuracy in the computation of tax measures, in line with the arguments in Harberger (1964b) and Harberger et al. (1967). This, however, restricts the degrees of freedom for econometric analysis, although we minimize the problem by giving some emphasis to panel techniques that exploit time-series and cross-section features of the data. The remainder of this section summarizes basic stylized facts linking taxation, investment, and growth, based on a bivariate analysis in which the cross-country panel is broken down into quinquenial averages for each variable and country, as is done in some of the regressions of the next section.

The tax rates estimates illustrate important features of the structure of tax systems of OECD countries. Table 2 provides summary statistics useful to compare tax structures, including means of quinquenial averages, as measures of average taxes, and the difference between maximum and minimum quinquenial averages, as a good indicator of variability given that there are only five quinquenia for each country and variable in the sample. In line with Mendoza et al. (1994), we find that labor, capital, and consumption taxes have fluctuated sharply, and while capital and consumption taxes have not exhibited a

[16]This definition of pre-tax capital income implicitly assumes zero net profits and an aggregate constant-returns-to-scale technology (see Razin and Sadka 1993).

marked trend, the tax on labor income has increased over time in all countries. Two important exceptions are Japan, where the capital income tax did increase sharply from the mid 1960s to the late 1980s, and the Nordic countries (Finland, Norway, and Sweden) where all tax rates displayed upward trends. The Nordic countries have above-average tax rates with respect to all three taxes considered, while continental Europe has above-average taxes on consumption and labor income, and below-average taxes on capital income. The opposite holds for OECD countries outside of Europe (Australia, Canada, Japan, New Zealand, and the United States) and for the United Kingdom. Thus, the data clearly distinguish between three groups of countries: a group where all taxes are high (Nordic countries), a group with high capital income taxes and low consumption and labor taxes (nonEuropean OECD countries and the United Kingdom), and a group with low capital income taxes and high consumption and labor taxes (continental Europe). Note, however, that cross-country differences in tax rates narrowed considerably by the end of our sample period for some countries, particularly in Europe as a result of tax harmonization policies.

The data in Table 2 also shed some light on the co-movement between tax rates, GDP growth and private investment rates. This evidence is illustrated more clearly in the scattered diagrams in Figures 1-6 and in the correlation coefficients listed in Table 3. Consider first the link between the investment rate and tax structure. Figures 1 and 2 illustrate a clear and strong negative relationship between factor income taxes and the private investment rate (the correlation coefficients are -0.4 and -0.23 for the capital income and labor income taxes respectively) and Figure 3 shows that the investment rate and the consumption tax are positively, albeit weakly, correlated. These co-movements are consistent with the predictions of the endogenous growth models reviewed in Section 2. As the analysis is extended to consider the link between growth and taxation the results are qualitatively similar, but quantitatively less significant. Moreover, if one takes out of the sample the first quinquenial averages for Japan (i.e. the averages for 1966-70), since Japanese growth in that period was clearly an outlier (see

Figures 4-6), the correlations between factor income (consumption) taxes and growth are negative (positive) but small.

In summary, the evidence from bivariate analysis is in line with Harberger's hypothesis that although we could expect income taxes to have notable adverse effects on investment, these effects do not result in large growth effects. Figures 4-5 are also in line with similar charts examined in the recent empirical literature on taxation and growth (see Plosser (1992)), which suggest some causality from higher taxes to lower growth. However, as this literature discovered, this result often disappears when other determinants of long-run growth are considered. Thus, either to provide stronger evidence on Harberger's superneutrality conjecture or to examine whether the Mendoza-Razin-Tesar tax measures improve the results of existing empirical studies of the growth effects of taxation, we need to examine the relationship between growth, investment, and taxes within the multivariate growth regression framework proposed by Barro (1991).

4. Tax Structure and Economic Growth: Empirical Evidence

This section conducts several econometric tests to assess the empirical relevance of the channels of transmission between tax structure, investment, and growth examined in Section 2. The tests are conducted using the data on tax rates on labor income (*TAXLAB*), capital income (*TAXCAP*), and consumption (*TAXCON*) for 18 OECD countries constructed in Section 3, and other determinants of economic growth that have been found to be robust to model specifications in the literature on cross-country growth regressions (see Barro and Sala-i-Martin (1995) for a comprehensive summary). These robust growth determinants include initial output (*GDP1965*), enrollment in secondary education (*SYR*), the terms of trade (*TOT*), government purchases as a share of GDP (*G/Y*), and private investment as a share of GDP (*I/Y*). We also include the ratio of individual income tax revenue to GDP (*TAXPERS*) to study how the results of the tests vary when the Mendoza-Razin-Tesar tax rates are replaced with one of the traditional indicators of tax policy. The data cover the period 1965-1991, with exceptions for a few tax rates that cover shorter samples as explained in Section 2.

Because the theory we reviewed in Section 2 postulates that the investment rate and the rate of growth are jointly determined by the tax structure, the "robust" growth determinants, and preference and technology parameters, our analysis separates growth and investment regressions which are conducted under a mix of panel and cross-section assumptions. The regressions are estimated using standard panel techniques based on Heteroskedastic-consistent standard errors, corrections for outliers, and, when required, instrumental variables. We consider regressions based on a cross-section of quinquenial averages and full time-series panel regressions. The cross section analysis follows the conventional treatment in Barro's (1991) setting, while the focus on panel regressions is in line with Fischer's (1993) findings that time-series information contained in some growth determinants plays an important role. Further justification for considering time-series information comes from stochastic growth models as Hopenhayn and Muniagurria (1993), Obstfeld (1994), and Mendoza (1995), which are based on the savings-under-uncertainty models of Phelps (1962) and Levhari and Srinivasan (1969). In these models, the variability of the engines of growth affects the rates of saving and investment, and hence the rate of growth. It is also likely that time-series information will capture the macroeconomic transitional dynamics induced by tax rate changes. Numerical simulations of transitional growth effects in models similar to those studied in Section 2 suggest that these effects can be substantial (see King and Rebelo (1990) and Mendoza and Tesar (1995)).

Tax Structure and the Investment Rate

As argued above, we examine first the relationship between the tax structure and the investment rate because in the models we reviewed most of the effects of taxation on growth operate directly or indirectly through the rate of investment on physical capital. Thus, while there may be sound theoretical reasons for including investment as an exogenous growth determinant along with tax rates, as is done in several recent empirical studies (see Levine and Renelt (1991), Mankiw, Romer, and Weil (1992), and DeLong and Summers (1991)), it is important to consider that this may induce a simultaneous-equation bias resulting from the fact that the investment rate depends in part on the tax structure. Similarly, as Barro and Sala-i-Martin (1995) argue, it is important to modify the estimation technique so as to consider the fact that investment, tax rates, and growth may exhibit two-way causality.

Table 4 presents the results for the cross-sectional regressions of the private investment rate as a function of the tax rates and the other growth determinants. The table reports results of four regression models, each estimated first using the tax rate indicators constructed in Section 2 and then using *TAXPERS*. The model estimated in Columns (1) and (2) is a benchmark case in which tax policy and the convergence factor (*GDP1965*) are the only growth determinants considered (except for the fact that the regressions, as all other regressions in the paper, include time dummies to capture country-specific time trends and common cross-sectional deterministic trends). The results reflect the intuition derived from the scattered diagrams plotted in Figures 1-3. Both *TAXCAP* and *TAXLAB* have strong and significant negative effects on the investment rate, while the effect of *TAXCON* is significant and positive. A reduction (increase) of 10 percentage points in labor and capital income (consumption) taxes increases the investment rate by 1.8 and 1 percent (1.3) respectively. Interestingly, these estimates are consistent with both the results of the numerical simulations reported in Table 1, particularly for the case of inelastic labor (or no leisure), and with Harberger's (1964b) calculations for the U.S. economy. The results in Column (2) show that if instead of the Mendoza-Razin-Tesar tax rates we use *TAXPERS*, the benchmark regression model cannot detect a significant effect of taxation on private investment.

Columns (3)-(8) extend the first regression model to incorporate additional explanatory variables. Columns (3) and (4) add the terms of trade and the level of enrollment in secondary education at the beginning of each quinquenial unit. *TOT* and *SYR* are statistically significant determinants of the investment rate when the Mendoza-Razin-Tesar taxes are used, but not when tax policy is measured with

TAXPERS. The new information added by *SYR* and *TOT* strengthens both the convergence effect and the effects of the three tax rates and allows to identify these effects with more precision. Overall, the regression in Column (3) explains nearly 60 percent of the cross-sectional variability of the private investment rate. In contrast, Column (4) shows that *TAXPERS* remains insignificant for explaining private investment and the regression as a whole can only explain about 1/3 of the movements in investment. Columns (5) and (6) add government expenditures and represent results based on instrumental variables, with the first lag of taxes and *G/Y* as instruments, in order to account for possible simultaneity problems and to address the causality between public revenues and expenditures resulting from the government's budget constraint. In Column (5), the coefficients of *TAXCON, TAXLAB*, and *TAXCAP*, are robust to the addition of *G/Y* as an explanatory variable and to the change in estimation method--in fact, the investment effect of *TAXCON* rises from 0.13-0.18 to 0.28 percent. Column (6) shows that *TAXPERS* still cannot capture the effects of taxation on private investment. Finally, Columns (7) and (8) estimate a fixed-effects model using country dummies. Because the convergence effect captured by *GDP1965* is a linear combination of the country dummies, the fixed effects model cannot identify the convergence factor, although it is implicit in the country dummies. Also, the fixed-effects model is estimated with OLS, since instrumental variables reduce sharply the degrees of freedom because it requires to estimate coefficients for 6 time and 18 country dummies and current and lagged values of the explanatory variables. Column (7) shows that the fixed-effects model predicts even stronger investment effects from *TAXCON* and *TAXLAB,* but the effect of *TAXCAP* is reduced sharply. Unable to control for the simultaneity between public revenues and expenditures, a significantly negative effect of higher government purchases on investment absorbs the effect of the capital income tax. The specification based on *TAXPERS* in Column (8) continues to perform unfavorably, although the coefficient rises from -0.04 in Column (2) to -0.18 and it has a higher t-statistic.

Table 5 reports results for experiments that estimate similar regressions as in Table 4 but based on a full time-series, cross-sectional panel, instead of using quinquenial averages. The implications for the link between tax rates and investment that follow from Columns (1)-(4) of the two tables are essentially the same, which suggests that our estimates of the investment effects of taxation are robust not only to the addition of other explanatory variables, but also to the choice of emphasis between cross-sectional and time-series dimensions of the panel. This result is not at odds with the strong transitional growth effects predicted by neoclassical models. In these models, a sharp tax cut induces transitional investment and output booms, as the capital stock grows from the low level of a heavily distorted economy to the high level of a tax-reformed economy. Thus, the *ratio* of investment to output may not rise significantly more during the transition compared to the overall change between the long-run equilibria of the two regimes. In contrast, Tables 4 and 5 differ in that Columns (5)-(8) in Table 5 show that in the full panel regressions *G/Y* absorbs almost completely the investment effects of *TAXCAP*, even when the regressions are estimated using instrumental variables. The GDP identity suggests that, if the GDP share of consumption does not fluctuate much from year to year, yearly changes in *I/Y* will be matched in part with changes in *G/Y*, and in part with changes in the trade deficit-GDP ratio. Thus, there is a natural tendency for *G/Y* to be negatively associated with *I/Y* which helps explain why *G/Y* easily outweighs taxes as an explanatory variable in full panel regressions.

In summary, the evidence documented so far shows that the Mendoza-Razin Tesar measures of effective tax rates are robust determinants of the investment rate both in a cross-section of quinquenial averages, in which time-series variability is sharply reduced, and in a full panel that allows for substantial time-series variability. Factor income taxes have significant negative effects on the investment rate, while the consumption tax and the investment rate are positively related. These results are in line with Harberger's (1964b) intuition that the mix between direct and indirect taxation should alter investment patterns, and they are also consistent with the quantitative predictions derived in the numerical simulations of endogenous growth models presented in Section 2. In contrast, a more conventional measure of tax policy (the ratio of income tax revenue to GDP) is not statistically significant for explaining the private investment rate. Since *I/Y* in the data depends on the tax rates, the analysis of Harberger et al. (1967) applies and we must control for the investment effects of taxes when considering *I/Y* as an explanatory variable in growth regressions.

Tax Structure and GDP Growth

Tables 6 and 7 report the results for regressions relating taxation and growth, organized in a similar manner as Tables 4 and 5. Table 6 refers to a panel based on quinquenial averages, while table 7 refers to the full panel.[17] Because according to the theory of Section 2, *I/Y* and GDP growth are jointly determined by taxes and the other exogenous variables of the model, we view our growth regressions as a reduced form of a simultaneous equation system in which *I/Y* has been solved for.[18] These regressions thus identify the overall effects of taxation on growth, including those that operate through the private investment rate. This approach seems reasonable in light of the empirical evidence showing that growth regressions fail to pass robustness tests in part because of the complex mutual feedback between growth and its determinants.

As before, the first two columns of each table report results obtained by regressing per-capita growth on tax measures, controlling for initial income.[19] Columns (3) and (4) present the results obtained by adding *TOT*, *SYR*, and *G/Y*. Columns (7) and (8) present regressions that control for country-specific fixed effects. The instrumental variables estimates in Columns (5) and (6) differ in that, instead of invoking the reduced-form assumption to abstain from adding *I/Y* as a right-hand-side

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[17] We do not present results based on decade-averages or full sample means because of the limited number of countries in the sample and because our measures of tax rates are not available for some countries until relatively late in the sample period.

[18] For this interpretation to be correct, the residuals of the two equations need to be "well behaved".

[19] Results are similar if in the five-year averages panel we use income at the beginning of each five-year period, rather than income in 1965.

variable, we control for the two-way causality between private investment, taxes, and growth using two-stage least squares with lags of the variables as instruments. As an alternative to the private investment share, we also used the share of total investment in GDP, taken from Summers and Heston. The results, not reported, are analogous to those presented in the Tables.

As discussed earlier in Section 3, it appears that detection and exclusion of outliers is important for growth regressions, to avoid having the regression results be driven by "extreme" observations. Based on the evidence documented in Figures 4-6 and Table 3, we chose to report results in Tables 6 and 7 excluding outliers defined as observations that yield residuals larger than two standard errors of a full sample regression. Admitting the very few outliers we identified, such as the first quinquenial average for Japan, yields statistically significant growth effects of taxation, but the coefficient estimates are very small and not too different from the ones reported.

Table 6 shows that in the regressions based on quinquenial averages all tax rates are generally not statistically significant for explaining growth. The only variables that are statistically significant in all regressions are initial income and the terms of trade. In contrast to the investment regressions, the regressions that use the share of tax revenue have a higher R^2 than those that use our tax measures. This, however, is due to the smaller number of observations for the latter -- when both regressions are run over the same sample, the fit using our tax measures is better. Wald tests suggest, however, that the hypothesis that the three coefficients on *TAXCON, TAXLAB*, and *TAXCAP* are equal to zero is rejected by the data at the 1 percent significance level. Thus, the regressions based on five-year averages seem to support Harberger's view and the models' numerical predictions that taxes matter for explaining growth but only very marginally.

The results for the full panel are presented in Table 7. Here we find statistically significant effects of taxes on economic growth in a number of regressions, although for the most part the coefficients are smaller than those detected in the investment regressions by a factor of 4 or more. The positive sign on the consumption tax rate is mostly due to its positive effect on private investment, as can be seen by comparing columns (3) and (7) to Column (5). The coefficients on income taxes have the expected sign, with the labor income tax significant in columns (1) and (3). There is some evidence that along the time series dimension higher capital income taxes and a higher share of tax revenue are associated with lower growth (columns (7) and (8)). Not surprisingly, however, the improvement in the fit using country-specific dummies is much lower than in the investment regression, given the low persistence of growth (see Easterly et al.(1993)).

Overall, we conclude that the results of the growth regressions obtained using our tax rate measures are broadly in line with Harberger's superneutrality conjecture and with the predictions of the models we reviewed. We could not, for the most part, identify statistically significant effects of taxes on economic growth in the panel using five-year averages. We find some evidence of an effect of taxes on growth in the full panel, although this evidence is not very robust given the instability of coefficients across different specifications. Also, the coefficients are rather small, in line with the results of numerical simulations.

5. Conclusions

This paper provides evidence in support of Arnold Harberger's contention that, although the mix of direct and indirect taxation is an important determinant of growth and investment rates in theory, in practice plausible changes in taxes around the current "nth-best" tax system are unlikely to affect growth. The case in favor of this view is made by analyzing the effects of changes in the tax structure on growth and investment in the class of endogenous growth models driven by human capital accumulation, and by conducting several econometric tests based on a cross-country, time-series panel that includes new measures of tax rates and the robust determinants of growth emphasized in recent empirical studies.

The examination of endogenous growth theory illustrates the different implications that taxes on labor income, capital income, and consumption have for output growth and the private investment rate.

We consider first a basic model in which human capital accumulation is a tax-free, non-market activity, leisure is modelled as "raw" time, and physical capital enters in the production of human capital. In this setting, growth increases as taxes are reduced, and the investment rate rises when factor income taxes fall or consumption taxes rise. Numerical simulations show that the effects of 10-percentage point tax changes on the investment rate are economically significant (about 1/2 to 1.5 percentage points) but the growth effects are very small in the range of 1/10 to 1/20 of a percentage point--exactly as inferred by Harberger (1964b). These growth and investment effects are generally even weaker, and in some instances completely neutralized, if the model is altered by assuming that labor supply is inelastic, by eliminating physical capital as an input in human capital accumulation, and/or by modelling leisure as quality time. In contrast, the growth and investment effects of tax cuts are stronger if human capital accumulation is a taxed market activity. The size of investment and growth effects depends not only on model specification but also on the tax considered. In general, changes in labor income taxation have stronger effects than changes in capital income and consumption taxation. In light of this evidence, it is to be expected that econometric analysis seeking to isolate the contribution of tax policy to the divergent growth performance of different countries will face problems of identification and robustness.

The results of the analysis of a cross-country, time-series panel for 18 OECD countries, based on measures of aggregate effective tax rates on factor incomes and consumption proposed in a recent study by Mendoza, Razin, and Tesar (1994), are roughly in line with the predictions from the theoretical framework and with Harberger's superneutrality conjecture. Our results improve upon some existing empirical studies in that the measures of tax rates used here are robust determinants of the private investment rate, in contrast to a conventional measure based on the ratio of income tax revenue to GDP. In our empirical analysis of the private investment rate and GDP growth we use both cross-section regressions based on five-year averages and full panel regression, and include as explanatory variables tax rates, initial income levels, enrollment in secondary education, government purchases, and the terms of trade.

In general, we find in both cross-section and full panel regressions that cuts of 10 percentage points in income taxes increase the investment rate by about 1 to 2 percentage points, while cuts in consumption taxes of similar magnitude have effects of similar size but in the opposite direction. Similar figures are obtained from numerical simulations of the model, and roughly the same estimates were reported in Harberger's (1964b) study for the U.S. economy. In contrast, tax rates show up as robust and statistically significant determinants of growth only when the time-series dimension of the data is considered, and even then the magnitude of the growth effects of tax changes is very small. Thus, we conclude with Harberger that changes around current "nth-best" tax structures would need to be very substantial to result in noticeable effects on economic growth. We also agree with Harberger, however, that this superneutrality does not imply that tax reforms are worthless, since the welfare gains of these reforms, induced by the reduction in tax distortions, are substantial (see Lucas (1990) and Mendoza and Tesar (1995)).

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Figure 1
Private Investment Rate and the Capital Income Tax

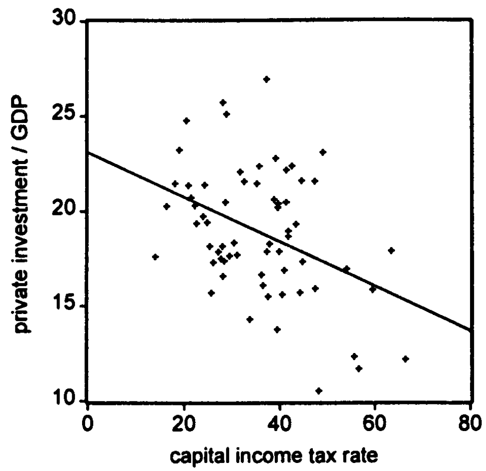

Figure 2
Private Investment Rate and the Labor Income Tax

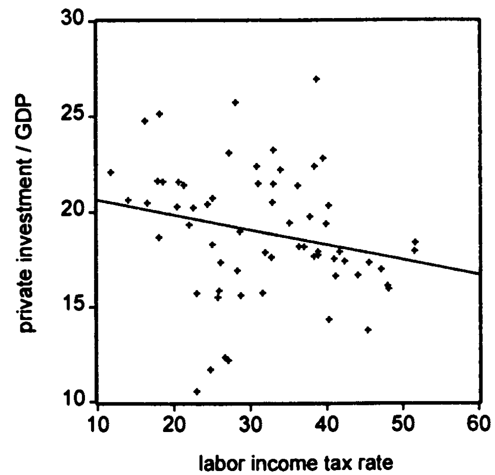

Figure 3
Private Investment Rate and the Consumption Tax

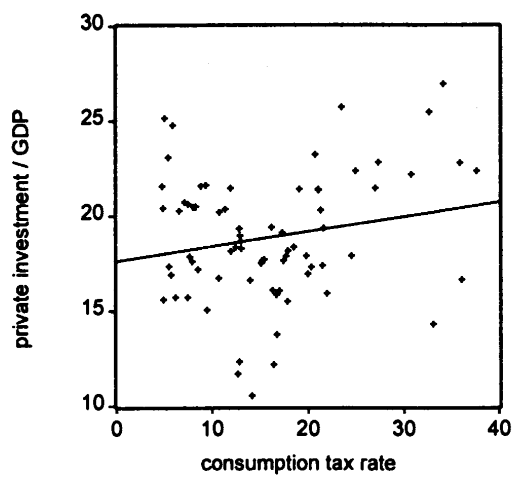

Figure 4
Growth and the Capital Income Tax

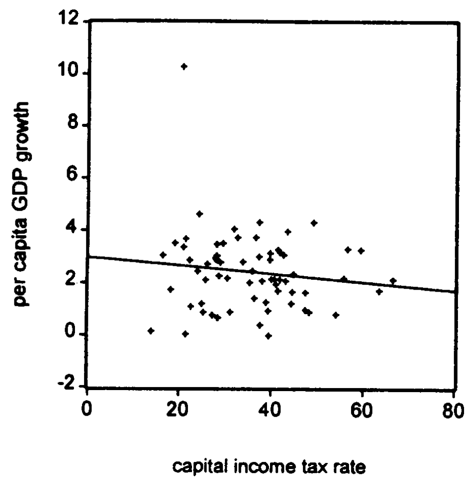

Figure 5
Growth and the Labor Income Tax

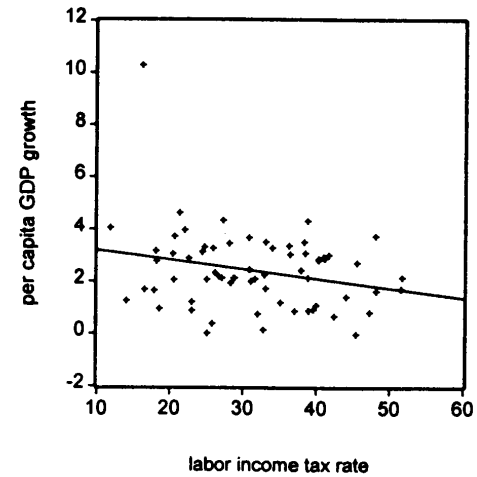

Figure 6
Growth and the Consumption Tax

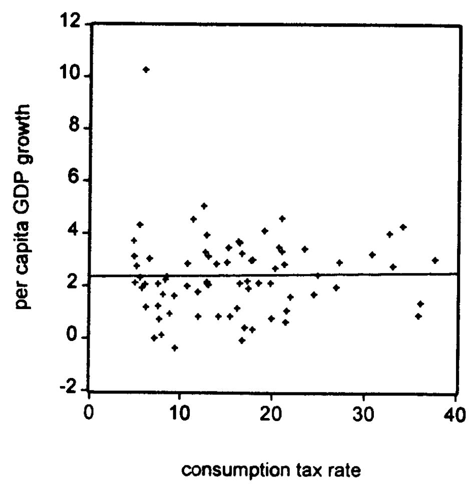

Table 1: Long-Run Growth and Investment Effects of Fiscal Policies*

	Baseline**	reduce τ^K 10 pct. pts.	reduce τ^H 10 pct. pts.	increase τ^C 10 pct. pts.	increa. g 5 pct. pts.
i) **Benchmark model**					
Growth	0.03	0.032	0.037	0.028	0.033
Investment/GDP	0.251	0.267	0.253	0.256	0.245
ii) **Benchmark model, $\beta = 0$**					
Growth	0.03	0.031	0.034	0.027	0.032
Investment/GDP	0.125	0.146	0.123	0.127	0.124
iii) **H-sector taxed**					
Growth	0.03	0.036	0.044	0.028	0.033
Investment/GDP	0.183	0.207	0.178	0.187	0.18
iv) **Leisure = quality time**					
Growth	0.03	0.031	0.032	0.03	0.03
Investment/GDP	0.239	0.247	0.237	0.249	0.231
v) **Leisure = quality time, $\beta = 0$**					
Growth	0.03	0.03	0.03	0.03	0.03
Investment/GDP	0.079	0.093	0.079	0.079	0.079
vi) **No leisure**					
Growth	0.03	0.031	0.032	0.03	0.03
Investment/GDP	0.252	0.27	0.263	0.252	0.252

* Parameter values: $\alpha = \beta = 0.33$; $A = 1$; $\eta = \theta = 2.5$; $\delta = 0.1$; $\rho = 0.024$;
Values for B -- Model (i): 0.75; (ii): 0.44; (iii): 1.4; (iv): 0.55; (v): 0.31; (vi): 0.275

** Baseline fiscal policy: $\tau^K = 0.43$; $\tau^H = 0.285$; $\tau^C = 0.05$; $g = 0.19$

Table 2. Tax Rates, Private Investement and GDP Growth: Summary Statistics from Quinquenial Averages 1/

	Consumption Tax		Labor Income Tax		Capital Income Tax		GDP Growth		Private Investment	
	mean	max-min	mean	max-min	mean	max-min	mean	max-min	mean	max-min
Australia	8.410	1.853	15.786	6.770	40.769	15.645	1.926	3.100	21.286	1.611
Austria	20.744	2.506	37.390	7.198	21.098	3.591	2.994	3.050	21.147	3.871
Belgium	17.163	1.569	42.855	11.637	35.337	11.416	2.808	4.310	16.977	5.183
Canada	12.519	2.290	23.273	10.601	40.896	5.490	2.844	1.900	19.095	1.930
Denmark	34.553	3.014	42.149	3.801	34.976	2.477	2.020	1.740	17.635	5.617
Finland	25.413	9.725	29.068	12.643	32.941	17.168	3.164	2.620	22.638	4.345
France	20.881	1.140	39.690	12.468	24.079	10.305	2.506	4.350	19.323	4.166
West Germany	15.684	1.371	36.832	10.097	26.852	9.730	2.436	2.790	18.072	1.906
Italy	12.289	2.583	39.086	4.064	26.675	2.805	3.200	5.010	19.479	4.869
Japan	5.190	1.142	21.328	11.017	34.147	28.659	4.852	7.500	23.006	4.741
Netherlands 2/	17.552	1.496	51.642	NA	30.413	NA	2.242	3.990	17.795	3.041
New Zealand 2/	11.623	9.393	25.767	NA	37.584	NA	1.059	2.730	15.929	2.129
Norway	33.508	10.370	38.920	1.142	39.725	5.246	3.068	3.400	24.090	4.572
Spain 2/	10.191	4.560	32.792	NA	13.942	NA	2.976	4.970	20.640	5.646
Sweden	21.553	4.717	46.430	12.674	51.212	23.594	1.812	1.970	17.581	3.300
Switzerland	7.394	1.782	28.398	12.487	23.811	12.229	1.642	3.030	19.016	5.021
United Kingdom	14.578	4.057	25.488	4.107	57.290	18.289	2.356	2.440	12.520	5.323
United States	5.648	1.236	25.360	8.238	42.719	4.159	1.938	1.120	16.399	1.731
Average	16.383	3.600	33.459	8.596	34.137	11.387	2.547	3.334	19.035	3.834

1/The table reports the mean of quinquenial averages and the difference between the maximum and minimum quinquenial averages.
2/For these countries, OECD data permits calculation of the tax rates only for six years.

Table 3. Tax Rates, Private Investment, and Growth: Simple Correlations for a Panel of Quinquenial Averages

	Consumption Tax	Capital Income Tax	Labor Income Tax
Private Investment / GDP	0.196	-0.404	-0.232
No. of observations	73	64	64
GDP growth (including Japan's first quinquenial average)	0.027	-0.122	-0.238
No. of observations	75	66	66
GDP growth (excluding Japan's first quinquenial average)	0.140	-0.020	-0.149
No. of observations	74	65	65

Table 4: Regressions for Private Investment Rate
Panel data, five-year averages (1966-90)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimation Method	OLS	OLS	OLS	OLS	INST	INST	FE	FE
GDP 1965	-3.68 (-3.33)	-4.67 (-4.59)	-5.37 (-4.68)	-6.79 (-5.42)	-3.31 (-2.18)	-5.08 (-6.08)		
TAXCON	0.13 (2.59)		0.18 (5.12)		0.28 (5.21)		0.31 (2.89)	
TAXLAB	-0.18 (-3.98)		-0.22 (-4.95)		-0.21 (-3.23)		-0.23 (-2.09)	
TAXCAP	-0.09 (-2.38)		-0.14 (-3.75)		-0.12 (-2.09)		-0.01 (-2.36)	
TAXPERS		-0.04 (-0.97)		-0.01 (-0.17)		0.10 (1.21)		-0.18 (-1.94)
TOT			0.29 (2.55)	0.12 (0.84)	0.05 (0.51)	-0.08 (-0.62)	0.13 (2.00)	0.10 (1.97)
SYR			1.09 (4.18)	0.58 (1.97)	0.62 (1.99)	0.29 (0.88)	1.52 (2.82)	0.84 (2.20)
G/Y					-0.44 (-1.58)	-0.33 (-2.39)	-0.55 (-2.57)	-0.69 (-4.94)
Observ.	60	85	59	81	43	69	61	84
$\bar{R}^2$	0.44	0.34	0.57	0.33	0.56	0.31	0.87	0.85

* All regressions include an intercept and time dummies, and are estimated excluding outliers, defined as observations that yield residuals larger than two standard errors of a full sample regression. t-statistics, calculated using White's heteroskedasticity robust standard errors, are reported in brackets. The instruments for the tax variables, PRINV and G/Y in regressions (5) and (6) are their own first lags; the other variables are their own instruments.

Table 5: Regressions for Private Investment Rate
Annual data (1966-90)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimation Method	OLS	OLS	OLS	OLS	INST	INST	FE	FE
GDP 1965	-3.30 (-5.97)	-4.64 (-14.25)	-4.80 (-7.96)	-6.21 (-9.96)	-2.58 (-6.11)	-5.48 (-9.09)		
TAXCON	0.14 (5.79)		0.17 (8.07)		0.31 (11.65)		0.17 (3.22)	
TAXLAB	-0.20 (-9.50)		-0.19 (-9.53)		-0.08 (-2.17)		-0.16 (-3.35)	
TAXCAP	-0.07 (-6.45)		-0.09 (-5.07)		0.00 (0.32)		0.03 (2.00)	
TAXPERS		-0.04 (-1.72)		-0.00 (-0.10)		0.11 (2.90)		-0.08 (-1.91)
TOT			-0.02 (-1.07)	-0.03 (-1.19)	-0.03 (-1.42)	-0.02 (-0.77)	-0.03 (-2.49)	-0.03 (-2.80)
SYR			0.78 (5.20)	0.37 (2.69)	0.53 (3.49)	0.26 (1.84)	1.31 (4.11)	0.95 (4.54)
G/Y					-0.77 (-6.29)	-0.35 (-5.64)	-0.91 (-8.51)	-0.77 (-11.76)
Observ.	322	442	311	420	260	372	317	424
R^2	0.39	0.32	0.45	0.30	0.50	0.35	0.86	0.84

* All regressions include an intercept and time dummies, and are estimated excluding outliers, defined as observations that yield residuals larger than two standard errors of a full sample regression. t-statistics, calculated using White's heteroskedasticity robust standard errors, are reported in brackets. In regressions (5) and (6) the instruments for the tax variables and for G/Y are their third and fourth lag; the other variables are their own instruments.

Table 6: Regressions for Per-Capita Real Output Growth Rate
Panel data, five-year averages (1966-90)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimation Method	OLS	OLS	OLS	OLS	INST	INST	FE	FE
GDP 1965	-2.12 (-4.98)	-2.37 (-6.09)	-1.75 (-4.29)	-2.39 (-6.38)	-2.43 (-4.37)	-2.43 (-4.56)		
I/Y					-0.08 (-0.94)	-0.00 (-0.06)		
TAXCON	0.01 (0.64)		0.03 (1.57)		0.03 (1.30)		-0.02 (-0.26)	
TAXLAB	-0.01 (-0.56)		-0.02 (-1.02)		-0.04 (-1.68)		-0.06 (-0.66)	
TAXCAP	0.00 (0.52)		0.01 (0.57)		-0.01 (-0.56)		-0.02 (-0.75)	
TAXPERS		-0.03 (-1.36)		-0.02 (-0.76)		-0.02 (-0.88)		-0.17 (-2.04)
TOT			0.17 (4.37)	0.17 (4.64)	0.18 (4.21)	0.16 (4.35)	0.17 (4.23)	0.18 (4.41)
SYR			0.06 (0.63)	0.10 (1.20)	0.16 (1.60)	0.13 (1.36)	0.19 (0.79)	-0.19 (-0.87)
G/Y			-0.04 (-0.48)	0.00 (0.07)	-0.02 (-0.22)	0.02 (0.52)	-0.07 (-0.37)	-0.16 (-0.11)
Observ.	60	85	58	81	56	76	59	83
$\bar{R}^2$	0.33	0.49	0.45	0.48	0.43	0.47	0.44	0.37

* All regressions include an intercept and time dummies, and are estimated excluding outliers, defined as observations that yield residuals larger than two standard errors of a full sample regression. t-statistics calculated using White's heteroskedasticity robust standard errors, are reported in brackets. The instruments for PRINV and G/Y in regressions (5)-(8) are their own first lags; the other variables are their own instruments.

Table 7: Regressions for Output Growth Rate
Panel yearly data (1966-90)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimation Method	OLS	OLS	OLS	OLS	INST	INST	FE	FE
GDP 1965	-1.85 (-4.36)	-1.97 (-5.13)	-2.31 (-4.59)	-2.51 (-5.40)	-2.59 (-4.59)	-2.94 (-5.27)		
I/Y					-0.08 (-1.06)	-0.02 (-0.39)		
TAXCON	0.04 (2.40)		0.05 (2.79)		0.03 (1.25)		0.14 (2.09)	
TAXLAB	-0.05 (-2.98)		-0.04 (-2.00)		-0.01 (-0.24)		-0.02 (-0.34)	
TAXCAP	-0.01 (-1.50)		-0.01 (-1.22)		0.01 (0.63)		-0.09 (-3.72)	
TAXPERS		-0.06 (-2.35)		-0.03 (-1.19)		-0.03 (-0.94)		-0.16 (-2.73)
TOT			0.02 (1.19)	0.02 (1.33)	0.02 (1.01)	0.02 (1.35)	0.01 (0.95)	0.02 (1.55)
SYR			0.28 (2.45)	0.26 (2.46)	0.11 (0.83)	0.25 (2.16)	0.60 (1.41)	0.36 (1.41)
G/Y			-0.05 (0.80)	-0.02 (-0.51)	-0.07 (-0.79)	0.06 (1.34)	-0.35 (-2.07)	-0.14 (-1.37)
Observ.	325	442	317	422	252	363	315	420
$\bar{R}^2$	0.36	0.45	0.38	0.41	0.34	0.42	0.44	0.46

* All regressions include an intercept and time dummies, and are estimated excluding outliers, defined as observations that yield residuals larger than two standard errors of a full sample regression. t-statistics calculated using White's heteroskedasticity robust standard errors, are reported in brackets. The instruments for the tax variables, PRINV and G/Y in regressions (5) and (6) are their own third and fourth lag; the other variables are their own instruments.

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