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Endogenous Growth: Empirical Approaches

Marginal income tax rates and economic growth in developing countries*

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One of the central predictions of growth theory, old and new, is that income taxes have a negative effect on the pace of economic expansion. In the Cass–Koopmans version of the neoclassical model and in the Lucas (1988) model, a higher income tax rate reduces the steady-state ratio of physical capital to effective labor and leads to a temporary decline in the rate of growth. In the 'lab-equipment model' of Rivera-Batiz and Romer (1991) and in the models of Jones and Manuelli (1990) and Rebelo (1991), increases in income taxes lead to permanent declines in the rate of economic expansion.[1]

While the study of the effects of taxation in growth models continues to be an extremely active research area, there is little empirical work on this topic. This scarcity of empirical work is due to the difficulties involved in measuring the relevant marginal tax rates.

In this paper we experiment with a method of obtaining average marginal income tax rates that combines information on statutory rates with the amount of tax revenue collected and with data on income distribution. We apply this method to the countries included in Sicat and Virmani's (1988) summary of statutory income tax rates for 1984. The Sicat–Virmani data set includes fifty developing countries and three industrialized economies: the

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[1]See Rebelo and Stokey (1992) for a discussion of effects of taxation in models of the Lucas–Uzawa variety

U.S., Japan and Ireland. Our sample includes only 32 countries due to the scarcity of data on income distribution and on the amount of revenue collected in 1984.

The effects of income taxation on economic growth can be easily described in the context of a simple 'AK' model. In this model there is a single sector whose output (y_t) is a linear function of a comprehensive measure of the capital stock, which encompasses both physical and human capital (k_t): $y_t = Ak_t$.

Households have identical preferences, defined over consumption (c_t) sequences:

$$U = \int_0^{\infty} e^{-\rho t} \frac{c_t^{1-\theta} - 1}{1-\theta} \mathrm{d}t, \qquad \rho > 0, \quad \theta > 0, \tag{1}$$

but differ in their capital holdings. Given the linearity of the production function, the distribution of capital and the distribution of pre-tax income coincide. Both are described by the p.d.f. $\phi(y)$.

A household with income y pays taxes according to the non-linear tax schedule $\tau(y)$. $\tau(y)$ is not the statutory tax schedule but is the 'true' tax schedule faced by the household, after taking into account deductions and credits that increase with the income level as well as opportunities for tax avoidance and tax evasion.

The non-linearities in the tax schedule complicate the model to the point where the growth rate of income cannot be computed with pencil-and-paper methods. For this reason we will focus on the growth rate of consumption which is analytically more tractable.

The optimal growth rate of consumption for a household with pre-tax income y is a function of $\tau'(y)$, the marginal tax rate for that household:

$$g_c(y) = (1/\theta)\{[1 - \tau'(y)]A - \rho]\}. \tag{2}$$

The growth rate of per-capita consumption is

$$g_c = (1/C) \int_0^{\infty} \phi(y)\, c(y)\, g_c(y)\, \mathrm{d}y. \tag{3}$$

In this expression $c(y)$ is the optimal level of consumption chosen by a household with pre-tax income y, while C is the level of per capita consumption in the economy: $C = \int_0^{\infty} \phi(y)\, c(y)\, \mathrm{d}y$. Eq. (3) describes the rate of growth at time t, not the steady-state growth rate. Substituting $g_c(y)$ from (2) in eq. (3) it is easy to see that the growth rate of per capita consumption depends in a familiar fashion on the real interest rate (A), on the elasticity of intertemporal substitution ($1/\theta$), and on the pure rate of time preference (ρ):

$$g_c = (1/\theta)(A-\rho) - (A/\theta)(1/C)\int_0^\infty \phi(y)\,c(y)\,\tau'(y)\,\mathrm{d}y. \tag{4}$$

The new determinant of the rate of consumption expansion introduced by income taxation is the consumption-weighted average of marginal tax rates: $\Omega_c = (1/C)\int_0^\infty \phi(y)\,c(y)\,\tau'(y)\,\mathrm{d}y$.

This average marginal tax rate can in principle be computed using the data from income and expenditure surveys that is available for different countries. Unfortunately, we have been unable so far to obtain the breakdown of consumption by income classes that is needed to compute Ω_c. For this reason we will focus on the average marginal tax rate which can be computed with the data that is currently available – the income-weighted average marginal tax rate: $\Omega_Y = (1/Y)\int_0^\infty \phi(y)\,y\,\tau'(y)\,\mathrm{d}y$, where Y denotes per capita income defined as $Y = \int_0^\infty \phi(y)\,y\,\mathrm{d}y$.

Ω_Y can be computed using individual data on incomes and associated taxes, as in Barro and Sahasakul (1983, 1986) and in Gouveia and Strauss (1992). Unfortunately, this data is obtainable, at most, for a handful of countries.

Our method for computing Ω_Y makes use of all the information on income taxation that may be obtainable for a broad set of countries: income distribution data, statutory tax rates and information on the amount of revenue collected. Our key assumption is that the marginal tax rate schedule has a logistic functional form:

$$\tau'(y) = \frac{a_0}{1 + a_1 \exp(-a_2 y)}. \tag{5}$$

This function implies that the marginal tax rate takes values between two thresholds: $a_0/(1+a_1)$ (the lowest rate) and a_0 (the highest rate). For each country we set a_0 equal to the highest statutory rate for 1984 reported by Sicat and Virmani (1988). We experimented with two procedures for computing a_1.

The first procedure involves choosing a_1 so that $a_0/(1+a_1)$ coincides with the lowest statutory rate reported in Sicat and Virmani (1988). When we applied this method we found that about two thirds of the countries in our sample generated less revenue than the one that would be collected by implementing a linear tax with a rate that coincides with the lowest statutory rate. To avoid excluding these countries from the sample we divided iteratively the lowest statutory rate by 2 until our algorithm to choose a_2 (described below) converged.

The second procedure ignores the information on the lowest statutory rate and sets $a_0/(1+a_1)$ close to zero. The two methods produce similar values for the simple average of marginal tax rates, but the second method produces significantly higher income-weighted marginal tax rates. However, the correlation between the income-weighted average marginal tax rates obtained under the two methods is extremely high: 93%.

Eq. (5) implies that the tax schedule has the form

$$\tau(y) = a_0 y + (a_0/a_2)\log[1 + a_1 \exp(-a_2 y)] + a_3 \quad \text{for} \quad y > \underline{y},$$
$$\tau(y) = 0 \quad \text{for} \quad y < \underline{y}. \tag{6}$$

The information reported in Sicat and Virmani (1988) for the income threshold that corresponds to zero income tax [i.e. the value $\underline{y}$ such that $\tau(\underline{y}) = 0$] was used to choose a_3.

Finally, the parameter a_2 in eqs. (5) and (6) was chosen to ensure that the tax revenue implied by the tax schedule $\tau(y)$ coincides with the tax revenue that was actually collected:

$$\text{Tax Revenue Collected} = \int_0^{\infty} \phi(y)\,\tau(y)\,\mathrm{d}y. \tag{7}$$

The data on the amount of personal income tax revenue collected in 1984 was obtained from the International Monetary Fund's *Government Financial Statistics*.

This revenue consistency requirement allows us to correct the statutory tax schedule to account for tax avoidance and tax evasion as well as for deductions and credits. This requirement implies that countries that have high statutory schedules but collect very little revenue have a $\tau(y)$ schedule that is close to the low tax rate for the levels of income where there is significant probability mass.

Using the amount of revenue collected to choose the shape of the tax function is likely to underestimate the distortions caused by taxation; it is possible to significantly distort behavior while generating little revenue. An extreme example of this bias would be present if the income tax schedule entailed two tax rates, a zero tax rate for incomes up to y^0 and a 100% marginal tax rate for incomes above y^0. With this tax system it would be unlikely to observe incomes above y^0; the tax collected would be zero and our method would produce a zero average marginal tax rate. However, this tax system is far from being distortion free: the relevant marginal tax rate, for households with income y^0 is 100%.

To implement the revenue consistency condition in eq. (7) we need to know the income p.d.f. $\phi(y)$. We assumed that income follows a log-normal distribution with mean μ and variance σ^2.

For each country the parameter σ was chosen to be the one that minimizes the sum of absolute differences between the empirical Lorenz curve and the theoretical Lorenz curve implied by the lognormal distribution: $\mathscr{L}(x)=\mathrm{N}[\mathrm{N}^{-1}(x)-\sigma]$; where $\mathscr{L}(x)$, represents the fraction of aggregate income held by the poorest $x\%$ of the population, N(.) is the cumulative normal distribution and $\mathrm{N}^{-1}(.)$ its inverse. All calculations were carried out by using Lorenz curves expressed in terms of quintiles and of the upper decile. Most of our income distribution data was obtained from the World Bank data. A detailed description of data sources is available in our working paper version of this article.

We followed Sicat and Virmani (1988) in assuming that the income tax is paid at the level of the household and that each household has five members. The value of μ was chosen so that the mean of income is equal to $\exp[\mu+(1/2)\sigma^2]$. Household income was computed as five times personal income, which is the income concept reported in the National Income Accounts that is closest to the income tax base. The income tax base in the sample used by Gouveia and Strauss (1992) in their estimation of U.S. marginal tax rates represents on average, from 1979 to 1987, 81% of personal income. In countries for which there is no personal income data, we extrapolated the ratio of personal income in GDP by running a regression of this ratio on the Summers and Heston (1991) purchasing-parity-power-adjusted real income in 1980.[2] Improving on this extrapolation procedure would greatly enhance the quality of our tax rate estimates.

The value of μ allows us to calculate a_2 using the revenue consistency requirement and proceed to compute the marginal tax schedule, as well as its income-weighted average Ω_y.

Table 1 summarizes some of the information used to produce our marginal tax rate estimates: σ [the estimate of the standard deviation of log(y)], the fraction of personal income in GDP [countries for which this number was extrapolated are marked with an (e)], the lowest and highest statutory tax rate, the income threshold $\underline{y}$, and the revenue collected (both expressed as a fraction of personal income). Table 2 reports our estimates for the simple and income-weighted marginal tax rate computed using the two methods for choosing a_1 described before. Column (3) of this table reports the value of the lowest effective rate $(a_0/(1+a_1))$ adopted as a fraction of the lowest statutory rate.

Our marginal income tax rates estimates are closest in spirit to the 'effective tax rates' computed by Gouveia and Strauss (1992) with panel data, by regressing individual taxes on individual incomes, using a non-linear

[2]We used a sample of 30 observations, which included mostly OECD countries. The regression results were (t-statistics in parentheses):

$$\text{Personal Income/GDP} = 0.23 + 0.07 \times \text{Summers–Heston GDP}.$$
$$(0.92)\quad(2.44)$$

The R^2 of this regression is 0.20.

Table 1

	σ	Revenue/ Personal income	Lowest marginal statutory tax rate	Highest marginal statutory tax rate	Income threshold/ Personal income	Personal[a] income/ GDP
Argentina	0.7881	0.0002	0.064	0.54	1.4536	0.7890(e)
Brazil	1.1708	0.0338	0.05	0.60	0.7412	0.7960(e)
Chile	0.9555	0.0159	0.08	0.54	1.1772	0.8070
Colombia	0.9253	0.0175	0.07	0.49	0.0706	0.8500
C. d'Ivoire	0.9145	0.0229	0.025	0.725	0.0000	0.7340(e)
Egypt	0.7504	0.0063	0.02	0.73	0.4564	0.7230
Ghana	0.6594	0.0088	0.05	0.60	0.0288	0.6940(e)
Greece	0.7000	0.0557	0.121	0.69	0.6221	0.8680
Guatemala	0.9750	0.0040	0.050	0.48	1.6579	0.7600(e)
India	0.6001	0.0126	0.33	0.62	2.3529	0.6630(e)
Indonesia	0.5868	0.0107	0.15	0.35	1.7942	0.7190(e)
Ireland	0.5946	0.1466	0.35	0.66	0.1956	0.8180
Jamaica	0.8269	0.0763	0.30	0.575	0.5952	0.7560(e)
Japan	0.3987	0.0523	0.145	0.84	0.1247	0.8820
Korea	0.7026	0.0263	0.071	0.701	0.4887	0.7890
Malaysia	0.8750	0.0312	0.06	0.55	0.5912	0.7950(e)
Mexico	1.1398	0.0225	0.031	0.55	0.1722	0.8130(e)
Morocco	0.5344	0.0315	0.003	0.802	0.0000	0.7400(e)
Pakistan	0.7332	0.0101	0.15	0.60	1.2518	0.7033(e)
Peru	0.8975	0.0014	0.02	0.65	1.0049	0.8160
Philippines	0.7995	0.0104	0.01	0.35	0.5598	0.7860
Portugal	0.6748	0.0265	0.055	0.955	0.1783	1.2220
Senegal	1.1334	0.0342	0.05	0.65	0.6931	0.7070(e)
Singapore	0.8241	0.1030	0.036	0.405	0.0956	0.8370(e)
Sri Lanka	1.0057	0.0143	0.093	0.615	0.3722	0.8060
Tanzania	0.7873	0.0276	0.20	0.95	1.0648	0.6480(e)
Thailand	0.8104	0.0230	0.07	0.65	0.6300	0.7460(e)
Tunisia	0.9865	0.0261	0.053	0.893	0.2474	0.7680(e)
Turkey	1.0981	0.0763	0.36	0.65	0.0780	0.7690(e)
U.S	0.6965	0.0949	0.11	0.50	0.1418	0.8460
Zambia	1.0030	0.0410	0.05	0.80	1.3941	0.5380
Zimbabwe	1.2852	0.1090	0.12	0.63	0.4603	0.7170(e)

[a]The symbol (e) denotes observations that were obtained by extrapolating on the basis of a regression with a sample of 30 observations, which included mostly OECD countries The regression results were (t-statistics in parentheses).

$$\text{Personal Income/GDP} = \underset{(0.92)}{0.23} + \underset{(2.44)}{0.07} \times \text{Summers–Heston GDP}$$

The R^2 of this regression is 0.20

functional form suggested by the equal sacrifice theory of taxation. Our estimates for the U.S. (12% for the simple average and 24% for the income-weighted average) are higher than their estimates for 1984 (14% for the simple average and 18% for the income-weighted average) but lower than Barro and Sahasakul's (1986) income-weighted marginal tax estimate for 1983: 27.2%. The Barro–Sahasakul estimates are higher because they use the

Table 2

Average marginal tax rates.

	Computed with $a_0/(1+a_1)\simeq 0$		Computed with $a_0/(1+a_1)$ = lowest statutory rate × factor in column (3)		
	Simple average (1)	Income-weighted average (2)	Factor (3)	Simple average (4)	Income-weighted average (5)
Argentina	2.3799e-4	6.1108e-4	0.0156	2.3799e-4	6.1108e-4
Brazil	0.0094	0.0852	1.0000	0.0217	0.0578
Chile	0.0074	0.0479	0.5000	0.0125	0.0330
Colombia	0.0100	0.0502	0.2500	0.0184	0.0201
C. d'Ivoire	0.0128	0.0679	0.5000	0.0198	0.0400
Egypt	0.0056	0.0220	0.5000	0.0080	0.0102
Ghana	0.0099	0.0294	0.1250	0.0098	0.0130
Greece	0.0648	0.1988	1.0000	0.0766	0.1036
Guatemala	0.0016	0.0137	0.2500	0.0026	0.0094
India	0.0169	0.0557	1.0000	0.0173	0.0537
Indonesia	0.0158	0.0441	1.0000	0.0164	0.0404
Ireland	0.2350	0.3726	0.5000	0.1822	0.1869
Jamaica	0.0685	0.1946	0.5000	0.0887	0.1298
Japan	0.1328	0.2047	0.2500	0.0750	0.0850
Korea	0.0282	0.0878	0.5000	0.0351	0.0490
Malaysia	0.0212	0.0893	1.0000	0.0342	0.0516
Mexico	0.0069	0.0589	0.5000	0.0169	0.0390
Morocco	0.0545	0.1156	1.0000	0.0519	0.1019
Pakistan	0.0090	0.0370	0.2500	0.0118	0.0260
Peru	9.5044e-4	0.0048	0.1250	0.0012	0.0034
Philippines	0.0085	0.0327	1.0000	0.0113	0.0228
Portugal	0.0298	0.0928	0.5000	0.0321	0.0359
Senegal	0.0105	0.0883	1.0000	0.0237	0.0584
Singapore	0.1058	0.2215	1.0000	0.1078	0.1814
Sri Lanka	0.0060	0.0108	0.1250	0.0116	0.0279
Tanzania	0.0216	0.0929	0.2500	0.0286	0.0691
Thailand	0.0177	0.0728	0.5000	0.0260	0.0448
Tunisia	0.0114	0.0771	0.5000	0.0257	0.0395
Turkey	0.0331	0.1752	0.1250	0.0614	0.1222
U.S	0.1217	0.2363	1.0000	0.1099	0.1109
Zambia	0.0178	0.1137	1.0000	0.0240	0.0979
Zimbabwe	0.0333	0.2187	1.0000	0.0684	0.1666

marginal statutory rate to measure the additional tax liability which a household will incur if it earns an additional dollar of income. The Gouveia–Strauss measure takes into account the marginal tax actually paid when an extra dollar is earned. This marginal tax is lower than the statutory rate because with an additional dollar new opportunities for deductions, credits, tax avoidance and tax evasion arise.

Whether statutory rates or effective rates (that is the additional tax effectively paid if the household earns an extra dollar) are relevant depends on the type of decision being considered. If as income goes up, deductions, credits and opportunities for tax evasion automatically increase, the effective tax rate is the one that determines the household's behavior. But if deductions, credits and tax evasion require re-arranging the consumption and production patterns of the household, it is the statutory tax rate that is relevant.

As a test of the results produced by our method we multiplied the U.S. personal income by 81% [the ratio of the income tax base to personal income in the Gouveia–Strauss (1992) sample], choosing $a_0/(1+a_1)$ to be equal to the lowest statutory rate (0.11). We obtained estimates for the simple and income-weighted average marginal rates of 14% and 17%, respectively. These estimates turn out to be remarkably close to the ones obtained by Gouveia and Strauss (1992): 14% and 18% respectively. Partly for this reason, we view the estimates reported in columns (4) and (5) (which use information on the lowest statutory rate) as the most plausible.

As we would expect, there is a positive correlation between our income-weighted average marginal tax rates and the level of real per capita income. This simply reflects the fact that developed economies tend to rely more on income taxes than less developed countries.

Even though our marginal tax rate estimates are very preliminary we investigated whether they would have explanatory power in a Barro (1991)-type cross-country regression. We regressed the least squares growth rate of per capita consumption for the period from 1970 to 1988 on the level of real per capita GDP in 1970, on proxies for human capital (primary and secondary enrollment in 1960), measures of political instability (number of revolutions and coups and of assassinations from 1970 to 1985). We obtained a negative but statistically insignificant coefficient when we included (one at a time) our two measures of marginal income tax rates, reported in columns (2) and (5). In fact, probably as a result of the extremely small number of observations, we could not reject the hypothesis that the coefficients on all the regressors in the equation are zero. It is clearly essential to enlarge the sample before proceeding with an in-depth cross-section study.

Our estimates of average marginal tax rates can be significantly improved, both in terms of country coverage and in terms of the quality of the underlying data. The number of countries in our sample can be significantly enlarged by collecting data on the statutory income tax schedules of the OECD countries that were excluded from the Sicat–Virmani (1988) study. One avenue for improving the quality of our estimates involves improving the personal income estimates and obtaining more information on the relation between this concept and the base of the income tax. The possibility of estimating marginal income tax rates suggests two lines of research: the study of the properties of models with non-linear income taxes and the search for the adequate empirical strategies to test those models with cross-country data.

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