Fiscal Policy and the Growth-Inequality Tradeoff: The case of a small open economy

Adela Arguello[a], Gerhard Glomm[a]

May 8, 2016

Abstract This paper examines the growth-inequality tradeoff in the context of fiscal policy reform in a developing, small open economy. The public sector finances its expenditures with income taxation and allocates a portion of its resources to the education and infrastructure sectors. The main interest is on the impact of reform on households' allocation decisions, particularly the decision to invest in the education of their child or, alternatively, to send him or her to work in the informal economy. The results point to greater distortionary effects of taxation for middle-income households. Poor households escape this distortion almost entirely owing primarily to an increase in their rate of return to education investment. By contrast, households in the upper-income brackets operate at a corner, choosing a full course of schooling for their children for virtually all sizes of government. As a result, increases in taxation above a certain threshold of public spending can increase growth and, at the same time, fuel inequality by shrinking the middle class. In evaluating the effects on the growth-inequality tradeoff of changes in the relative size of the education and infrastructure budgets, we find that spending is more heavily skewed towards education if the goal is to reduce inequality. Prioritizing education spending over infrastructure beyond a specified threshold, however, is inconsistent with a pro-growth policy strategy.

Keywords: Heterogenous Agents, Human Capital, Income Inequality, Economic Development

JEL Classification Numbers: R14, H0, XY.

[a]Department of Economics, Indiana University

1 Introduction

This paper studies the effect of fiscal policy reform on the growth-inequality tradeoff in the context of a small, open and developing economy. The analysis uses an overlapping generations framework where final goods are produced using three inputs: labor, public infrastructure capital, and private physical capital. The labor input is an aggregation of adult and child labor. Adult labor is measured in efficiency units -or human capital- which is produced from a combination of parental level of human capital, public education spending (the public input) and household's education investment (the private input). Households are heterogeneous in their level of human capital so they face different challenges and opportunities in allocating resources, but they all share an altruistic concern for the level of human capital of their offspring. Education investment comes at a cost; households incur expenses related to schooling and forgo the labor income the child can earn in the informal sector. The other two inputs in the production of final goods are determined as follows. Private physical capital is determined by the firm's demand for capital, which is readily satisfied from abroad given the assumption of a small open economy. Infrastructure capital is a government provided input in the same fashion as in Barro (1990), but in the form of a stock following Glomm and Ravikumar (1994). The government finances its operations by taxing labor and capital interest income.

The economy is calibrated to Costa Rica in the period of 1950 to 1979 as this lower-middle income country successfully implemented a large expansion of public programs, particularly in the area of education. Finally, I use the calibrated model as a benchmark to conduct two quantitative exercises that alter public expenditures to quantify the impact on household behavior and macroeconomic aggregates. The experiments simulate a permanent change in the level or composition of government spending and measures its effects on growth, the incidence of child labor, years of schooling and inequality. The first policy experiment changes the size of government by increasing and decreasing all tax rates by the same percentage. The second experiment changes the expenditure shares of education and infrastructure leaving the government budget size unchanged. The goal of both exercises is

to define more clearly the growth-inequality tradeoff in the context of fiscal policy reform, and identify those policies that can generate a more robust growth while reducing the dispersion of income.

The results show that growth follows the inverted u-shaped trajectory with increases in government size described in the literature. In contrast, inequality and government size display a u-shaped relationship, with the exception of a drastic decline in inequality that occurs at a very large government size. Given the joint evolution of these variables, an increase in the tax rates generates a tradeoff between growth and inequality for certain ranges of government size. When the government's share of output is between 3% and around 15% of output, an increase in the tax rates results in an improvement on both fronts. When the government is larger, higher taxes are associated with a tradeoff between these two goals or a decline in growth coupled with an increase in inequality. A similar growth-inequality relationship arises when the education share of productive spending is increased. Prioritizing education increases growth and reduces inequality as long as infrastructure investment does not fall below 30% of productive public expenditures. A further expansion in the education system creates an underinvestment in infrastructure that lowers growth or adversely affects the accumulation of human capital, especially among households in the lowest deciles of the income distribution.

This paper is related to the literature that studies the relationship between growth and inequality when growth is generated endogenously by households' allocations. Galor and Zeira (1993) show that, under imperfect capital markets, growth differences across countries can be explained in terms of differences in the level of human capital investment, which is determined by the initial distribution of wealth. Galor and Moav (2004) argue that inequality can enhance growth by encouraging physical capital accumulation in the early stages of development, and harm growth by limiting human capital accumulation in mature stages of development. The second branch of the literature is concerned with the study of the role of government policies on the growth-inequality relationship. Government can influence growth and inequality by affecting inputs of production directly or indirectly through its effect on household behavior. An example of the latter is Maoz and Moav

(1999), who show that redistributive taxation in the form of a transfer to uneducated workers can have a positive effect on growth if the magnitude of the growth-enhancing effect of relaxing liquidity constraints exceeds the magnitude of the distortionary effect on the incentive to acquire education. In most of the literature, tax revenues are not redistributed but rather invested in areas such as education, health, public infrastructure, R&D, social security, and others[1].

The present paper belongs to the sub-literature that focuses on the growth-inequality tradeoff in the context of fiscal policy reform, and more specifically to those studies where public expenditures are both productive and distortionary. Glomm and Ravikumar (1998) is one of the first papers to account for the potentially distortionary effect of fiscal policy on the private decision to acquire education. They evaluate changes in public expenditures when the government uses tax revenue from flat-rate taxes to finance transfers and public education, and find that changes in taxation and education expenditures have a quantitatively small effect on growth and learning time. Glomm and Kaganovich (2008) expand this analysis to include heterogenous agents and a tax-financed social security system. They find that the growth-inequality relationship can be negative or positive depending on the relative size of the social security and education budgets. Similarly, Bandyopadhyay and Tang (2011) evaluate a change in the degree of progressivity of the income tax structure focusing on the distortion to the incentives to save and work. They find that higher progressivity can lead to a positive growth-inequality relationship when the reform is complemented with subsidies aimed at ameliorating these distortions, given progressivity remains below a certain threshold.

The present paper echoes these findings of a nonmonotonic relationship between growth and inequality resulting from the interplay of counteracting effects. The contribution made here is twofold. First, it extends the analysis to a developing country setting offering policy

1. A partial list of papers studying public spending on education or infrastructure includes the following. Among studies evaluating the effects of public education expenditures on both growth and inequality are Benabou (1996); Glomm and Ravikumar (1992); Fernandez and Rogerson (1996); Eckstein and Zilcha (1994) and others. Some of the papers evaluating only the growth effects of public infrastructure investment are Barro (1990); Glomm and Ravikumar (1994); Rioja (1999), and among the papers evaluating the effects on both growth and the distribution of income are Martin (1999); Getachew (2010) and Chatterjee and Turnovsky (2012)

guidance concerning issues that are at the top of the agenda such as the persistence of child labor and stagnant school enrollment rates. Second, it provides a detailed account of the impact of fiscal policies at the household level. Understanding how reform affects the poor, middle-class and more affluent types is critical to the design of policies that can deliver the proper balance between the contribution from the state and the contribution from individuals to take advantage of complementarities and maximize the productivity of investment.

This paper is organized as follows. In the next subsection we briefly describe the context around the implementation of the education reforms in Costa Rica. We do this to motivate the choice of the main ingredients of the theoretical model, which is presented in section 2. Section 3 describes the calibration. Section 4 explains the policy experiments and discusses the results. Concluding remarks are offered in Section 5.

1.1 The case of Costa Rica

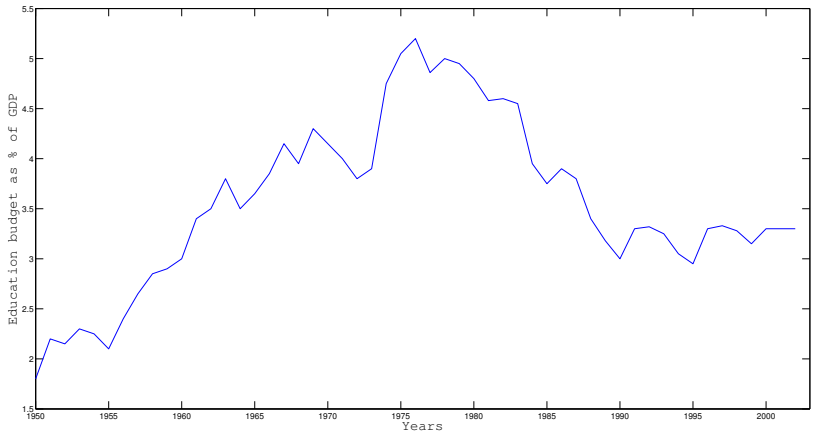
In the late 1940s, Costa Rica was, like many other nations in the region, a poor, inegalitarian society controlled by an agrarian elite[2]. But following the civil war of 1948, the ruling government introduced a series of political and economic reforms that were instrumental to the social and economic development experienced in the 1960s and 1970s. These reforms focused on alleviating poverty by expanding basic coverage of social programs to vulnerable groups. The most significant reforms were the abolition of the army and the universalization of basic education. Both were established as constitutional provisions to ensure its long-term commitment. The abolition of the army allowed the government to focus a greater share of public spending on social and infrastructure investments compared to neighboring nations[3]. The new political constitution made pre-school through high school free of charge, designated a minimum spending of 10% of the education budget

2. Early studies on income distribution show that the top 20% of the population accounted for an average of 63% of the income, figures similar to Mexico, Brazil, Venezuela, and El Salvador (Stycos (1982))

3. Public spending was no greater in Costa Rica than in other Central American nations. By 1975, the public sector had about the same proportion of GDP as other Central American countries -only Guatemala's public spending was significantly lower. The difference was in the small proportion dedicated for military security purposes (Carnoy and Torres (1992)).

to universities, and required the state to offer financial assistance to those students without the resources to attend college. There were also significant investments in health care, social security, and infrastructure projects, but in the period studied, 1950 to 1979, the expansion in the education system was the most significant[4]. Figure 1 depicts the share of education spending of GDP in the years 1950 to 2002.

Figure 1: Costa Rica: Expenditures of the Department of Education (as % of GDP)



Source: Robles (2005) using data from Instituto de Investigaciones en Ciencias Economicas, Divulgacion economica No.28, Universidad de Costa Rica 1997

Infrastructure projects improved the nation's transportation, water and sewer, and communication systems. These investments preceded the education reforms and continued in the following decades. The most important project was the construction of the Inter American highway in the 1940s, which connected rural areas with the rest of the country and established access to Panama and Nicaragua. The new infrastructure had a positive impact on the economy as it facilitated agricultural and manufacturing commerce, and opened access by ground to the Panama Canal (Sáenz and Arroyo (2010), Fox (2012)). We include infrastructure public capital as an input in the production function to capture the role that infrastructure had on aggregate productivity.

In the period between 1950 and 1980 poverty decreased from 50% to 25%, the percentage of illiterates went from 21% to 10%, and access to basic health care and social security increased from

4. An anecdote often found in history books says that when the army was abolished in 1949, the keys to the main military barracks were given to the Minister of Education.

8% to 75% (Morice and Robles (2011)). GDP per capita also increased, from $340 in 1947 to over $900 in 1979 in 1970s prices (Rosero (1983)). This growth was associated with an increase in labor productivity of the labor force as reflected in the decrease in the share of employment in the agricultural sector from 50% in the early 1960s to 27.5% in the 1980s (Bourguignon and Morrisson (1989)).

2 The model

Consider a small open economy with overlapping generations of agents with heterogeneous human capital and perfect foresight. The government levies taxes on labor and capital interest income to finance its consumption, investment in education and infrastructure, and social security payments. Agents are born without wealth at age 6 and live for five 15-year periods so they die with probability 1 at age 81. Population size is constant, and each generation is of measure 1/5. During the first fifteen years, a period we call childhood, the agent either works or learns. The fraction of childhood time allocated between schooling and work is determined by the parent, who has an altruistic concern for the child's human capital level. At age 21 the child becomes a young adult and has a child of its own. Young adulthood is followed by middle and old age. During these three periods individuals supply labor inelastically. Capital markets are imperfect, so households can't borrow. When the adult reaches age 65, he enters the fifth and last period of his life, and becomes a retired worker. Agents leave no bequests upon death.

2.1 Household behavior

Households of the initial young generation are endowed with a level of human capital h^j, where $j \in \{1, 2, ..., J\}$ refers to the type of household and $\{h^j\}_{j=1}^J$ is an increasing sequence that defines effective labor capacity of each type of worker. Each household is made of one agent except during young adulthood when we assume the household consists of one young agent and the child. All agents have identical preferences over consumption and over the stock of human capital of their

offspring. The utility function of any young individual at time t is given by

$$ln\, c_t^{y,j} + \beta\, ln\, c_{t+1}^{m,j} + \beta^2\, ln\, c_{t+2}^{o,j} + \beta^3\, ln\, c_{t+3}^{r,j} + \psi\, \frac{(h_{t+1}^j + \underline{h})^{1-\xi}}{1-\xi}, \tag{1}$$

where $c_t^{y,j}$, $c_{t+1}^{m,j}$, $c_{t+2}^{o,j}$, and $c_{t+3}^{r,j}$ denote the consumption of the type j household when young, middle aged, old aged, and retired, respectively. The level of human capital of the child of this household is denoted by h_{t+1}^j. The discount factor is β, the degree of altruistic concern about the child's human capital is ψ and $\underline{h}$ and ξ are constants.

The education sector is assumed to be exclusively public, i.e. there are no private material inputs. The level of human capital of a child born to agent j h_{t+1}^j depends on the parental human capital level h_t^j, the level of public education expenditures E_t, and the fraction of time the child attended school during the first period of life $(1 - n_t^j)$. The fraction of the time the child of the j household works is n^j, and he earns a wage rate of w^c. The possibility the child neither works nor attends school is excluded from the model. Schooling increases the child's future labor capacity and thus the household's income and hence utility, but it is also costly. The financial cost of sending a child to school is given by p, which includes expenses such as tuition, uniforms, materials or transportation. These components are combined according to the following learning technology.

$$h_{t+1}^j = \theta\, (h_t^j)^{\sigma}\, E_t^{\eta}\, (1 - n_t^j)^{\phi}, \tag{2}$$

where $\theta > 0$, $n_t < 1$, and σ, η, $\phi \in (0, 1)$. The public educational input E determines educational quality which is uniform for all children. All three factors exhibit diminishing returns to learning. This learning technology is used by Glomm and Ravikumar (1992), Benabou (1996) and others.

Once agents enter young adulthood their effective labor capacity remains constant thereafter. During their working lives agents earn a wage rate per effective unit of labor equal to w^a, and they may choose to save a portion of their earnings to finance consumption in later periods. Adult labor earnings and interest income are taxed at a flat-rate equal to τ and τ_s, respectively. We assume the child's labor income is tax-exempt.

The constraints faced by the j young household of generation t are

$$\begin{aligned} c_t^{y,j} + s_t^{y,j} + p_t(1 - n_t^j) &= (1-\tau)w_t^a h^j + w_t^c n_t^j, \\ c_{t+1}^{m,j} + s_{t+1}^{m,j} &= (1-\tau)w_{t+1}^a h^j + (1 + (1-\tau_s)r^*)s_t^{y,j}, \\ c_{t+2}^{o,j} + s_{t+2}^{o,j} &= (1-\tau)w_{t+2}^a h^j + (1 + (1-\tau_s)r^*)s_{t+1}^{m,j}, \text{ and} \\ c_{t+3}^{r,j} &= tr_{t+3} + (1 + (1-\tau_s)r^*)s_{t+2}^{o,j}, \end{aligned} \tag{3}$$

where $s_t^{y,j}$, $s_{t+1}^{m,j}$, $s_{t+2}^{o,j} \geq 0$ are his savings in youth, middle age, and old age, respectively. The interest rate that prevails in international markets is r^*. In retirement the agent receives a transfer payment from the government equal to tr_{t+3}.

From (3) we can express the discounted value of lifetime expenditures for household j as

$$\text{Expenditures}_t^j = c_t^{y,j} + \frac{c_{t+1}^{m,j}}{1 + (1-\tau_s)r} + \frac{c_{t+2}^{o,j}}{(1 + (1-\tau_s)r)^2} + \frac{c_{t+3}^{r,j}}{(1 + (1-\tau_s)r)^3}, \tag{4}$$

while the discounted value of lifetime income equals

$$\text{Income}_t^j = (1-\tau)w_t^a h_t^j + w^c n_t^j - p_t(1-n_t^j) + \frac{(1-\tau)w_{t+1}^a h_t^j}{(1 + (1-\tau_s)r^*)} + \frac{(1-\tau)w_{t+2}^a h_t^j}{(1 + (1-\tau_s)r^*)^2} + \frac{tr_{t+3}}{(1 + (1-\tau_s)r^*)^3}. \tag{5}$$

The intertemporal budget constraints requires equality between the present value of expenditures and the present value of lifetime income.

2.2 Production

Capital markets are open so firms can satisfy their capital demand from abroad. We assume the world interest rate r^* is constant, and labor is immobile. The economy's aggregate production function is:

$$Y_t = \left(\lambda L_t^\rho + N_t^\rho\right)^{\frac{\alpha}{\rho}} K_t^{1-\alpha} G_t^\gamma, \tag{6}$$

where Y_t is total output, K_t is the aggregate stock of private capital, G_t is the aggregate stock of public capital available to all firms, L_t is aggregate supply of adult labor in efficiency units, and N_t is aggregate supply of child labor. The output elasticities of labor, private capital, and public

capital are α, $(1-\alpha)$, and γ, respectively. The elasticity of substitution between adult and child labor $1/(1-\rho)$ as well as α, ρ, and γ are less than one. The technology exhibits constant returns to private factors so that profits are zero in equilibrium.

The supply of skilled labor L_t is equal to the average stock of human capital of the three generations of workers alive at time t. Since each agent works for three periods after childhood, the workers at time t are the young generations of periods t, $t-1$, and $t-2$. The stock of human capital of the young at time t, L_t^y, is obtained by summing up individual amounts of effective labor across all household types:

$$L_t^y = \sum_{j=1}^{J} h_t^j. \tag{7}$$

Similarly, the supply of child labor at time t is obtained by summing up individual amounts of child labor across all households:

$$N_t = \sum_{j=1}^{J} n_t^j. \tag{8}$$

The private stock of capital is determined by the firm's profit maximization condition

$$K_t = (1-\alpha)^{1/\alpha}(1+r)^{-1/\alpha}(\lambda L_t^{\rho} + N_t^{\rho})^{1/\rho} G_t^{\gamma/\alpha}, \tag{9}$$

under the assumption of a small open economy.

2.3 The government

The government collects tax revenue to finance education expenditures E, infrastructure investment I, transfers to the old T, and government consumption D. The government budget constraint at time t is

$$\tau_s \, r^* \, K_t + \tau \, w_t^a \, L_t = T_t + E_t + I_t + D_t, \tag{10}$$

where τ_s and τ are the capital interest tax rate and labor tax rate, respectively, r^* is the interest rate, and K_t is the firms' demand for capital. The stock of public capital grows according to the following equation:

$$G_{t+1} = I_t + (1-\delta_G)G_t, \tag{11}$$

where δ_G is the rate of depreciation of the public capital stock.

2.4 Equilibrium

Given an initial set of exogenous government policy rules $\{\tau, \tau_s, E_t, I_t, T_t, D_t\}$ and initial aggregate inputs $\{G_t, K_t, L_t, N_t\}$, an equilibrium is characterized by the following:

(i) Households choose a sequence of consumption allocations $\{c_t^{y,j}, c_{t+1}^{m,j}, c_{t+2}^{o,j}, c_{t+3}^{r,j}\}$, savings allocations $\{s_t^{y,j}, s_{t+1}^{m,j}, s_{t+2}^{o,j}\}$, and schooling time allocation $\{(1 - n_t^j)\}$ taking as given prices $\{r^*, w_t^c, w_t^a, w_{t+1}^a, w_{t+2}^a\}$, the transfer received in old-age $\{tr_{t+3}\}$, and his initial level of human capital h_t^j, such that (1) is maximized subject to (2) and (3);

(ii) Child labor supply N_t is equal to

$$N_t = \sum_j n_t^j, \quad \text{for } j \in \{1, 2, ...J\}, \tag{12}$$

(iii) Private capital stock is equal to

$$K_t = (1-\alpha)^{1/\alpha}(1+r)^{-1/\alpha}(\lambda L_t^\rho + N_t^\rho)^{1/\rho} G_t^{\gamma/\alpha}, \tag{13}$$

where G_t follows the law of motion given by (11), and L_t is the average of L_t^y, L_{t-1}^y, and L_{t-2}^y, where L^y follows (7);

(ii) The rate of return to adult and child labor equal their marginal productivity according to the economy's production function (6):

$$w_t^a = \alpha(L_t^\rho + N_t^\rho)^{(\frac{\alpha}{\rho}-1)} K_t^{1-\alpha} G_t^\gamma \, \lambda L_t^{\rho-1} \tag{14}$$

$$w_t^c = \alpha(L_t^\rho + N_t^\rho)^{(\frac{\alpha}{\rho}-1)} K_t^{1-\alpha} G_t^\gamma \, N_t^{\rho-1}; \tag{15}$$

and finally,

(iii) The government satisfies its budget constraint as given by (10).

The young household's optimization yields the following Euler equations:

$$\begin{aligned}
\frac{1}{c_t^{y,j}} &= \frac{\beta}{c_{t+1}^{m,j}}(1+(1-\tau_s)r^*) \\
\frac{1}{c_{t+1}^{m,j}} &= \frac{\beta}{c_{t+2}^{o,j}}(1+(1-\tau_s)r^*) \\
\frac{1}{c_{t+2}^{o,j}} &= \frac{\beta}{c_{t+3}^{r,j}}(1+(1-\tau_s)r^*)
\end{aligned} \tag{16}$$

and the first-order condition associated with the schooling choice:

$$\frac{w_t^c + p_t}{c_t^{y,j}} = \psi\,\phi\,\theta\,h_t^{j^\sigma}\,E_t^\eta(1-n_t^j)^{\phi-1}(\theta h_t^{j^\sigma}E_t^\eta(1-n_t^j)^\phi + \underline{\mathrm{h}})^{-\xi} \tag{17}$$

Equation (17) implies that the amount of schooling chosen equalizes the marginal benefit of increasing education investment by one unit to the marginal cost of that investment, which is equal to the cost of schooling and the forgone wage earnings for the child times the marginal utility of consumption. Thus, households continue to demand education for their children until the rate of return to this investment equals the cost in terms of the utility loss from lower consumption.

Combining equations (16), (17), and the intertemporal budget constraint given by setting (4) equal to (5), we obtain:

$$\begin{aligned}
\frac{(w_t^c + p_t)(\theta\,h_t^{j^\sigma}\,E_t^\eta(1-n_t^j)^\phi + \underline{\mathrm{h}})^\xi}{\psi\,\phi\,\theta\,h_t^{j^\sigma}\,E_t^\eta(1-n_t^j)^{\phi-1}} \;=\; & \frac{1}{(1+\beta+\beta^2+\beta^3)}\left[\frac{tr_{t+3}}{(1+(1-\tau_s)r^*)^3}\right. \\
& + \frac{(1-\tau)w_{t+2}^a h_t^j}{(1+(1-\tau_s)r^*)^2} + \frac{(1-\tau)w_{t+1}^a h_t^j}{(1+(1-\tau_s)r^*)} \\
& \left. +(1-\tau)w_t^a h_t^j + w^c n_t^j - p_t(1-n_t^j)\right]
\end{aligned} \tag{18}$$

Equation (18) allows us to simplify the characterization of the household's optimal choice of n_t^j in terms of wages and exogenous variables. Furthermore, we can rewrite the wage equations in terms of the labor inputs and public infrastructure capital by substituting for K_t using (1.9):

$$w_t^a = \alpha\,(1-\alpha)^{\frac{1}{\alpha}-1}\,(1+r^*)^{1-\frac{1}{\alpha}}(\lambda L_t^\rho + N_t^\rho)^{\frac{1}{\rho}-1}\,G_t^{\gamma/\alpha}\,\lambda L_t^{\rho-1} \tag{14'}$$

$$w_t^c = \alpha\,(1-\alpha)^{\frac{1}{\alpha}-1}\,(1+r^*)^{1-\frac{1}{\alpha}}(\lambda L_t^\rho + N_t^\rho)^{\frac{1}{\rho}-1}\,G_t^{\gamma/\alpha}\,N_t^{\rho-1}; \tag{15'}$$

Hence, we can state the definition of equilibrium more simply as given by equation (18), where: (i) factor prices are determined by their marginal products following (14′) and (15′); (ii) aggregate inputs are determined as follows: L_t is the average of L_t^y, L_{t-1}^y, and L_{t-2}^y, where the effective labor of each generation follows the form specified in (1.7), N_t is given by (8), and G_t is determined according to the law of motion (11); and (iii) government expenditures are determined according to (10).

2.4.1 Comparative Statics

In this section we look at comparative statics using the optimization conditions to understand the basic mechanics of variations in policy parameters and the demand for education. Consider an increase in public spending through higher taxation. At the household level, the parental level of human capital, fiscal policies and current and future prices are exogenous to the child labor-learning allocation decision. Equation (18) makes it clear that the time allocation decision of parents depends on the initial level of human capital of the household as it affects the return to education investment and lifetime income. A change in taxes has a direct and indirect effect on both fronts creating different schooling responses across the income distribution. Higher taxation lowers the present value of total income for all households, particularly for those with a higher level of human capital whose income is earned in the formal sector. To compensate for this negative income effect a household in the first decile would have to increase child labor by one year, while a household in the third decile would have to increase child labor by 5 years, everything else equal.

Beyond this adverse income effect, higher taxation increases investment on education and infrastructure, and the resulting expansion in human and public capital stocks impact the schooling choice through several channels. First, the increase in educational quality from higher E_t raises the marginal utility of schooling, especially for households in the bottom deciles. In response, households demand more education. The precise increase in E_t from a given increase in the tax rate cannot be determined analytically given that it depends on the net effect on tax revenue, which is determined by general-equilibrium adjustments. However, if we isolate the effect of education quality by assuming an increase of 20% and abstracting from all other effects, we find that the impact on the schooling time of a household in the first decile is neglible and very small for a

household in the third decile (about 22 days more of schooling). The magnitude of this response is linked to the size of the elasticity of public education expenditures. If this elasticity took a value of 0.13, instead of the benchmark value of 0.10, the response on the schooling choice would be greater. A household in the first decile would increase the child's learning time by close to 0.2 years and a household in the third decile would increase the child's learning time by almost half a year.

A greater availability of skilled labor and infrastructure capital also affects wages. The effect on the skilled labor wage is positive, increasing family income and making schooling more affordable for the household. Despite this positive income effect, the net effect on disposable adult labor income is unclear as it depends on the relative sizes of the reduction in household income from higher taxation (affecting different households to different degrees) and the increase in the wage rate. The effect on the child labor wage is less clear given that it depends on the effect on the relative supply of skilled labor and child labor. Equation 19 shows that the relative wage of skilled and unskilled labor depends on the ratio of the supply of both types of labor, the relative efficiency of skilled labor given by λ, and the substitutability parameter ρ. The calibration assumes both types of labor are imperfect substitutes ($\rho < 1$) so an increase in the supply of skilled labor has the effect of lowering the child labor wage.

$$\frac{w_t^a}{w_t^c} = \lambda \left(\frac{L_t}{N_t} \right)^{\rho - 1}. \tag{19}$$

The effect of changes in the child wage on the schooling choice works through two channels. The first channel is household income. Consider an increase in the child wage of 20%. All else equal, a higher child wage will increase household earnings, especially for those in lower deciles who rely on the child's labor earnings. If the additional income were spent on more schooling, a household in the first decile would increase learning time by 1.3 years and a household in the third decile would increase schooling by 0.4 years. The second channel through which the child wage affects the schooling choice is by changing the cost of education. The first-order condition for the schooling choice shows that an increase in the child wage rate of the same magnitude (20%) would have a negative effect on learning time. Households would have to reduce schooling to equalize the cost of education to the return to investment. For a household in the first decile schooling would have to

decrease by 0.2 years and for a household in the third decile schooling would have to decrease by 1.2 years.

3 Calibration

The benchmark calibration is modeled after the Costa Rican economy in the period of 1950 to 1979. This period is split in half to fit the period duration of the model: the years between 1950 to 1964 is defined as period one, and the years between 1965 to 1979 is defined as period two. We choose 1979 as the last year of the calibration to avoid including effects related to the debt crisis of the early 1980s. Governments across the region reduced public spending on several social programs in an effort to meet the demands associated with debt repayment negotiations. In the case of Costa Rica, the adjustment program changed the priority given to education relative to other social programs (such as housing and social security). Both public and private educational inputs were affected: education expenditures declined by 18.8% in 1981 and 24.9% in 1982 from the previous year (Reimers, 1990), and school enrollment fell and drop out rates increased (Vedova (1986)).

We begin by generating three log-normal distributions of human capital, one for each generation of adult workers, such that the dispersion of a distribution computed from an average of the three matches a desired moment from the data. We target the first available measure of inequality in Costa Rica, a Gini coefficient of 0.50 in 1961 (ECLAC (1970)). This new distribution becomes the distribution of the labor force in the first period of the model. In the second and subsequent periods, the labor force gets updated as the generation of young workers replaces the generation of retired worker.

The policy instruments and parameters associated with the government are set as follows. The share of the government's budget allocated to education expenditures and infrastructure investment are calibrated to match the ratios of public education spending and public infrastructure investment to GDP in the time frame considered. The capital income tax rate is set at 10% based on data for the late 1950s. The income tax rate is calibrated to match average shares of tax revenue in GDP. The value for the output elasticity of public capital is set at 0.1 based on a study by Hulten (1996)

for low- and middle-income countries.

The parameters that govern the evolution of the distribution of the human capital of the young generation are of considerable importance given that as young workers replace retirees they drive changes in the level of inequality and schooling of the labor force. The parameters associated with the human capital technology are grounded on data or calibrated to match moments from the data. For the elasticity of public education expenditures η we follow Krueger and Card (1990) and others in using a value of 0.1. Given a certain level of public expenditures and its allocation to education and infrastructure spending, the parameters governing the productivity of private inputs in the production of human capital (σ, ϕ), the degree of parental altruism (ψ), the cost of schooling (p_t), and the multiplicative factor in the human capital technology (θ) are calibrated to generate a human capital distribution of younger workers that meets the following requirements. The incorporation of the young generation into the labor force must produce an average of years of schooling that matches the data for periods one and two. Furthermore, the resulting distribution of young workers must produce the change in inequality observed in the data from period one to period two. The target for the Gini coefficient of period two is 0.46, obtained from averaging the available coefficients of the 1970s [5]. Table 2 presents the data moments and the corresponding model results.

The rest of the parameters are set as follows. The discount factor is set to 0.97^{15}, or 0.63, following Ríos-Rull (1996) calibration of an overlapping generations model. The parameter values for the production function are dictated by data or estimates commonly used in the literature. The value for the labor share of income is set at 0.6 based on an estimate for Costa Rica in 1963 by the Inter-American Development Bank (Rodríguez-Clare, Sáenz, and Trejos (2002)). The interest rate is set to 5% to match data for Costa Rica from the International Financial Statistics database by the IMF. Table 1 summarizes the values chosen and those obtained from the calibration.

The combination of these parameter values produce a learning technology of increasing returns as long as the fraction of childhood time allocated to work activities is positive, i.e. $(1 - n_j) < 1$.

5. During the 1960s and beginning of 1970s, most sources agree that there was an improvement in the distribution of income. However, in the late 1970s, just prior to the start of the debt crisis, inequality stopped diminishing and according to several studies it increased (Rotenberg and Bensión (1993), Bourguignon and Morrisson (1989), Chalker (1994)). The coefficient used for the second period is obtained by taking an average of the data figures available.

Table 1: Parameters Values for Calibration

Parameter	Value	Description
β	0.97	Yearly discount factor
α	0.60	Output elasticity of labor
γ	0.10	Output elasticity of public capital
θ	2.68	Technology level in the production of new human capital
ψ	0.8	Parental altruism
p	1.4	Cost of schooling
σ	0.63	Exponent on parental human capital
ϕ	0.30	Elasticity of the fraction of time during first period spent in school
η	0.10	Elasticity of public education expenditures
$\underline{h}$	2.3	Constant
λ	5	Relative weight of adult labor in production
r	5%	Interest rate
δ_G	2.5%	Yearly depreciation rate of public capital

Consequently, the human capital growth rate for poorer agents whose children have a low level of schooling is increasing over time, while the growth rate for richer agents whose children are approaching full schooling is decreasing over time. As agents accumulate increasing levels of human capital over time, the dynamics of aggregte effective labor, and the paths of the public capital stock and in turn, output growth is dominated by decreasing returns in the learning technology.

4 Policy Experiments

In this section we carry out two policy experiments that change the level of public expenditures. The first one changes the government's share of output while keeping the composition of government expenditures constant. The second shifts funds between education and infrastructure without directly affecting revenues or other government programs. The benchmark for all experiments is the economy obtained from the calibration to Costa Rica. Deviations from these allocations are analyzed to draw policy implications for average schooling of the population, output, and the distribution of income, as well as to understand the size of the growth effects that result from an education expansion. Each experiment starts with an analysis at an aggregate level, followed by a

Table 2: Model outcomes that match Costa Rican data

Moments	Period	Data	Model
Demographics			
Gini coefficient	Period 1	0.50	0.50
	Period 2	0.46	0.46
Average years of schooling of the labor force	Period 1	4.69	4.70
	Period 2	6.05	6.06
Government Size			
Tax Revenue (%of GDP)	Period 1	11.79	11.77
	Period 2	15.12	15.15
Expenditures			
Public Expenditures in Education (% of GDP)	Period 1	2.70	2.72
	Period 2	4.40	4.38
Public Expenditures in Infrastructure (% of GDP)	Period 1	1.90	1.86
	Period 2	2.99	2.97

look at the agent level according to their relative income. The time horizon studied is 5 periods, equivalent to 75 years.

4.1 First Policy Experiment: Changing the size of government

The benchmark case sets the size of government, measured by the ratio of tax revenue to total output, equal to 11.8% in period one and around 15% in later periods as seen in table 2. This experiment varies government size by adjusting tax rates in all periods by the same percentage. The size of government in each scenario is characterized by the ratio of tax revenue to total output of the second period, which remains relatively constant thereafter. For example, a decrease in the tax rate of 35% is equivalent to a government size of 7.7% in period one and 10% in subsequent periods. We compare this scenario, which we refer to as a government size of 10%, to the benchmark of 15%. The comparative analysis covers scenarios where the government's share of output is as small as 3% and as large as 60% of output.

4.1.1 Effects on schooling time

An increase in the size of the government generates counteracting effects on households incentive to invest in education. An increase in the size of the government generates a negative income effect by increasing the tax burden on all households. On the other hand, a larger government means more expenditure on public education which increases the rate of return on education and therefore the incentive to send children to school longer. These effects influence households across the income distribution differentially.

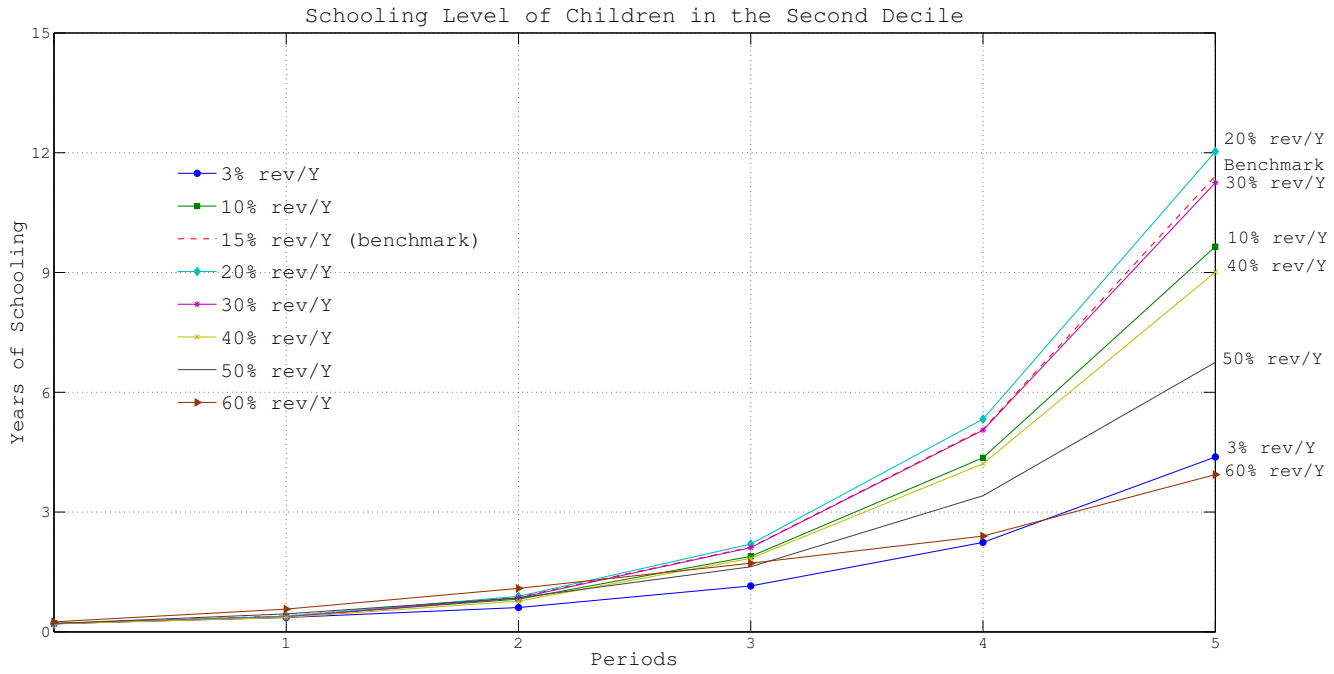


Figure 2: Years of schooling of children in the second decile

Figures 2-4 show the effect of changing government size on the schooling decision of households in the second, fifth and ninth deciles of the income distribution to illustrate the differential effect by income. As could be expected, at the bottom of the distribution, the second decile, the effect of changing government size on schooling choice is non-monotonic. The benchmark case of a government size of 15% is very close to the growth maximizing size of 20%, with steep drop-offs as government size increases or decreases. With government size too small or too large, at the extremes of 3% or 60% schooling time would be cut in half, approximately. In the middle of the

distribution, at the 5th decile, similar results prevail with the adverse effects of larger government size becoming very large. At the top of the distribution, the households are on the corner solution, with most children attending school full time. We can think of this as finishing university. Only when government size becomes very large do some households choose less than full schooling.

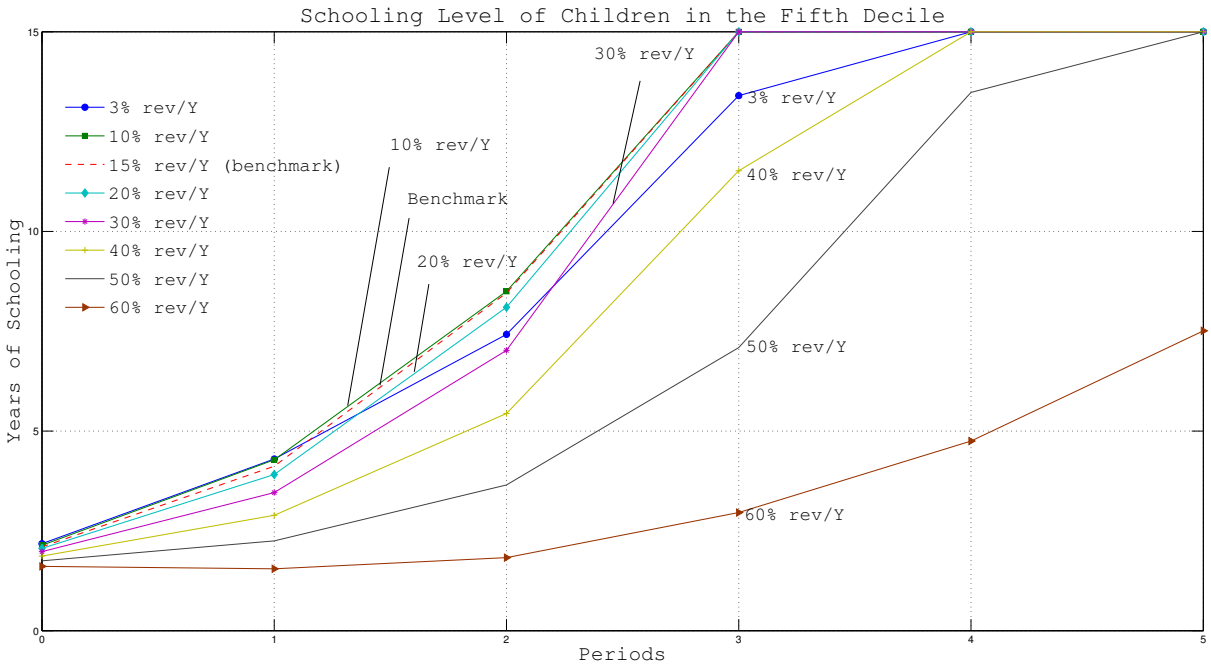


Figure 3: Years of schooling of children in the fifth decile

The aggregate effects of changing government size on schooling choice are depicted in Figure 5. Unsurprisingly, these aggregate effects mirror the effects of the on the median decile with large adverse effects on schooling time from large government sizes.

Changing the government size also has definite impacts on wages, both on adult and child wages. As after tax income falls, child labor will be affected. Moreover, changing the size of government influenced schooling and child labor supply choices as these are just the opposite sides of the same coin. In the long run, child wages are increasing in the size of the government, up to government size of 50%. Only extremely large government sizes in the neighborhood of 60% reduce child wages, as do very small government sizes.

Adult wages exhibit a similar pattern as child wages: There are sizeable increases in the adult

wage associated with large increases in government size.

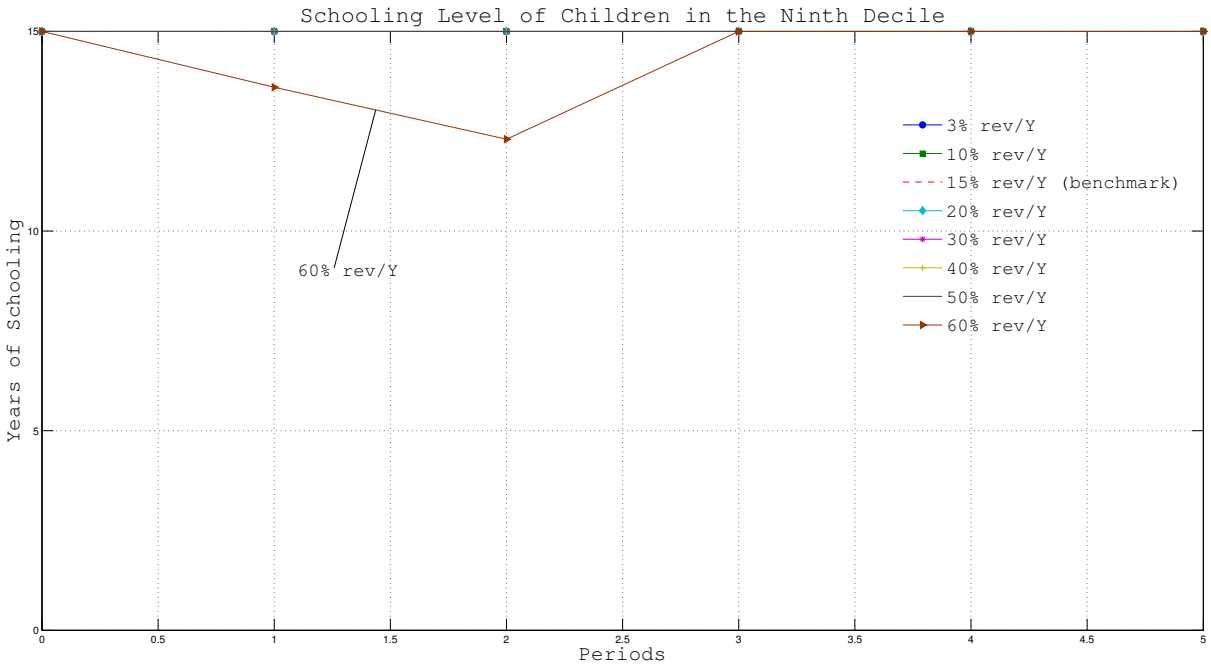


Figure 4: Years of schooling of children in the ninth decile

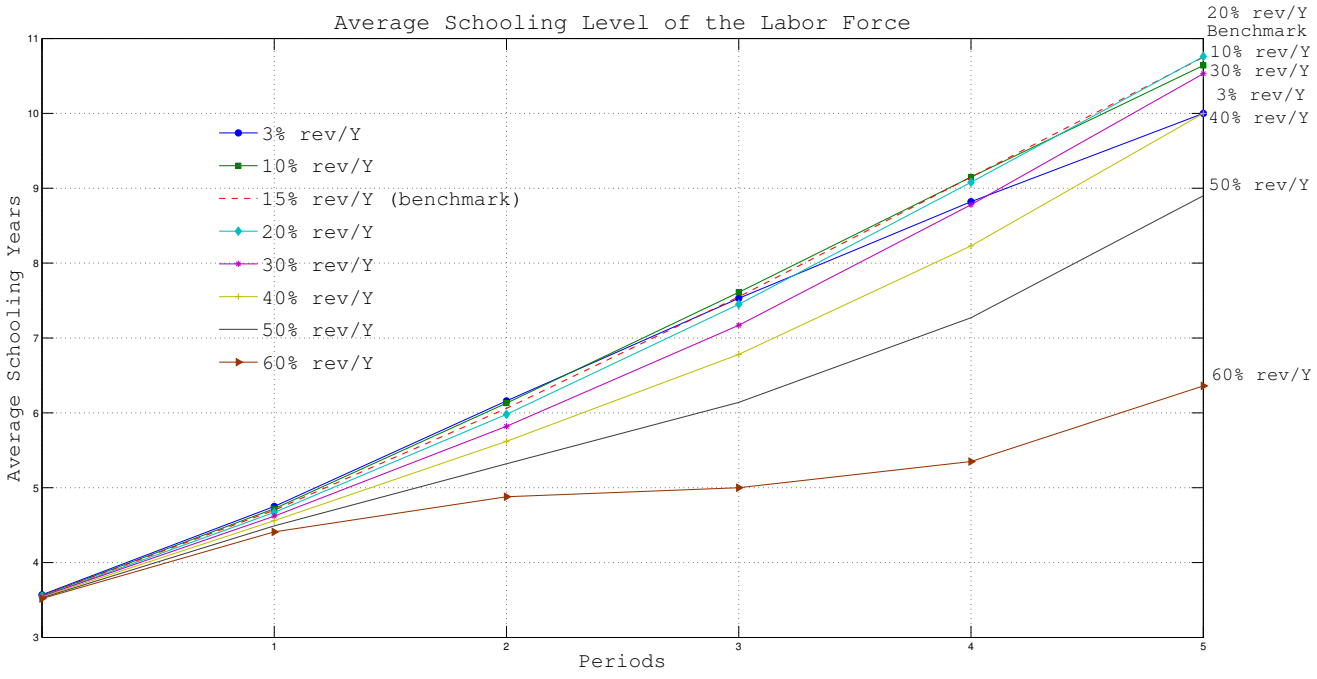


Figure 5: Average years of schooling of the labor force

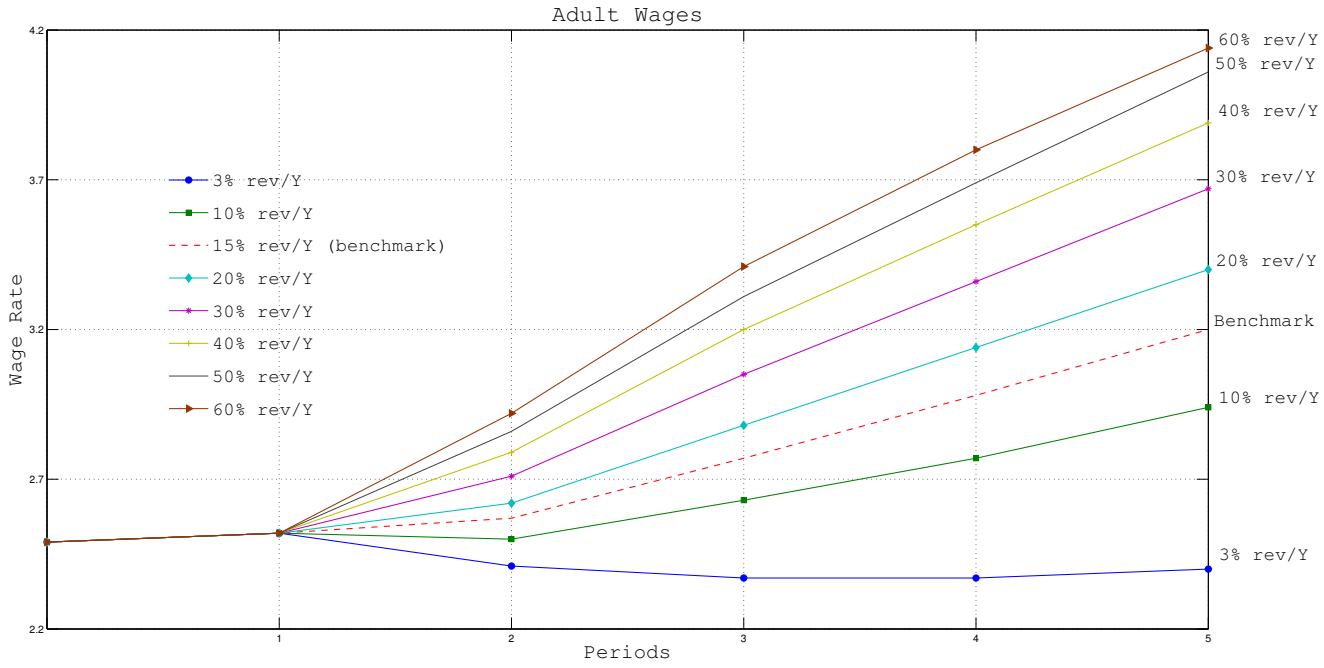


Figure 6: Adult wage rate

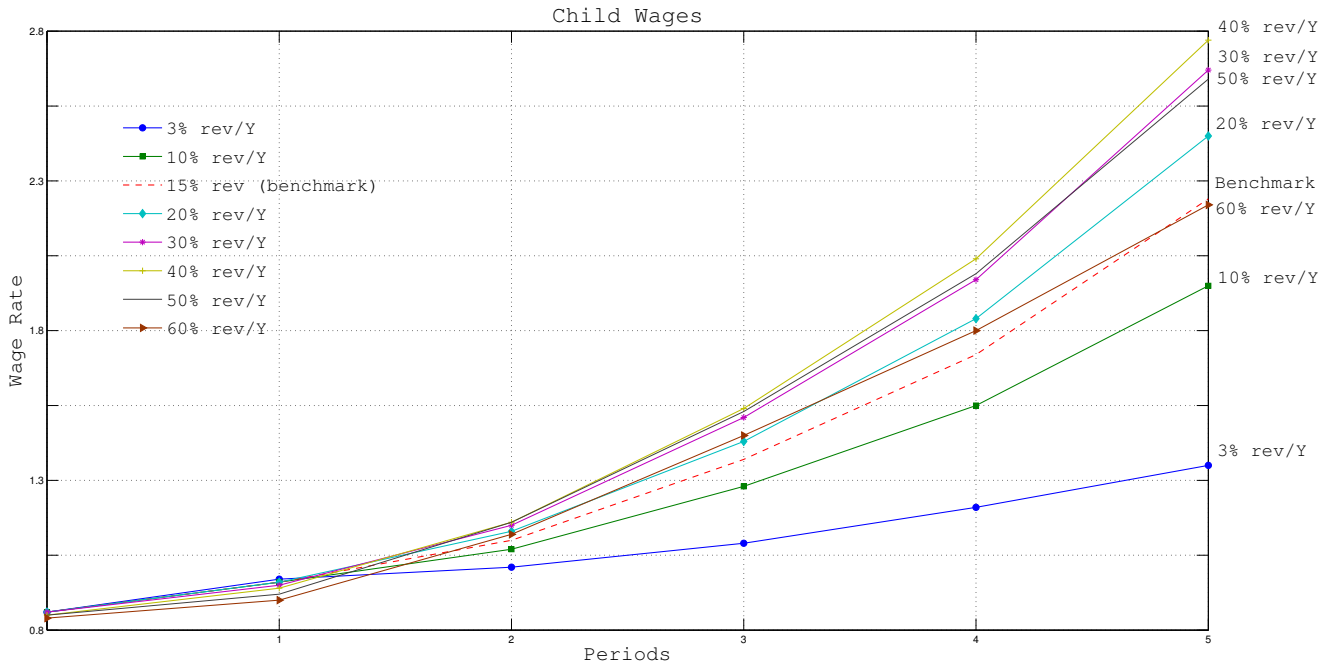


Figure 7: Child wage rate

4.1.2 Effects on effective labor

Figures 8-10 present the level of effective units of labor for workers in deciles two, five, and ninth for different sizes of government. The effective labor of workers in the second income decile increases monotonically with higher government spending so effective labor is maximized when government size is 60% of output. In contrast, effective labor of workers in the fifth and ninth deciles behaves non-monotonically with increases in government spending after period one. The non-monotonicity arises from the tension between the increase in public education spending and infrastructure investment, both working to increase effective labor, and the distortion to the schooling time allocation decision, working to lower effective labor. For the fifth decile, effective labor is maximized when the government size is 20% in periods two and three, and 30% in periods four and five.

For the ninth decile, effective labor is maximized at a government size of 50%. These households maximize effective labor at a significantly larger government because the distortion to schooling time is absent in all scenarios where government spending does not exceed 50% of output. Consequently, unlike the rest of workers, an increase in effective labor is mostly a result of changes in the quality of education, as their level of schooling remains unchanged.

Lastly, notice the non-monotonicity in the relationship between the level of human capital and the government size that maximizes effective labor. For the lowest and highest deciles effective labor is maximized when the government size is 50% or 60%, but for the the fifth decile effective labor is maximized when the government size is no greater than 30%. The effective labor for the second and ninth decile is highest at a large government size for different reasons. In the case of the ninth decile, the level of school expenditures chosen is at or close to the desired level so the income elasticity of the demand for education is low. This allows for a large level of government spending by reducing the distortionary effects of taxation. In the case of households in the second decile, their reliance on (tax-exempt) child labor earnings helps mitigate the negative income effect of a larger government. Therefore, any reduction in parental education investment, if any, is offset by the increase in public education expenditures. For the fifth decile, on the other hand, the negative income effect of larger government is greater than for lower deciles, and their schooling expenses take a larger fraction of household income compared to upper deciles. Therefore, effective

labor maximization requires a much smaller government.

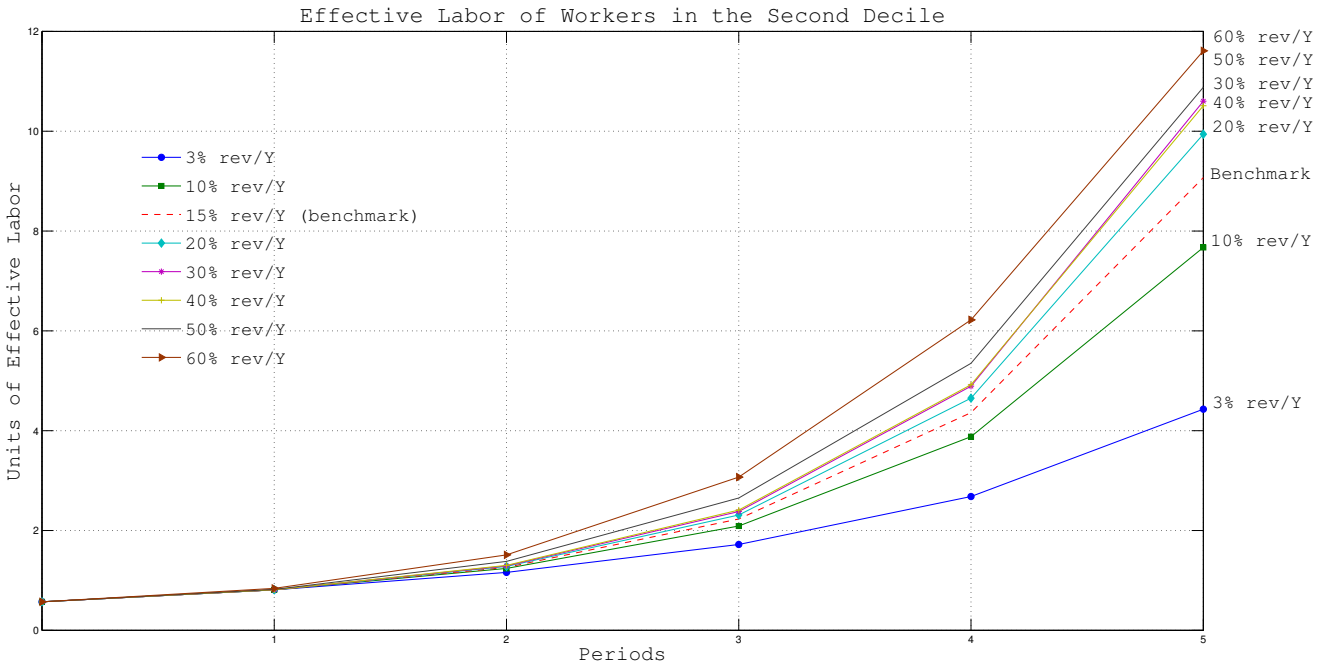


Figure 8: Human capital of workers in the second decile

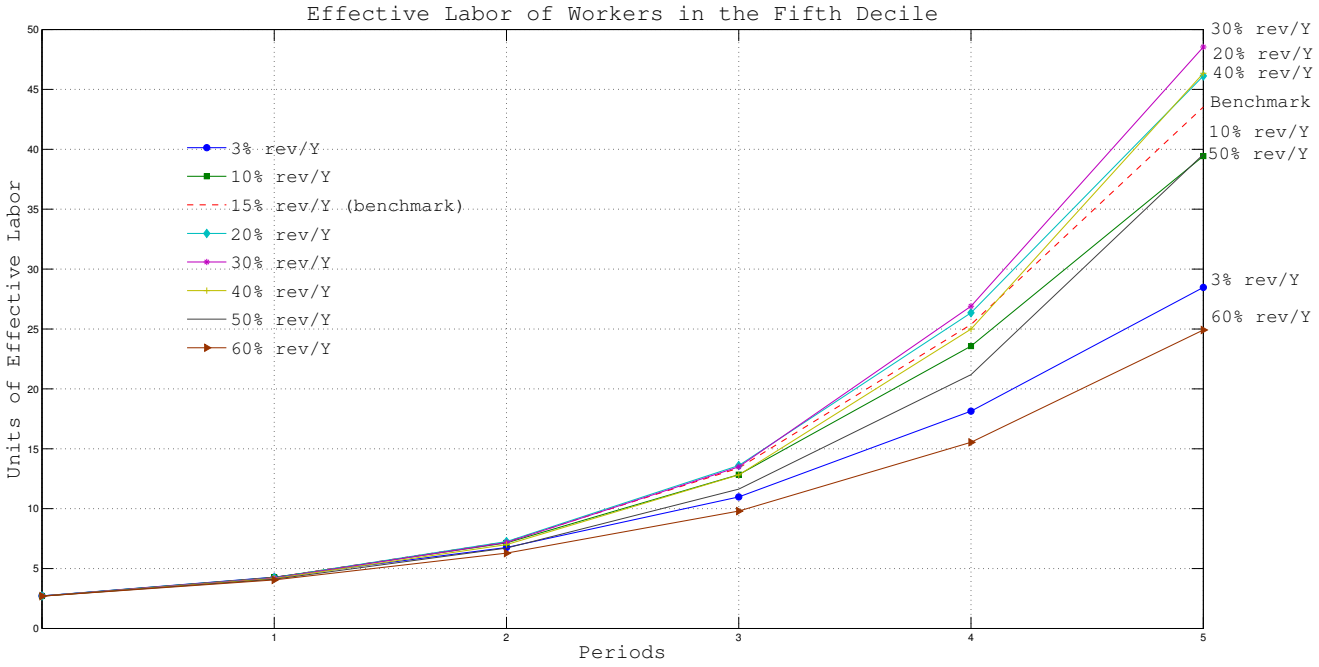


Figure 9: Human capital of workers in the fifth decile

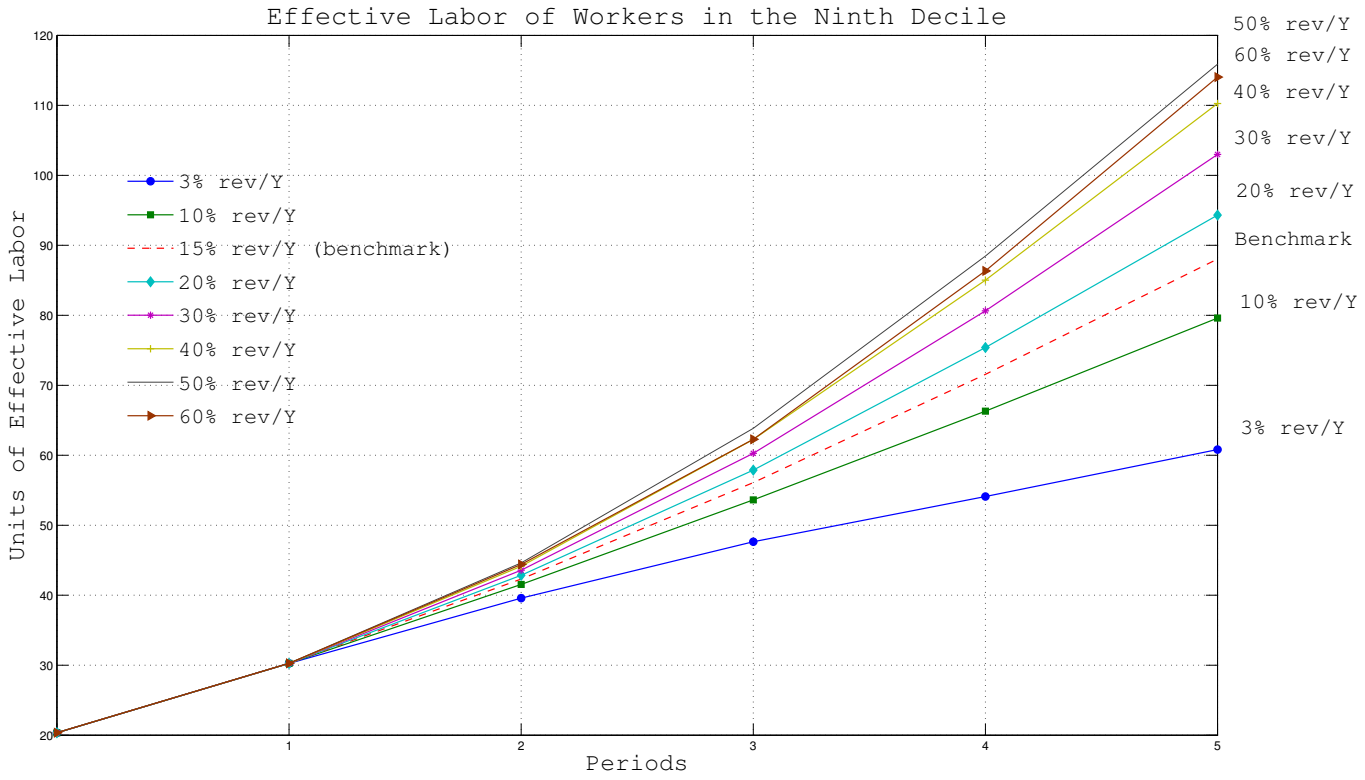


Figure 10: Human capital of workers in the ninth decile

Figure 11 presents the effect on effective labor aggregated across all worker types. Effective labor is maximized when the government size is 3% in period one and 40% in subsequent periods. Initially, the maximizing government size is driven by the increase in labor productivity of workers in middle deciles, while in later periods it falls midway between the maximizing levels for workers in deciles in either end of the income distribution and those in middle deciles. The expansion in labor productivity is 2% in the second period, and increases to 19% in the last period relative to the benchmark. This expansion, however, is only a fraction compared to the expansion in the stock of infrastructure capital. The lower return to public education spending is due to several factors. First, increases in public education expenditures affect only one input in the production of human capital while increases in infrastructure investment affect the only input in the production of public capital. Second, higher education spending is accompanied by a decrease in the private input in most scenarios, as explained in section 4.1.1. Third, the labor force updates only gradually as older workers retire and younger workers, whose effective labor reflects the new level of educational inputs, take their place.

Figure 11: Human capital of all workers

4.1.3 Effects on savings

Figures 12-14 show the level savings of households in deciles two, five and nine. The response of savings to variations in the size of government is similar across income categories. A larger government has a direct negative effect on disposable incomes and, given that saving is a normal good, the level of savings decrease. But the additional investment in both inputs to production financed by higher tax rates creates a positive general equilibrium effect on savings. The first effect dominates in the initial periods and as a result, savings are initially maximized when the size of government is 3%. Over time, as the availability of skilled labor and infrastructure capital increase the second effect pulls in the direction of higher government spending, and the savings maximizing government size increases to 10% and 15% in periods four and five. Increases in government spending above the benchmark level significantly reduce savings for all deciles and in all periods, including in the scenarios where effective labor rises.

The effect on aggregate savings is shown in figure 15. The government size that maximizes aggregate savings at any point in time is determined by the relative magnitude of the two opposing effects of higher taxes. The positive general equilibrium effect becomes larger over time shifting

the national savings maximizing tax rate to the right. In periods one through three savings are highest when taxation is at the lowest level. In later periods, the level of government that maximizes savings increases to 10% in period four and 15% in period five.

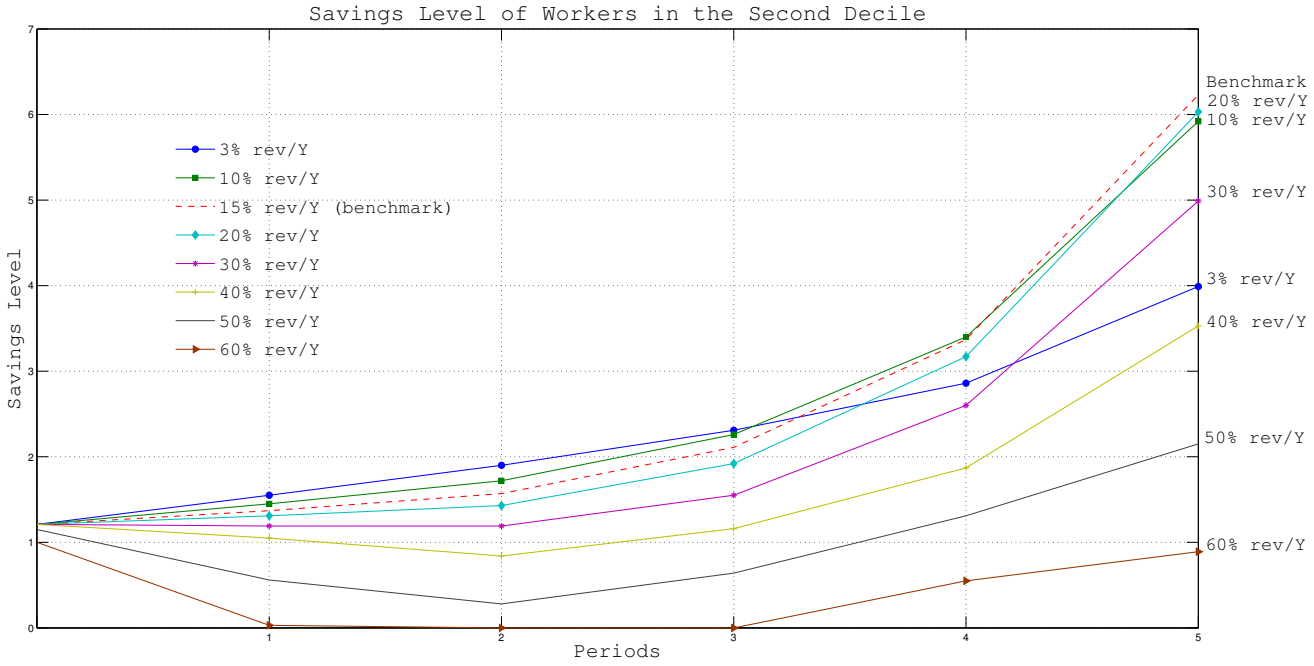


Figure 12: Level of savings of households in the second decile

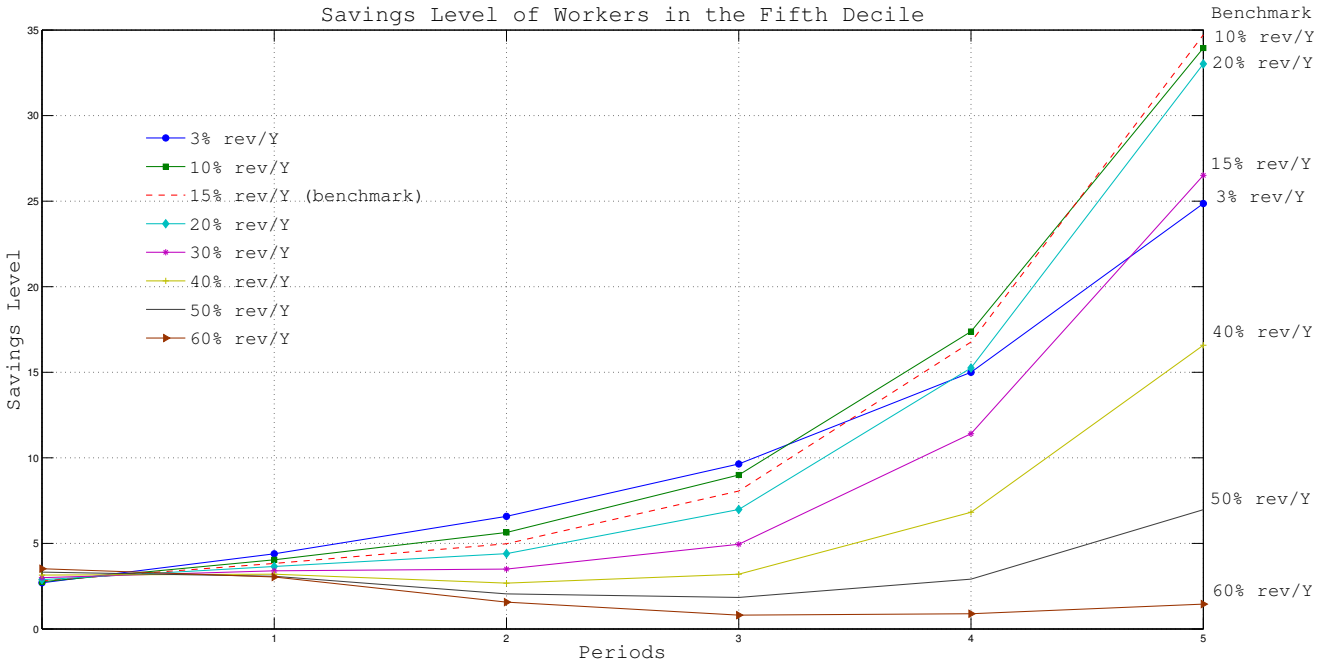


Figure 13: Level of savings of households in the fifth decile

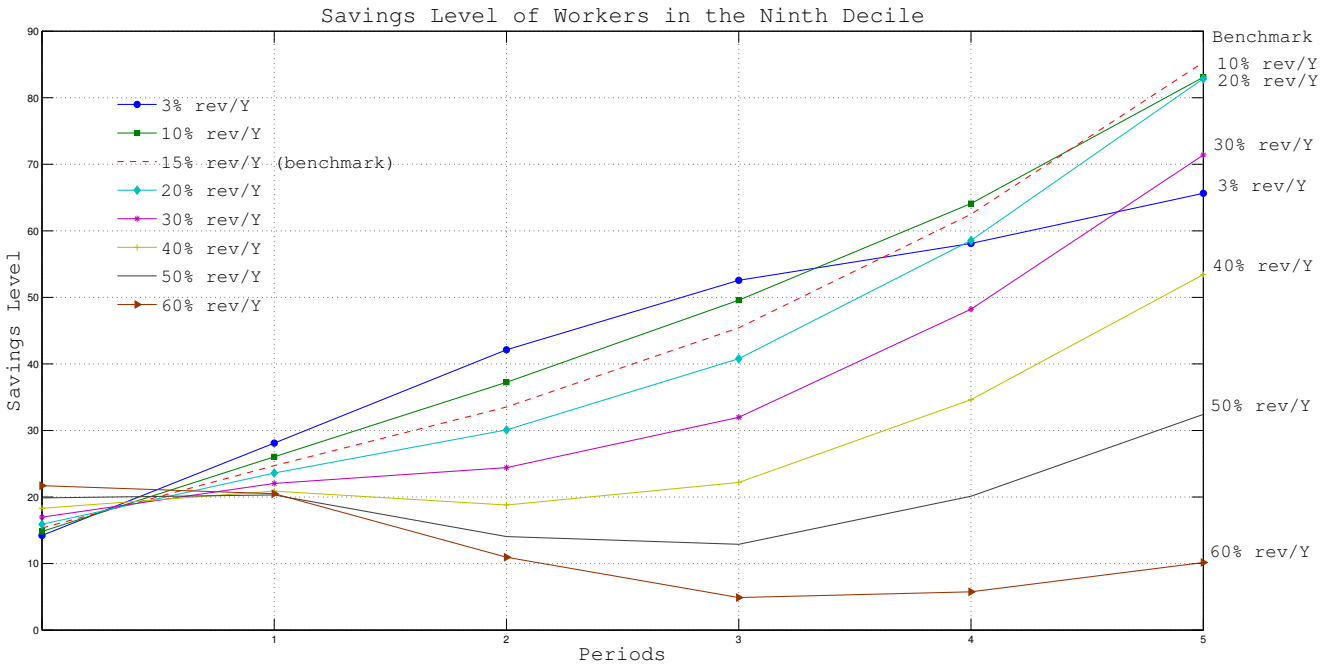


Figure 14: Level of savings of households in the ninth decile

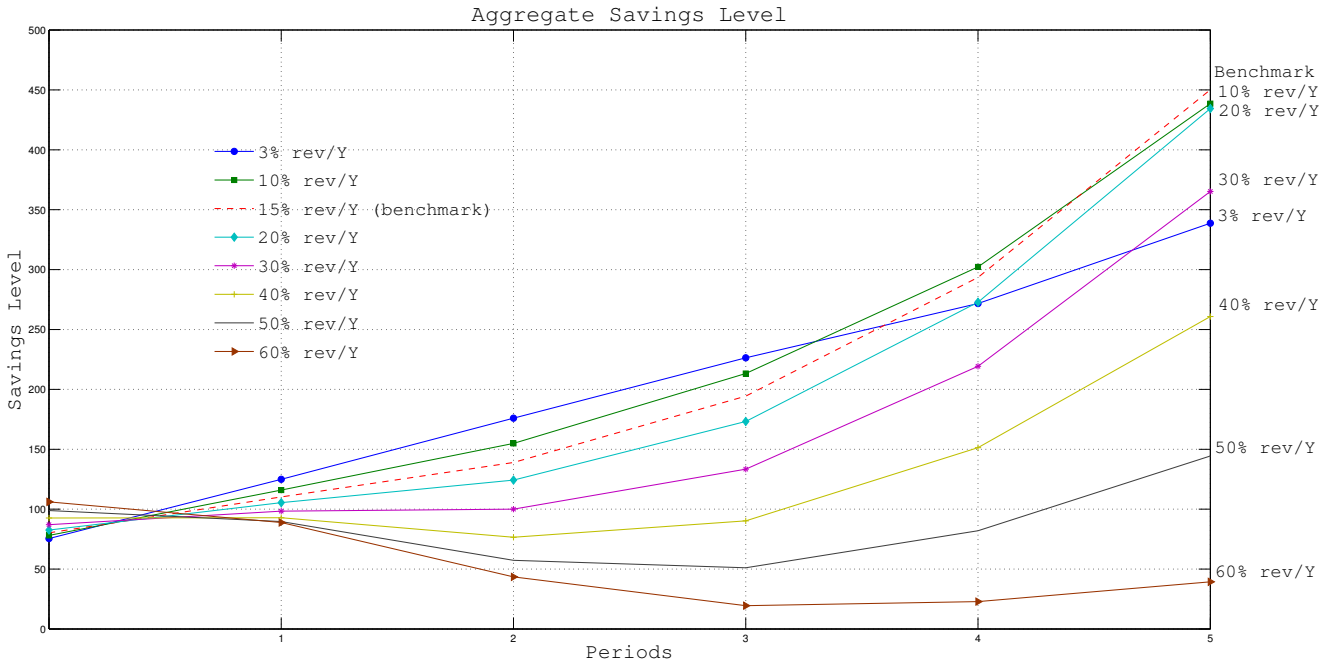


Figure 15: National savings

4.1.4 Effects on Output growth

Figures 16-19 plot output growth rates across all scenarios in each period following the reform. Growth rates behave non-monotonically according to the government's share of output similar to Barro (1990) and Glomm and Ravikumar (1994). Growth is maximized when the government's share of output is 45.6% in periods two and three, 48.7% in period four, and 50.4% in period five. The reason behind the large size of the public sector that maximizes growth is the government's role in the production of two of the three inputs to production: infrastructure capital and human capital. The increase in the growth maximizing government size is the result of an increase in the government size that maximizes effective labor caused by a weakening of the distortionary effects on schooling time over time. The government size that maximizes effective labor is 33.5% in period two, 40% in period three and 43.3% in periods four and five.

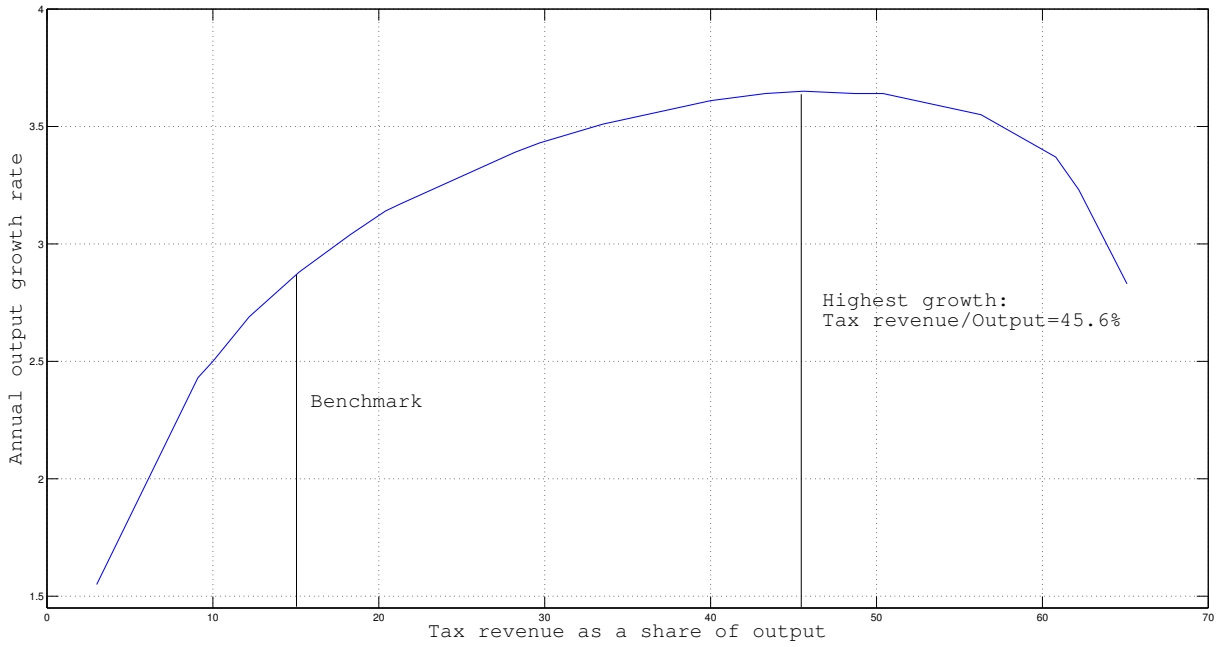


Figure 16: Output growth rates in period 2

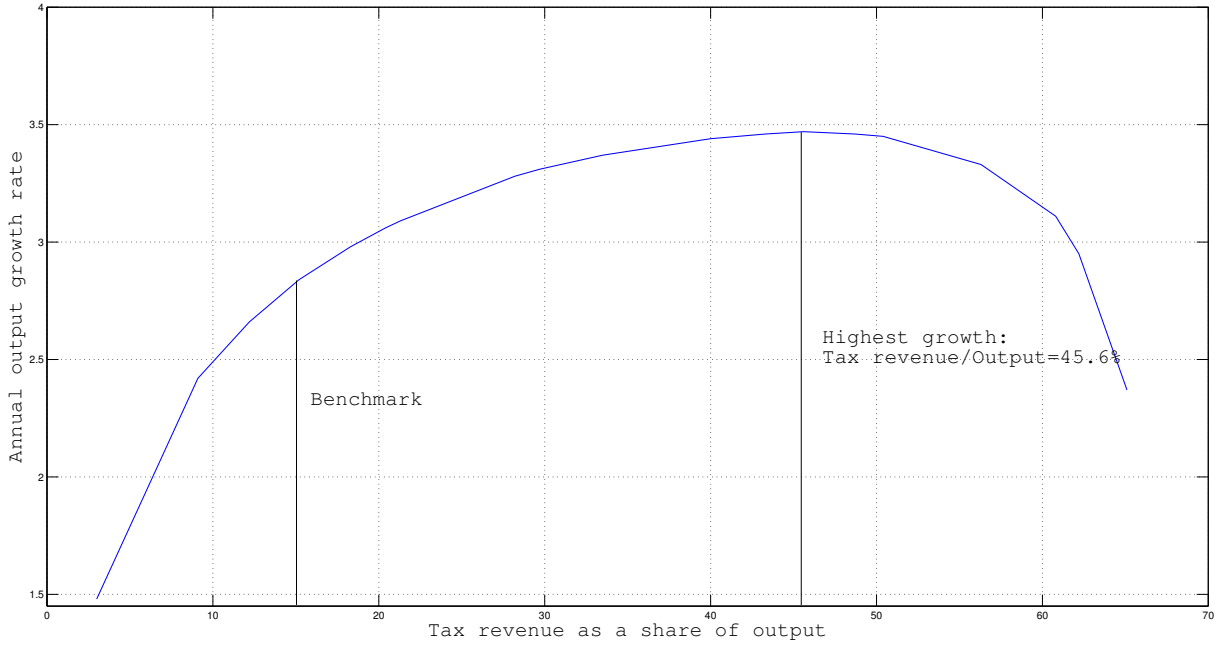


Figure 17: Output growth rates in period 3

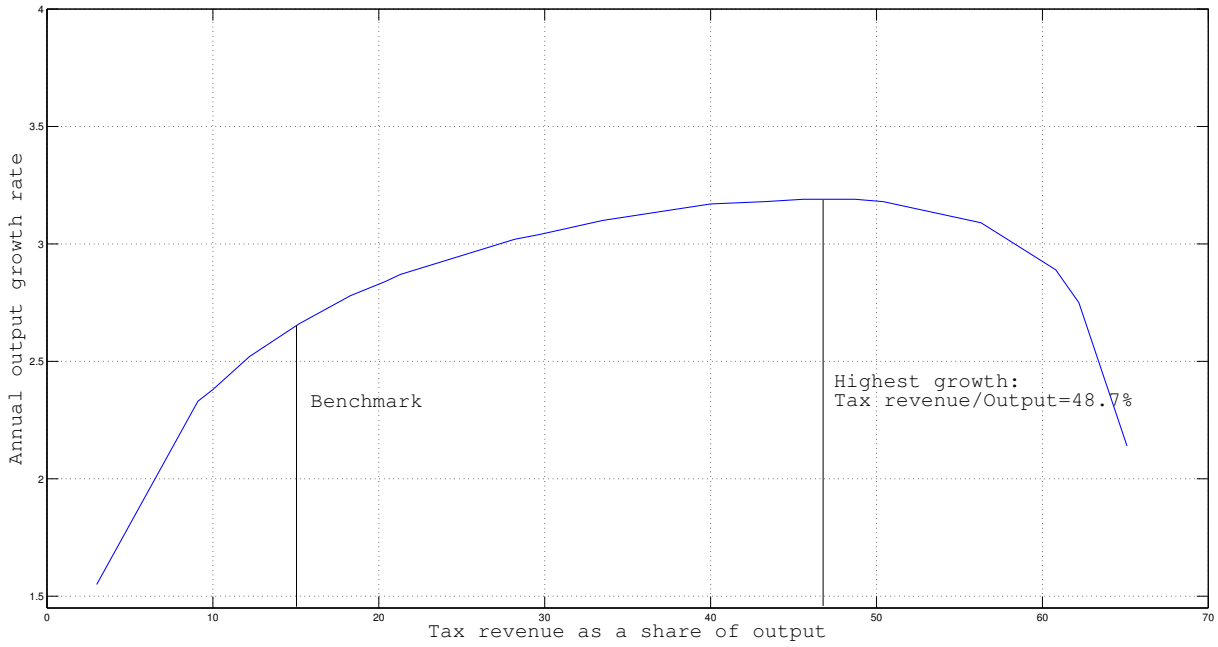


Figure 18: Output growth rates in period 4

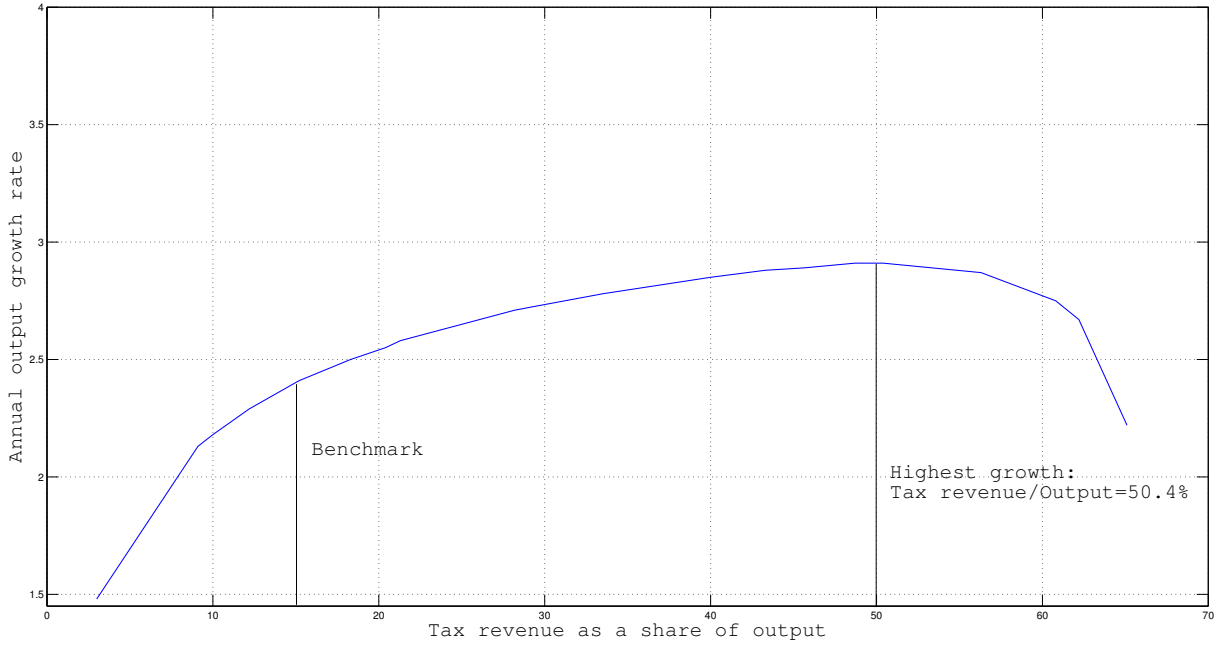


Figure 19: Output growth rates in period 5

4.1.5 Effects on Gini coefficient

Two results emerge from the analysis of variations in government size on income inequality. The first is a pattern common to all the periods: as taxes increase inequality first declines, then rises, and then declines again as seen in figures 20-23. Higher tax rates always increase the share of income of the bottom quintile, but it can lower or increase the share of income of middle and top deciles. Starting from a government size of 3%, an increase in taxes increases the income share of households with low and intermediate incomes at the expense of the share of the highest quintile. The result is a less concentrated distribution of income. At some point, higher tax rates lead to a redistribution of income from those with intermediate incomes to those in the top quintile. This shrinking of the middle class results in a higher Gini coefficient. The trend reverses when the public sector surpasses 60% of output. Households in the 80th percentile, who are otherwise unaffected by changes in the size of government, experience a decline in their share of total income relative to economies with a smaller public sector. As a result, households in the fifth and sixth deciles join those in lower deciles in enjoying a larger income share.

The second result is an increase in the size of the public sector that minimizes inequality over time. Inequality is minimized in the first and second periods when the public sector is 10% and 12.2% of output, both shares are below the share in the benchmark economy. The inequality minimizing share increases to the benchmark of 15% in period four and 18.3% in the last period. The reason behind this result is that higher tax rates accelerate the process of human capital accumulation for poorer households relative to richer households. So in any one period, the inequality minimizing tax rate does not produce the most equity-enhancing distribution of income the following period. Instead, the economy with a slightly higher tax rate and an initially (slightly) worse distribution of income produces a greater increase in the income share of poorer households and a greater decline in the income share of richer households.

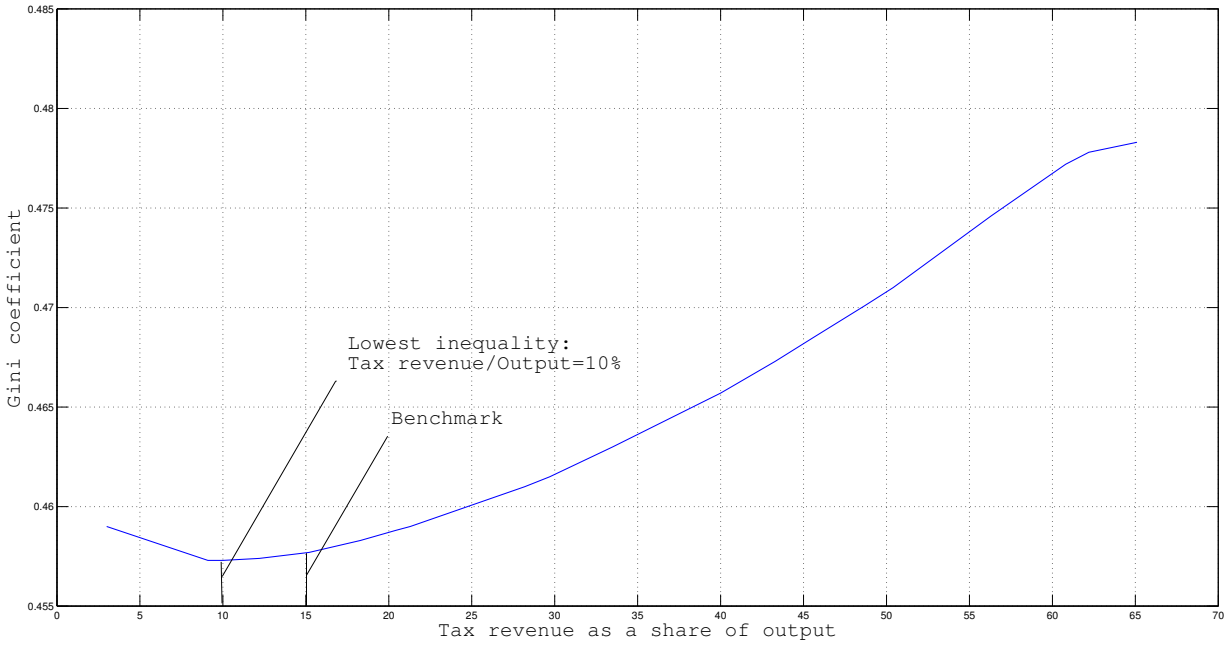


Figure 20: Gini coefficient in period 2

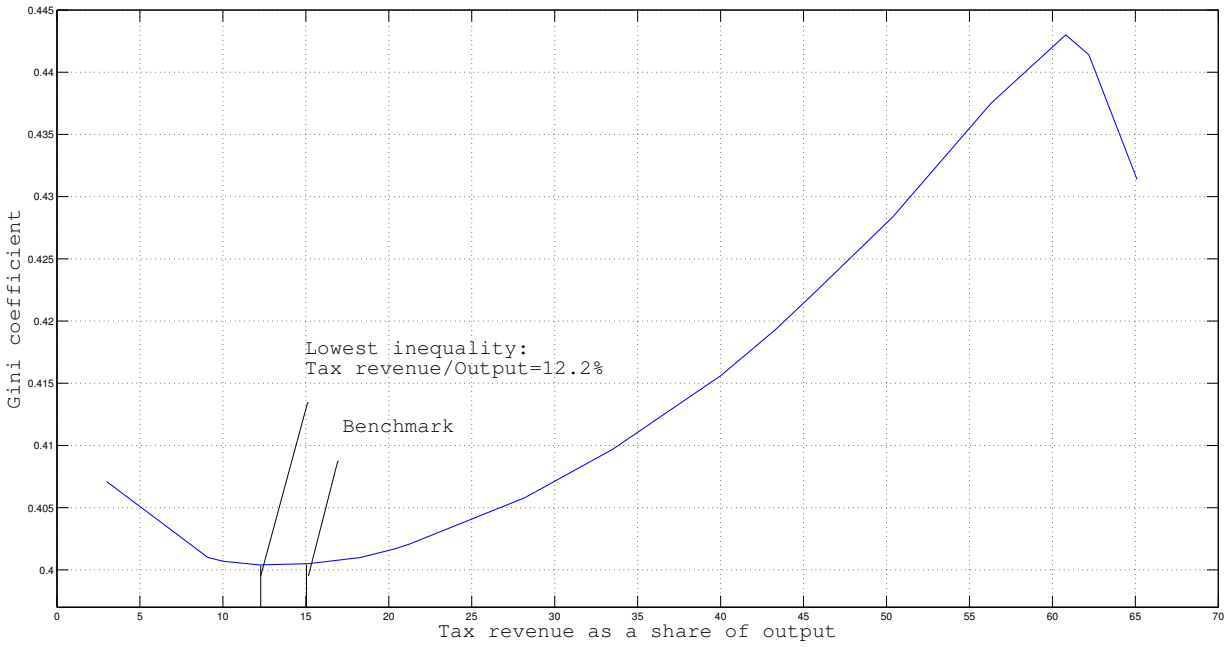


Figure 21: Gini coefficient in period 3

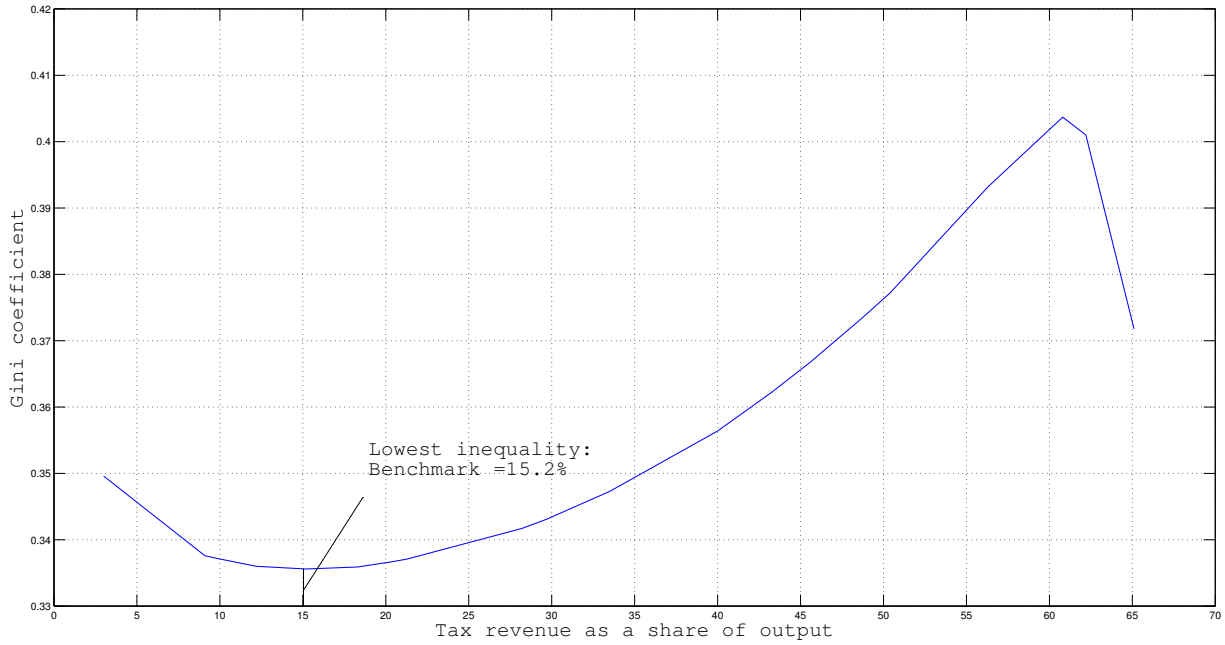


Figure 22: Gini coefficient in period 4

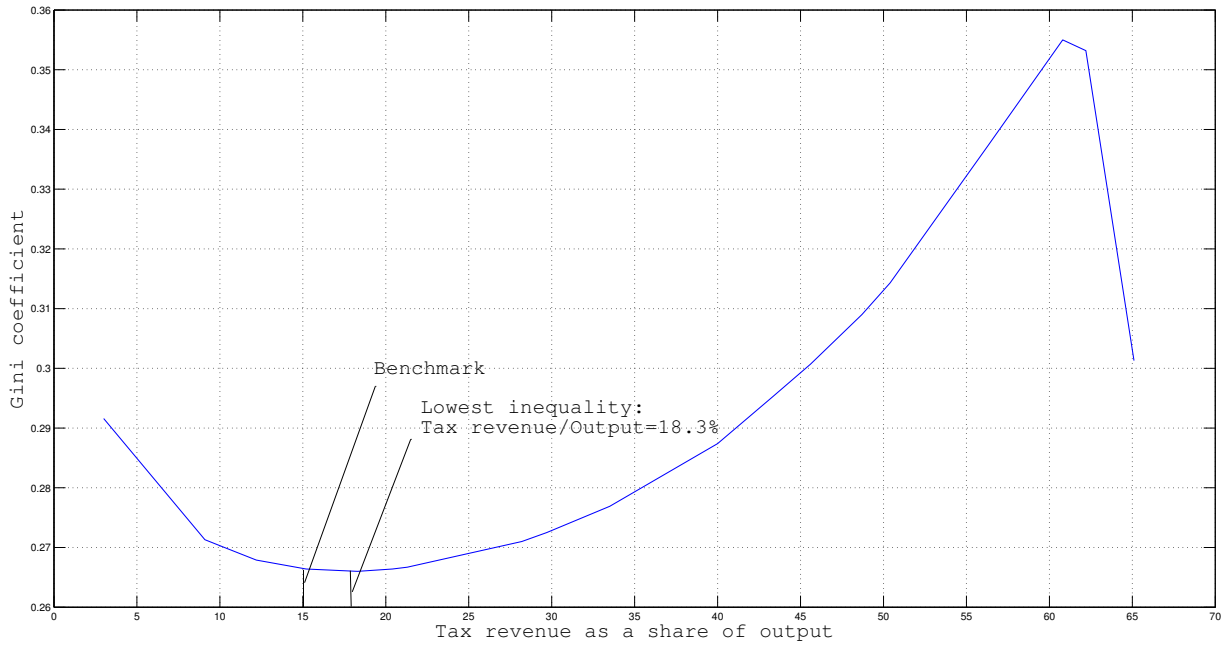


Figure 23: Gini coefficient in period 5

4.1.6 Growth-Inequality Tradeoff

The growth maximizing size of government does not coincide with the inequality minimizing size of government generating a tradeoff between growth and inequality for certain ranges of government size. Figure 24 provides a graphical illustration of the joint evolution of the Gini index, graphed using the left y-axis, and the growth rate, graphed using the right y-axis against the ratio of public spending to total output. As observed in the figure, the behavior of growth and inequality with respect to government size changes slightly over time.

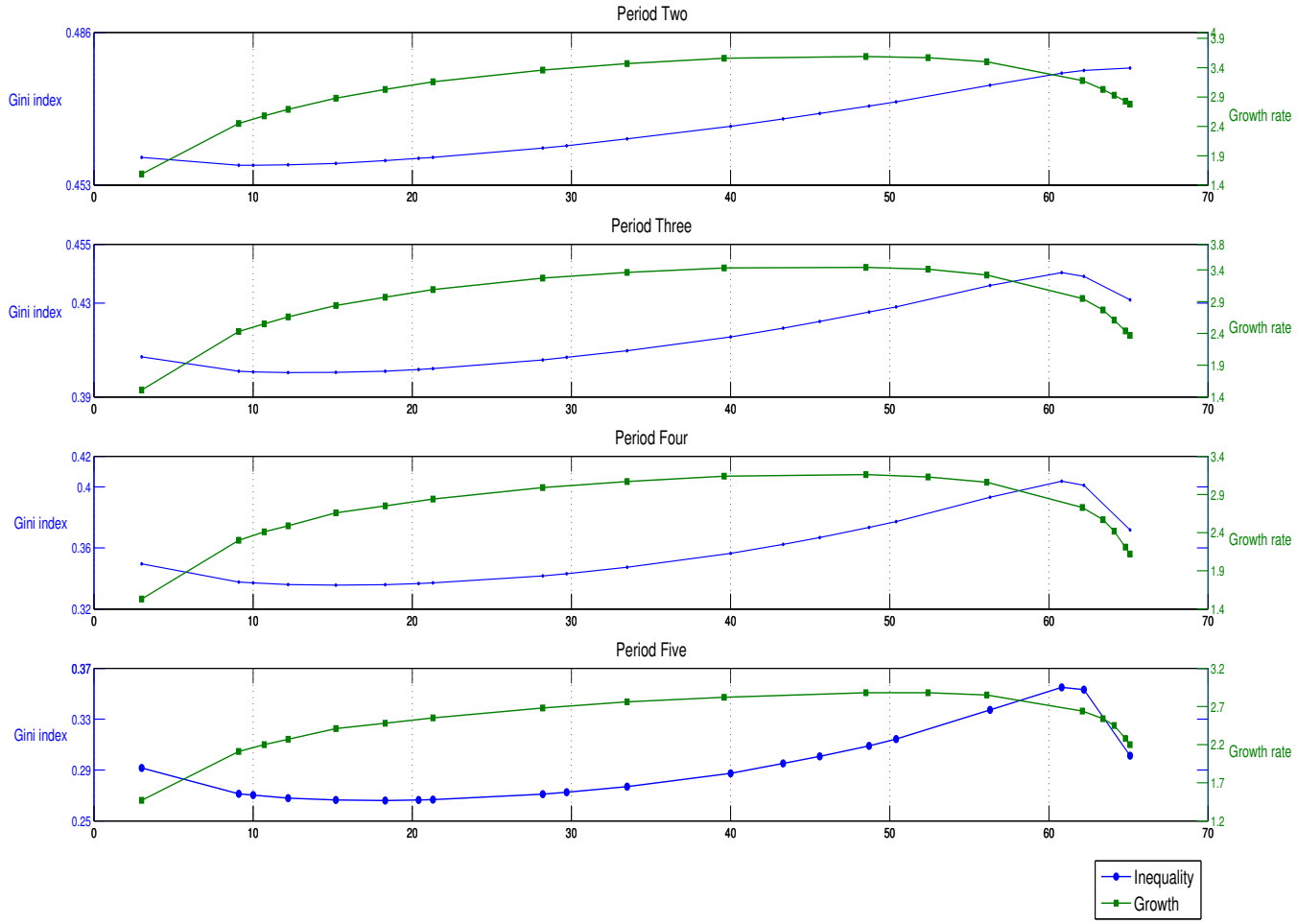


Figure 24: Growth and Inequality behavior for different tax rates

Table 3 divides the space of government size according to whether increases in the tax rates within the specified intervals generate a tradeoff between inequality and growth. We identify four regions in most time periods. Increases in the tax rate in region I increase growth while reducing

inequality. Increases in the tax rate in region II continue to increase growth, but inequality begins to increase posing a tradeoff between the two. Region III generates lower growth rates and higher inequality. Finally, region IV is associated with a less concentrated distribution of income as explained in section 4.1.5, but at the expense of a lower growth rate.

Table 3: Growth-Inequality Tradeoff

Region	**Public spending as a share of output**	**Period**	**Tradeoff**
Region I	$[3, 10]$ $[3, 12.2]$ $[3, 15]$ $[3, 18.3]$	Period 2 Period 3 Period 4 Period 5	***No tradeoff*** Higher growth and Lower Inequality
Region II	$(10, 45.6]$ $(12.2, 45.6]$ $(15, 48.7]$ $(18, 50.4]$	Period 2 Period 3 Period 4 Period 5	***Tradeoff*** Higher growth and Higher Inequality
Region III	$(45.6, 65]$ $(45.6, 62.2]$ $(48.7, 60.8]$ $(50.4, 60.8]$	Period 2 Period 3 Period 4 Period 5	***No tradeoff*** Lower growth and Higher Inequality
Region IV	$(62.2, 65]$ $(60.8, 65]$ $(60.8, 65]$	Period 3 Period 4 Period 5	***Tradeoff*** Lower growth and Lower Inequality

4.2 Second Policy Experiment: Shifting funds between education and infrastructure spending

In the second policy experiment we evaluate an alternative policy. The combined allocation to education expenditures and infrastructure investment as a share of output in the benchmark economy is 4.6% in the first period and 7.3% in all subsequent periods. Education spending accounts for 60% of that figure while the rest goes into infrastructure investment. This section examines the effects of varying the share of productive spending dedicated to education and adjusting infrastructure spending accordingly, holding all government expenditures constant. Public funding is shifted away from infrastructure investment by increasing education spending to 70%, 80% and 90% of productive spending. Alternatively, funds are shifted in favor of infrastructure investment

by reducing education spending to 50%, 40%, 30%, 20% and 10% of productive spending.

4.2.1 Effects on schooling time

Figures 25 and 26 plot average schooling of children in the second and fifth deciles as the education spending share of productive spending increases. Shifts in the allocation of public spending do not have an effect on the schooling of children in the top deciles so we have omitted the results. These parents are able to afford sending the child to school for the entirety of childhood regardless of the level of public education spending. The same applies to households in middle deciles who eventually accumulate enough human capital to choose a full course of schooling. Households in the fifth decile, for example, are no longer affected by shifts in public spending starting in period three as seen in figure 26. Only in the case where education spending is reduced to the minimum share of 10% of productive spending are there significant adverse effects on schooling.

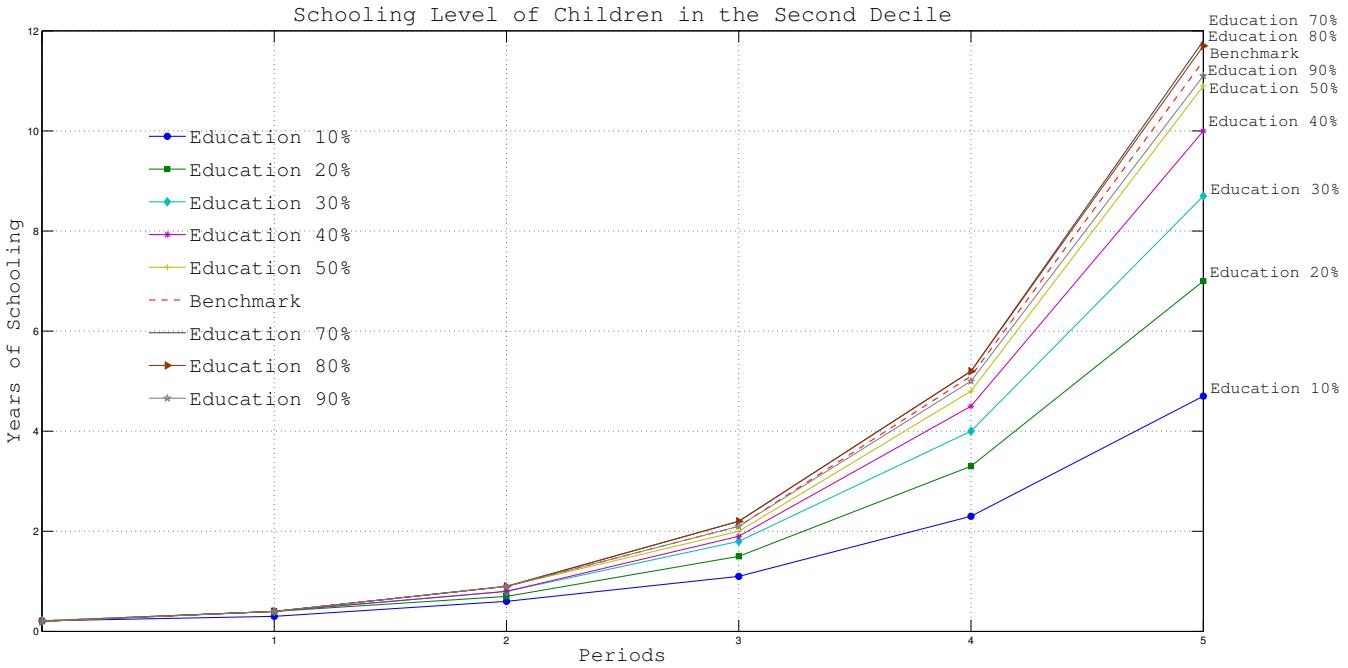


Figure 25: Years of schooling of children in the second decile

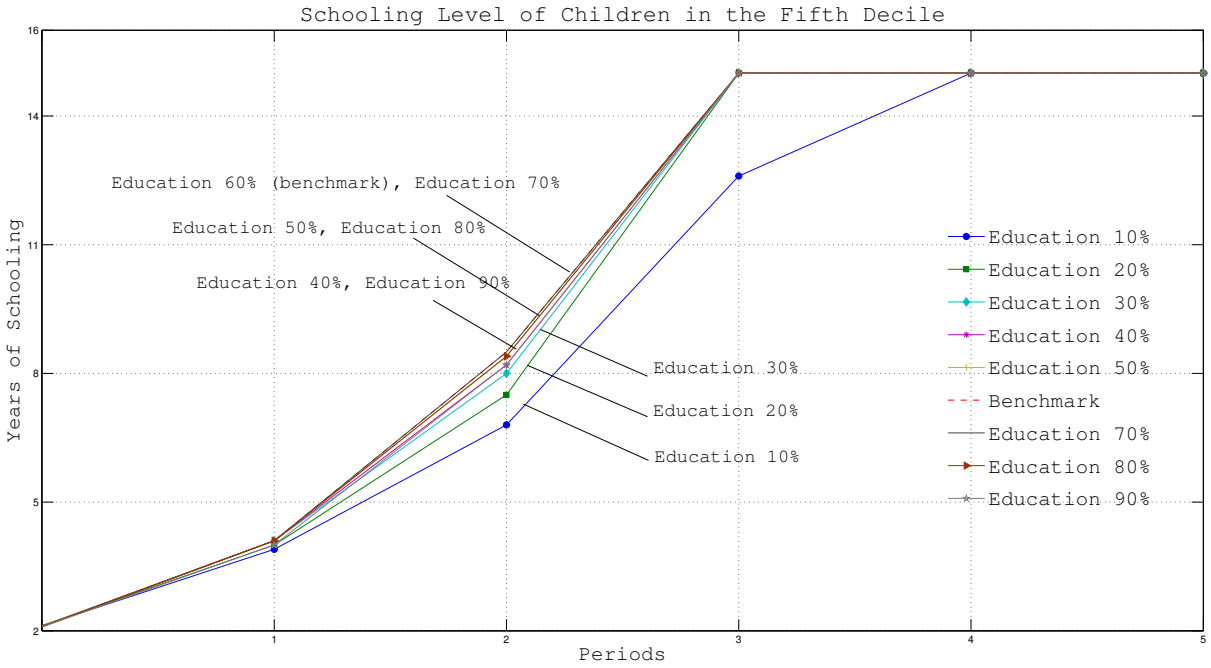


Figure 26: Years of schooling of children in the fifth decile

Increasing education spending has two effects on schooling time for the rest of households. The first effect is positive, and it results from the complementarity between private and public inputs to human capital formation. Parents in the second decile, as observed in figure 25, increase schooling time of their children when education spending increases to 70% and 80% of productive investment. This is the allocation of public spending that maximizes their children's schooling time. The second effect is a negative effect that results from the reduction in infrastructure investment. The resulting decline in infrastructure capital stock reduces the demand for human capital given the complementarity of these two inputs in production. This effect dominates for households in the fifth decile in periods one and two. In the alternative scenarios when infrastructure investment is increased, the effect operating at the household level is stronger for both deciles. The reduction of public spending in education discourages parents from sending their children to school and as a result, schooling time falls.

Figure 27 shows average years of schooling of all workers. The two effects of increasing education spending are balanced differently at any point in time. The schooling-maximizing share of education spending is below or at the benchmark in the initial periods driven by a small increase in schooling

among workers in middle deciles. In the last two periods, the education share that maximizes schooling is above that of the benchmark economy. The shift over time is the result of a change in the weight of the contribution of each decile to total schooling. As education levels rise, gains in aggregate schooling come mostly from poorer households who make the most progress towards completing a full course of schooling when education spending is higher.

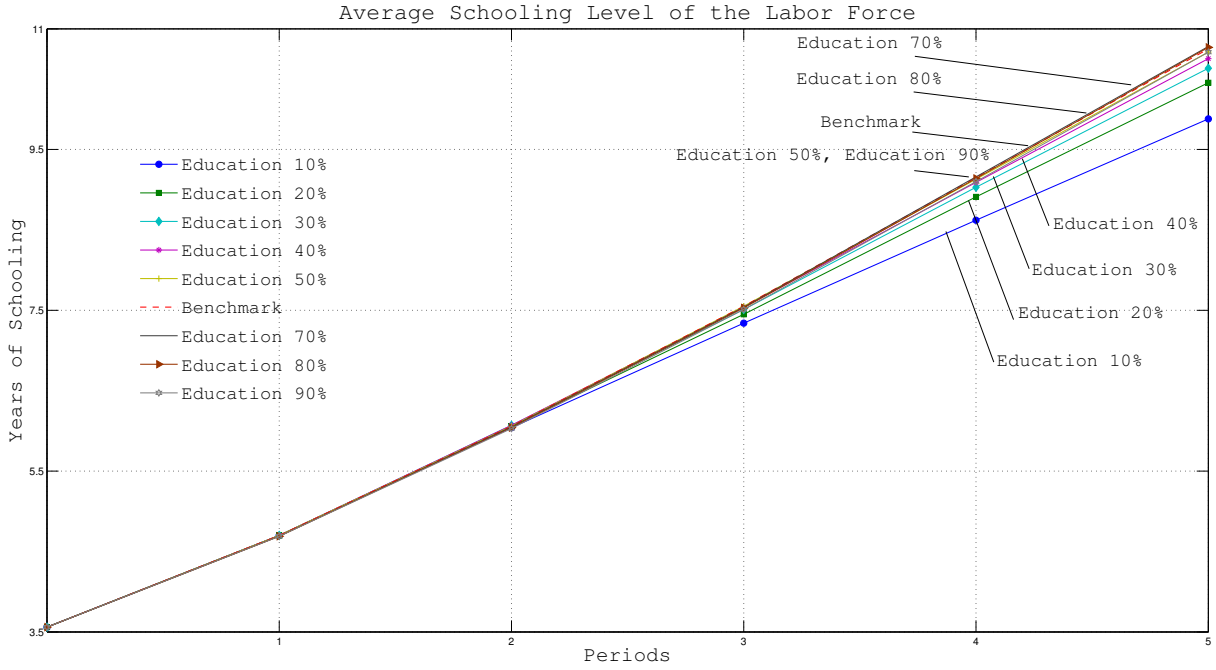


Figure 27: Average years of schooling of the labor force

4.2.2 Effect on effective labor

The effect on effective labor of households in selected deciles is shown in figures 28-30. Effective labor is maximized for all three deciles when education accounts for 90% of productive spending in periods two through five. This result suggests that the increase in public education expenditures outweighs any reduction in schooling time associated with a level of infrastructure investment equal to 10% of productive spending.

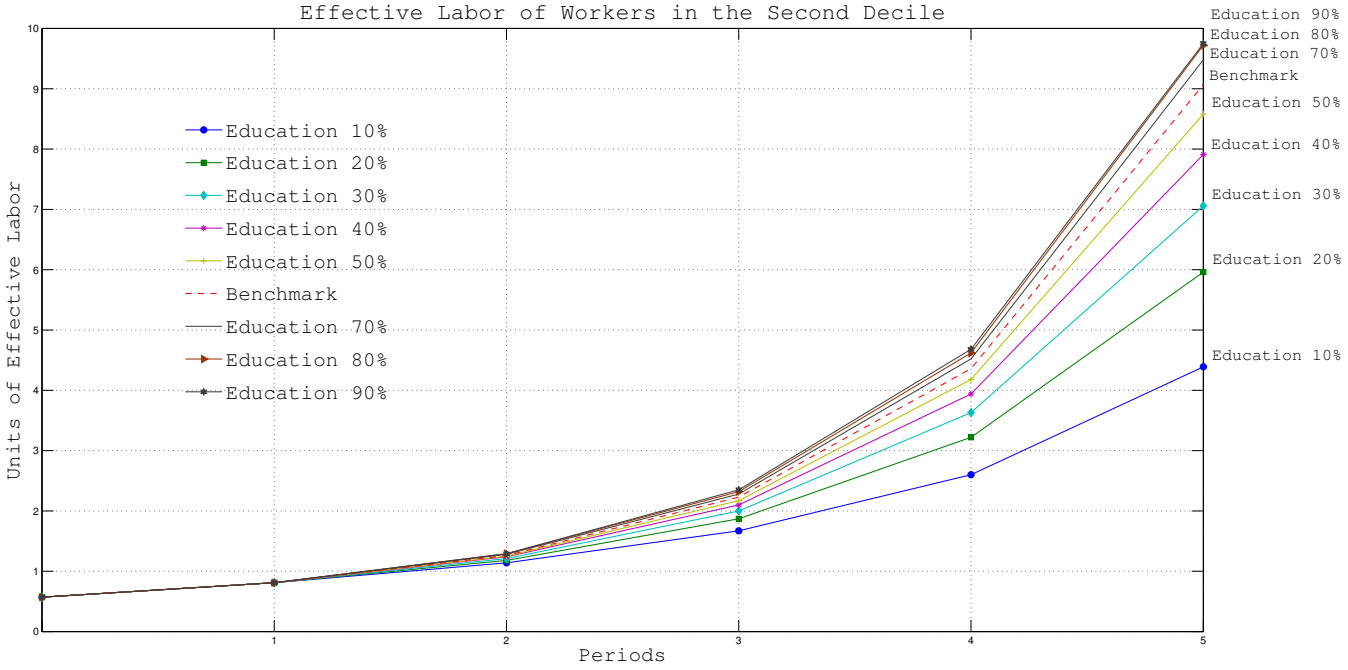


Figure 28: Human capital of workers in the second decile

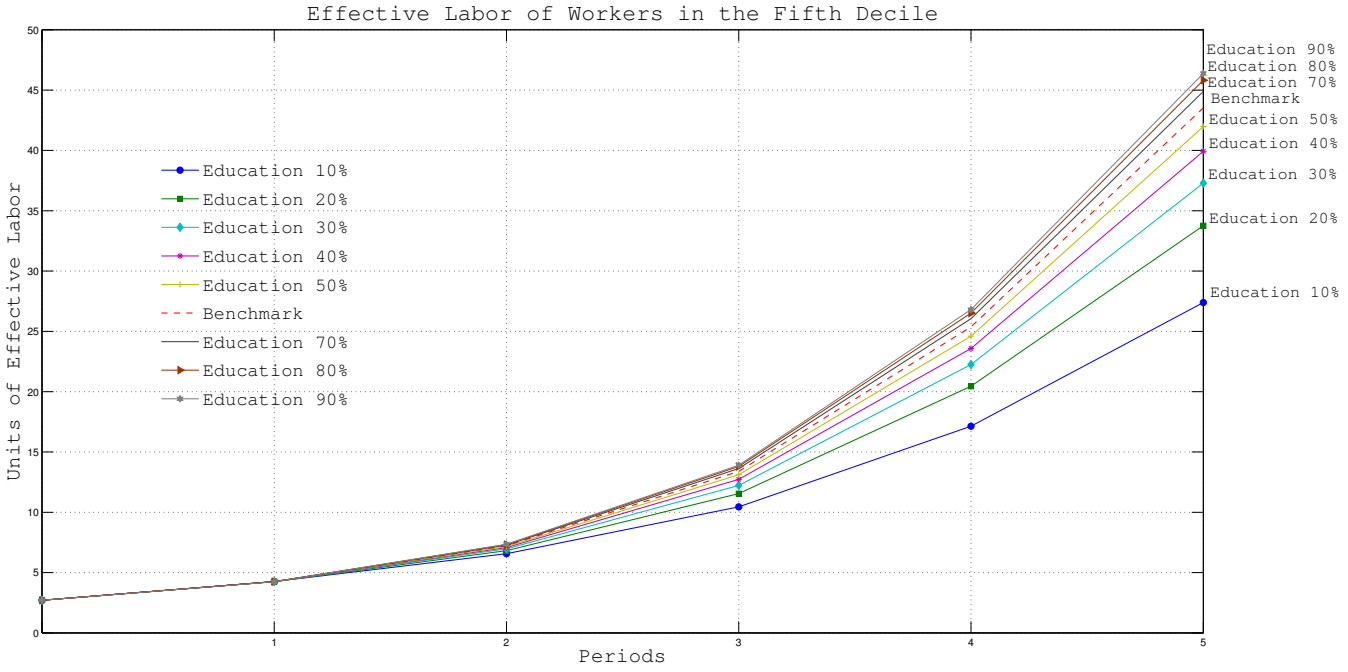


Figure 29: Human capital of workers in the fifth decile

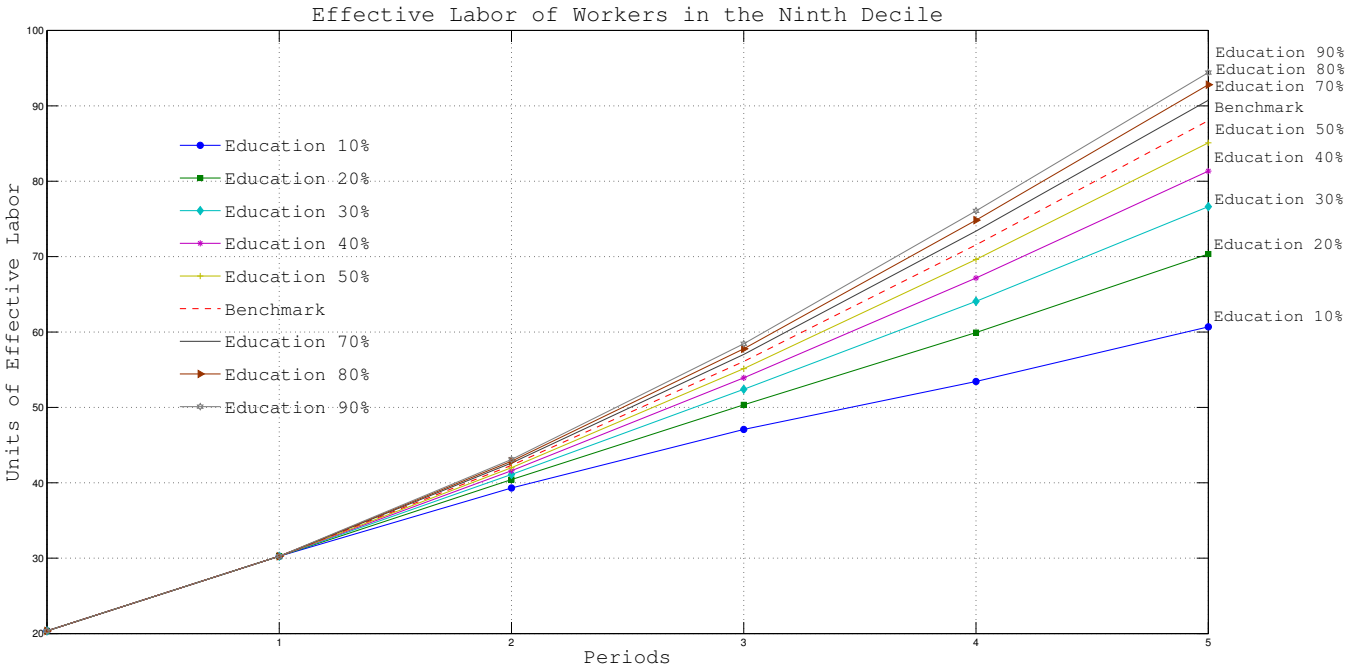


Figure 30: Human capital of workers in the ninth decile

Figure 31 shows the effect on aggregate effective labor. Lowering the fraction of total spending dedicated to education reduces effective labor through its direct effect on the level of public education spending and its indirect effect on the private investment in human capital. Alternatively, increasing the fraction of productive spending for education increases effective labor. The increase, however, comes at the expense of a large reduction in infrastructure capital. The 1.8% initial increase in effective labor is accompanied by a contraction of 30% in the stock of public capital relative to the benchmark economy. This contraction in the public capital stock affects aggregate productivity and in turn, tax revenue causing diminishing returns to increases in education spending.

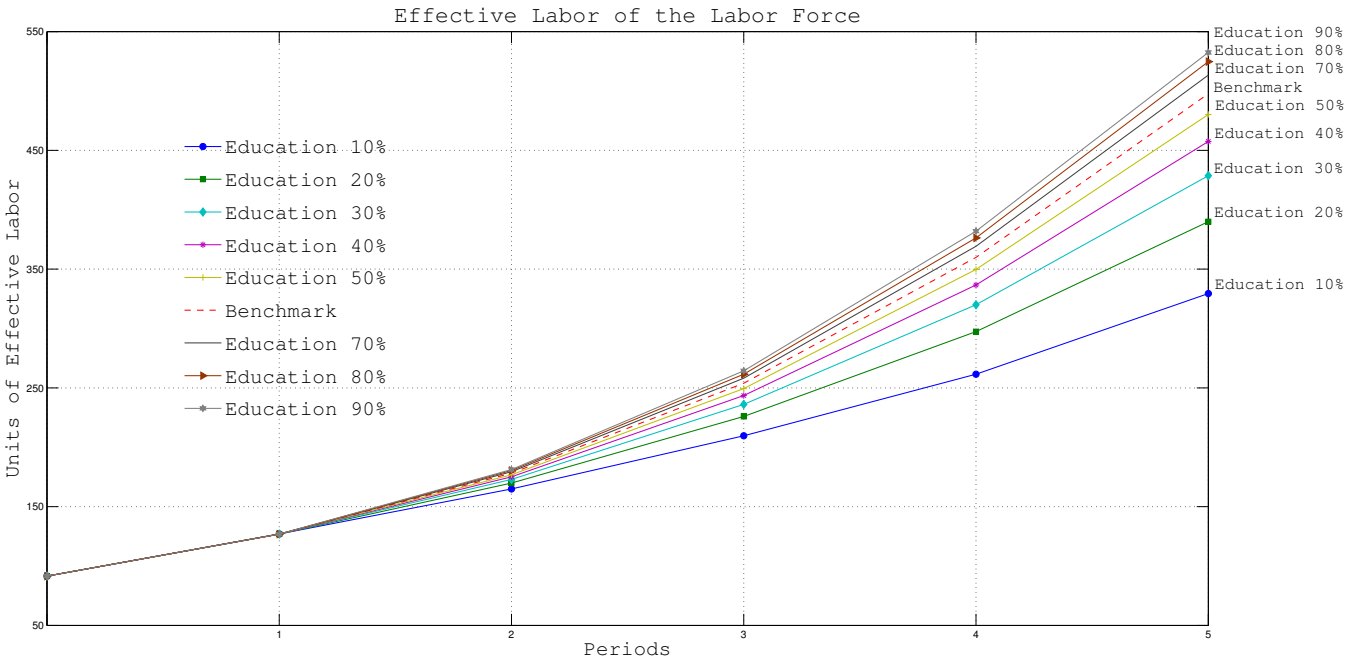


Figure 31: Human Capital Level of all Workers

4.2.3 Effect on savings

The effect on the savings level of workers in deciles two, five and nine are presented in figures 32-34. Savings are maximized in the initial periods when education spending is 90% of productive expenditure. Higher savings are households' responses to the expectation of lower wages in the future as a result of an underinvestment in infrastructure. The temporary decline in wages is caused by a declining private capital to labor and public capital to labor ratios. As the economy continues to grow in the following periods, the level of infrastructure investment recovers and wages begin increasing. The impact on adult and child wages can be observed in figures 36 and 37.

Savings are maximized for households in the fifth and ninth deciles when education spending is 90% in period three, and between 50% and 60% in periods four and five. Households in the second decile maximize their savings at a lower level of education spending. The savings maximizing allocation of productive spending for them is 30% in period three, and between 50% in periods four and five. The negative income effect created by a lower level of education spending is smaller for households in the second decile owing to the larger contribution of child labor earnings to household income. In the last three periods, child labor is only observed among households in the bottom

deciles. When education spending is reduced relative to the benchmark economy, working children not only work more, but their wages are generally higher as seen in figure 37.

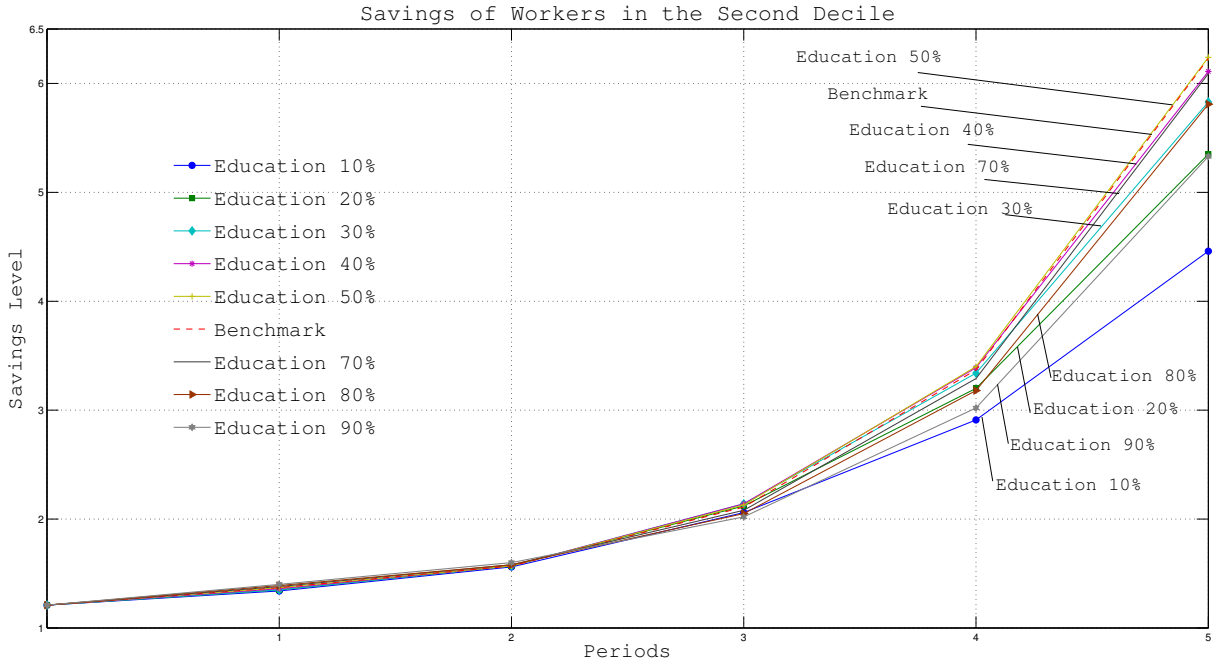


Figure 32: Savings of households in the second decile

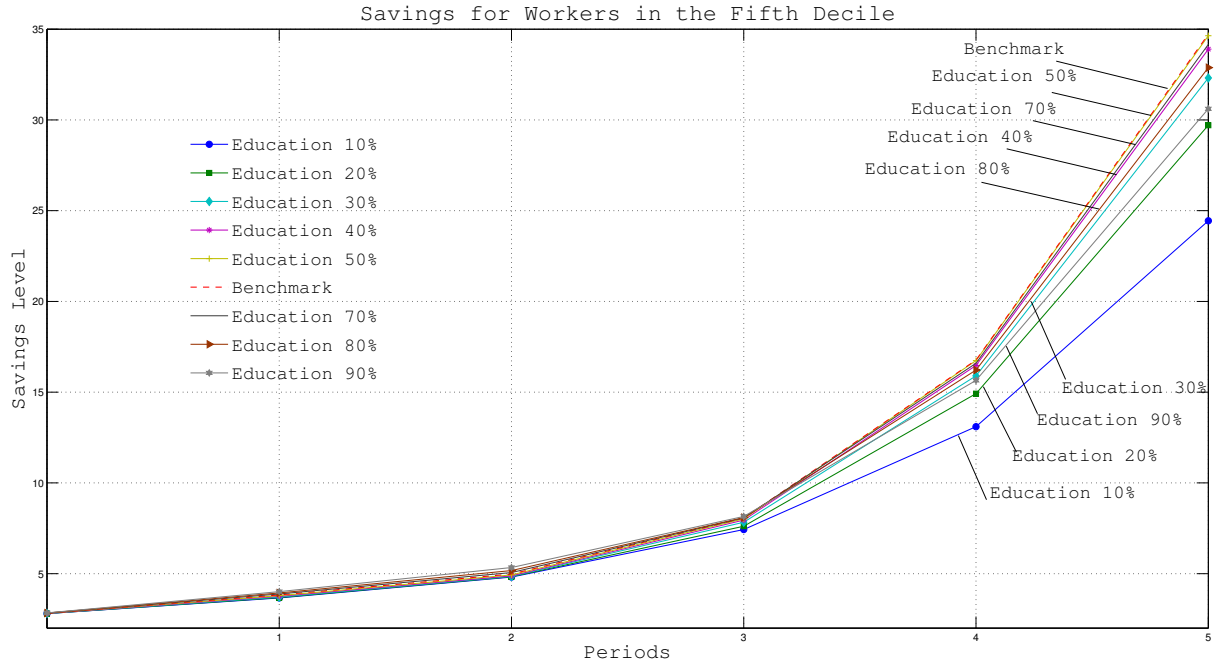


Figure 33: Savings of households in the fifth decile

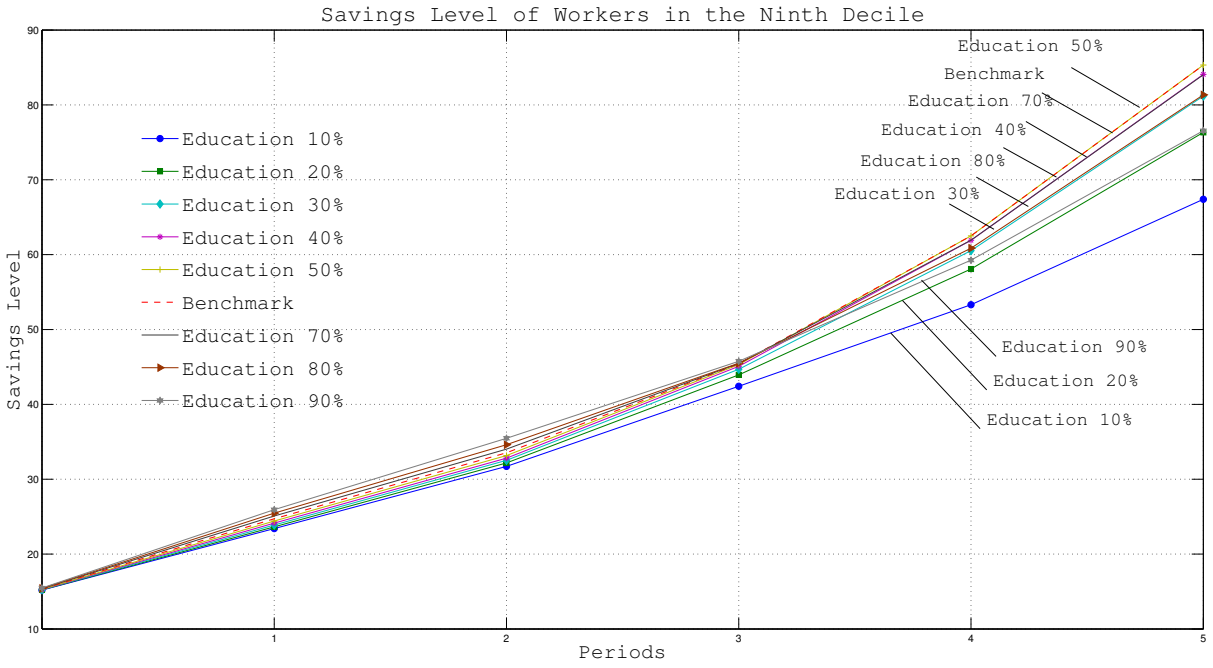


Figure 34: Savings of households in the ninth decile

Notice that for all three deciles, there is a temporary recovery in savings behavior around the third period in scenarios where education spending is in the range of 20% to 50% of productive spending. The recovery is most visible for households in the second decile for which it translates into a small increase in savings. This response is the effect of rising wages over the lifetime of workers whose human capital remains unchanged during their working lives. Young workers in the second period, for example, save less than their counterparts in economies where education spending is higher given their lower human capital. These workers will continue to save in the following two periods as middle-age and old-age workers, and while their human capital will always be lower, the wage they earn will rise faster. The net effect on total savings is positive whenever the increase in the wage rate produces an increase in the savings of older workers that can offset the decline in the savings of younger workers.

Figure 35 presents the effect on aggregate savings for all worker types. National savings are initially maximized when education spending is 90% of productive government expenditures. In the last two periods, the share of education spending that maximizes national savings falls to 50% and 60% of productive spending.

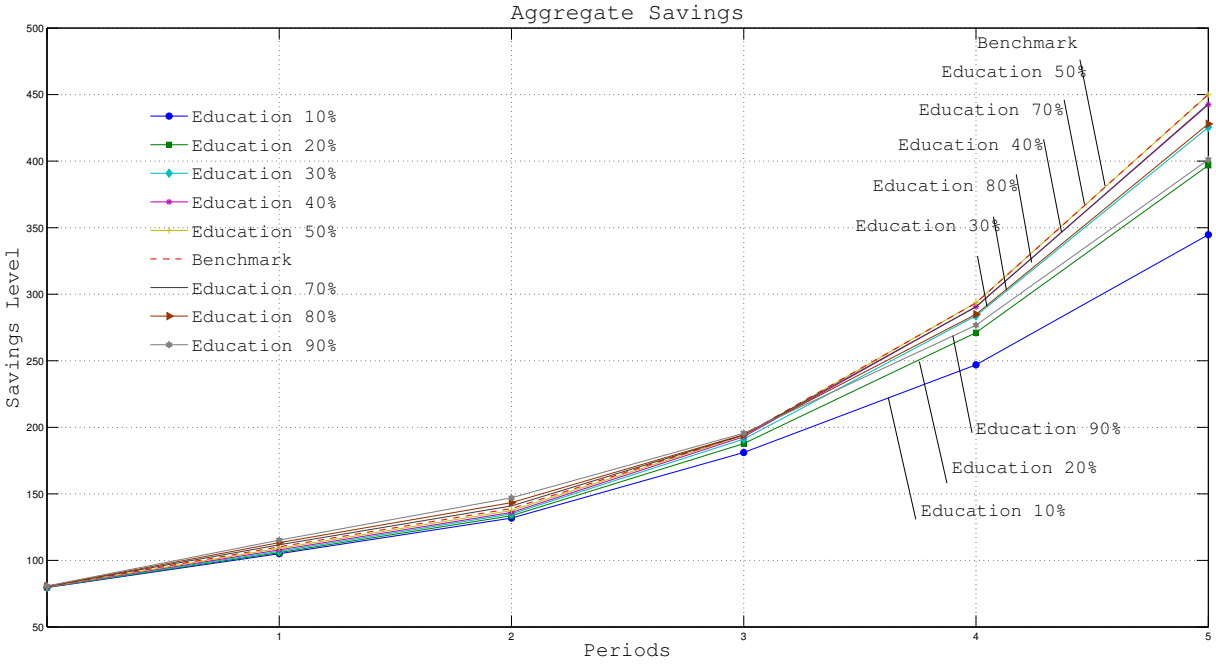


Figure 35: Aggregate Savings

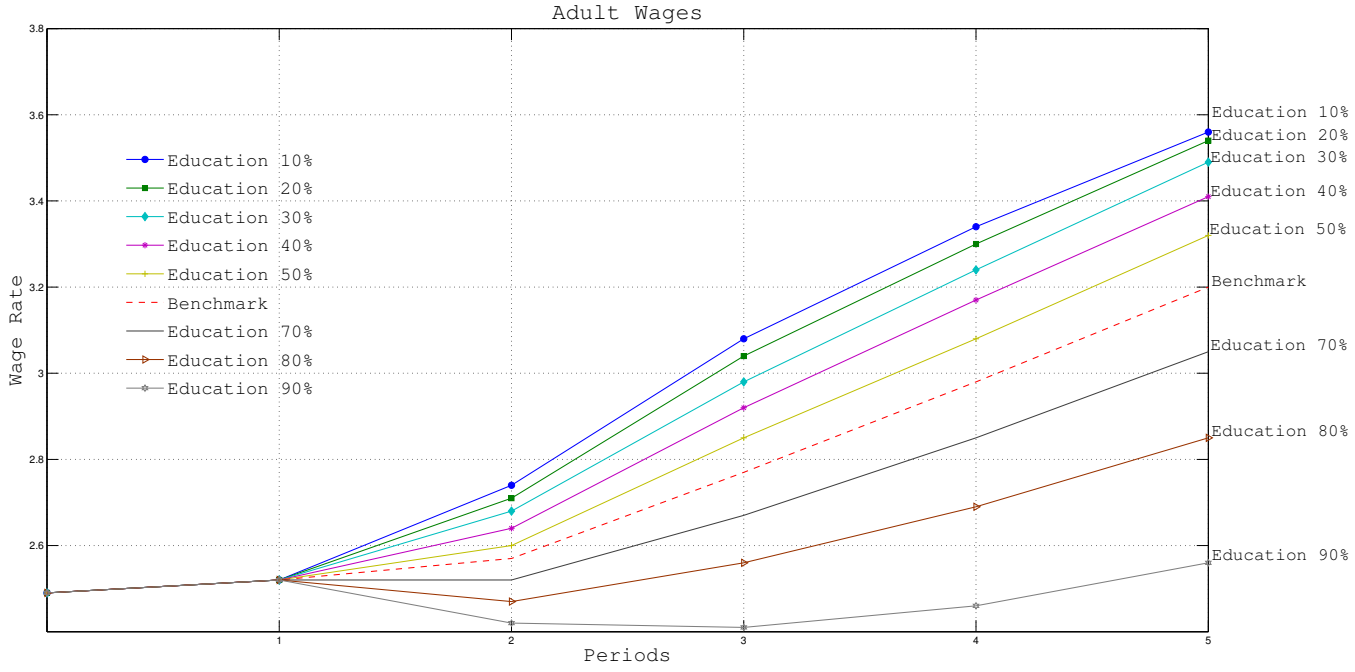


Figure 36: Adult wage rate

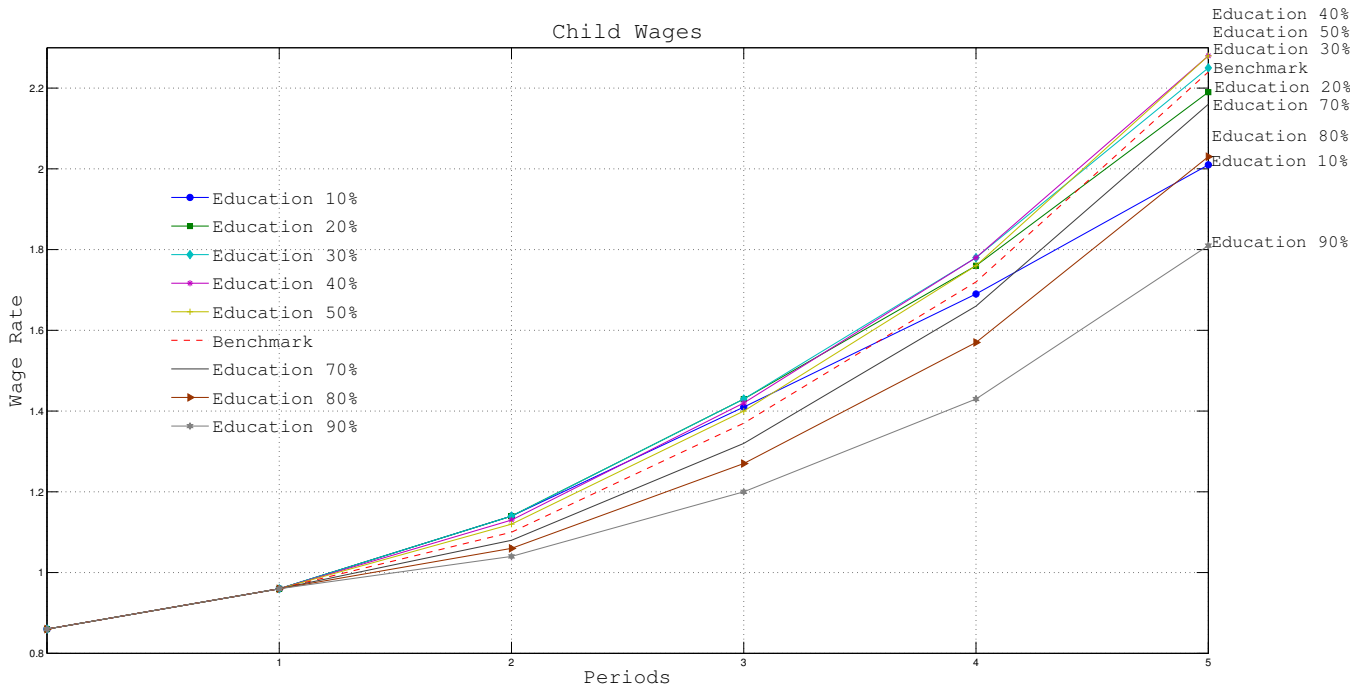


Figure 37: Child wage rate

4.2.4 Effect on Output growth

Shifting public funds away from education and into infrastructure yields a higher output growth in period one given the growth effects of an immediate expansion in infrastructure spending. Figure 38 shows that an even split between infrastructure and education spending maximizes output growth. As the level of effective labor builds up, output growth is maximized at higher levels of education spending. Figures 39-41 show the growth maximizing share is 60%, the benchmark level, in period three and 70% in the last two periods.

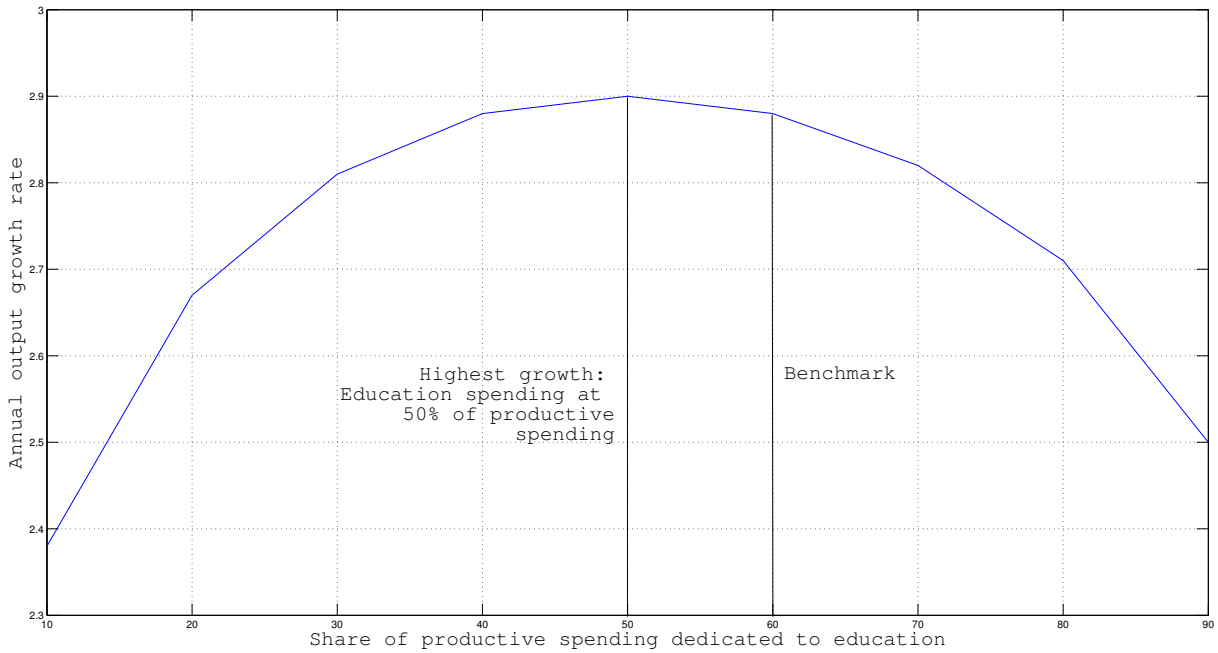


Figure 38: Output growth rates in period 2

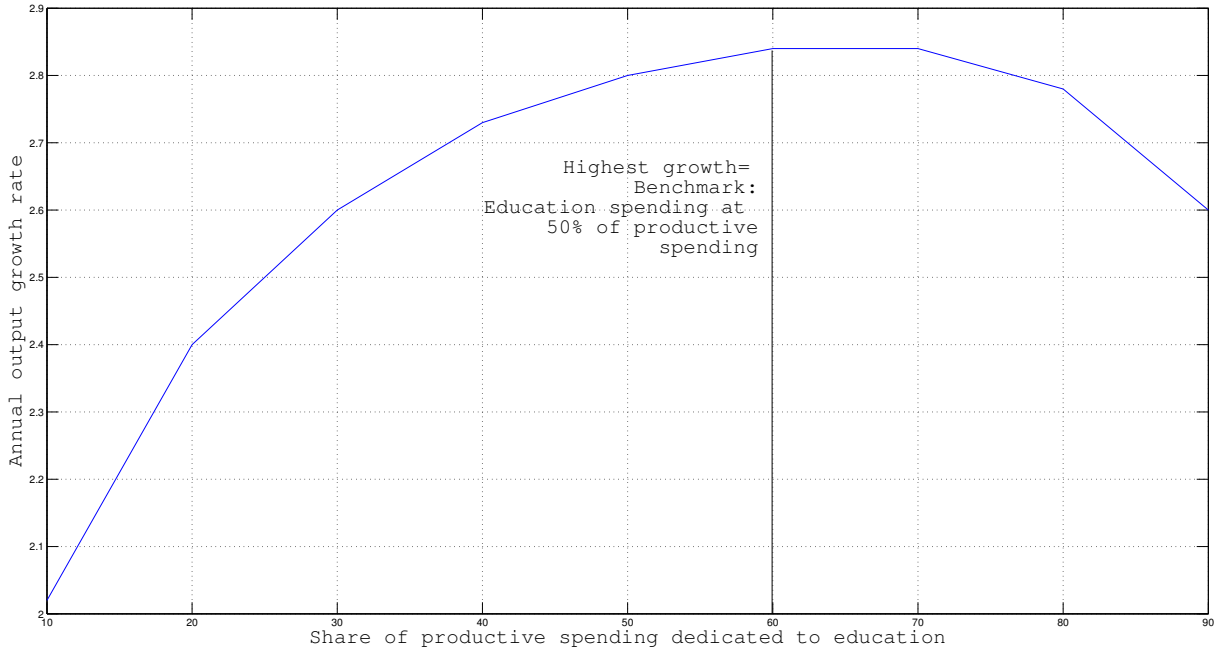


Figure 39: Output growth rates in period 3

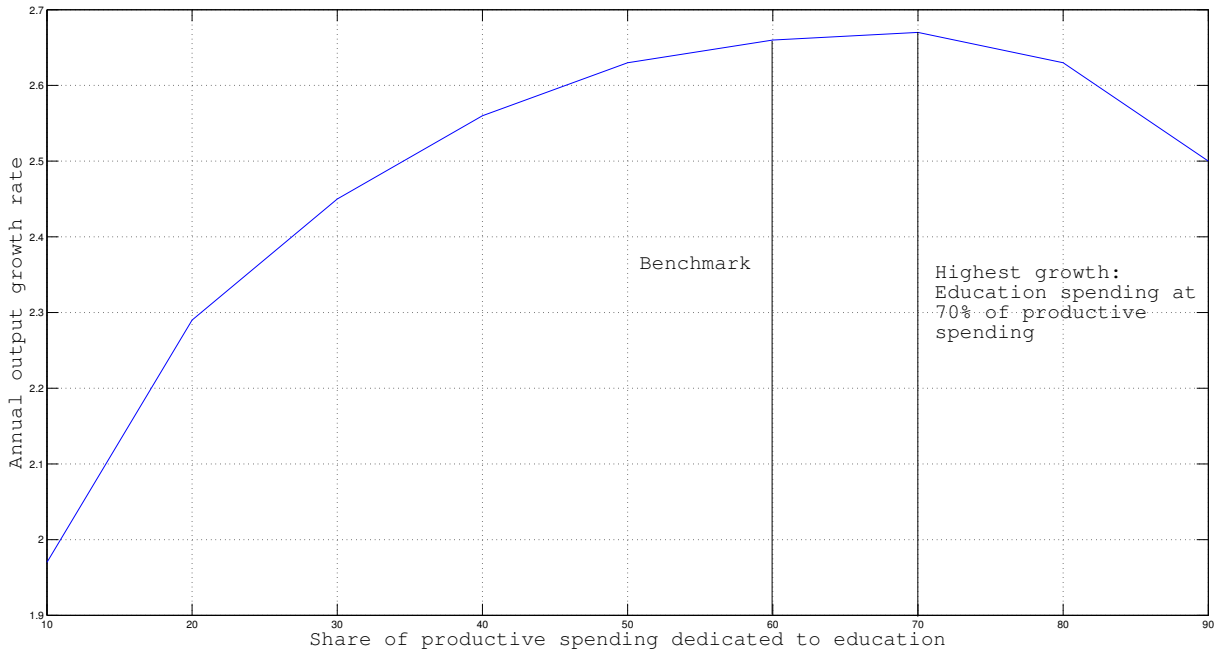


Figure 40: Output growth rates in period 4

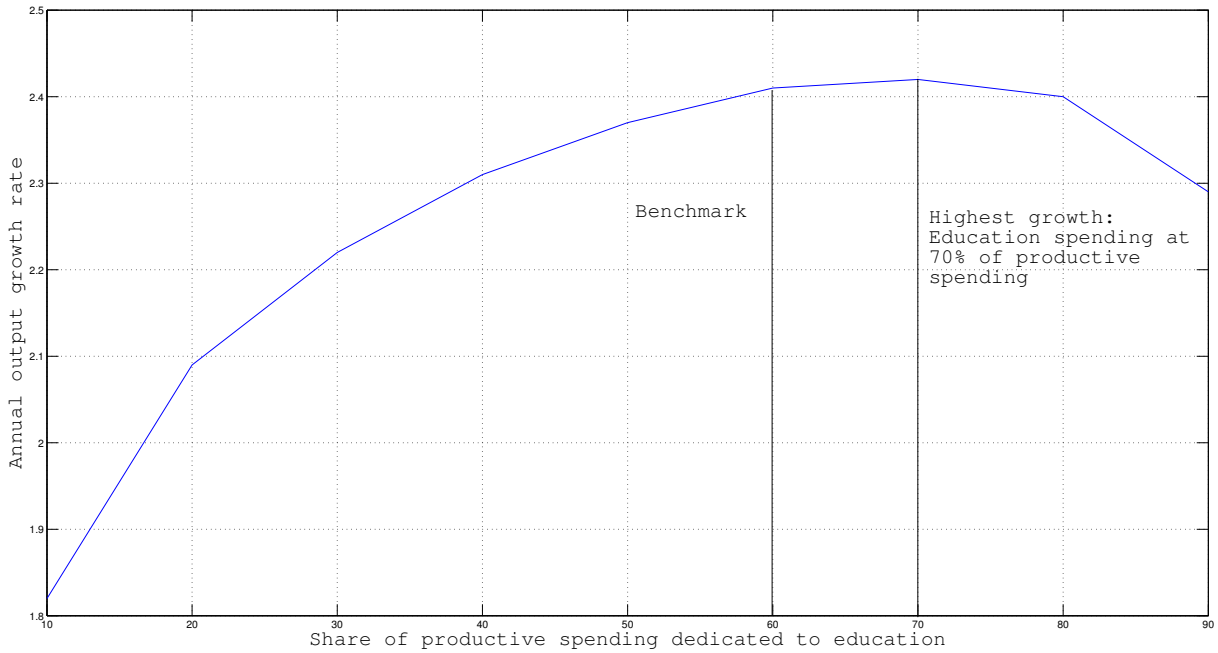


Figure 41: Output growth rates in period 5

4.2.5 Effect on Gini coefficient

Inequality is minimized when the share of education spending exceeds the share in the benchmark economy. Inequality reaches its lowest points when education spending is 80% in the first two periods, and 70% in the last two periods. In the last two periods, higher education spending increases the income shares of the bottom half of the income distribution in most scenarios. But when infrastructure investment falls below 30% of total spending, human capital formation among lower deciles slows down despite higher public education spending. As a result, the growth in labor productivity of households in the top decile exceeds that of households in lower deciles causing a redistribution of income in favor of richer households and increasing inequality.

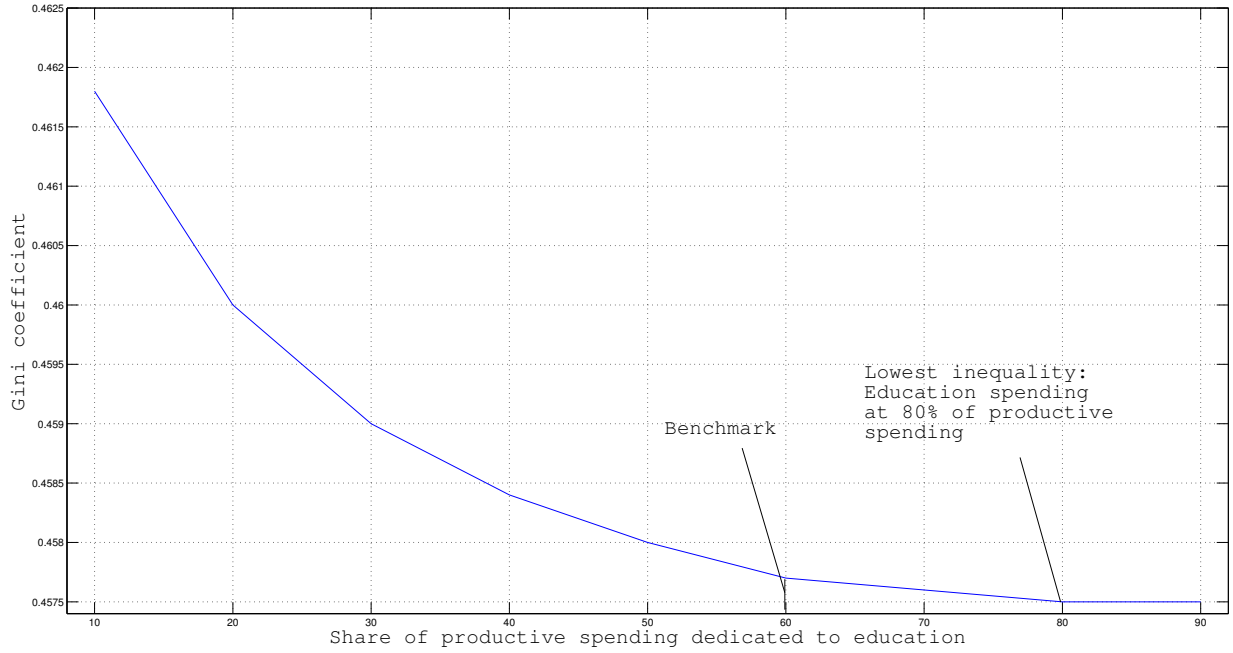


Figure 42: Gini coefficient in period 2

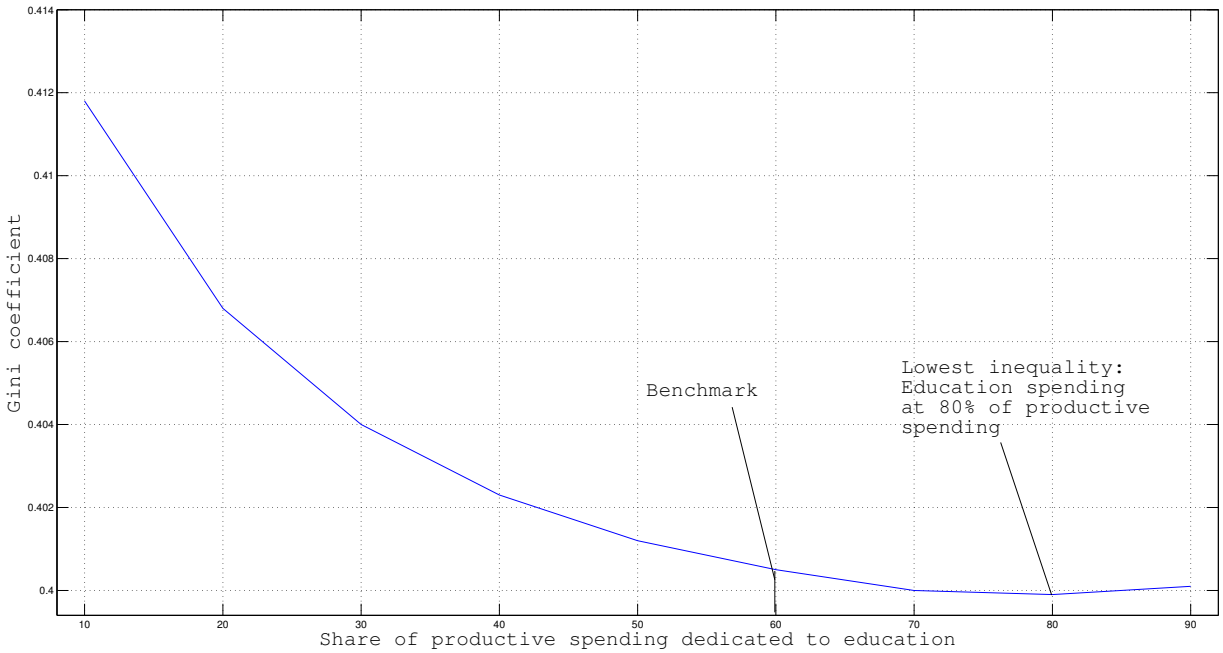


Figure 43: Gini coefficient in period 3

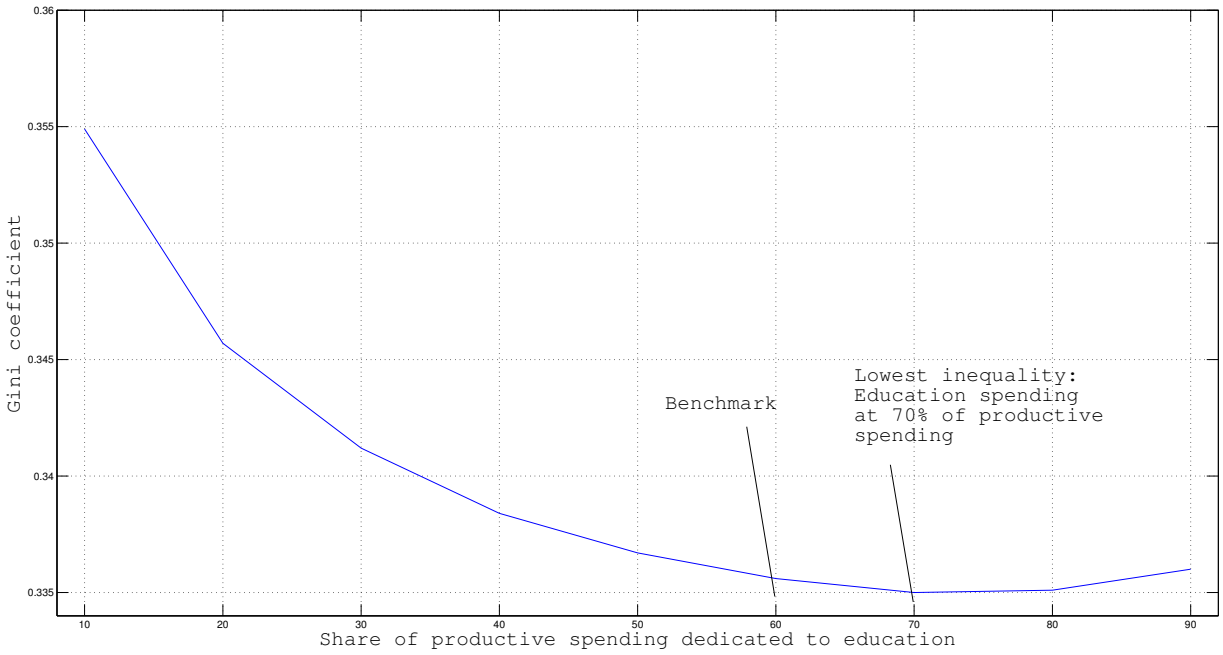


Figure 44: Gini coefficient in period 4

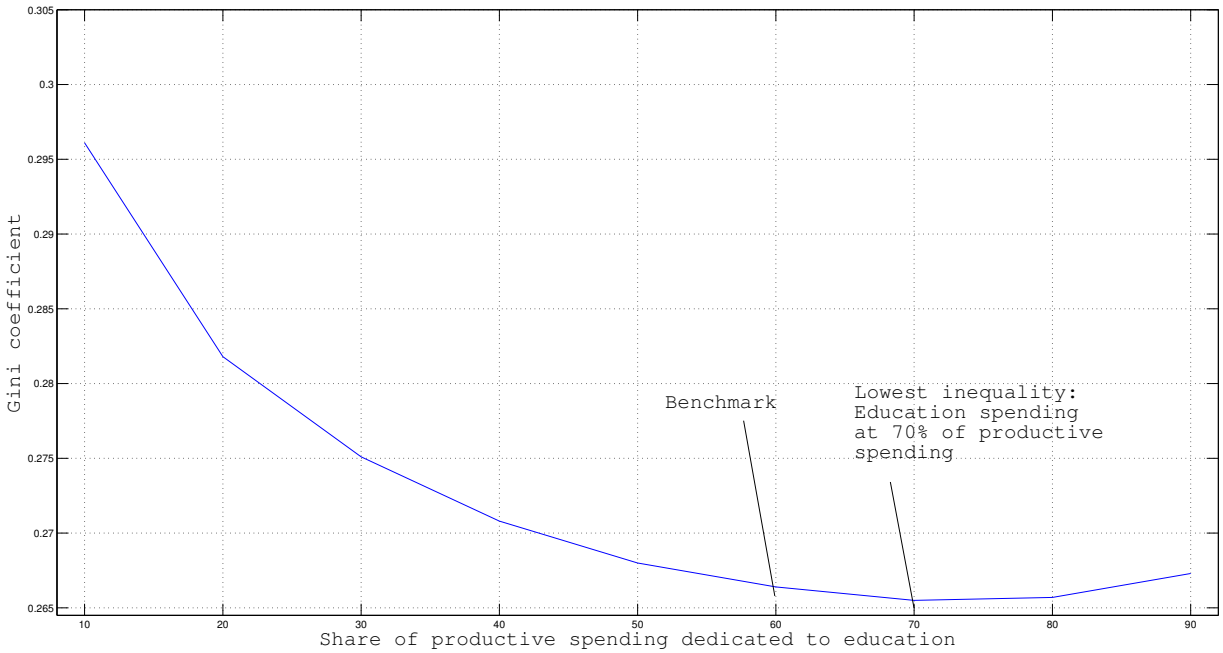


Figure 45: Gini coefficient in period 5

4.2.6 Growth-Iequality Tradeoff

Figure 46 brings together the behavior of output growth and inequality to provide a graphical representation of the tradeoff involved in shifting funds between education and infrastructure.

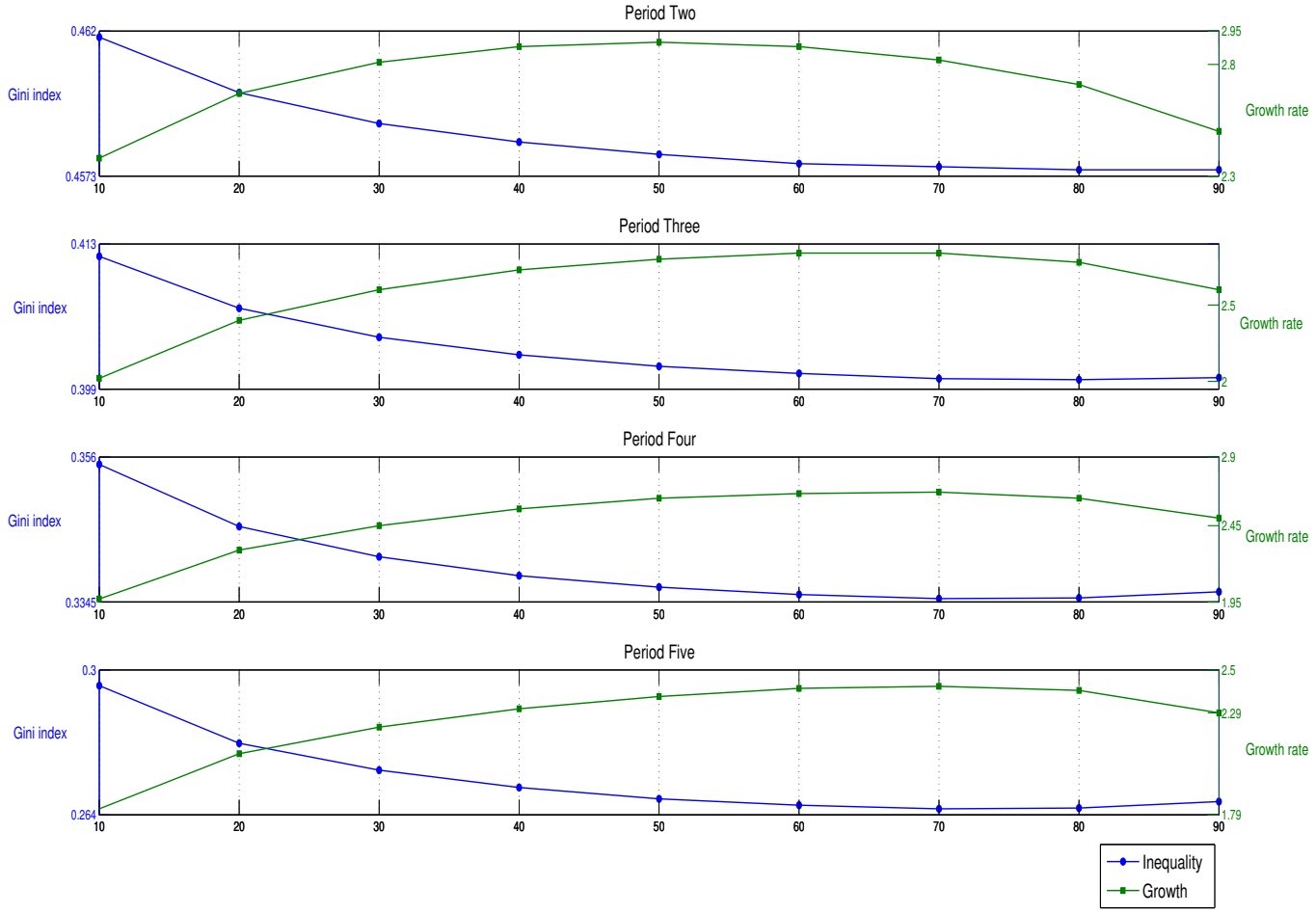


Figure 46: Growth and Inequality behavior for different shares of Education Spending

Table 4 presents a breakdown of the composition of productive spending according to its relation to the growth-inequality tradeoff. Prioritizing education spending over infrastructure investment enhances growth and diminishes inequality as long as infrastructure spending does not fall below 50% in period two, 40% in period three, or 30% in periods four and five. Further increases in education spending in region II lead to lower inequality, but the depletion to the infrastructure stock harms growth and as a result, we observe a tradeoff between the two. When education spending takes most of productive spending as seen in region III, the economy continues to shrink and inequality begins to rise.

Table 4: Growth-Inequality Tradeoff

Region	Education Spending (% of productive spending)	Period	Tradeoff
Region I	$[10, 50]$	Period 2	***No tradeoff***
	$[10, 60]$	Period 3	Higher growth and Lower Inequality
	$[10, 70]$	Period 4	
	$[10, 70]$	Period 5	
Region II	$(50, 80]$	Period 2	***Tradeoff***
	$(60, 80]$	Period 3	Lower growth and Lower Inequality
Region III	$(80, 90]$	Period 2	***No tradeoff***
	$(80, 90]$	Period 3	Lower growth and Higher Inequality
	$(70, 90]$	Period 4	
	$(70, 90]$	Period 5	

5 Conclusion

We have used an overlapping generations model to study the effects of fiscal policy on economic growth and the evolution of the income distribution. We calibrated the model to Costa Rica. Calibrating the model to Costa Rica is useful because of the unusual fiscal policy stands in Costa Rica relative to its other Latin American neighbors with a relatively heavy emphasis on social expenditures. Many papers in this literature focus on a balanced growth path. Many indicators of fiscal policy and many income inequality indices do not seem to follow a balanced growth trajectory. We therefore take the alternative approach and calibrate the model economy to a 30- year period, which corresponds to two model periods of 15 years each and then let the economy run for 5 periods. We study two policy reforms: (i) changing the size of the overall government budget, keeping the composition of productive government expenditures constant and (ii) changing the composition of productive government expenditures, holding the overall size of the government budget constant. We find: (i)The effects of changes in fiscal policy on human capital investment, on wages, on savings vary fundamentally across the income distribution. (ii) The effects of fiscal policy on the endogenous variables varies substantially over time and these differences are large. (iii) The relationship between the size of the government and economic growth is U-shaped as in most of the literature; however the growth maximizing size of the government is larger and in Barro (1990) and it tends to be increasing over time. (iv) The relationship between government size and

income inequality measured by the Gini Coefficient is rather complex. (v) The regions in the policy space in which there are or are not growth-inequality trade-offs varies over time. Similar results obtain for the other policy experiment where we vary the fraction of the public budget allocated to education rather than infrastructure. It would be interesting, in future work, to import the fiscal policies of other neighboring Latin American economies with less emphasis on productive government expenditures in the model to ascertain the relative growth and income distribution effects of policies of neighboring countries. In our model children either go to school or they work. In many low income countries many children neither go to school nor do they work; they are idle. It could be useful to incorporate such idleness in future work to get a better sense of the effects of education policies on economic growth, especially in poor countries.

Appendix

Sensitivity Analysis

This section presents the results of changing the size of the public sector under alternative values for the elasticity of the publicly provided inputs. The benchmark calibration assumes that the elasticity of public infrastructure and the elasticity of public education expenditures are equal to 0.1. The requirement to generate the change in the Gini coefficient as well as the change in average years of schooling observed in the data limits the range of values that other parameter values can take, especially considering that the high level of educational attainment by households at the top of the distribution causes average schooling levels and inequality to be inversely correlated.

The results of changing tax rates using alternative values for the output elasticity of capital show that the growth maximizing size of government is slightly greater in economies where public infrastructure capital is more productive as shown in figures 25-28. Growth is maximized in the benchmark specification when the public sector size is equal to 45.6% in periods two and three, 48.7% in period four, and 50.4%. When γ is equal to 0.15 the growth maximizing size of government is 50.3% in periods two and three, and 52.5% in periods four and five. Alternatively, when γ is reduced to 0.05 the growth maximizing size of government is about 40% in periods two, three, and four, and it increases to 50.15% in the last period.

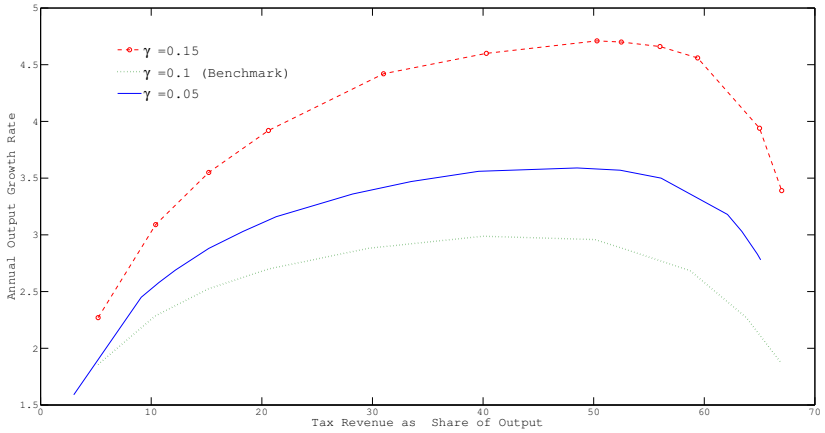


Figure 47: Output growth rates in period 2

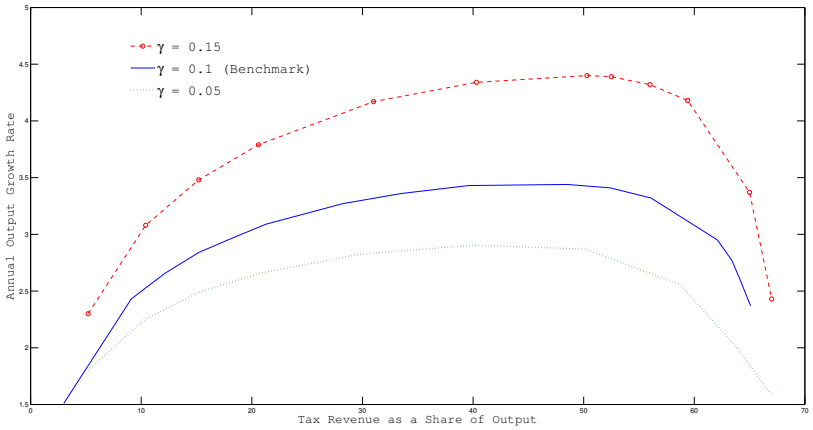


Figure 48: Output growth rates in period 3

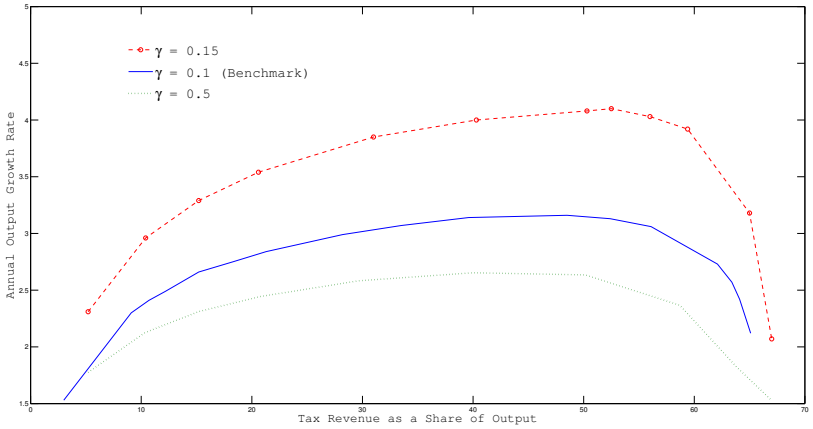


Figure 49: Output growth rates in period 4

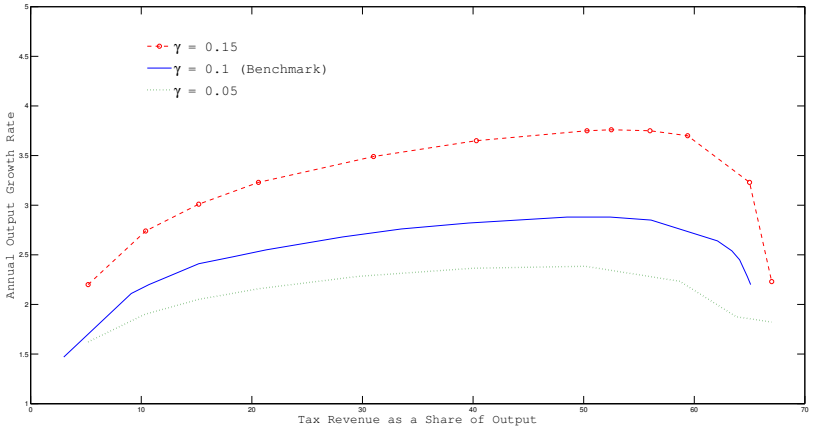


Figure 50: Output growth rates in period 5

Figures 29-32 present the results for the distribution of income of varying the output elasticity

of infrastructure capital. The Gini coefficient behaves similarly over time across the different scenarios considered, the main difference is that inequality is higher when the value for the elasticity is assumed to be higher. When public infrastructure capital is more productive incomes rise and households choose higher levels of schooling for their offspring. Calibration to moments of the data requires that the elasticity of parental human capital in the human capital technology and schooling costs take higher values. The result is a higher level of inequality after the initial period.

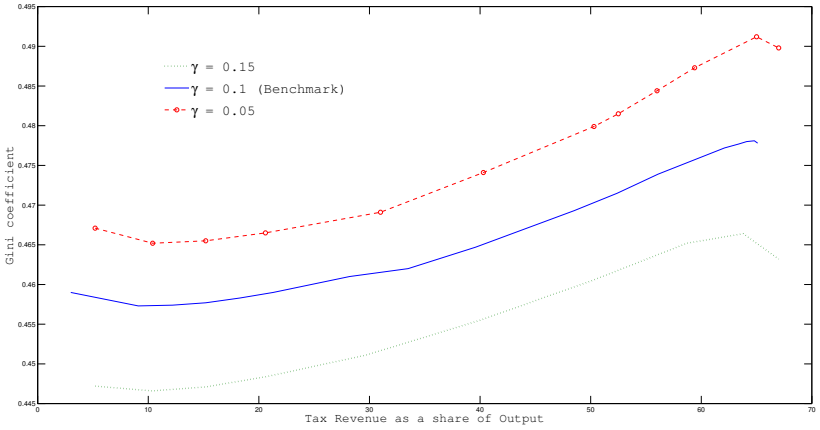


Figure 51: Gini coefficient in period 2

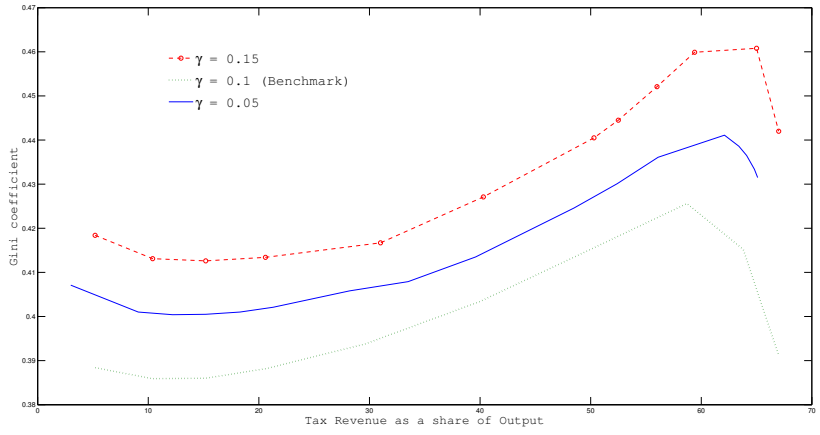


Figure 52: Gini coefficient in period 3

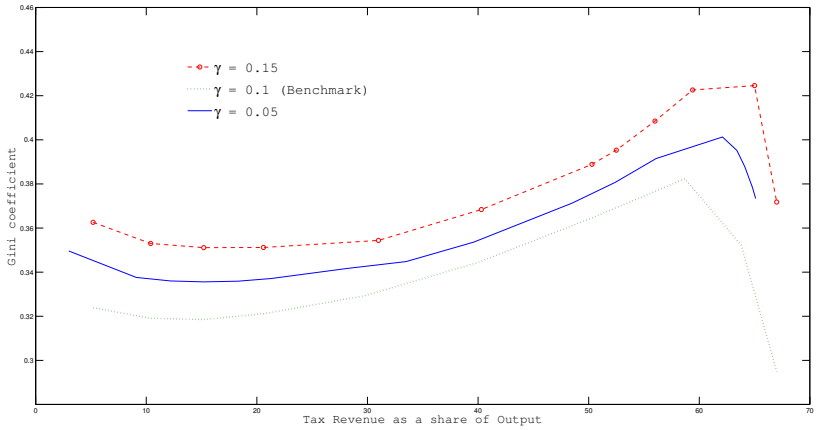


Figure 53: Gini coefficient in period 4

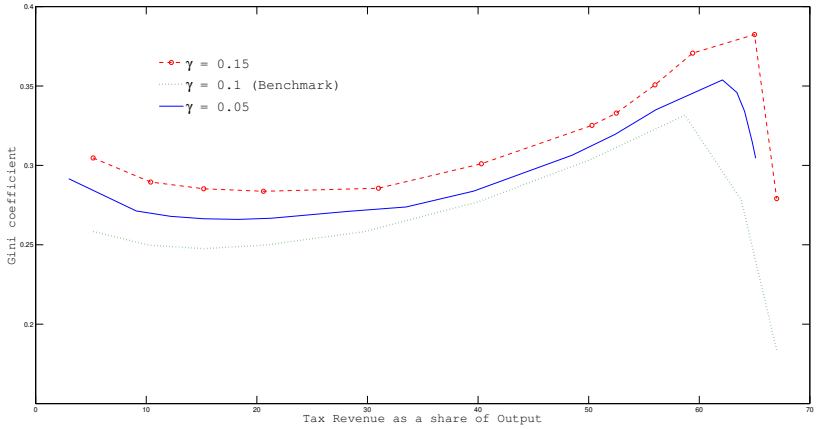


Figure 54: Gini coefficient in period 5

Figures 33 to 36 show the results of changing the value of the elasticity of public education expenditure relative to the benchmark. At low levels of government there is little difference across scenarios, but as the size of the public sector increase we observe that growth in the case where public education expenditure is less productive lags behind. The growth maximizing government size remains at roughly the same level for the different values of the public education expenditure elasticity, in the range of 40% to 50% in all time periods.

Figures 37-40 shows the behavior of the Gini coefficient as the size of government increases. Inequality follows the same trend as tax rates are increased: decreasing initially, rising, and falling precipitously when the government size exceeds 60% of output. The difference in the level of inequality across scenarios is caused by the values taken by other parameters. The higher Gini

coefficient of the baseline scenario is due to a slightly higher value for the elasticity of parental human, which makes differences in efficiency units of labor across households more persistent over time. Tables 11 and 12 in the appendix show the data and model outcomes using higher and lower values for the elasticities of public capital and public education expenditure.

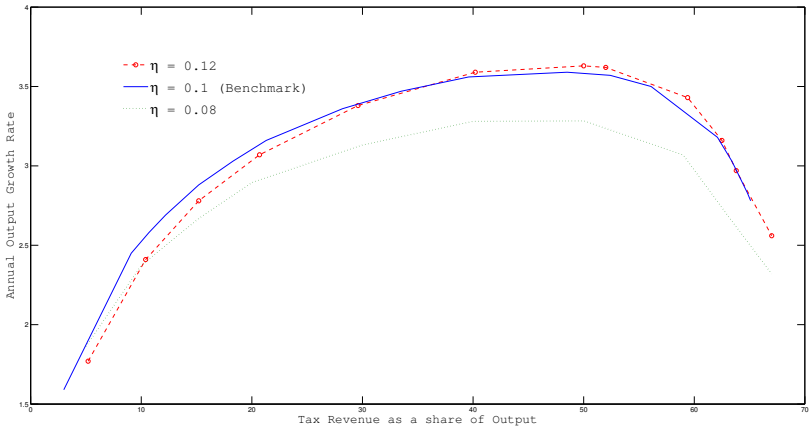


Figure 55: Output growth rates in period 2

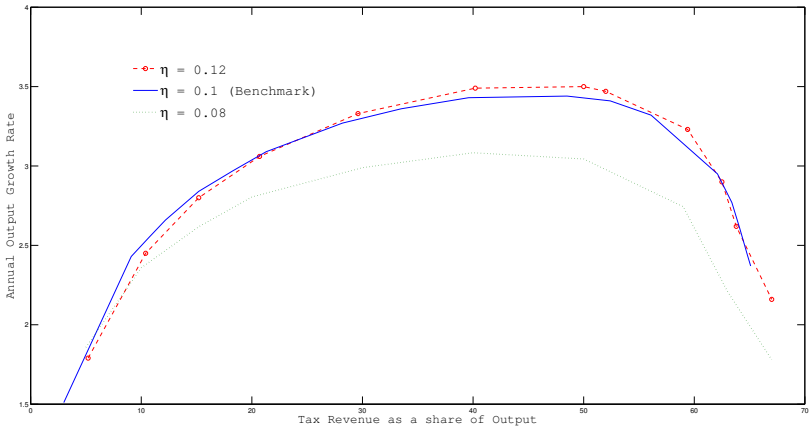


Figure 56: Output growth rates in period 3

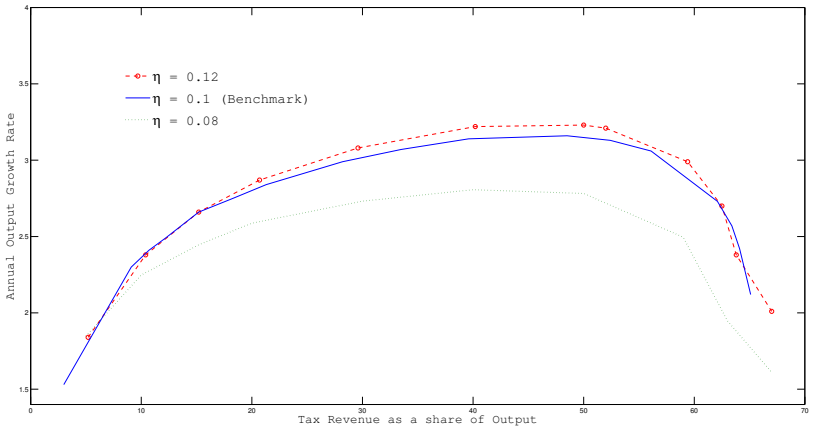


Figure 57: Output growth rates in period 4

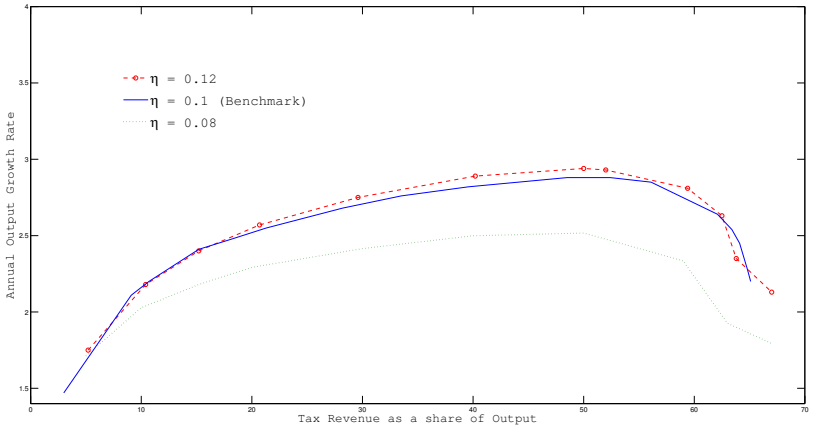


Figure 58: Output growth rates in period 5

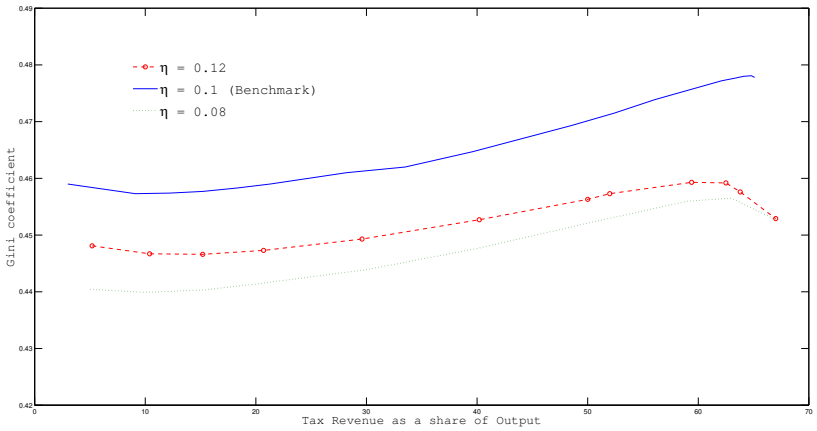


Figure 59: Gini coefficient in period 2

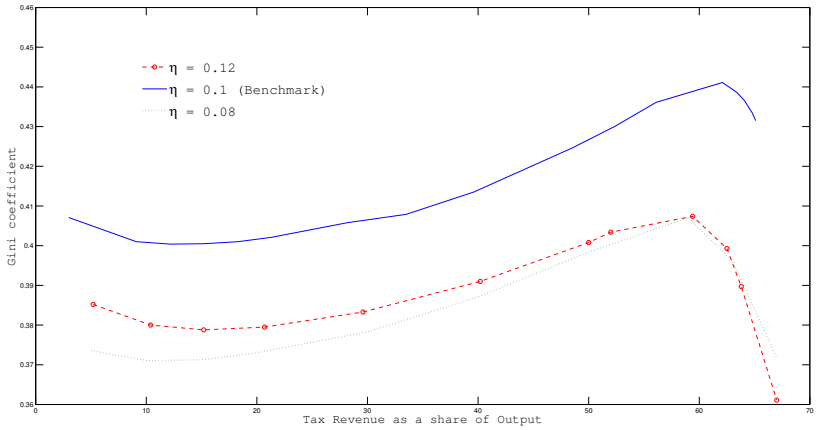


Figure 60: Gini coefficient in period 3

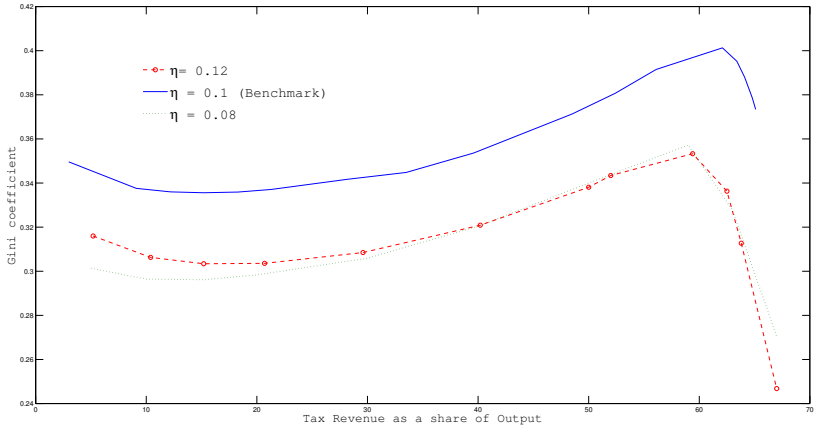


Figure 61: Gini coefficient in period 4

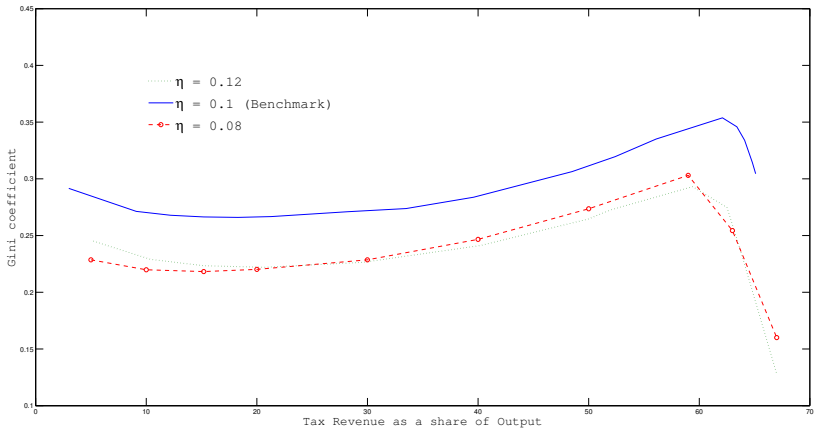


Figure 62: Gini coefficient in period 5

Table 5: Model Outcomes using alternative values for the Elasticity of Public Capital

Moments	Period	Data	$\gamma = 0.15$	$\gamma = 0.05$
Demographics				
Gini coefficient	Period 1	0.50	0.50	0.50
	Period 2	0.46	0.466	0.45
Average years of schooling of the labor force	Period 1	4.69	4.66	4.67
	Period 2	6.05	6.1	6.05
Government Size				
Tax Revenue (%of GDP)	Period 1	11.79	11.78	11.77
	Period 2	15.12	15.15	15.17
Expenditures				
Public Expenditures in Education (% of GDP)	Period 1	2.70	2.72	2.72
	Period 2	4.40	4.38	4.38
Public Expenditures in Infrastructure (% of GDP)	Period 1	1.90	1.86	1.86
	Period 2	2.99	2.97	2.97

Table 6: Model Outcomes using alternative values for the Elasticity of Public Education Expenditure

Moments	Period	Data	$\eta = 0.12$	$\eta = 0.08$
Demographics				
Gini coefficient	Period 1	0.50	0.50	0.50
	Period 2	0.46	0.45	0.44
Average years of schooling of the labor force	Period 1	4.69	4.67	4.58
	Period 2	6.05	5.98	5.99
Government Size				
Tax Revenue (%of GDP)	Period 1	11.79	11.75	11.76
	Period 2	15.12	15.13	15.15
Expenditures				
Public Expenditures in Education (% of GDP)	Period 1	2.70	2.72	2.72
	Period 2	4.40	4.38	4.38
Public Expenditures in Infrastructure (% of GDP)	Period 1	1.90	1.86	1.86
	Period 2	2.99	2.97	2.97

References

Bandyopadhyay, Debasis, and Xueli Tang. 2011. "Understanding the economic dynamics behind growth–inequality relationships." *Journal of macroeconomics* 33 (1): 14–32.

Barro, Robert. 1990. "Government Spending in a Simple Model of Endogeneous Growth." *The Journal of Political Economy* 98, no. 5 (October).

Benabou, Roland. 1996. "Heterogeneity, stratification, and growth: Macroeconomic implications of community structure and school finance." *The American Economic Review* 86:584–609.

Bourguignon, F., and C Morrisson. 1989. *External Trade and Income Distribution.* Development Centre studies. Development Centre of the Organisation for Economic Co-operation / Development.

Carnoy, Martin, and Carlos Alberto Torres. 1992. *Educational change and structural adjustment: a case study of Costa Rica.* UNESCO, Bureau for the Coordination of Operational Activities (BAO).

Chalker, Cynthia H. 1994. "Social policy, equity, and adjustment: the case of Costa Rica." In *XVIIIth International Congress of the Latin American Studies Association, Atlanta.* University of Pittsburgh.

Chatterjee, Santanu, and Stephen J Turnovsky. 2012. "Infrastructure and inequality." *European Economic Review.*

Eckstein, Zvi, and Itzhak Zilcha. 1994. "The effects of compulsory schooling on growth, income distribution and welfare." *Journal of Public Economics* 54 (3): 339–359.

ECLAC. 1970. *Economic Survey of Latin America, 1968.* UN Economic Commission for Latin America and the Caribbean, New York.

Fernandez, Raquel, and Richard Rogerson. 1996. "Income distribution, communities, and the quality of public education." *The Quarterly Journal of Economics* 111 (1): 135–164.

Fox, James. 2012. "Real progress: Fifty Years of USAID in Costa Rica." *Center for Development Information and Evaluation, U.S. Agency for International Development.*

Galor, Oded, and Omer Moav. 2004. "From physical to human capital accumulation: Inequality and the process of development." *The Review of Economic Studies* 71 (4): 1001–1026.

Galor, Oded, and Joseph Zeira. 1993. "Income distribution and macroeconomics." *The review of economic studies* 60 (1): 35–52.

Getachew, Yoseph Yilma. 2010. "Public capital and distributional dynamics in a two-sector growth model." *Journal of Macroeconomics* 32 (2): 606–616.

Glomm, Gerhard, and Michael Kaganovich. 2008. "Social security, public education and the growth–inequality relationship." *European Economic Review* 52 (6): 1009–1034.

Glomm, Gerhard, and Balasubrahmanian Ravikumar. 1992. "Public versus Private Investment in Human Capital: Endogenous Growth and Income." *Journal of Political Economy* 100:818–834.

———. 1994. "Public investment in infrastructure in a simple growth model." *Journal of Economic Dynamics and Control* 18, no. 6 (November).

———. 1998. "Flat-rate taxes, government spending on education, and growth." *Review of Economic Dynamics* 1 (1): 306–325.

Hulten, Charles R. 1996. *Infrastructure capital and economic growth: How well you use it may be more important than how much you have.* National Bureau of Economic Research.

Krueger, Alan, and David Card. 1990. "Does school quality matter? Returns to education and the characteristics of public schools in the United States." *Journal of Political Economy* 100 (1).

Maoz, Yishay D, and Omer Moav. 1999. "Intergenerational mobility and the process of development." *The Economic Journal* 109 (458): 677–697.

Martin, Philippe. 1999. "Public policies, regional inequalities and growth." *Journal of public economics* 73 (1): 85–105.

Morice, Ana, and Arodys Robles. 2011. "Impact of long-term policies based on social determinants of health: The Costa Rican experience."

Reimers, Fernando. 1990. "A new scenario for education planning and management in Latin America. The impact of the external debt." *International Institute for Educational Planning, UNESCO. IIEP Research Report* 81.

Rioja, Felix K. 1999. "Productiveness and welfare implications of public infrastructure: a dynamic two-sector general equilibrium analysis." *Journal of Development Economics* 58 (2): 387–404.

Ríos-Rull, Jose Víctor. 1996. "Life-cycle economies and aggregate fluctuations." *The Review of Economic Studies* 63 (3): 465–489.

Robles, Arodys. 2005. "Cambio demográfico, inversión social y diferencias generacionales en Costa Rica." *Taller sobre transformaciones demograficas, transferencias intergeneracionales y proteccion social en America Latina.*

Rodríguez-Clare, Andrés, Manrique Sáenz, and Alberto Trejos. 2002. "Economic Growth in Costa Rica: 1950-2000." *Interamerican Development Bank (IDB), San José.*

Rosero, Luis. 1983. *Social and economic policies and their effect on mortality: The Costa Rican case.* Institut National d'Etudes Demographiques (INED), International Union for the Scientific Study of Population (IUSSP).

Rotenberg, S., and A. Bensión. 1993. *Costa Rica and Uruguay.* A World Bank Comparative Study. the Political Economy of Poverty, Equity, and Growth. World Bank.

Sáenz, Jorge León, and Nelson Arroyo. 2010. "Desarrollo Histórico del sector Agroindustrial de la caña de azúcar en el sigle XX." In *Informe para Discusión,* edited by Instituto de Investigaciones en Ciencias Económicas. Universidad de Costa Rica, January.

Stycos, J Mayone. 1982. "The decline of fertility in Costa Rica: Literacy, modernization and family planning." *Population Studies* 36 (1): 15–30.

Vedova, Mario A. 1986. "Economic Recession in Costa Rica and the Consequences on the poor." *San Jose, Prodesarrollo.*