



ELSEVIER

Journal of Public Economics 66 (1997) 99–126

JOURNAL OF
PUBLIC
ECONOMICS

On the ineffectiveness of tax policy in altering long-run growth: Harberger's superneutrality conjecture

Enrique G. Mendoza^{a,*}, Gian Maria Milesi-Ferretti^b, Patrick Asea^c

^a*Board of Governors of the Federal Reserve, Washington, DC 20551, USA*

^b*International Monetary Fund and CEPR, Washington, DC 20431, USA*

^c*University of California—Los Angeles and NBER, Los Angeles, CA 90024, USA*

Received 30 June 1995; accepted 26 August 1996

Abstract

In 1964 Harberger conjectured that, although theory predicts that changes in tax rates affect investment and growth in the long-run, in practice tax policy is an ineffective instrument to influence growth. This paper provides theoretical and empirical evidence in favor of this view. The growth effects of tax policy in the class of endogenous growth models driven by human capital accumulation are examined, and numerical simulations of these models confirm the results Harberger predicted. Cross-country panel regressions, estimated using a new method for measuring effective tax rates, produce significant investment effects from taxes that are consistent with negligible growth effects. These results are robust to the introduction of other growth determinants. © 1997 Elsevier Science S.A.

Keywords: Endogenous growth; Private investment; Tax structure; Tax rate estimates

JEL classification: E6; E62; O4; O5

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. (Harberger (1964b), pp. 62–63)

*Corresponding author. Internet: mendozae@frb.gov

1. Introduction

Is tax policy an effective instrument to alter a country's rate of economic growth in the long-run? More than 30 years ago Harberger (1964a), (1964b) made a compelling case arguing that it is not. He claimed that, while scientifically the most satisfying approach to study the growth effects of tax policy is to develop neoclassical intertemporal models, as is common practice today, the fact is that the U.S. saving and growth rates have been invariant to large changes in the tax structure (Harberger (1964a)). Furthermore, using a growth-accounting framework, he showed that changes in the mix of direct and indirect taxes have negligible effects on output growth because they have negligible effects on the growth of labor supply and on labor's income share, and because their effect on savings and investment rates is not sufficiently large (Harberger (1964b)). He estimated that tax changes cannot increase output growth by more than 0.1 or 0.2 of a percentage point, even when savings and investment rates may rise 1 or 2 percentage points. Thus, in Harberger's view tax policy appears to be "superneutral": changes in tax policy may affect investment rates, and improve welfare through efficiency gains, but do not affect growth.

This paper examines Harberger's superneutrality conjecture in the light of modern endogenous growth theory. We aim to answer two questions. First, does endogenous growth theory support the view that changes in the tax structure have noticeable investment effects and negligible growth effects? We answer this question by examining the qualitative and quantitative predictions of one class of endogenous growth models for the effects of taxes on labor income, capital income, and consumption. Second, do the data support both the predictions of the theory and Harberger's superneutrality conjecture? This question is answered by undertaking an econometric investigation of the growth and investment effects of taxes using a new method for constructing macroeconomic measures of effective tax rates.

The class of growth models we study are the subject of an important branch of the recent literature on endogenous growth theory. This class of models is driven by the existence of multiple accumulable factors (human and physical capital) and constant-returns-to-scale (CRS) accumulation technologies. Several theoretical studies in this literature have examined the mechanisms by which taxes affect growth, (see, for example, Lucas (1990) and King and Rebelo (1990)), while empirical studies have generally provided ambiguous evidence on the growth effects of tax policy (as in Easterly and Rebelo (1993a)) which in principle seems to support Harberger's views. There are, however, two aspects of this literature that deserve further consideration. One is that, while the studies of cross-country panel growth regressions pioneered by Barro (1991) have examined growth implications of *aggregate* tax measures, they have not studied explicitly the growth effects of the tax structure, nor have they generally followed the theory in setting the criteria to define tax variables. The second is that few theoretical studies

have provided a systematic treatment of the various mechanisms linking different taxes to growth, and these have generally avoided quantitative analysis. Thus, Harberger's superneutrality conjecture remains unresolved both from empirical and theoretical standpoints.

The endogenous growth models we examine predict that the 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. In general, income taxes are growth-reducing, while growth effects of consumption taxes are ambiguous and depend in particular on the elasticity of labor supply. The numerical simulations we conduct show that Harberger's superneutrality conjecture is consistent with the predictions of the models. Changes of 10 percentage points in tax rates, around the values that reflect actual tax policies, induce changes in the long-run investment rate of 1 to 2 percentage points, while changes in the long-run rate of output growth are only about 0.2 of a percentage point.

The paper's empirical analysis aims to extend recent panel studies of taxation and growth (as in Easterly and Rebelo (1993a); Engen and Skinner (1992); Koester and Kormendi (1989); Plosser (1992)) by trying to address two of their shortcomings. First, the indicators of tax policy that have been commonly used are too general to constitute good proxies for the measures of tax rates on factor incomes and consumption referred to in endogenous growth theory. In particular, the effects of direct and indirect taxes, and different types of direct taxes, have not been separated because cross-country studies commonly use a general measure of the tax burden, such as the tax revenue–GDP ratio. Some country-specific studies for countries like the United States have used estimates of aggregate marginal tax rates, as those produced by Barro and Sahasakul (1986), but these also generally do not separate different factor income taxes and indirect taxes, and are not available for a large number of countries. Second, several studies fail sensitivity and robustness tests. Tax rates are significant in bivariate analysis, but not in multivariate regressions, in part because of the measurement error affecting tax rate estimates. To address these shortcomings, our econometric analysis uses cross-country measures of effective tax rates on labor income, capital income, and consumption designed specifically for use in macroeconomic models by Mendoza et al. (1994). These authors provide the data for the G7 countries covering the period 1965–1988. We use their methodology to add 11 OECD countries to the sample and to update the estimates until 1991.

The panel data analysis follows standard procedures outlined in Barro and Sala-i-Martin (1995). Panel regressions are estimated correcting for the indirect growth effects of taxation via the effects of tax rates on other growth determinants, and including variables that explain growth independently of tax rates, such as the terms of trade or initial income. Moreover, since in the endogenous growth models we examine long-run growth and investment rates are simultaneously determined by tax rates and other growth determinants, the analysis begins with an examina-

tion of the determinants of investment, proceeding in a second stage to study “reduced-form” growth equations.

The results of the econometric analysis support Harberger’s superneutrality conjecture and generally lend support to the quantitative predictions derived from endogenous growth models. Panel regressions based on 5-year averages 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 noticeable growth effects. In contrast, the conventional indicator of tax policy based on the ratio of income tax revenue to GDP is not significant for explaining investment or growth. In line with both model simulations and Harberger’s estimates, the regressions predict that feasible changes to the tax structure affect the investment rate by 1 to 2 percentage points, while taxes are generally insignificant for explaining growth. There are some indications that income taxes affect growth at the higher frequency captured in a panel of annual data, but we view this as evidence of either the potential role of the short-term variability of growth determinants in explaining growth in stochastic models, or the short-run growth effects that tax changes can induce even in the absence of long-run growth effects.

The paper is organized as follows. Section 2 examines growth models highlighting the main results for the effects of taxation, along with a discussion of numerical simulations. 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 the panel analysis. Section 5 concludes.

2. Tax policy implications of endogenous growth theory

This section examines the growth effects of changes in direct and indirect taxes in growth models based on human capital accumulation. We discuss first a basic two-sector model with a market sector producing goods and physical capital, and a non-market sector producing human capital. Then we move on to examine how the effects of taxes vary as key assumptions of the model change.

2.1. The basic growth model driven by human capital accumulation

Output is produced with a Cobb-Douglas, CRS technology that uses human capital H and physical capital K as inputs:

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

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

Human capital creation is a non-market, tax-free activity, undertaken using a CRS technology that uses both H and K as inputs. The production function is Cobb-Douglas:

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

where $1 - v(z)$ is the share of $K(H)$ devoted to the accumulation of human capital. Eqs. (1) and (2) assume linear “point-in-time” technologies: if a fraction v of K is employed to produce final goods, the “effective capital” is vK .

Firms rent capital at the rate of interest R^K and hire labor at the wage rate R^H . Profit maximization implies that labor and capital are used up to the point at which marginal products equate marginal costs:

$$R_t^K = \alpha A \left(\frac{v_t K_t}{u_t H_t} \right)^{\alpha-1}, \tag{3}$$

$$R_t^H = (1 - \alpha) A \left(\frac{v_t K_t}{u_t H_t} \right)^\alpha. \tag{4}$$

Households are identical and infinitely-lived. Their lifetime utility is represented by a standard time-separable utility function:

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

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

$$u(C_t, l_t) = \frac{(C_t l_t^\eta)^{1-\theta}}{1-\theta} - 1 \quad \theta \neq 1 \tag{6}$$

$$u(C_t, l_t) = \log C_t + \eta \log l_t \quad \theta = 1,$$

where θ is the inverse of the intertemporal elasticity of substitution. This functional form is chosen because, as King et al. (1988) showed, it is consistent with the balanced-growth assumption defined below. Households take as given the intertemporal sequences of wage and interest rates, government transfers, and tax rates, and choose the sequences of C, K, H, u, v, z so as to maximize (5) subject to the technological 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 τ^K and τ^H are the tax rates on capital and labor income, respectively, τ^C is a consumption tax, and S are government transfers. Each individual’s time endowment is normalized to one, so that $l_t + u_t + z_t = 1$.

The government finances exogenous paths of public expenditure and lump-sum transfers. For simplicity, we impose a balanced-budget condition:

$$G_t + S_t = T_t, \quad (8)$$

where G_t is government expenditure and T_t is tax revenue ($T = \tau^K R^K vK + \tau^H R^H uH + \tau^C C$).

The competitive equilibrium of the economy implies that the resource constraint is:

$$\dot{K}_t = Y_t - \delta K_t - C_t - G_t, \quad (9)$$

We study long-run, balanced-growth competitive equilibria in which K , H and C grow at the common rate γ and factor allocations (u , v and z) remain constant. Let r be the net, after-tax rate of return on physical capital, $r \equiv R^K (1 - \tau^K) - \delta$. The following conditions characterize the balanced-growth path:

$$\gamma = \frac{1}{\theta}(r - \rho), \quad (10)$$

$$r = (1 - \tau^K) \alpha A \left(\frac{vK}{uH} \right)^{\alpha-1} - \delta \quad (11)$$

$$r = (1 - \beta) B \left(\frac{(1-v)K}{zH} \right)^\beta (u+z) - \delta, \quad (12)$$

$$\frac{v}{u} = \frac{\alpha}{1-\alpha} \frac{1-\beta}{\beta} \frac{1-\tau^K}{1-\tau^H} \frac{1-v}{z}, \quad (13)$$

$$\gamma = Bz \left[\frac{(1-v)K}{zH} \right]^\beta - \delta, \quad (14)$$

$$\frac{C}{H} = \frac{1-\tau^H}{1+\tau^C \eta} (1-u-z)(1-\alpha) A \left(\frac{vK}{uH} \right)^\alpha, \quad (15)$$

$$\frac{1}{v} A \left(\frac{vK}{uH} \right)^{\alpha-1} - \frac{C}{H} \frac{H}{K} - \frac{G}{K} = \gamma + \delta. \quad (16)$$

Eq. (10) is the familiar “fundamental” growth equation, according to which the growth rate equals the difference between the return on capital and the rate of time preference, adjusted for intertemporal substitution. Eq. (11) determines r as the net, after-tax marginal product of capital. Eqs. (12) and (13) reflect arbitrage conditions: (12) equates rates of return between sectors producing goods and human capital, and (13) equates rates of return on physical and human capital in the two sectors. Eq. (14) describes balanced-growth equilibrium in the human capital accumulation process (human capital grows at the same rate as consumption and physical capital). Eq. (15) reflects the equality between the marginal rate

of substitution in consumption and leisure and the real rate of return on human capital. Eq. (16) is the aggregate resource constraint.

2.2. Effects of taxes on long-run growth and variations to the basic model

The system (10)–(16) determines the values of γ , r , K/H , C/H , u , v and z as functions of fixed parameters and 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 (10)–(13):

$$\gamma = \frac{1}{\theta} \left([D(1 - \tau^K)^{\alpha\beta} (1 - \tau^H)^{\beta(1-\alpha)} (u+z)^{1-\alpha}]^{\frac{1}{1-\alpha+\beta}} - \rho - \delta \right), \quad (17)$$

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

Given the “fundamental growth equation” (10), and the fact that θ and ρ are preference parameters, it follows that taxes can only affect growth if they directly or indirectly affect r . Inspection of (11)–(17) reveals that in general all three taxes affect r . τ_K and τ_H affect r directly (see (11)–(12)), and indirectly through their effects on leisure and labor supply (see (13)–(15)). In contrast, τ_C affects r only indirectly through the labor–leisure choice. The specific channels for transmission of tax policy are the following:

2.2.1. Tax on physical capital

K.1: τ^K reduces r , for a given capital/labor ratio in production (vK/uH). This reduces growth.

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

K.3: τ_K affects the labor/education–leisure decision ($u+z$), which in turn affects (vK/uH). The sign of the growth effect depends on θ .

2.2.2. Tax on human capital¹

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

H.2: τ_H affects ($u+z$), which in turn affects (vK/uH). The sign of the growth effect depends on θ .

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

2.2.3. 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.

Devereux and Love (1994) proved that, for low θ , the growth effects of the three taxes in the basic model are negative. Modifications of the model alter the transmission channels and hence yield different growth effects for tax changes. Three issues are important to examine in this regard: the elasticity of labor supply, the human capital accumulation technology, and the tax treatment of human capital.²

If labor supply is inelastic ($\eta=0$), there are no indirect growth effects of taxation (channels K.3, H.2 and C.1 disappear), implying no growth effects of consumption taxes. The same result obtains if the leisure activity has human capital, in addition to time, as an input, and adopts a CRS form (leisure as quality time). In this case τ^C affects the allocation of resources between production of (taxed) consumption goods and (untaxed) leisure but not the growth rate.³

If human capital accumulation requires only human capital as an input ($\beta=0$), as in Lucas (1990), the direct effects of factor income taxes on growth are shut down, so that taxes affect growth only through their impact on labor supply. Formally, channels K.1 and K.2 exactly offset each other, and channel H.1 vanishes – the labor income tax becomes analogous to a consumption tax.

Finally, if H is a market good and its factor payments are taxed (see Pecorino (1993), Stokey and Rebelo (1995) and Milesi-Ferretti and Roubini (1996)), expression (17) becomes:

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

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 derived from H are taxed. A comparison of (18) with (17) shows that the exponents on $1 - \tau^K$ and $1 - \tau^H$ are larger in (18). Note finally that, if factor incomes in the H sector are taxed at preferential rates relative to other factor incomes, these negative growth effects of taxation are less severe.

It is also worth noting that most of the transmission channels that explain the growth effects of taxation also affect the physical investment rate. This is important to note because of the key role that the investment rate plays as an

²Milesi-Ferretti and Roubini (1995) discuss alternative model specifications in greater detail.

³Formally, the term $u + z$ does not appear in Eq. (13), and the system can be solved recursively with Eqs. (11)–(14) determining γ , r , vK/uH and $(1 - v)K/zH$.

exogenous explanatory variable in many empirical growth studies [see the review in Barro and Sala-i-Martin (1995)]. In contrast, in the class of models reviewed here, both investment and growth rates are simultaneously determined by tax rates and other parameters. In the basic 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 increasing τ_C reduces the consumption-output share, and thus raises the investment rate.⁴

We conduct next some 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 in the basic model. Tax rates and the share of G in GDP were set to match values for the USA economy reported in Mendoza and Tesar (1998). For model specifications other than the basic model, 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 effects on the growth and investment rates and on the labor–education time allocation that follow from reducing τ_K and τ_H , and increasing 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 H in both sectors are set higher than the shares of K – the latter are $\alpha = \beta = 1/3$ – and hence the exponents on the terms including τ_H in (17) and (18) 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 , an increase 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 value of the ratio G/GDP increases growth because it induces agents to substitute work for leisure.⁵

With respect to investment effects of tax changes, Table 1 shows that a 10 percentage 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

⁴This result depends on whether K and C are perfect substitutes or not [see Pecorino (1993)].

⁵Devereux and Love (1995) examine in detail the effects of government purchases.

Table 1
Quantitative tax experiments^a

	Baseline ^b	Reduce τ^K 10 pct. pts.	Reduce τ^H 10 pct. pts.	Increase τ^C 10 pct. pts.	Increase g 5 pct. pts.
<i>(i) Benchmark model</i>					
Growth	0.03	0.032	0.037	0.028	0.033
Investment/GDP	0.251	0.267	0.253	0.256	0.245
Work/education time	0.37	0.375	0.396	0.386	0.386
<i>(ii) Benchmark model, $\beta=0$</i>					
Growth	0.03	0.031	0.034	0.027	0.032
Investment/GDP	0.125	0.146	0.123	0.127	0.124
Work/education time	0.443	0.449	0.466	0.428	0.442
<i>(iii) H-sector taxed</i>					
Growth	0.03	0.036	0.044	0.028	0.033
Investment/GDP	0.183	0.207	0.178	0.187	0.18
Work/education time	0.299	0.306	0.334	0.283	0.315
<i>(iv) Leisure = quality time</i>					
Growth	0.03	0.031	0.032	0.03	0.03
Investment/GDP	0.239	0.247	0.237	0.249	0.231
Work/education time	0.456	0.455	0.470	0.446	0.466
<i>(v) Leisure = quality time, $\beta=0$</i>					
Growth	0.03	0.03	0.03	0.03	0.03
Investment/GDP	0.079	0.093	0.079	0.079	0.079
Work/education time	0.536	0.538	0.548	0.528	0.543
<i>(vi) No leisure</i>					
Growth	0.03	0.031	0.032	0.03	0.03
Investment/GDP	0.252	0.27	0.263	0.252	0.252
Work/education time	1	1	1	1	1

^a 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.

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

would increase overall investment if one included investment in human capital.⁶ As argued earlier, a rise in τ_C reduces the consumption GDP share and hence increases the investment rate.

The results of this numerical analysis are consistent with Harberger's superneutrality conjecture. 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 range of 0.1 to 0.2 of a percentage point

⁶ Further numerical analysis shows that the negative effect of higher τ_H on the investment rate increases as the elasticities of intertemporal substitution and labor supply increase.

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. Secondly, 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), in the nature of leisure time, and in preferential tax treatment to the returns paid on human and physical capital. Thus, theory yields no argument for expecting cross-sectional regressions of growth on tax rates to provide robust results.

3. Tax structure, investment and growth: measurement issues and international regularities

The main obstacle that empirical research on growth effects of tax policy faces is the difficulty in constructing accurate tax measures that correspond to tax rates in theoretical models. The endogenous growth models reviewed in the previous section focus on ad-valorem tax rates on the income derived from capital and labor services and on consumption expenditures applied to a hypothetical representative household. In contrast, the extensive empirical literature on measurement of tax rates for macroeconomic models has focused on either general 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 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.⁷ 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.

Mendoza et al. (1994) proposed a new method for computing aggregate effective tax rates based on data from revenue statistics and national accounts. Their estimates of ad-valorem tax rates, which we denote by MRT taxes, represent

⁷See Easterly and Rebelo (1993a), (1993b); Mendoza et al. (1994) for literature reviews.

the wedges distorting optimal plans in a macroeconomic, representative agent setting. MRT taxes are constructed by comparing measures of aggregate post and pre-tax incomes and prices. Mendoza et al. constructed estimates of tax rates for G7 countries covering the period 1965–1988. These tax rates share the key features of the most recent tax-rate estimates obtained with conventional methods, with the advantages that tax rates on different factor incomes and consumption are separated and the development of a cross-country, time-series database is straightforward. Moreover, the authors showed that income-weighted marginal tax rates do not differ substantially from their estimates. Thus, we decided to apply here this new strategy for measuring tax rates.

3.1. Computing the MRT tax rates

Computing effective tax rates useful for empirical analysis at a national or international level is a complex task because of (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 et al., 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 MRT method offers a useful alternative 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 MRT tax rates 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 key data sources are the *OECD Revenue Statistics* (OECD, 1990) and *National Accounts: Volume II, Detailed Tables* (OECD, 1991a).

3.1.1. MRT 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.

3.1.2. MRT 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, the MRT method computes 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.

3.1.3. MRT capital income tax rate

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. Second, 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, income taxes paid 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 (wages and salaries plus employers' contributions to social security), consumption of fixed capital, and indirect taxes reduced by subsidies.⁸

3.2. MRT tax rates and economic growth: international empirical regularities

We constructed time-series of tax rates extending the MRT computations for the G7 by adding 3 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,b), but we opted to maintain a high degree of accuracy in the computation of tax measures, at the cost of reducing the degrees of freedom for econometric analysis. The remainder of the section summarizes basic stylized facts linking taxes, investment, and growth, based on a bivariate analysis of a cross-country panel of quinquennial averages.

The tax rate 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 quinquennial averages, as measures of average taxes, and the difference between maximum and minimum quinquennial averages, as a good indicator of variability given that there are only five quinquennia 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 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 the three tax rates displayed upward trends. The Nordic countries have above-world-average tax rates with respect to all three taxes considered, while continental Europe has above-world-average taxes on consumption and labor income, and below-world-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 (non-European OECD countries and the United Kingdom), and a group with low capital income taxes and high consumption and

⁸This definition assumes zero net profits and a CRS technology (see Razin and Sadka, 1993)).

Table 2
Tax rates, private investment and GDP growth: summary statistics from quinquennial averages^a

	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 ^b	17.552	1.496	51.642	NA	30.413	NA	2.242	3.990	17.795	3.041
New Zealand ^b	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 ^b	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

^a The table reports the mean of quinquennial averages and the difference between the maximum and minimum quinquennial averages.

^b For these countries, OECD data permits calculation of the tax rates only for 6 years.

labor taxes (continental Europe). Note, however, that cross-country differences in tax rates had narrowed considerably by 1991 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 scatter diagrams plotted in Figs. 1–6 and in the correlation coefficients of Table 3. Consider first the link between the investment rate and tax structure. Figs. 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 Fig. 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

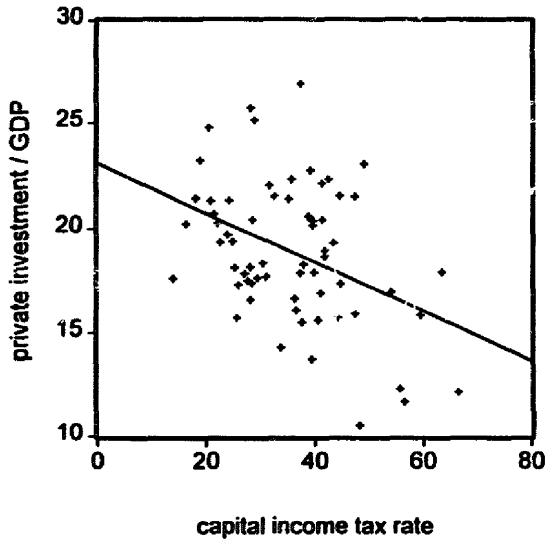


Fig. 1. Private investment rate and the capital income tax.

quinquennial averages for Japan (i.e. the averages for 1966–70), since Japanese growth in that period was clearly an outlier (see Figs. 4–6), the correlations between factor income or consumption taxes and growth are almost zero.

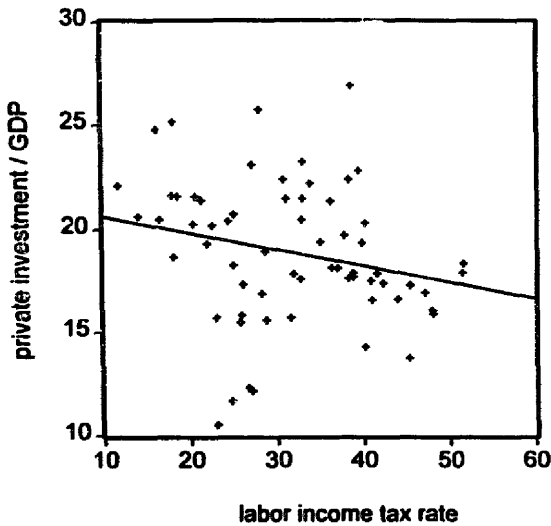


Fig. 2. Private investment rate and the labor income tax.

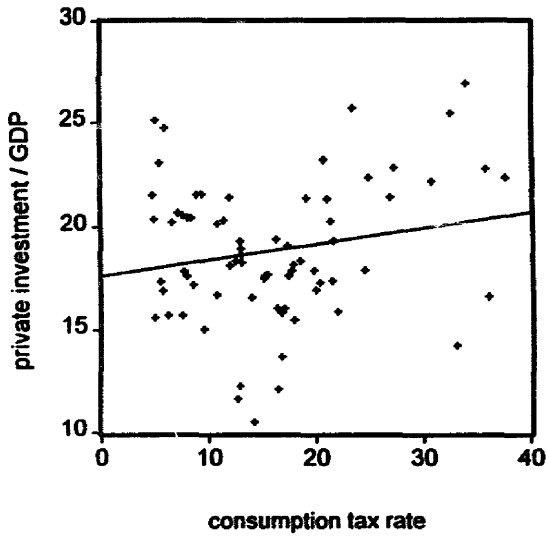


Fig. 3. Private investment rate and the consumption tax.

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. Figs. 4

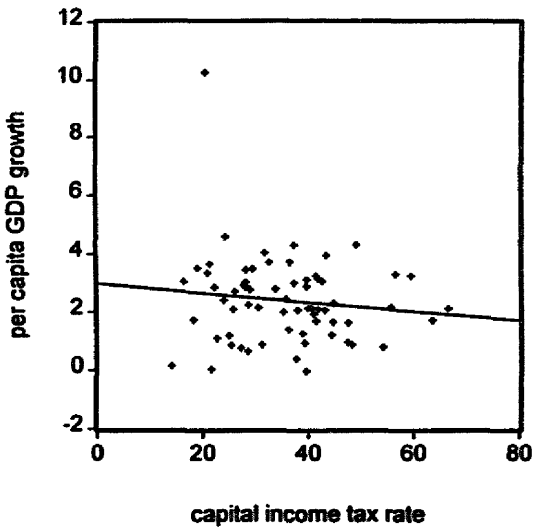


Fig. 4. Growth and the capital income tax.

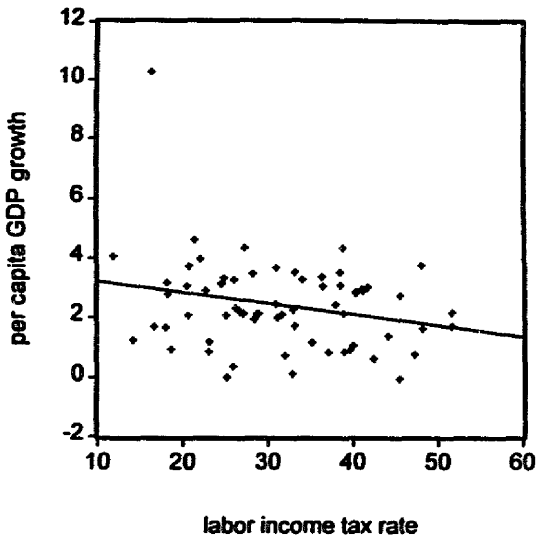


Fig. 5. Growth and the labor income tax.

and 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 that literature discovered, this result often disappears when other determinants of long-run growth are considered. Thus,

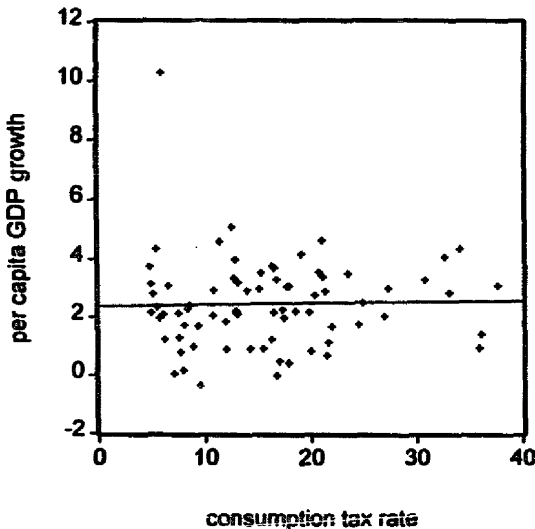


Fig. 6. Growth and the consumption tax.

Table 3

Tax rates, private investment, and growth: simple correlations for a panel of quinquennial 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 quinquennial average)	0.027	-0.122	-0.238
No. of observations	75	66	66
GDP growth (excluding Japan's first quinquennial average)	0.140	-0.020	-0.149
No. of observations	74	65	65

we need to examine the relationship between growth, investment, and taxes within the multivariate framework proposed by Barro (1991).

4. Tax structure, investment, and economic growth: econometric analysis

This section conducts an econometric analysis of the relationship between tax rates, the private investment rate (I/Y) and per-capita GDP growth in a panel of quinquennial averages for 18 OECD countries covering the period 1965–1991. The analysis uses the MRT tax rates on consumption ($TAXCON$), labor income ($TAXLAB$) and capital income ($TAXCAP$), and compares results obtained using these tax rates with those produced by a conventional measure of taxation (the ratio of individual income tax revenue to GDP, $TAXPERS$). Robustness tests are conducted by adding other growth determinants emphasized in the recent empirical literature on cross-country growth regressions, including initial GDP ($GDP\ 1965$), secondary education enrollment (SYR), changes in the terms of trade (TOT), and the GDP share of government purchases (G/Y).^{9,10} The regressions are estimated using the same standard panel techniques applied in the cross-country growth regression framework [see Barro and Sala-i-Martin (1995)], based on ordinary least squares (OLS) with heteroskedastic-consistent standard errors. Time dummies are added to control for common deterministic trends, and outliers are excluded according to a criterion that eliminates observations deviating more than two standard errors of a full-sample regression.

⁹GDP growth, $GDP1965$ and G/Y are taken from the Penn World Tables (mark 5.5), I/Y and TOT come from the OECD *National Income Accounts*, $TAXPERS$ is from OECD *Revenue Statistics* and SYR comes from Barro and Lee (1994).

¹⁰Results for all regressions are analogous if we use per capita GDP at the beginning of each five-year period, instead of GDP in 1965. We chose the latter approach because of concerns with stationarity.

4.1. Tax structure and private investment

We present below strong evidence showing that the MRT tax measures are key determinants of investment rates. This evidence is in contrast with the ambiguous investment effects that have been produced in other international and country-specific studies (see Bosworth (1993)). The relationship between taxes and investment is examined separately from the growth effects because, in the models we reviewed, taxes affect growth mainly through effects on the investment rate. Thus, although there are some theoretical models, and many empirical studies, that treat the investment rate as an exogenous growth determinant (see Levine and Renelt (1992); Mankiw et al. (1992); DeLong and Summers (1991); Barro and Sala-i-Martin (1995)), it is important to consider that failure to control for potential simultaneity bias between investment and growth may affect OLS estimates.

Table 4 presents the results of panel regressions of the private investment rate. Columns (1) and (2) are benchmark cases in which tax policy and the convergence factor (*GDP 1965*) are the only explanatory variables considered. The results reflect the intuition derived from the scatter diagrams in Figs. 1–3: both *TAXCAP*

Table 4
Regressions for private investment rate: panel data, five-year averages (1966–90)

Explanatory variables	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) INST	(6) INST
<i>GDP 1965</i>	-3.68 (3.33)	-4.67 (-4.59)	-5.37 (-4.68)	-6.79 (-5.42)	-3.31 (-2.18)	-5.08 (-6.08)
<i>TAXCON</i>	0.13 (2.59)		0.18 (5.12)		0.28 (5.21)	
<i>TAXLAB</i>	-0.18 (-3.98)		-0.22 (-4.95)		-0.21 (-3.23)	
<i>TAXCAP</i>	-0.09 (-2.38)		-0.14 (-3.75)		-0.12 (-2.09)	
<i>TAXPERS</i>		-0.04 (-0.97)		-0.01 (-0.17)		0.10 (1.21)
<i>TOT</i>			0.29 (2.55)	0.12 (0.84)	0.05 (0.51)	-0.08 (-0.62)
<i>SYR</i>			1.09 (4.18)	0.58 (1.97)	0.62 (1.99)	0.29 (0.88)
<i>G/Y</i>					-0.44 (-1.58)	-0.33 (-2.39)
Observ.	60	85	59	81	43	69
<i>R</i> ²	0.44	0.34	0.57	0.33	0.56	0.31

Note: 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 in regressions (5) and (6) are the first lags of the tax variables and *G/Y* and the current values of *GDP 1965*, *SYR* and *TOT*.

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 magnitudes are consistent with the numerical simulations reported in Table 1 and with the calculations of Harberger (1964b) for the U.S. economy.

A comparison of Columns (1) and (2) demonstrates the effectiveness of the MRT taxes relative to *TAXPERS*. In Column (2), *TAXPERS* is not significant for explaining *I/Y*, and, despite the larger number of observations (85), the regression explains only 34 percent of the cross-section variability of *I/Y*, compared to the regression in Column (1) (with 60 observations) which explains 44 percent.

The robustness of the investment effects of taxes is examined in Columns (3)–(6). It is well-known that the effects of most of the variables used in growth regressions, including taxes, tend to vary widely as the set of explanatory variables changes (see Easterly and Rebelo (1993a)). In contrast, the remarkable robustness of MRT taxes relative to *TAXPERS* is clearly illustrated in Columns (3) and (4), which add *SYR*, at the beginning of each quinquennial unit, and *TOT* as independent variables. The MRT taxes and these additional growth determinants are all statistically significant in Column (3), while Column (4) shows that using *TAXPERS* there are no statistically significant effects from *SYR*, *TOT* or *TAXPERS*. The information added by *SYR* and *TOT* strengthens the convergence effect and the effects of the MRT tax rates, and allows us to identify these effects with more precision. Indeed, 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 the regression with *TAXPERS* explains only about 1/3 of the movements in investment rates. These results highlight the difficulties inherent in making precise inferences about the relationship between taxes and investment when taxes are not measured properly.

Columns (5) and (6) add government expenditures to the set of explanatory variables. Following the standard practice of the growth regression framework [see Barro and Sala-i-Martin (1995)] the equation is estimated using instrumental variables (IV). In principle, IV estimation is desirable because of the possible endogeneity of tax rates and public expenditure, although it is extremely difficult in this context to propose instrumental variables that can be truly exogenous and mutually independent.¹¹ The instruments are the first lags of each tax rate and *G/Y*. Column (5) shows that 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.

To explore further the robustness of these results, we also estimated fixed effects

¹¹In fact, running the regressions using OLS yields similar results as using IV.

(FE) and random effects (RE) models (see the CEPR Working Paper version of this paper, Mendoza et al. (1996), for details). In the FE model, the effects of *TAXCON* and *TAXLAB* are significant and stronger than before, but the effect of *TAXCAP* is weaker, possibly because of simultaneity problems (the negative effect of higher *G/Y* on *I/Y* may absorb the effect of *TAXCAP*). The results of the RE model produce coefficients on *TAXLAB* and *TAXCAP* that are virtually identical to those in Columns (5)–(6). *TAXPERS* continues to perform poorly in both FE and RE models.

In summary, we found evidence showing that the MRT tax rates are robust determinants of the investment rate. 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 the claim of Harberger (1964b) that the mix between direct and indirect taxation should alter investment patterns, and they are also consistent with the results of the numerical simulations of growth models presented in Section 2. In contrast, the conventional measure of taxes (*TAXPERS*) does not have a statistically measurable effect on investment and is not robust across model specifications.

4.2. Tax structure and long-run growth

Table 5 reports the results of panel growth regressions. The first two columns regress growth on taxes, controlling only for initial income. Columns (3) and (4) add *TOT*, *SYR*, and *G/Y*, and Columns (5)–(6) add *I/Y* using the IV method. Since the theory of Section 2 showed that *I/Y* and growth are jointly determined by taxes and other exogenous variables, the regressions in Columns (1)–(4) can be interpreted as a reduced-form of a simultaneous equation system in which *I/Y* has been solved for. This approach is reasonable in light of the evidence showing that growth regressions fail robustness tests in part because of the mutual feedback between growth and its determinants. The IV models with *I/Y* as explanatory variable are an alternative approach to address the endogeneity problem, since the orthogonality condition between the errors and the explanatory variables is very likely to be violated. This is the approach commonly used in the growth regression literature [see Barro and Sala-i-Martin (1995)], although, as noted earlier, it is difficult to define good instruments for IV estimation in panel growth regressions. Thus, IV estimates are included here mainly to facilitate comparison with the existing literature. We also estimated the regressions using the Summers-Heston share of total investment in GDP, as an alternative to the private *I/Y* ratio. The results, not reported, are similar to those shown in Table 5.

Table 5 shows that tax rates are generally *not* statistically significant for explaining growth. The only variables that are significant in all regressions are initial income and the terms of trade. Thus, these panel regressions support Harberger's superneutrality conjecture, and the numerical predictions of endogenous growth models, regarding the negligible long-run growth effects of changes in

Table 5

Regressions for per-capita real output growth rate: panel data, five-year averages (1966–90)

Explanatory variables	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) INST	(6) INST
<i>GDP 1965</i>	-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>I/Y</i>					-0.08 (-0.94)	-0.00 (-0.06)
<i>TAXCON</i>	0.01 (0.64)		0.03 (1.57)		0.03 (1.30)	
<i>TAXLAB</i>	-0.01 (-0.56)		-0.02 (-1.02)		-0.04 (-1.68)	
<i>TAXCAP</i>	0.00 (0.52)		0.01 (0.57)		-0.01 (-0.54)	
<i>TAXPERS</i>		-0.03 (-1.36)		-0.02 (-0.76)		-0.02 (-0.88)
<i>TOT</i>			0.17 (4.37)	0.17 (4.64)	0.18 (4.21)	0.16 (4.35)
<i>SYR</i>			0.06 (0.63)	0.10 (1.20)	0.16 (1.40)	0.13 (1.36)
<i>G/Y</i>			-0.04 (-0.48)	0.00 (0.07)	-0.02 (-0.27)	0.02 (0.52)
Observ.	60	85	58	81	56	76
R^2	0.33	0.49	0.45	0.48	0.43	0.47

Note: 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 in regressions (5) and (6) are the first lags of *I/Y*, *G/Y* and the current values of *GDP 1965*, *SYR*, *TOT* and the tax variables.

tax rates.¹² Wald tests show, however, that the hypothesis that the coefficients on *TAXCON*, *TAXLAB*, and *TAXCAP* are jointly equal to zero is rejected by the data at the 1 percent significance level.

One important aspect of the growth regressions that deserves further comment is the sensitivity of the results to the procedure used to exclude outliers. Figs. 4–6 and Table 3 clearly suggest that outliers can be a problem in the growth regressions. As noted, we excluded outliers defined as observations that yield residuals larger than two standard errors of a full sample regression. Including the few outliers identified in this way, notably the first quinquennial average for Japan, yields in some instances statistically significant growth effects of taxes. However, the coefficient estimates are very small and similar to the ones reported. We also considered a more rigorous method to eliminate outliers based on leveraged-

¹²Growth regressions using *TAXPERS* have a higher R^2 than those using MRT taxes because the latter have fewer observations. If both regressions are run over a common sample, the fit using MRT taxes is better.

residual plots and Huber's M estimators. Outliers are so obvious in our analysis that the results obtained (available from the authors on request) are virtually identical to those produced with the simpler method.

Some limited evidence of statistically significant effects of taxes on per-capita GDP growth was found using a panel of annual data.¹³ These short-run effects are likely to capture transmission mechanisms different from those emphasized in the deterministic long-run growth models reviewed in Section 2. One of these mechanisms works through the variability of growth determinants, which in stochastic versions of endogenous growth models determines savings, investment, and growth (see Phelps (1962); Levhari and Srinivasan (1969); Fischer (1993); Hopenhayn and Muniagurria (1993); Mendoza (1996); Obstfeld (1994) and Ramey and Ramey (1995)). Another mechanism is the one that links the short and long-run effects of taxes. Changes in tax rates affect the long-run investment rate as the end result of a lengthy process of transition, even in cases in which long-run growth is invariant to changes in the investment rate and tax rates (see Lucas (1990) or Mendoza and Tesar (1998)). During the initial stages of transition, growth exceeds significantly its long-run constant rate, and then it monotonically declines as it converges to the balanced-growth path. Important transitional growth effects are also produced by models that explain international income disparities, as Parente and Prescott (1994) and Chari et al. (1996). In these models, convergence to the balanced-growth path is affected by stochastic taxes and barriers to technology adoption, and as a result investment and growth rates may not converge monotonically to their steady state and growth may not display high persistence. Thus, the finding that taxes may be statistically significant in annual growth regressions is best viewed as evidence suggesting that taxes affect mostly transitional growth, not long-run growth.

We conclude that the results of the growth regressions obtained using MRT tax rates are broadly in line with Harberger's superneutrality conjecture and with the quantitative predictions of endogenous growth models. There are no statistically significant effects of taxes on economic growth in the panel of 5-year averages, although there is some evidence of an effect of taxes on growth in an annual panel.

5. Conclusions

This paper provides evidence in support of Harberger's (1964a and 1964b) claim that, although theory predicts that the mix of direct and indirect taxes is an important determinant of long-run growth and investment rates, in practice plausible changes in tax rates are unlikely to affect growth, even if they can alter moderately the investment rate. The case in favor of this "superneutrality

¹³See Mendoza et al. (1996) for details.

conjecture” is presented in two steps. First, we analyze qualitatively and quantitatively the effects of changes in the tax structure on growth and investment in the class of endogenous growth models driven by human capital accumulation. Second, we conduct econometric tests based on a cross-country, time-series panel that includes new measures of tax rates and other determinants of GDP 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 growth and the investment rate. We start with a basic model in which human capital accumulation is a tax-free, non-market activity, leisure is “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 cuts on the investment rate are economically significant (about 0.5 to 1.5 percentage points) but the growth effects are very small, in the range of 0.1 to 0.2 of a percentage point – exactly as inferred by Harberger (1964b). These effects are 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 modeling leisure as quality time. In contrast, 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 of tax changes is also highly dependent on the specific tax considered. In general, changes in labor income taxes have stronger effects than changes in capital income and consumption taxes. 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 macroeconomic measures of effective tax rates on factor incomes and consumption proposed in a recent study by Mendoza et al. (1994), are roughly in line with the predictions from the theoretical framework and with Harberger’s superneutrality conjecture. Panel regressions based on 5-year averages are estimated using as explanatory variables tax rates, initial income levels, enrollment in secondary education, government purchases, and the terms of trade. Our results improve upon existing empirical studies in that the measures of tax rates used here are robust determinants of the private investment rate, in contrast with a conventional measure based on the ratio of income tax revenue to GDP. 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. In contrast, tax rates are not statistically-significant determinants of growth. This evidence is consistent with the numerical simulations of the models and with the estimates of Harberger (1964b). Moreover, there is some evidence that taxes affect growth in a panel of

annual data, lending support to stochastic models that emphasize the variability of growth determinants, or models in which taxes affect only transitional growth.

We side with Harberger in concluding that changes around current tax structures would need to be very large to result in noticeable effects on economic growth. We also note, however, that this result does not imply that tax reforms are worthless. The welfare gains of these reforms, induced by efficiency gains on the levels of consumption, investment and output, have been estimated to be quite large, even in settings in which taxes do not affect long-run growth (see Lucas (1990); Mendoza and Tesar (1998)).

Acknowledgements

We thank Mick Devereux, Arnold Harberger, Andrew Levin, Sergio Rebelo, Nouriel Roubini and Sunil Sharma for helpful comments and suggestions. Comments by seminar participants at the Board of Governors of the Federal Reserve, the College of William and Mary, UCLA and the University of Washington are also gratefully acknowledged. This paper reflects only the authors' views and not those of the Board of Governors of the Federal Reserve System or the International Monetary Fund.

References

- Barro, R.J., 1991. Economic Growth in a Cross-Section of Countries. *Quarterly Journal of Economics* 104, 407–444.
- Barro, R.J., Lee J.-W., 1994. Sources of Economic Growth, *Carnegie-Rochester Conference Series on Public Policy* 40, June, 1–46.
- Barro, R.J., Sahasakul, C., 1986. Average marginal tax rates from social security and the individual income tax. *Journal of Business* 59, no. 4, University of Chicago.
- Barro, R.J., Sala-i-Martin X., 1995. *Economic Growth*, McGraw-Hill Inc., New York, NY.
- Bosworth, B., 1993. *Savings and Investment in a Global Economy*, Brookings Institution, Washington D.C.
- Chari, V.V., Kehoe P.J., McGrattan E.R., 1996. The Poverty of Nations: a Quantitative Exploration, Federal reserve Bank of Minneapolis Staff Report no. 204, January.
- DeLong, J.B., Summers, L.H., 1991. Equipment Investment and Economic Growth. *Quarterly Journal of Economics* 106, 445–502.
- Devereux, M.B., Love, D.R., 1994. The Effects of Taxation in a Two-Sector Model of Endogenous Growth. *Canadian Journal of Economics* 27, 509–536.
- Devereux, M.B., Love, D.R., 1995. The Dynamic Effects of Government Spending Policies in a Two-Sector Endogenous Growth Model. *Journal of Money, Credit and Banking* 27, 232–256.
- Easterly, W., Rebelo, S., 1993. Marginal Income Tax Rates and Economic Growth in Developing Countries. *European Economic Review* 37, 409–417.
- Easterly, W., Rebelo, S., 1993. Fiscal Policy and Economic Growth: an Empirical Investigation. *Journal of Monetary Economics* 32, 417–458.

- Engen, E.M., Skinner J., 1992. Fiscal Policy and Economic Growth, NBER Working Paper No. 4223, National Bureau of Economic Research.
- Fischer, S., 1993. The Role of Macroeconomic Factors in Growth, *Journal of Monetary Economics* 32 (3), 485–512.
- Frenkel, J., Razin A., Sadka E., 1991. *International Taxation in an Integrated World*, Cambridge, Mass: MIT Press.
- Harberger, A.C., 1964. The Measurement of Waste, *American Economic Review* LIV, 58–76.
- Harberger, A.C., 1964b. Taxation, Resource Allocation and Welfare, in *The Role of Direct and Indirect Taxes in the Federal Revenue System*, NBER and the Brookings Institution eds., Princeton Univ. Press, NJ.
- Hopenhayn, H.A., M.E. Muniagurria, 1993. Policy Variability and Economic Growth, *Economics Working Paper 30*, Universitat Pompeu Fabra, Barcelona, February 1993.
- King, R.G., Plosser, C.I., Rebelo, S.T., 1988. Production, Growth and Business Cycles: I. The Basic Neoclassical Model. *Journal of Monetary Economics* 21, 195–232.
- King, R.G., Rebelo, S., 1990. Public Policy and Economic Growth: Developing Neoclassical Implications. *Journal of Political Economy* 98 (5, part 2), S126–S150.
- Koester, R., Kormendi, R., 1989. Taxation aggregate activity and economic growth: cross-country evidence on some supply-side hypotheses. *Economic Inquiry* 27, 367–386.
- Levhari, D., Srinivasan, T.N., 1969. Optimal Savings Under Uncertainty, *Review of Economic Studies*, 153–163.
- Levine, R., Renelt, D., 1992. A Sensitivity Analysis of Cross-Country Growth Regressions, *American Economic Review* 82, 942–963.
- Lucas, Jr. R.E., 1990. Supply-Side Economics: an Analytical Review, *Oxford Economic Papers* 42, 293–316.
- Mankiw, N.G., Romer, D., Weil, D.N., 1992. A Contribution to the Empirics of Economic Growth, *Quarterly Journal of Economics* 107, 407–437.
- Mendoza, E.G., 1996. Terms-of-Trade Uncertainty and Economic Growth: Are Risk Indicators Significant in Growth Regressions, forthcoming, *Journal of Development Economics*.
- Mendoza, E.G., Milesi-Ferretti G.M., Asea P., 1996. On the Ineffectiveness of Tax Policy in Altering Long-Run Growth: Harberger's Superneutrality Conjecture, CEPR Discussion Paper 1378, April.
- Mendoza, E.G., Razin, A., Tesar, L.L., 1994. Effective Tax Rates in Macroeconomics: Cross-Country Estimates of Tax Rates on Factor Incomes and Consumption, *Journal of Monetary Economics*, 34, 297–323.
- Mendoza, E.G., Tesar L.L., 1998. Supply-side economics in a global economy, forthcoming. *American Economic Review*.
- Milesi-Ferretti, G.M., Roubini N., 1995. Growth Effects of Income and Consumption Taxes: Positive and Normative Analysis, NBER Working Paper no. 5317, October.
- Milesi-Ferretti, G.M., Roubini N., 1996. On the Taxation of Human and Physical Capital in Endogenous Growth Models, mimeo, CEPR Discussion Paper No. 1477, November.
- Obstfeld, M., 1994. Risk-Taking, Global Diversification, and Growth, *American Economic Review* 84, 1310–1329.
- Organization for Economic Cooperation and Development, 1990. Revenue Statistics of OECD Member Countries 1965–1989, magnetic tape, Organization for Economic Cooperation and Development, Paris.
- Organization for Economic Cooperation and Development, 1991a. National Accounts, Detailed Tables: Volume II, magnetic tape, OECD, Paris.
- Organization for Economic Cooperation and Development, 1991b. Taxing Profits in a Global Economy: Domestic and International Issues, OECD, Paris.
- Parente, S.L., Prescott E.C., 1994. Barriers to Technology Adoption and Development, *Journal of Political Economy* 102, April, 298–321.
- Pecorino, P., 1993. Tax Structure and Growth in a Model with Human Capital. *Journal of Public Economics* 52, 251–271.

- Phelps, E.S., 1962. The Accumulation of Risky Capital: A Sequential Utility Analysis. *Econometrica* 30 (4), 729–743.
- Plosser, C.I., 1992. The Search for Growth, in *Policies for Long-Run Economic Growth*, Symposium Sponsored by the Federal Reserve Bank of Kansas City, Kansas City, MO.
- Ramey, G., Ramey, V.M., 1995. Cross-Country Evidence on the Link Between Volatility and Growth. *American Economic Review* 85 (5), 1138–1151.
- Razin, A., Sadka E., 1993. *The Economy of Modern Israel: Malaise and Promise*, The University of Chicago Press, Chicago, IL.
- Stokey, N.L., Rebelo, S., 1995. Growth Effects of Flat-Rate Taxes. *Journal of Political Economy* 103, 519–550.