Endogenous Growth with Public Capital and Progressive Taxation

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Abstract

This paper considers an endogenous growth model with public capital and heterogeneous agents. Government expenditures, including public investment, are financed through a progressive income taxation scheme along with a flat tax on consumption. The model is calibrated to the postwar U.S. economy. Three major fiscal policy reforms are considered: (i) an increase in the degree of progressivity of the tax schedule, (ii) the adoption of a flat income tax rate, and (iii) an increase in the fraction of output allocated to public investment. The effects of each of these reforms on the economy's growth rate and income distribution are analyzed. It is shown that along the balanced growth path increasing investment in public capital is the only type of policy that simultaneously enhances growth and reduces income inequality.

Keywords: Nonlinear Income Taxation; Endogenous Growth; Taxes; Welfare; Government Expenditure

JEL Classification: E62; E21; H21

1 Introduction

Investment in public capital has long been recognized as one of the main driving forces of economic growth. In an influential study, Aschauer (1989) finds that public infrastructure has a strong positive impact on aggregate productivity in the U.S. economy. A large number of studies followed that used a wide variety of econometric techniques and data sets. Reviewing the empirical evidence provided by these studies, Glomm and Ravikumar (1997) argue that Aschauer's estimate of an output elasticity with respect to public capital of 0.39 appears to be too large and cite a wide range of estimates obtained starting from a value as low as 0.03.

Romp and de Haan (2007) review more recent empirical studies that examine the relationship between public capital and growth. They find that at present there is a bigger consensus regarding the growth-enhancing effect of public capital than in the past. Furthermore, the effect of public capital on growth appears to be significantly weaker compared to Aschauer's initial estimate and differs substantially across countries, regions and sectors.

Canning and Pedroni (2008) study the impact of various types of infrastructure provision in a panel of 67 countries during the period 1950−1992. They find that while infrastructure tends to have a positive impact on long-run growth, there is substantial variation across countries. They also provide evidence that the various infrastructure types provided are close to their growth-maximizing levels on average globally, but they are under-supplied in some countries and over-supplied in others.

The relationship between public investment and economic growth has been the subject of extensive research at the theoretical level as well.[1] However, the vast majority of the models considered in the related literature assume that the accumulation of public capital is financed through flat-rate taxes.[2] Hence, the fact that actual tax codes are generally progressive is ignored. Furthermore, these models employ a representative agent framework. As a consequence, the effects of fiscal policy reform on the income distribution are overlooked.

[1]Noticeable contributions include, among many others, Barro (1990), Futagami et al. (1993), Turnovsky and Fisher (1995), Turnovsky (1997) and Cassou and Lansing (1998). A detailed survey of the different modelling strategies and results is provided by Irmen and Kuehnel (2009).

[2]For example, see Baxter and King (1993), Cassou and Lansing (1998), Angelopoulos et al. (2012) and Papageorgiou (2012).

Li and Sarte (2004) explore the effects of progressive taxation in conventional endogenous growth models with heterogeneous households. One of the models they consider is that of Barro (1990) in which all tax revenue raised by the government is used to finance public services that enhance private production.

In the framework used by Barro, public services are a flow variable. Futagami et al. (1993) argue that several types of public infrastructure are actually stock variables in nature. In addition, as mentioned earlier, several empirical studies support the importance of public capital in private production. For these reasons, Futagami et al. introduce public capital along with private capital as an input in the production process and study its implications for the economy's long-run growth rate and transitional dynamics.

This paper considers a discrete version of the endogenous growth model with public capital of Futagami et al. with heterogeneous agents. Government expenditures, including public investment, are financed through a progressive taxation scheme along with a flat consumption tax.

The merits of the consumption tax have been analyzed at both the theoretical and empirical levels. Turnovsky (1996) uses an endogenous growth model to discuss the trade-off between consumption and income taxes in achieving the first-best optimum. His analysis suggests that there is potentially an important role for a consumption tax as part of an overall optimal fiscal package.

Arnold (2008) studies the relationship between different tax structures and economic growth for a panel of 21 OECD countries. His results suggest that income taxes are generally associated with lower economic growth compared to consumption and property taxes. Arnold also finds evidence of a negative relationship between the progressivity of personal income taxes and growth.

In the present paper, three major fiscal policy reforms are considered: (i) an increase in the degree of progressivity of the tax schedule, (ii) the adoption of a flat income tax rate, and (iii) an increase in the fraction of output allocated to public investment. The model is calibrated to the postwar U.S. economy. We analyze the effects of each of these reforms on the economy's growth rate and income distribution. The model is tractable enough that allows the study of the implications of a change in fiscal policy for both the economy's growth rate and income distribution. It is shown that increasing the progressivity of the income tax schedule or adopting a flat income tax rate has a small impact on the long-run growth rate. In contrast, increasing the fraction of output that is allocated to public investment has a positive and significant effect on the growth rate. In addition, all three of the above fiscal policy reforms generate substantial changes in the pre-tax income distribution. In the case of a flat income tax rate the distribution becomes more unequal. In contrast, both the increase in the progressivity of the income tax schedule and the increase in public investment reduce pre-tax inequality.

The paper is organized as follows. Section 2 presents the model with public capital and progressive taxation. Section 3 discusses the calibration of the model. Section 4 discusses the simulation results. The final section concludes.

2 The Model

Consider a closed economy populated by a large number of households that are uniformly distributed in the interval $[0, 1]$. Assume that there are N types of households. Each type is indexed by a discount factor β_j where

$$0 < \beta_1 < \ldots < \beta_N < 1.$$

The measure of households within each group is $1/N$. Assuming that households differ in their rates of impatience allows us to obtain a non-degenerate distribution of income and wealth that is quite tractable.

There are alternative ways in which heterogeneity can be introduced in an otherwise standard growth model relative to the one adopted in the present context. For instance, García-Peñalosa and Turnovsky (2011) examine how changes in tax policies affect the wealth and income distribution in a neoclassical growth model in which agents differ in their initial capital endowments. Carroll and Young (2011) consider a similar environment in which heterogeneous households differ in terms of their discount factors and permanent labor productivity. In their framework, there is a progressive income tax schedule that is used to finance wasteful government expenditures. Koyuncu (2011) develops an endogenous growth model in which agents are heterogeneous in their rates of time preference and labor skills. The model of this author incorporates progressive income taxes used to finance wasteful government expenditures.

In the present context, a single final good is produced using private capital, K_t, and public capital, K_{gt}, according to the production function:

$$Y_t = AK_t^{\alpha} K_{gt}^{1-\alpha},$$

where $0 < \alpha < 1$ and $A > 0$. In the absence of labor, we consider K_{gt} as a composite capital good that incorporates both human and physical capital components. There exists a large number of profit-maximizing firms that each period solve the static optimization problem:

$$\max_{K_t} \Pi_t = AK_t^{\alpha} K_{gt}^{1-\alpha} - r_t K_t - \delta_K K_t, \tag{1}$$

where r_t denotes the rental rate of aggregate private capital. The depreciation rate of the private capital stock is denoted by $0 < \delta_K < 1$. Profit maximization yields

$$r_t = \alpha A \left(\frac{K_{gt}}{K_t} \right)^{1-\alpha} - \delta_K. \tag{2}$$

Next, we describe the modeling of tax policy implemented by the government. The government is assumed to maintain a balanced budget in each period. Following the specification of Guo and Lansing (1998) and Li and Sarte (2004), the government chooses a tax schedule summarized by the tax rate, $\tau\left(\widehat{y}_j/\widehat{Y}_j\right)$, where $\widehat{y}_j$ denotes household income and $\widehat{Y}$ represents the economy-wide average aggregate taxable income in a particular period. This specification implies that the tax rate that applies to a given household depends only on its relative standing in the economy.[3]

We further assume that the tax schedule is given by

$$\tau\left(\frac{\widehat{y}_j}{\widehat{Y}}\right) = \zeta \left(\frac{\widehat{y}_j}{\widehat{Y}}\right)^{\phi}, \qquad \forall j = 1, \ldots, N \tag{3}$$

where $0 \leq \zeta < 1$ and $\phi > 0$. Parameter ζ determines the level of the tax schedule, while parameter ϕ determines its slope. When $\phi > 0$, the tax rate τ increases with the household's taxable income. In other words, households with higher taxable income are subject to higher tax rates. The most commonly case considered in the literature is that of proportional taxation. This case corresponds to setting $\phi = 0$ in (3). This implies that $\tau\left(\widehat{y}/\widehat{Y}\right) = \zeta$. In making decisions how much to consume and invest over their lifetimes, households take into account the way in which the tax schedule affects their after-tax earnings.

[3] This modeling assumption ensures that not all households eventually face the highest marginal tax rate simply as a result of economic growth. In other words, it allows us to abstract from the so-called "bracket-creep" considerations.

When studying progressive tax schedules, it is important to distinguish between marginal and average tax rates. The total amount of taxes paid by a household with income $\widehat{y}_j$ is equal to the product $\tau\left(\widehat{y}_j/\widehat{Y}\right)\widehat{y}_j$, where the tax rate is given by (3). The marginal tax rate, $\tau_m\left(\widehat{y}_j/\widehat{Y}\right)$, which is the tax rate applied to the last dollar earned, is given by

$$\tau_m\left(\widehat{y}_j/\widehat{Y}\right)=\frac{\partial\left[\tau\left(\widehat{y}_j/\widehat{Y}\right)\widehat{y}_j\right]}{\partial\widehat{y}_j}=(1+\phi)\,\zeta\left(\frac{\widehat{y}_j}{\widehat{Y}}\right)^{\phi}. \tag{4}$$

On the other hand, the average tax rate, $\tau_a\left(\widehat{y}_j/\widehat{Y}\right)$, is simply equal to $\tau\left(\widehat{y}_j/\widehat{Y}\right)$.

The ratio of the marginal to the average tax rate is an indication of the progressivity of the tax schedule. A tax schedule is more progressive the more the marginal tax rate exceeds the average tax rate at all levels of income. Combining (3) and (4) yields

$$\frac{\tau_m\left(\widehat{y}_j/\widehat{Y}\right)}{\tau_a\left(\widehat{y}_j/\widehat{Y}\right)}=1+\phi.$$

As a result, parameter ϕ captures the degree of progressivity in the tax schedule. If $\phi=0$, then $\tau_m\left(\widehat{y}_j/\widehat{Y}\right)=\tau_a\left(\widehat{y}_j/\widehat{Y}\right)$ and the tax schedule is "flat". As Li and Sarte (2004) argue, this specification allows for an explicit analysis of how changes in ϕ simultaneously influence both the distribution of pre-tax income and the economy's growth rate.

The income tax revenues raised by the government are used to finance a portion of its spending. Government expenditures, G_t, consist of public investment, I_{gt}, and public consumption, C_{gt}:

$$G_t=I_{gt}+C_{gt}. \tag{5}$$

Households are assumed to derive utility from public consumption goods as a share of output, $g_{Ct}\equiv C_{gt}/Y_t$. On the other hand, public investment leads to the accumulation of public capital:

$$I_{gt}=K_{gt+1}-(1-\delta_G)\,K_{gt}, \tag{6}$$

where $0 < \delta_G < 1$ is the depreciation rate of K_g. As it is clearly shown by expression (2), a larger stock of public capital raises the productivity of private capital.

An additional source of revenue for the government besides income tax revenues consists of revenues collected from taxing consumption. Using (3), income tax revenues are given by

$$\sum_{j=1}^{N} \tau_{jt}\widehat{y}_{jt}\left(\frac{1}{N}\right) = \sum_{j=1}^{N} \zeta \left(\frac{\widehat{y}_{jt}}{\widehat{Y}_t}\right)^{\phi} \widehat{y}_{jt}\left(\frac{1}{N}\right).$$

Revenues raised through the tax on consumption are equal to ωC_t, where $C_t = \sum_{j=1}^{N} c_{jt}(1/N)$ denotes aggregate consumption at time t and c_{jt} represents the consumption of a household of type j. Parameter $0 \leq \omega < 1$ denotes a flat and time-invariant consumption tax. The government is assumed to maintain a balanced budget in every period:

$$G_t = I_{gt} + C_{gt} = \sum_{j=1}^{N} \zeta \left(\frac{\widehat{y}_{jt}}{\widehat{Y}_t}\right)^{\phi} \widehat{y}_{jt}\left(\frac{1}{N}\right) + \omega C_t. \tag{7}$$

Each household of type j chooses paths for consumption, $\{c_{jt}\}_{t=0}^{\infty}$ and private capital, $\{k_{jt+1}\}_{t=0}^{\infty}$, to maximize lifetime utility

$$\sum_{t=0}^{\infty} \beta_j^t \left[\frac{c_{jt}^{1-\sigma} - 1}{1-\sigma} + B\ln(g_{Ct})\right], \qquad \sigma > 0, B > 0, j = 1, \ldots, N, \tag{8}$$

subject to the flow budget constraint

$$(1+\omega)\, c_{jt} + k_{jt+1} = \left[1 - \zeta\left(\frac{\widehat{y}_{jt}}{\widehat{Y}_t}\right)^{\phi}\right] \widehat{y}_{jt} + k_{jt} \tag{9}$$

where

$$\widehat{y}_{jt} = r_t k_{jt} + \pi_{jt}, \tag{10}$$

$$\widehat{Y}_t = \sum_{j=1}^{N} \widehat{y}_{jt}\frac{1}{N} \tag{11}$$

and $c_{jt}, k_{jt} \geq 0$ for all j and t, and $k_{j0} > 0$ for each type j. Variable π_{jt} denotes the profits share of each household of type j.[4]

As pointed out by Lansing (1998), the specification of additive separability in public consumption goods is supported by the empirical estimates in McGrattan, Rogerson and Wright (1997) based on postwar U.S. data. This specification simplifies the computations, since the term involving g_{Ct} in the utility function can be ignored when the optimality conditions for the household's problem are derived.

In maximizing (8), all households take the sequence of prices $\{r_t\}_{t=0}^{\infty}$, profits $\{\Pi_t\}_{t=0}^{\infty}$ and the government's fiscal policy as given. The following Euler equation is obtained for each household of type j:

$$\left(\frac{c_{jt+1}}{c_{jt}}\right)^{\sigma} = \beta_j \left\{ \left[1 - (1+\phi)\,\zeta \left(\frac{\widehat{y}_{jt+1}}{\widehat{Y}_{t+1}} \right)^{\phi} \right] r_{t+1} + 1 \right\}, \tag{12}$$

where $j = 1, \ldots, N$.

Finally, aggregating budget constraint (9) across all household types and using (1), (7), (10) and (11) yields the economy-wide resource constraint:

$$C_t + G_t + K_{t+1} - (1 - \delta_K)\, K_t = A K_t^{\alpha} K_{gt}^{1-\alpha}. \tag{13}$$

Along a balanced-growth path equilibrium all individual and aggregate variables grow at the same constant rate γ. Furthermore, in this long-run equilibrium, relative income $\widehat{y}_j/\widehat{Y}$ is constant for each j. Evaluating the Euler equation (12) along the balanced growth equilibrium and using (2) yields:

$$\gamma^{\sigma} = \beta_j \left\{ \left[1 - (1+\phi)\,\zeta \left(\frac{\widehat{y}_j}{\widehat{Y}} \right)^{\phi} \right] \left(\alpha A \left(\frac{K_g}{K} \right)^{1-\alpha} - \delta_K \right) + 1 \right\}, \qquad j = 1, \ldots, N \tag{14}$$

where K_g/K is the constant ratio of public to private capital.

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[4] Note that GDP is given by $A K_t^{\alpha} K_{gt}^{1-\alpha}$. This is not equal to $\widehat{Y}_t$ since the latter represents the household's taxable income which consists of the sum of its capital income and profits dividend minus the private capital stock depreciation allowance. Formally,

$$\widehat{Y}_t = Y_t - \delta_K K_t.$$

Combining (1) and (2) implies that aggregate profits in the long-run equilibrium are given by $\Pi = (1-\alpha) AK^{\alpha} K_g^{1-\alpha}$. Hence, aggregating income (10) across all types and evaluating it along the balanced growth path yields

$$\frac{\widehat{Y}}{K} = A\left(\frac{K_g}{K}\right)^{1-\alpha} - \delta_K. \tag{15}$$

We also make the assumption that the governments allocates a constant proportion $0 < g_I < 1$ of every period's output to public investment:

$$I_{gt} = g_I A K_t^{\alpha} K_{gt}^{1-\alpha}. \tag{16}$$

Dividing both (6) and (16) by K_t, evaluating the resulting expressions along the balanced growth path and combining them yields

$$g_I = \frac{\gamma - (1-\delta_G)}{A}\left(\frac{K_g}{K}\right)^{\alpha}. \tag{17}$$

Combining the government's balanced budget constraint (7) with the economy-wide resource constraint (13) along the balanced growth path, and substituting for the taxable income-to-private capital ratio from (15) we obtain:

$$\frac{G}{K} = \left(\frac{1}{1+\omega}\right)\left[A\left(\frac{K_g}{K}\right)^{1-\alpha} - \delta_K\right]\left[\omega + \sum_{j=1}^{N}\zeta\left(\frac{\widehat{y}_j}{\widehat{Y}}\right)^{1+\phi}\left(\frac{1}{N}\right)\right] + \frac{(1-\gamma)\,\omega}{1+\omega}. \tag{18}$$

In the long-run equilibrium, the growth rate, γ, the public capital-to-private capital ratio, K_g/K, the ratio of government expenditures to private capital, G/K, and the relative income earned by households of different types, $\widehat{y}_j/\widehat{Y}$, are being simultaneously determined from a system of $N+3$ equations in $N+3$ unknowns. These equations are (14), (17), (18) and

$$\sum_{j=1}^{N}\left(\frac{\widehat{y}_j}{\widehat{Y}}\right)\frac{1}{N} = 1. \tag{19}$$

Equation (19) is simply condition (11) evaluated along the balanced growth path.

3 Calibration

To investigate the quantitative implications of the model, we assign values to parameters based on empirically observed features of the postwar U.S. economy. These values are reported in Table 1 below. Table 2 displays the main properties of the model economy in the long run and their data counterparts.

Based on data obtained from the Bureau of Labor Statistics, the average long-run growth rate of real output per capita during the period 1961-2010 was approximately 2.0275%. Therefore, when calibrating key parameters of the model we set $\gamma = 1.0203$. Regarding the depreciation rate of private physical capital, we follow Li and Sarte (2004) and choose the value of δ_K in order to match a ratio of private investment to private capital of 0.076. As a result, we set δ_K equal to 0.0557.

Using data that covers the postwar period 1946-2006, Atolia et al. (2011) determine that the private capital-to-output ratio is roughly equal to 2.17. This implies that the GDP-to-private capital ratio is 0.4608. Given this ratio and the value for parameter δ_K, we set the value of α in order to match a real rental rate of private capital of 6.40% (see Lucas (1990)). As a result, we set the elasticity of output with respect to private capital equal to 0.2597. Note that this necessarily implies an elasticity of output with respect to public capital of 0.7403. Although this value seems high, one should take into account that the model assumes a broad concept of public capital. In this sense, the chosen value of α is consistent with the reported estimates of Mankiw, Romer and Weil (1992) who augment the standard Solow growth model with human capital accumulation and show that it explains a significant portion of cross-country income differences.

According to the calculations of Atolia et al. (2011), the ratio of public capital-to-private capital is 0.5070. Since the private capital-to-GDP ratio is 2.17, these values imply that the public capital-to-output ratio is equal to 1.1002. We set A equal to 0.7619 in order to match this ratio in the long-run equilibrium of the economy.

Based on data obtained from the National Income and Product Accounts, the average real government gross investment as a share of output for the period 1995-2010 is approximately 0.0318. Given the value for parameters γ and A, and the public capital-to-private capital ratio K_g/K, the value of parameter δ_G is chosen in order to yield a value of g_I from (17) equal to 0.0318. As a consequence, we set $\delta_G = 0.0086$. Note that the rate of depreciation of public physical capital is lower than the rate of depreciation of private physical capital. This captures the fact that a substantial portion of public capital consists of infrastructure which tends to depreciate at a slower pace than plant and machinery.

These values imply a private investment-to-output ratio of 0.1649 along the BGP which is slightly higher than the actual average value of 0.1335 for the period 1961-2010. For the same period, the average private consumption-to-output ratio is 0.6577, while in the long-run equilibrium of the model it is 0.6553.

Note that the model overpredicts the share of aggregate profits in output. Cassou and Lansing (1998) calibrate the value of this share to be equal to 0.1230. In the present model, the implied value of this share is equal to $1 - \alpha = 0.7403$. In contrast to the specification of Cassou and Lansing, there is no labor/leisure choice. Hence, the measure of profits in the present context includes labor income earnings.

The parameters governing the tax code, ζ and ϕ, are calibrated to the values used by Li and Sarte (2004). They use the Internal Revenue Service (IRS) Statistics of Income - Individual Income Tax Returns publications, which contain data on total adjusted gross income (AGI) and total taxes paid by all filers. They set $\zeta = 0.083$ in order to match the average tax rate of 12.9% in 1991. Since the estimated average marginal tax rate in 1991 was 22.55%, the implied progressivity ratio is 1.75. Therefore, ϕ is set equal to 0.75 in order to reproduce this ratio.

Recall that we are assuming that the government maintains a balanced budget. According to the Historical Budget Data provided in the Budget and Economic Outlook reports by the Congressional Budget Office (CBO), the average share of revenues in GDP for the period 1971-2010 is 0.1798. We set the consumption expenditure tax rate, ω, equal to 0.1062 in order to obtain a government expenditure-to-GDP ratio in the long-run equilibrium of the model equal to 0.1798. Note that the average share of real government consumption and gross investment in GDP during the period 1995-2010 is 0.1938. The value of the public consumption-to-output ratio is 0.1620, while the model yields a slightly lower value along the balanced growth path of 0.1480.

In the long-run equilibrium of the model, the implied value of consumption tax revenues as a share of GDP is 0.0696. On the other hand, the share of income tax revenues is 0.1102. Note that according to the CBO budget data, the revenues from individual income taxes and corporate income taxes as a percentage of GDP sum up to 10.2% on average during the period 1971-2010.

Households are assumed to have logarithmic utility. This implies a benchmark value of σ equal to 1. We use equation (14) in order to choose the values of the discount factors, β_j, $j = 1, \ldots, N$, that fit the quintile distribution of the Adjusted Gross Income of all filers computed by Li and Sarte (2004). The Gini coefficient for pre-tax income associated with this distribution is 0.54.

As it is shown in the second panel of Table 2, the model essentially replicates the U.S. pre-tax income distribution since the calculated shares of income by quintile are quite close to the ones from the data. The Gini coefficient of 0.4965 is slightly lower than the one reported by Li and Sarte (2004). The reason is that these authors used the entire pre-tax income distribution to calculate the Gini coefficient while we used only the income shares by quintile.

Although the average tax rate and average marginal tax rates are slightly lower than their data counterparts, the progressivity ratio is equal to 1.75 as in the data. Finally, the model overpredicts the tax liabilities of the highest and lowest quintiles, and underpredicts the tax liabilities of the remaining quintiles. However, the differences with the actual values calculated from the data appear to be small.

4 Results

4.1 An Increase in the Progressivity Ratio

The first case of a fundamental change in fiscal policy that we consider is an 10% increase in the progressivity ratio. This implies that ϕ increases from 0.7500 to 0.9250. Tables 3(a)-3(c) below compare the main properties of the pre-reform benchmark model economy (first column) with the properties of the post-reform economy (second column).

As it is shown in Table 3(a), the effect on the economy's long-run growth rate is negligible since it decreases by only 0.6709% from 2.0299% to 2.0163% per year. The rise in the degree of progressivity of the tax schedule distorts private investment leading to an increase in the public capital-to-private capital ratio from 0.5070 to 0.5163. It follows from (2) that the fall in private capital relative to public capital causes r to increase by 2.5342% from 6.4008%

to 6.5630%.

The negative impact of a more progressive income taxation on private capital accumulation can be clearly seen from the reduction in private investment as a share of GDP which falls from 0.1649 to 0.1624. This results in a private capital-to-output ratio of 2.1408 which is lower than the pre-reform ratio of 2.1699. These changes also imply that the private investment-to-capital ratio falls from 0.0760 to 0.0759.

On the other hand, the public capital-to-GDP ratio increases from 1.1002 prior to the tax reform to 1.1054 after the reform. Since the government allocates a fixed portion of output to public investment, this change reflects primarily the reduction in economic activity resulting from a smaller accumulation of private capital. Similarly, aggregate consumption as a share of GDP increases from 0.6553 to 0.6681. This is a consequence of the disincentive to save caused by a lower after-tax return to capital which, in turn, reduces the accumulation of private capital and output.

Naturally, the fall in production reduces the revenues collected by the government. Total tax revenues as a share of GDP fall from 0.1798 prior to the tax reform to 0.1695. This reduction in revenues is reflected in the fall of total government expenditures as a share of output. The share of income tax revenues in output falls from 0.1102 to 0.0985, while the share of consumption tax revenues rises from 0.0696 to 0.0710. Prior to the tax reform, income tax revenue as a portion of total revenues is 61.2841% and consumption tax revenue is 38.7159%. After the tax reform, the portion of income tax revenue falls to 58.1256% while the portion of consumption tax revenue increases to 41.8744%.

In terms of government expenditures, public investment as a share of output remains by construction fixed at 0.0318. As a consequence, public consumption as a share of GDP absorbs the fall in revenues as a share of GDP in order to ensure that a balanced budget is maintained. This ratio decreases from 0.1480 prior to the tax reform to 0.1377 after the tax reform. Note that public investment as a portion of total government expenditures increases from 17.6901% to 18.7666%. In contrast, the portion of public consumption falls from 82.3099% to 81.2334%.

The negative impact of the higher degree of progressivity in the income tax schedule on savings has a pronounced effect on the distribution of pre-tax income. The latter becomes significantly more equal. As it is shown in Table 3(b), this effect on inequality is reflected by the reduction in the Gini coefficient for the pre-tax income distribution from 0.4965 to 0.3632. The share of the highest quintile falls substantially from 54.6244% prior to the tax reform to 43.6395% after the reform. In contrast, the shares of total pre-tax income for the remaining quintiles increase with the share of the first quintile rising by nearly five times relative to its level prior to the tax reform.

The change in the pre-tax income distribution naturally alters the shares of the income tax liability for each quintile. The share for the highest quintile falls from 74.0896% to 64.2466%. In contrast, the shares of income tax liabilities for the remaining quintiles all increase. The most noticeable change is related to the share of the income tax liability for the first quintile which increases by roughly fifteen times compared to its original level: this share rises from 0.0574% prior to the increase in the progressivity of the tax schedule to 0.8811% after the increase.

These results reflect the disincentive effect on capital accumulation generated by the higher degree of progressivity in the income tax schedule. This effect appears to have a stronger impact on the highest quintile. In order to access the redistributive effect of this fiscal policy reform, we need to derive the after-tax income distribution. Let $\overline{y}_j$ denote the after-tax taxable income for a type j household and $\overline{Y}$ the aggregate after-tax taxable income. It can then be easily shown that the share of each type j household in the after-tax income distribution is given by

$$\frac{\overline{y}_j}{\overline{Y}}\left(\frac{1}{N}\right)=\frac{\left[1-\zeta\left(\frac{\widehat{y}_j}{\widehat{Y}}\right)^{\phi}\right]\frac{\widehat{y}_j}{\widehat{Y}}\left(\frac{1}{N}\right)}{\sum_{j=1}^{N}\left[1-\zeta\left(\frac{\widehat{y}_j}{\widehat{Y}}\right)^{\phi}\right]\frac{\widehat{y}_j}{\widehat{Y}}\left(\frac{1}{N}\right)}.$$

As it is reported in Table 3(b), the increase in the progressivity ratio by 10% causes the Gini coefficient for the after-tax income distribution to fall from 0.4742 to 0.3372. The income share of the highest quintile falls from 51.8357% to 41.0448%, while the share of the fourth quintile is reduced only slightly from 24.5596% to 24.3672%. In contrast, the income shares of the remaining quintiles all increase reflecting the substantial reduction in after-tax income inequality.

The bottom panel of Table 3(b) reports the consumption of type j households relative to aggregate consumption. The change in these shares reflects the change in the after-tax income shares for each quintile. The consumption share of the highest quintile falls from 51.6663% of aggregate consumption to 40.8933%. The consumption share of the fourth quintile falls as well, but only by a small amount: it drops from 24.6165% prior to the tax reform to 24.3947%. On the other hand, the consumption shares of the remaining quintiles all increase. The most noticeable increase is that for the lowest quintile: its consumption share rises from 1.0418% to 5.2099%.

The top and middle panel of Table 3(c) report the profits dividend and capital income for each quintile as a share of aggregate taxable income $\widehat{Y}$, respectively. The profits dividend share for the highest quintile falls from 45.9947% to 36.6778%, while it rises for all the remaining quintiles. For instance, the share of the fourth quintile increases from 19.8912% to 20.0840%, while the share of the first quintile increases from 0.7678% to 3.9510%. Similar changes are observed with respect to capital income as a share of $\widehat{Y}$. The capital income share for the highest quintile falls from 8.6297% to 6.9617%, while it rises for all the remaining quintiles. For example, the share of the fourth quintile increases from 3.7321% to 3.8121%, while the share of the first quintile increases from 0.1441% to 0.7499%.

Finally, the bottom panel of Table 3(c) reports the ratio of consumption to the stock of private capital holdings for each quintile. It can be shown that this ratio for each type j household is given by

$$\frac{c_j}{k_j} = \left(\frac{1}{1+\omega}\right)\left\{\left[1-\zeta\left(\frac{\widehat{y}_j}{\widehat{Y}}\right)^{\phi}\right]\left[r+(1-\alpha)\left(\frac{Y}{K}\right)\right]+(1-\gamma)\right\}. \quad (20)$$

The effect of a increase in the degree of progressivity in the income tax schedule on this ratio is uniform: relative to the pre-reform economy, the ratio rises for all quintiles. This reflects the disincentive effect on capital accumulation generated by the new tax policy: the stock of private capital falls relative to consumption for all quintiles.

4.2 A Flat Income Tax Rate

The second case of a fundamental change in fiscal policy that we consider is the elimination of progressivity in the income tax schedule. The introduction of a flat income tax rate implies that $\phi = 0$. Table 4(a)-4(c) below compare the main properties of the pre-reform benchmark model economy (first column) with the properties of the post-reform economy (second column).

As it is shown in Table 4(a), the positive effect on the economy's long-run growth rate is small since it increases by only 0.3785% from 2.0299% to 2.0376% per year. The elimination of progressivity in the tax schedule stimulates private investment leading to a reduction in the public capital-to-private capital ratio from 0.5070 to 0.4881. It follows from (2) that the rise in private capital relative to public capital causes the real rental rate of private capital to decrease by 5.1901% from 6.4008% to 6.0686%.

The positive impact of a flat income tax on private capital accumulation can be clearly seen from the increase in private investment as a share of GDP which rises from 0.1649 to 0.1698. This results in a private capital-to-output ratio of 2.2318 which is higher than the pre-reform ratio of 2.1699. These changes also imply that the private investment-to-capital ratio rises from 0.0760 to 0.0761.

The public capital-to-GDP ratio decreases from 1.1002 prior to the tax reform to 1.0894 after the reform. Since the government allocates a fixed portion of output to public investment, this change reflects primarily the increase in economic activity resulting from a larger accumulation of private capital. Similarly, aggregate consumption as a share of GDP increases from 0.6553 to 0.6872. This is a consequence of the stronger incentive to save caused by a higher after-tax return to capital which, in turn, increases the accumulation of private capital and output.

The elimination of progressivity in the income tax schedule reduces the revenues collected by the government. Total tax revenues as a share of GDP fall from 0.1798 prior to the tax reform to 0.1430. The share of income tax revenues in output falls from 0.1102 to 0.0701, while the share of consumption tax revenues rises from 0.0696 to 0.0730. Recall that prior to the tax reform, income tax revenue as a portion of total revenues is 61.2841% and consumption tax revenue is 38.7159%. After the tax reform, the portion of income tax revenue falls to 48.9781% while the portion of consumption tax revenue increases to 51.0219%.

In terms of government expenditures, public investment as a share of output remains fixed by construction at 0.0318. As a consequence, public consumption as a share of GDP absorbs the fall in revenues as a share of GDP in order to ensure that a balanced budget is maintained. It decreases from 0.1480 prior to the tax reform to 0.1112 after the tax reform. Note that public investment as a portion of total government expenditures increases from 17.6901% to 22.0726%. In contrast, the portion of public consumption falls from 82.3099% to 77.9274%.

The positive impact of the elimination of progressivity in the income tax schedule on savings has a major effect on the distribution of pre-tax income. The latter becomes significantly more unequal. As it is shown in Table 4(b), this effect on inequality is reflected by the increase in the Gini coefficient from 0.4965 to 0.5446. The share of the highest quintile rises substantially from 54.6244% prior to the tax reform to 59.2964% after the reform. In contrast, the shares of total pre-tax income for the remaining quintiles decrease with the share of the first quintile falling by nearly nine times relative to its level prior to the tax reform.

In addition, the change in the pre-tax income distribution alters the shares of the income tax liability for each quintile. The introduction of a flat income tax causes the average tax rate to be equal to the marginal tax rate for all quintiles. As a consequence, the share of the individual income tax liability for each quintile is equal to its share of total pre-tax income. The share of income tax liability for the highest quintile falls from 74.0896% to 59.2964%. In contrast, the shares of income tax liabilities for the remaining quintiles all increase. The most noticeable change is related to the share of the income tax liability for the second quintile which increases by 2.6230 times compared to its original level. The second largest increase in the income tax liability is for the third quintile (1.8288 times) followed by the increase for the first (1.7840 times) and fourth (1.3453 times) quintiles.

These results reflect the positive incentive effect on capital accumulation generated by the elimination of progressivity in the income tax schedule. This effects appear to have a stronger impact on the highest quintile. As it is reported in Table 4(b), the adoption of a flat income tax causes the Gini coefficient for the after-tax income distribution to rise from 0.4742 to 0.5446. Note that this is the same Gini coefficient for the pre-tax income distribution. The equality between the two coefficients is a natural consequence of the elimination of any redistributive role for fiscal policy with the adoption of a flat income tax. Furthermore, the after-tax income share for all quintiles are equal to their pre-tax income shares.

The bottom panel of Table 4(b) reports the consumption of type j households relative to aggregate consumption. As it was the case for the share of the individual income tax liabilities and the after-tax income share for each quintile, in the post-reform economy this ratio is equal to the share of total pre-tax income for each quintile.

The top and middle panel of Table 4(c) report the profits dividend and capital income for each quintile as a share of aggregate taxable income $\widehat{Y}$, respectively. The profits dividend share for the highest quintile rises from 45.9947% to 50.1253%, while it declines for all the remaining quintiles. For instance, the share of the fourth quintile decreases from 19.8912% to 19.4329%, while the share of the first quintile decreases from 0.7678% to 0.0866%. Similar changes are observed with respect to capital income as a share of $\widehat{Y}$. The capital income share for the highest quintile rises from 8.6297% to 9.1711%, while it declines for all the remaining quintiles. For example, the share of the fourth quintile decreases from 3.7321% to 3.5555%, while the share of the first quintile decreases from 0.1441% to 0.0158%.

Finally, the bottom panel of Table 4(c) reports the ratio of consumption to the stock of private capital holdings for each quintile. With $\phi = 0$, expression (20) reduces to

$$\frac{c_j}{k_j} = \left(\frac{1-\zeta}{1+\omega}\right)\left\{\left[r + (1-\alpha)\left(\frac{Y}{K}\right)\right] + (1-\gamma)\right\},$$

which is a constant along the balanced growth path and independent of the type of a household. As a consequence, the ratio c_j/k_j is equal to 0.3079 for all quintiles.

4.3 An Increase in g_I

The third case of a fundamental change in fiscal policy that we consider is an increase in the resources allocated by the government to public investment. It is assumed that the government devotes an additional 1% of every period's output to public investment. This implies that g_I increases from its current value of 0.0318 to 0.0418. Table 5(a)-5(c) below compare the main properties of the pre-reform benchmark model economy (first column) with the properties of the post-reform economy (second column).

Compared to the previous two cases of fiscal policy reform, the positive effect on the economy's long-run growth rate is now significant since it increases by roughly 40% from 2.0299% to 2.8351% per year. The rise in the fraction of output allocated to public investment increases the economy's stock of public capital. This, in turn, leads to an increase in the public capital-to-private capital ratio from 0.5070 to 0.5641. It follows from (2) that the real rental rate of private capital increases by 15.3484% from 6.4008% to 7.3832%.

The positive impact of the higher public capital-to-private capital ratio on the marginal productivity of private capital encourages the accumulation of private capital. This can be clearly seen from the increase in private investment as a share of GDP which rises from 0.1649 to 0.1685. However, the increase in the stock of private capital is smaller than the overall increase in output which is driven mainly by the higher stock of public capital. This results in a private capital-to-output ratio of 2.0053 which is higher than the pre-reform ratio of 2.1699. These changes also imply that the private investment-to-capital ratio rises from 0.0760 to 0.0841.

The public capital-to-GDP ratio increases from 1.1002 prior to the fiscal policy reform to 1.1311 after the reform. Similarly, aggregate consumption as a share of GDP increases from 0.6553 to 0.6592. This is a consequence of the stronger incentive to save caused by a higher return to capital which, in turn, increases the accumulation of private capital and output.

The increase in the public investment-to-output ratio has a minor negative impact on the revenues collected by the government. Total tax revenues as a share of GDP fall from 0.1798 prior to the tax reform to 0.1722. The share of income tax revenues in output falls from 0.1102 to 0.1022, while the share of consumption tax revenues rises from 0.0696 to 0.0700. Recall that prior to the tax reform, income tax revenue as a portion of total revenues is 61.2841% and consumption tax revenue is 38.7159%. After the tax reform, the portion of income tax revenue falls to 59.3548% while the portion of consumption tax revenue increases to 40.6452%.

In terms of government expenditures, public investment as a share of output remains fixed at 0.0418 by construction. As in the case of the flat income tax reform, public consumption as a share of GDP absorbs the fall in revenues as a share of GDP in order to ensure that a balanced budget is maintained. It decreases from 0.1480 prior to the tax reform to 0.1304 after the tax reform. Note that public investment as a portion of total government expenditures increases from 17.6901% to 24.2682%. In contrast, the portion of public consumption falls from 82.3099% to 75.7318%.

The allocation of a higher portion of output to public investment has a major effect on the distribution of pre-tax income. The latter becomes significantly more equal. As it is shown in Table 5(b), this effect on inequality is reflected by the reduction in the Gini coefficient from 0.4965 to 0.4393. The share of the highest quintile falls substantially from 54.6244% prior to the tax reform to 50.2110% after the reform. Similarly, the share of the fourth quintile falls from 23.6233% to 23.4862%. In contrast, the shares of total pre-tax income for the remaining quintiles increase with the share of the first quintile rising by nearly three times relative to its level prior to the tax reform.

In addition, the change in the pre-tax income distribution alters the shares of the income tax liability for each quintile. The average tax rate falls from 12.5310% prior to the reform to 11.5089% after the reform. Similarly, the marginal tax rate falls from 21.2293% to 20.1405%. The changes in the average and marginal tax rates are such that the progressivity remains constant at the value of 1.75. The share of income tax liability for the highest quintile falls from 74.0896% to 69.6119%. In contrast, the shares of income tax liabilities for the remaining quintiles all increase. The most noticeable change is related to the share of the income tax liability for the first quintile which increases by 7.4024 times compared to its original level. The second largest increase in the income tax liability is for the second quintile (1.6017 times) followed by the increase for the third (1.2336 times) and fourth (1.0778 times) quintiles.

As it is reported in Table 5(b), the increase in the portion of output allocated to public investment causes the Gini coefficient for the after-tax income distribution to decline from 0.4742 to 0.4166. The income share of the highest quintile falls from 51.8357% to 47.6878%, while the share of the fourth quintile is reduced only slightly from 24.5596% to 24.1456%. In contrast, the income shares of the remaining quintiles all increase reflecting the substantial reduction in after-tax income inequality.

The bottom panel of Table 5(b) reports the consumption of type j households relative to aggregate consumption. The change in these shares reflects the change in the after-tax income shares for each quintile. The consumption share of the highest quintile falls from 51.6663% of aggregate consumption to 47.4911%. The consumption share of the fourth quintile falls as well, but only by a small amount: it drops from 24.6165% prior to the tax reform to 24.1970% post-reform. On the other hand, the consumption shares of the remaining quintiles all increase. The most noticeable increase is that for the lowest quintile: its consumption share rises by almost three times from 1.0418% to 3.0480%.

The top and middle panel of Table 5(c) report the profits dividend and capital income for each quintile as a share of aggregate taxable income $\widehat{Y}$, respectively. The profits dividend share for the highest quintile falls from 45.9947% to 41.8423%. The profits dividend share for the fourth quintile falls as well from 19.8912% to 19.5718%, while it rises for all the remaining quintiles. In particular, the share of the third quintile increases from 11.7222% to 12.4591%, while the shares of the second and first quintile increase from 5.8258% to 7.1884% and from 0.7678% to 2.2712%, respectively.

Similar changes are observed with respect to capital income as a share of $\widehat{Y}$. The capital income share for the highest quintile falls from 8.6297% to 8.3687%, while it rises for all the remaining quintiles. For example, the share of the fourth quintile increases from 3.7321% to 3.9145%, while the share of the first quintile increases from 0.1441% to 0.4543%.

Finally, the bottom panel of Table 5(c) reports the ratio of consumption to the stock of private capital holdings for each quintile. The effect of a increase in the degree of progressivity in the income tax schedule on this ratio is uniform: relative to the pre-reform economy, the ratio rises for all quintiles.

5 Conclusions

This paper considers an endogenous growth model with public capital and heterogeneous agents. Government expenditures, including public investment, are financed through a progressive income taxation scheme along with a flat tax on consumption. Three major fiscal policy reforms are considered: (i) an increase in the degree of progressivity of the tax schedule, (ii) the adoption of a flat income tax rate, and (iii) an increase in the fraction of output allocated to public investment. We analyze the effects of each of these reforms on the economy's growth rate and income distribution.

It is shown that a substantial increase in the progressivity ratio of 10% has only a mild negative effect on the economy's long-run growth rate. On the other hand, this fiscal policy reform has a pronounced effect in reducing income inequality.

The adoption of a flat income tax schedule generates also a negligible effect on the economy's long-run growth: it increases from 2.0299% to only 2.0376% per annum. Furthermore, it is shown that the elimination of progressivity in the income tax schedule increases income inequality substantially.

In contrast to the previous two fiscal policy reforms, an increase by 1% of the fraction of output allocated to public investment has a significant positive effect on the economy's long-run growth rate: it increases from 2.0299% to 2.8351% per annum. In addition, it is shown that this fiscal policy reform generates a significant reduction in income inequality.

Table 1: Calibrated Benchmark Parameters

Parameter	Description	Value
α	Output elasticity with respect to private capital	0.2597
δ_K	Private capital depreciation rate	0.0557
δ_G	Public capital depreciation rate	0.0086
g_I	Public investment as a share of output	0.0318
A	Technology shift parameter	0.7619
ζ	Scalar in tax schedule	0.083
$1+\phi$	Ratio of marginal to average tax rate	1.75
ω	Consumption tax rate	0.1062
σ	Intertemporal elasticity of substitution	1
β_j	Discount factors	$0.9597, 0.9626, 0.9651, 0.9682, 0.9764$

Table 2: Properties of Benchmark Economy

Variables	U.S. Data	Model
γ	1.0203	1.0203
r (%)	6.4000	6.4008
G/Y	0.1938	0.1798
g_I	0.0318	0.0318
g_C	0.1620	0.1480
K_g/K	0.5070	0.5070
K/Y	2.1700	2.1699
K_g/Y	1.1002	1.1002
I/Y	0.1335	0.1649
I/K	0.0760	0.0760
C/Y	0.6577	0.6553
Share of total pre-tax income by quintile (%):		
Highest quintile	54.6	54.6244
Fourth quintile	23.6	23.6233
Third quintile	13.9	13.9215
Second quintile	6.9	6.9189
First quintile	0.9	0.9119
Gini coefficient (pre-tax income)	0.54	0.4965
Average tax rate τ_a (%)	12.90	12.5310
Average marginal tax rate τ_m (%)	22.55	21.9293
Progressivity ratio τ_m/τ_a	1.75	1.75
Share of individual income tax liabilities (% by income quintile)		
Highest quintile	70.3	74.0896
Fourth quintile	18.9	17.0874
Third quintile	8.2	6.7730
Second quintile	2.2	1.9925
First quintile	0.4	0.0574

Table 3(a): An Increase in the Progressivity Ratio by 10%

Variables	Pre-Reform $1 + \phi = 1.7500$	Post-Reform $1 + \phi = 1.9250$
Growth Rate (%)	2.0299	2.0163
r (%)	6.4008	6.5630
K_g/K	0.5070	0.5163
K/Y	2.1699	2.1408
K_g/Y	1.1002	1.1054
I/Y	0.1649	0.1624
I/K	0.0760	0.0759
C/Y	0.6553	0.6681
G/Y	0.1798	0.1695
g_I	0.0318	0.0318
g_C	0.1480	0.1377
C_g/G	0.8231	0.8123
I_g/G	0.1769	0.1867
Income tax revenues/Y	0.1102	0.0985
Consumption tax revenues/Y	0.0696	0.0710
Average tax rate τ_a (%)	12.5310	11.1829
Average marginal tax rate τ_m (%)	21.9293	21.5271
Progressivity ratio τ_m/τ_a	1.7500	1.9250

Table 3(b): An Increase in the Progressivity Ratio by 10%

Variables	Pre-Reform $1+\phi=1.7500$	Post-Reform $1+\phi=1.9250$
Share of total pre-tax income by quintile (%):		
Highest quintile	54.6244	43.6395
Fourth quintile	23.6233	23.8960
Third quintile	13.9215	16.7800
Second quintile	6.9189	10.9836
First quintile	0.9119	4.7009
Gini coefficient (pre-tax income)	0.4965	0.3632
Share of total after-tax income by quintile (%):		
Highest quintile	51.8357	41.0448
Fourth quintile	24.5596	24.3672
Third quintile	14.9456	17.6079
Second quintile	7.6247	11.7982
First quintile	1.0343	5.1818
Gini coefficient (after-tax income)	0.4742	0.3372
Share of individual income tax liabilities (% by income quintile)		
Highest quintile	74.0896	64.2466
Fourth quintile	17.0874	20.1539
Third quintile	6.7730	10.2049
Second quintile	1.9925	4.5135
First quintile	0.0574	0.8811
Share of individual consumption (c_j/C) (% by income quintile)		
Highest quintile	51.6663	40.8933
Fourth quintile	24.6165	24.3947
Third quintile	15.0079	17.6562
Second quintile	7.6675	11.8458
First quintile	1.0418	5.2099

Table 3(c): An Increase in the Progressivity Ratio by 10%

Variables	Pre-Reform $1+\phi=1.7500$	Post-Reform $1+\phi=1.9250$
Profit dividend as a share of $\widehat{Y}$ (% by income quintile)		
Highest quintile	45.9947	36.6778
Fourth quintile	19.8912	20.0840
Third quintile	11.7222	14.1031
Second quintile	5.8258	9.2314
First quintile	0.7678	3.9510
Capital income as a share of $\widehat{Y}$ (% by income quintile)		
Highest quintile	8.6297	6.9617
Fourth quintile	3.7321	3.8121
Third quintile	2.1994	2.6769
Second quintile	1.0931	1.7522
First quintile	0.1441	0.7499
Consumption to capital ratio (c_j/k_j) (% by income quintile)		
Highest quintile	28.5661	29.2452
Fourth quintile	31.4715	31.8604
Third quintile	32.5584	32.8388
Second quintile	33.4696	33.6591
First quintile	34.5022	34.5886

Table 4(a): Flat Income Tax

Variables	Pre-Reform $1+\phi=1.7500$	Post-Reform $1+\phi=1.0000$
Growth Rate (%)	2.0299	2.0376
r (%)	6.4008	6.0686
K_g/K	0.5070	0.4881
K/Y	2.1699	2.2318
K_g/Y	1.1002	1.0894
I/Y	0.1649	0.1698
I/K	0.0760	0.0761
C/Y	0.6553	0.6872
G/Y	0.1798	0.1430
g_I	0.0318	0.0318
g_C	0.1480	0.1112
C_g/G	0.8231	0.7793
I_g/G	0.1769	0.2207
Income tax revenues/Y	0.1102	0.0701
Consumption tax revenues/Y	0.0696	0.0730
Average tax rate τ_a (%)	12.5310	8.0000
Average marginal tax rate τ_m (%)	21.9293	8.0000
Progressivity ratio τ_m/τ_a	1.7500	1.0000

Table 4(b): Flat Income Tax

Variables	Pre-Reform $1+\phi=1.7500$	Post-Reform $1+\phi=1.0000$
Share of total pre-tax income by quintile (%):		
Highest quintile	54.6244	59.2964
Fourth quintile	23.6233	22.9884
Third quintile	13.9215	12.3864
Second quintile	6.9189	5.2264
First quintile	0.9119	0.1024
Gini coefficient (pre-tax income)	0.4965	0.5446
Share of total after-tax income by quintile (%):		
Highest quintile	51.8357	59.2964
Fourth quintile	24.5596	22.9884
Third quintile	14.9456	12.3864
Second quintile	7.6247	5.2264
First quintile	1.0343	0.1024
Gini coefficient (after-tax income)	0.4742	0.5446
Share of individual income tax liabilities (% by income quintile)		
Highest quintile	74.0896	59.2964
Fourth quintile	17.0874	22.9884
Third quintile	6.7730	12.3864
Second quintile	1.9925	5.2264
First quintile	0.0574	0.1024
Share of individual consumption (c_j/C) (% by income quintile)		
Highest quintile	51.6663	59.2964
Fourth quintile	24.6165	22.9884
Third quintile	15.0079	12.3864
Second quintile	7.6675	5.2264
First quintile	1.0418	0.1024

Table 4(c): Flat Income Tax

Variables	Pre-Reform $1+\phi=1.7500$	Post-Reform $1+\phi=1.0000$
Profit dividend as a share of $\widehat{Y}$ (% by income quintile)		
Highest quintile	45.9947	50.1253
Fourth quintile	19.8912	19.4329
Third quintile	11.7222	10.4707
Second quintile	5.8258	4.4181
First quintile	0.7678	0.0866
Capital income as a share of $\widehat{Y}$ (% by income quintile)		
Highest quintile	8.6297	9.1711
Fourth quintile	3.7321	3.5555
Third quintile	2.1994	1.9157
Second quintile	1.0931	0.8083
First quintile	0.1441	0.0158
Consumption to capital ratio (c_j/k_j) (% by income quintile)		
Highest quintile	28.5661	30.7906
Fourth quintile	31.4715	30.7906
Third quintile	32.5584	30.7906
Second quintile	33.4696	30.7906
First quintile	34.5022	30.7906

Table 5(a): An Increase in Public Investment by 1% of GDP

Variables	Pre-Reform $g_I = 0.0318$	Post-Reform $g_I = 0.0418$
Growth Rate (%)	2.0299	2.8351
r (%)	6.4008	7.3832
K_g/K	0.5070	0.5641
K/Y	2.1699	2.0053
K_g/Y	1.1002	1.1311
I/Y	0.1649	0.1685
I/K	0.0760	0.0841
C/Y	0.6553	0.6592
G/Y	0.1798	0.1722
g_I	0.0318	0.0418
g_C	0.1480	0.1304
C_g/C	0.8231	0.7573
I_g/C	0.1769	0.2427
Income tax revenues/Y	0.1102	0.1022
Consumption tax revenues/Y	0.0696	0.0700
Average tax rate τ_a (%)	12.5310	11.5089
Average marginal tax rate τ_m (%)	21.9293	20.1405
Progressivity ratio τ_m/τ_a	1.7500	1.7500

Table 5(b): An Increase in Public Investment by 1% of GDP

Variables	Pre-Reform $g_I = 0.0318$	Post-Reform $g_I = 0.0418$
Share of total pre-tax income by quintile (%):		
Highest quintile	54.6244	50.2110
Fourth quintile	23.6233	23.4862
Third quintile	13.9215	14.9510
Second quintile	6.9189	8.6262
First quintile	0.9119	2.7255
Gini coefficient (pre-tax income)	0.4965	0.4393
Share of total after-tax income by quintile (%):		
Highest quintile	51.8357	47.6878
Fourth quintile	24.5596	24.1456
Third quintile	14.9456	15.8089
Second quintile	7.6247	9.3330
First quintile	1.0343	3.0247
Gini coefficient (after-tax income)	0.4742	0.4166
Share of individual income tax liabilities (% by income quintile)		
Highest quintile	74.0896	69.6119
Fourth quintile	17.0874	18.4166
Third quintile	6.7730	8.3553
Second quintile	1.9925	3.1913
First quintile	0.0574	0.4249
Share of individual consumption (c_j/C) (% by income quintile)		
Highest quintile	51.6663	47.4911
Fourth quintile	24.6165	24.1970
Third quintile	15.0079	15.8757
Second quintile	7.6675	9.3881
First quintile	1.0418	3.0480

Table 5(c): An Increase in Public Investment by 1% of GDP

Variables	Pre-Reform $g_I = 0.0318$	Post-Reform $g_I = 0.0418$
Profit dividend as a share of $\widehat{Y}$ (% by income quintile)		
Highest quintile	45.9947	41.8423
Fourth quintile	19.8912	19.5718
Third quintile	11.7222	12.4591
Second quintile	5.8258	7.1884
First quintile	0.7678	2.2712
Capital income as a share of $\widehat{Y}$ (% by income quintile)		
Highest quintile	8.6297	8.3687
Fourth quintile	3.7321	3.9145
Third quintile	2.1994	2.4919
Second quintile	1.0931	1.4377
First quintile	0.1441	0.4543
Consumption to capital ratio (c_j/k_j) (% by income quintile)		
Highest quintile	28.5661	31.0929
Fourth quintile	31.4715	33.8685
Third quintile	32.5584	34.9069
Second quintile	33.4696	35.7774
First quintile	34.5022	36.7639

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