Public and Private Expenditures on Human Capital Accumulation in India*

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Abstract

We study a model of human capital driven growth, where the parent's human capital serves as a productive input in the child's human capital production only when that of the former exceeds a minimum level required to intellectually contribute to the child's learning. Private and public expenditures on education enter in the child's human capital production function, and are allowed to vary in terms of substitutability and relative productivity. Households receive income from labor and face both labor and consumption taxes. The government receives consumption tax revenues and a proportion of income tax revenues and spends these revenues on public education. We simulate the model to a state in India and experimentally increase public education spending through various tax instruments. We find: (i) large changes in education funding have very small effects on growth and on the evolution of income inequality, (ii) raising the consumption tax generates about as much economic growth as realizing an increase in the center-state transfer from the federal level, and (iii) financing this increase in public spending through the labor tax increases economic growth by less than utilizing the consumption tax; however, it reduces inequality by more than utilizing the consumption tax. Hence, there is growth-inequality trade-off.

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1 Introduction

This paper addresses two questions. First, how does education funding influence economic growth? At least since Lucas (1988) has human capital accumulation been at the forefront of the research on economic growth and in that literature human capital is often referred to as the "engine of growth". To the extent that public education funding determines human capital accumulation, exploring the nexus between public education funding and economic growth is crucial. Second: What is the influence of education funding on the evolution of the income distribution? According to Horace Mann, who is widely considered to be the father of public education in the US, public education is considered to be "the greatest equalizer of the condition of men." And in many countries the prime motivation behind public education is a concern for equity or equality of opportunity.

At least since Loury (1981) have researchers used dynamic general equilibrium models to study these two questions. Examples of papers addressing the first question include Glomm and Ravikumar (1998), Kaganovich and Zilcha (1999), Pecchenino and Pollard (2002), Blankenau and Simpson (2004), and others, while Loury (1981), Saint-Paul and Verdier (1993), Bénabou (1996a,b), Gradstein and Justman (1997), Durlauf (1996), Fernández and Rogerson (1998), Glomm and Kaganovich (2003) are examples of papers addressing the second question.

Many, if not most of these models, rely on some simplifying assumptions. (i) In Bénabou (1996a,b), for example, in addition to parental human capital and time, there is only public education in the production function for future human capital. (ii) There are only private inputs in human capital accumulation (Lucas, 1988). (iii) In many of these papers, including Glomm and Ravikumar (1998), Kaganovich and Zilcha (1999), Pecchenino and Pollard (2002), and Blankenau and Simpson (2004), the production function for human capital is Cobb-Douglas so that all inputs are essential and the elasticity of substitution among all inputs is pinned down at unity. (iv) If there is private education as well as public education,

these two inputs are often perfect substitutes as in Glomm and Kaganovich (2003). (v) Parental human capital has diminishing returns for children's human capital regardless of the relative levels of children's and parent's human capital.

In this paper we try to extend this literature by incorporating the following assumptions into the learning technology. First, we allow for the co-existence of public and private education. In the context of developing economies, public school quality is often poor and there is a sizable private sector in education suggesting that the substitutability of public and private education inputs is a possibility worthy of investigation (Tooley and Dixon, 2007). Glomm and Kaganovich (2008, 2003) allow for the existence of both public and private education inputs in human capital production, but for reasons of tractability use the assumption of perfect substitutability. We model public and private education as two inputs in the human capital production with variable elasticity of substitution.

Second, we incorporate into our model the idea that child's ability and parental human capital are strong complements. Third, the complementarity between parental human capital and child's ability is only operative if parental human capital exceeds an exogenous level of human capital representing the minimum knowledge to be effective in human capital production. The idea here is that a child can utilize a parent's human capital to acquire a certain piece of knowledge only if the parent is sufficiently on par with the current state of knowledge and technology. Chances are that a parent is of little help in the child's attempt to learn calculus if the parent barely mastered arithmetic. Also, an illiterate parent will most likely not be able to help a literate child with reading assignments at a time when the majority of the population is literate and teachers assign material with an implicit prerequisite for literacy. Furthermore, in an age when information technology is crucial and taught in primary and secondary schools, parents behind the technology curve may be much less able to provide intellectual capital in their child's human capital development.

We use this model to study the implications for growth and income distribution dynamics

of various public education financing reforms.

In addition to these theoretical extensions, we are interested in using our model to study the concrete economic and education environment in a developing country such as India, which brings us to our fourth consideration. Since in such developing countries per capita income is very low and often a quarter of the population live at or below the poverty line, we introduce a subsistence consumption level in the utility function. And finally, many of the above models assume that public education is financed with a (labor) income tax. Blankenau and Simpson (2004) study a variety of tax instruments and find that for income taxes the relationship between funding levels and the growth rate of GDP is non-monotonic, but in the case of pure consumption-tax financing this relationship is increasing. In India, public education is financed mostly at the state level through a consumption tax. There are also transfers to the state from the federal government. We allow for both sources of revenue in our model and study implications of changes in these financing instruments.

2 The Basic Model

The economy is populated by a large number, n, of families who are arranged in an overlapping generations fashion. All individuals live two periods, but essentially have one decision regarding how much of their income to consume and how much to invest on their child's education. Preferences are given by the following utility function:

$$u(c_t, h_{t+1}) = \phi \log(c_t - \underline{c}) + \log(h_{t+1}), \tag{1}$$

where c_t is own consumption, $\underline{c}$ is a threshold level of consumption, and h_{t+1} is the stock of human capital of the child in as an adult.

The production function for children's human capital is given by

$$h_{t+1} = \begin{cases} B(E_t^\rho + \theta e_t^\rho)^{\alpha/\rho}(a_t h_t)^\delta, & h_t \geq \bar{h}_t \\ B(E_t^\rho + \theta e_t^\rho)^{\alpha/\rho} a_t^\delta, & h_t < \bar{h}_t. \end{cases} \tag{2}$$

In order to maintain diminishing marginal returns, we make the following restrictions: $0 < \alpha < 1$ and $0 < \delta < 1$. We also restrict parental human capital to be greater than one so that the parent can only help and not hinder their child's human capital production.[1] Here, E_t and e_t represent public and private material inputs into education, respectively. Furthermore, public spending on education in this model does not exhibit non-rivalry, namely E_t is *per-capita* public spending. Typically, we will assume that $0 < \rho < 1$ so that these two inputs are substitutes. A complementary input is the ability of the child, a_t, re-enforced by parental human capital, h_t. Note that parental human capital is only effective as an input in the production function of the child's human capital if it is sufficiently high. This tries to capture the idea that parents can only help their children to gain knowledge if they themselves are sufficiently able.

In the large literature on the impact of parental income, parental decisions and parental education on child schooling it is often difficult to document a causal effect of non income related aspects of parental human capital on child schooling. Some of the conceptual issues in this nexus are described in Björklund and Salvanes (2010). Holmlund et al. (2008), for example conclude that the mother's schooling has little impact on the schooling of her child, holding everything else (including unobserved ability factors of either mother or father) constant. Chevalier et al. (2010) find some support for a causal connection between parental education, apart from income, on children's education. Bleakley and Chin (2008) find that at early ages of immigrants parental English proficiency is positively correlated with the child's

[1] We enforce this restriction in the simulations that follow by selecting the initial parent human capital distribution and parameters so that no individual's human capital ever falls below unity.

English proficiency even after correcting for income and labor market effects. The Cobb-Douglas assumption in our model is consistent with the empirical results in one specification in Cunha et al. (2010). Perhaps the best empirical support for our assumption that parental human capital is a complement in the education of the child if parental education is sufficiently high is Contreras (2011), who finds that parental education is positively correlated with child education, but only at relatively high levels of parental income.

Public education in India is financed largely at the level of the state through consumption taxes. The federal government also collects income taxes which it uses for a variety of purposes including transfers to the state governments earmarked for public education. We thus write the budget constraint of the individual household as

$$(1 + \tau_c)c_t + e_t = (1 - \tau_L)w_t h_t, \tag{3}$$

where τ_c and τ_L are the consumption and (labor) income tax rates, respectively, and w_t is the wage rate per effective unit of labor.

The state level government budget constraint can be written as

$$n_t E_t = \tau_c C_t + T_t, \tag{4}$$

where C_t denotes aggregate consumption at the state level and T_t represents the center-state transfer (hereafter, transfer) received by the state from the federal government. We write

$$T_t = \Delta \tau_L w_t H_t, \tag{5}$$

where H_t is aggregate human capital at the state level and $\Delta > 1$ signifies that the state is a net receiver of federal funds and $\Delta < 1$ signifies that the state is a net contributor of funds. The policy parameters Δ, τ_l, and τ_c are exogenous.

3 Solving the Model

The household solves the problem

$$\max_{c_t, e_t} \quad u(c_t, h_{t+1}) = \phi \log(c_t - \underline{c}) + \log(h_{t+1})$$

$$\text{subject to (2) and (3).}$$

The interior solution to this problem, $e_t^\star$, is given by

$$(\phi + \alpha)\theta(e_t^\star)^\rho = \alpha\theta\overline{e}_t(e_t^\star)^{\rho-1} - \phi E_t^\rho, \tag{6}$$

where $\overline{e}_t$ represents the maximum private expenditure possible for the household:

$$\overline{e}_t = (1 - \tau_L)w_t h_t - (1 + \tau_c)\underline{c}. \tag{7}$$

Since public and private education expenditures are imperfect substitutes, private education expenditure will be greater than zero only if parental human capital, h_t, is sufficiently high. Clearly it is necessary that human capital be large enough to finance subsistence consumption, inclusive of taxes, before a household chooses positive private expenditure. This is evident in (7), where $\overline{e}_t$ is positive only if human capital is at least large enough to finance subsistence consumption, after all taxes. However, this is not sufficient for the household's private expenditures to be positive. If public spending is sufficiently high a corner solution of zero private spending on education for the household obtains.

Therefore, there is a *cutoff* level of human capital below which private school expenditure is zero. This level may exceed the level necessary to finance subsistence consumption. This means that households may well choose zero private education expenditures even though their income permits them to consume beyond the subsistence level. The cutoff parental

human capital level below which parents choose zero private education spending, $\hat{h}$ is given by

$$\hat{h}_t \geq \frac{(1+\tau_c)\underline{c}}{(1-\tau_L)w_t}. \tag{8}$$

It is also clear from (6) that the interior solution for private education expenditure is decreasing in public education expenditure (E_t), increasing in parental human capital (h_t), and decreasing in both tax rates (τ_c and τ_L).

Substituting the above solution for private education into the law of motion for human capital allows us to track the evolution of the human capital distribution. For example, the human capital of a $t+1$ generation household is given by

$$h^{\star}_{t+1} = \begin{cases} B\left(E_t^{\rho} + \theta(e^{\star}_t)^{\rho}\right)^{\alpha/\rho}(a_t h_t)^{\delta}, & h_t > \bar{h}_t \text{ and } h_t > \hat{h}_t \\ BE_t^{\alpha}(a_t h_t)^{\delta}, & h_t > \bar{h}_t \text{and } h_t \leq \hat{h}_t \\ BE_t^{\alpha} a_t^{\delta}, & \text{otherwise} \end{cases} \tag{9}$$

A special case occurs when $\rho = 1$, meaning that public and private expenditures on education are perfect substitutes. In that case, the solution to the household's problem is

$$e^{\star}_t = \begin{cases} \frac{\alpha\theta\overline{e_t} - \phi E_t}{(\phi+\alpha)\theta}, & \overline{e}_t > (\alpha\theta)^{-1}\phi E_t \\ 0, & \text{otherwise} \end{cases} \tag{10}$$

In this case, the law of motion for human capital becomes

$$h^{\star}_{t+1}(\cdot\,;\rho=1) = \begin{cases} B\left[\left(\frac{\alpha}{\phi+\alpha}\right)\left(E_t + e^{\star}_t\right)\right]^{\alpha}(a_t h_t)^{\delta}, & h_t > \bar{h}_t \text{ and } h_t > \hat{h}_t \\ BE_t^{\alpha}(a_t h_t)^{\delta}, & h_t > \bar{h}_t \text{and } h_t \leq \hat{h}_t \\ BE_t^{\alpha} a_t^{\delta}, & \text{otherwise} \end{cases} \tag{11}$$

4 Simulating the Model

There are no analytical solutions for this model. Therefore, we solve the model numerically for parameters that are reasonable for a developing economy. We have data on education spending as a fraction of GDP on 15 states in India. In these 15 states the share of GDP allocated to public education rages from about 2.5% to 6.4%, with a median of 3.2%.[2] We calibrate the model to the median of the distribution. In the policy experiments we will increase the public education share from 3.2% to 4.24%, the second highest, and decrease it to 2.57%, the second lowest in our sample.

The baseline calibration exercise here is to choose the parameters such that the simulated model's moments match as closely as possible the observed moments in the data. Noting a few qualifications in the following two paragraphs, we have seven moments: the growth rate from 1985 to 2005, public expenditure per net state domestic product (NSDP) in both periods, private education expenditure per NSDP in both periods, and the Gini coefficient in both periods.

There are some notable qualifications regarding the data. First, the Gini coefficient was not available in our dataset after 1995, however, for the median state the consumption Gini coefficients from 1985 to 1995 show no trend, despite considerable variation. Therefore, we let the Gini's for both 1985 and 2005 equal roughly 1/3.

Second, we do not have data exactly concerning households' private expenditures on education. Our data does contain the fraction of children aged 6-14 attending private schools from 2006 to 2009. Since Kingdon (2007) reports that private school enrollments have accounted for a large percentage of the increase in total school enrollments in India over this time period, we make a very crude estimate for 1985 by assuming an upward trend.[3] Then, we map this private enrollment fraction into private expenditure shares by assuming that

[2]This is close to the public spending share in Tamil Nadu.

[3]The reported private school enrollment as a fraction of all 6-14 year olds from 2006-09 are 19.5%, 15.5%, 20.6%, and 19.7%, respectively. We chose the fraction to be 10% in 1985.

both public and private schools face the same costs per student.[4] While generous, this does not imply that both public and private expenditures are equally efficient, as the productivity coefficient on private expenditure, θ, may differ than one.

While coarse, our estimate of the private expenditures on education as a share of output is, if anything, low. According to Kingdon (1996a), government reports typically overstate public school enrollment, which results in lower reported private school enrollment, and the misreporting can be significant. Furthermore, this estimate does not account for any possible private expenditures incurred by households sending their children to public schools. At present it is difficult to establish how large these private supplements are, but we do know that many states only instituted free mid-day meals and free textbooks until relatively late in the 1980s. (Kajisa and Palanichamy, 2010). Thus, parents may well have supplemented public education via textbooks and other expenditures at least prior to 1985.

The mean of the human capital distribution of the initial parent generation is normalized to a value of ten. We then use the Gini coefficient to pin down the variance of this distribution. This characterization ensures that, for the sake of our simulation, there is never a case when parental human capital is less than unity.[5]

While there is no clear interpretation of subsistence consumption in the data, we set it equal to roughly 40% of mean income in the initial period. This figure falls in line with the international poverty line. For example, in 2009 Indian GDP per capita was approximately \$1,134, 40% of which equals \$454, almost exactly the cutoff for the international poverty line of \$456.25 per year.[6]

As a baseline case, we let the consumption tax equal to 2%. While this may seem low, it is reasonable given that, in our model, all tax revenues flow to education. Further, we

[4]For example, we let the private expenditure share equal $\frac{r}{1-r} \times$ (Public Expenditure Share), where r equals the share of enrollments in private school.

[5]It is important to restrict parental human capital to be greater than or equal to one because otherwise, the parent actually harms in the production of human capital. In other words, if parental human capital is less than unity, the child is actually better off without their parent's contribution.

[6]Data taken on October 3, 2010 from the World Bank's World Development Indicators Database.

let the federal transfer, Δ equal unity and the labor tax rate equal 1.5% so that the public expenditure equals 3.42% in the initial period, which closely compares to that of the median state of the expenditure distribution.

Parameter	Value	Parameter	Value	Parameter	Value
mean(h_0)	10	α	0.20	ϕ	8
var(h_0)	36.70	δ	0.80	θ	1.5
$\underline{c}$	4	mean(a)	1	ψ	0.05
τ_c	0.02	var(a)	0.05	w	1
Δ	1	B	5.5	ρ	0.50
τ_l	0.015				

Table 1: Parameter values for baseline calibration.

Card and Krueger (1992) estimate the expenditure share in human capital production (corresponding to α in our model) to be approximately 0.10. In our baseline calibration, we choose 0.20 for this parameter for the following reason. We impose constant returns to scale with regard to the two composite inputs, education expenditure and the child's ability (possibly augmented by parental human capital). It is the case that the larger is δ, the ability share of human capital production, the larger is inequality in the model. In order to maintain a Gini coefficient in the second period of the model that is consistent with our empirical observation in 2005, it is necessary to choose δ sufficiently small. Therefore, we let δ=0.80 and α=0.2 to maintain constant returns to scale.

Another dimension by which we may affect the Gini coefficient of the model in the second period is to choose the variance of the ability distribution of children. We let the mean of this distribution equal unity and variance equal 0.05. To match the empirical observation of roughly 5 to 6% annual growth in net domestic state product in the median state, we choose total factor productivity (B) of 5.5, along with an elasticity of substitution parameter, ρ, of 0.50.

To match the private expenditure share we let the preference rate on parental consump-

tion, ϕ, be 8 and the productivity premium on private expenditure, θ, be 1.50. The choice of θ is consistent with findings in (Kingdon, 1996b; Tooley and Dixon, 2007) where evidence suggests that private spending in India is, at the least, more productive that public spending.

Finally, we let the cutoff human capital level, $\bar{h}$ to be $F_{H_t}^{-1}(\psi)$ where F_{H_t} is the human capital cumulative distribution function at time t. Further, we set ψ equal to 0.05. Thus, for modeling purposes we assume that parents with human capital in the bottom fifth percentile are ineffective in augmenting their child's ability in human capital production. The efficiency-unit wage, w, is normalized to unity. We simulate the model for 500 families.

As is evident, our model contains more parameters than moments we can match from the available data. This is important to take into consideration when interpreting the results that follow. For example, we could have chosen a larger elasticity of substitution parameter, ρ, and offset the reduction in simulated growth by adjusting total factor productivity, B, or even the productivity premium on private expenditure, θ.[7] The point is that there are many choices of parameters that would provide a similar matching of the model's moments to the observed data. To inform the impact this has on our results, we do carry out sensitivity analyses on key parameters.

Therefore, we exhibit the experiments below as illustrations of the role of public and private spending, their relative productivity and the substitutability between them, in influencing the growth and inequality effects of changes in tax policies that fund public spending on education. Table 2 shows the observed and simulated moments we use for the computational exercises.

5 Tax Policy Experiments

The primary question we approach is how various economic aggregates are affected by the amount of public spending on education as well as how this spending is financed. Here we

[7] θ is not completely *free* in this case as changing it would also require a change in several other parameters.

	Data	Model
Annualized Growth Rate	0.0646	0.0570
Gini Coefficient, 1985	0.3200	0.3200
Gini Coefficient, 2005	0.3200	0.3416
Public Expenditure Share (nE/Y), 1985	0.0330	0.0342
Public Expenditure Share (nE/Y), 2005	0.0350	0.0341
Private Expenditure Share ($1/Y \sum e$), 1985	0.0037	0.0049
Private Expenditure Share ($1/Y \sum e$), 2005	0.0085	0.0096

Table 2: Observed and simulated moments corresponding to Tamil Nadu, 1985-2005.

experimentally change public spending to an economically significant but reasonable amount. We consider financing the change with three separate policy tools: consumption tax, labor tax, and center-state transfer.

5.1 Consumption Tax Experiments

Increasing public spending through an increase in the consumption tax will have numerous effects. First, the household will face both an income and substitution effect of the higher after-tax price of consumption, and these two effects will work in opposite directions on the private expenditure decision. However, there is also the direct effect of higher public spending and the indirect effect coming through the marginal product of private spending. Specifically, higher public spending will crowd out private spending when public and private inputs are close substitutes. As ρ decreases and public and private education expenditures become less and less substitutable, the crowding out effect decreases and may even turn into a crowding in effect. At any rate, the effect of higher public spending affect the relative attractiveness of private spending or consumption in the household's problem. The simulation results capture the net effect of these.

First we show in Figure 1 the effect of changing public spending through the consumption tax on the private education spending share of output. We consider increasing the

consumption tax such that the public spending share of output equals 4.24%, up from the benchmark case, and decreasing the tax such that the public spending share equals 2.57%. The necessary consumption tax rates required to raise or lower the public spending share to 4.24% or 2.57% are indicated in the legend. The higher consumption taxes lead to a decrease in private spending on education. These effects are, however, small; an almost doubling of the consumption tax financed increase in public education expenditures changes private education expenditures by less than 20% and these effects get smaller over time.

Figure 2 shows the effect of changing the consumption tax rate on human capital growth. These effects are small. An almost doubling of the consumption tax rate from 1.1% to 2.0% increases the growth rate by less than 3% all along the equilibrium path. These small effects of increased public education funding are accounted for by the accompanying decline in private expenditures and the choice of the spending share of human capital production, α. The affects on the annualized growth rate are small, but more perceptible over time. Figure 3 plots the level of average human capital, where the higher public spending results in the average family being roughly 1.1% wealthier in 20 years, 3.49% in 40 years, 5.16% in 60 years, 6.74% in 80 years, and 8.39% in 100 years.

Finally, the higher consumption tax effectively reduces a household's after-tax income. Because preferences are nonhomothetic, this results in reducing private spending proportionally more for wealthier households than for poorer households. This places downward pressure on inequality under the higher consumption tax. Figure 4 shows the path of the Gini coefficient under these various policies. Quantitatively, the effects are small despite their accumulation over time. Raising public spending from 3.42% to 4.24% via the consumption tax lowers the Gini coefficient by a little more than 3% 100 years.

5.2 Labor Tax Experiments

Increasing public spending on education through the labor tax will have similar effects as utilizing the consumption tax, with one important difference. The consumption tax increase raises the price of consumption relative to private spending on education and leads to a substitution effect that puts upward pressure on private spending, even though the net effect reduces private spending. Increasing the labor tax will not create this substitution effect, and therefore private spending on education decreases more in this scenario. Figure 5 shows the effect on the private spending share of output when public spending is increased by the same amount as before in section 5.1, but by raising (lowering) the labor tax.

By closely comparing Figures 5 and 1 it is evident that private spending decreases (increases) by more under the higher (lower) labor tax. However, the differences are small, in the neighborhood of 1.5 to 2%. Nonetheless, to elucidate the differences, Figure 6 shows the comparison explicitly. This graph plots separately the percent change in the private spending share relative to the baseline calibration of section 4 where the public expenditure share is about 3.42% of output. For example, the long-dashed line represents the percent change in private spending share relative to the baseline whenever public spending is raised to 4.24% of income through the income tax. This figure verifies that private spending declines by more when higher public spending is financed through through the labor tax instead of the consumption tax. Figure 7 illustrates the differential effect on economic growth between the consumption-tax and labor-tax financed increases in public education spending. Increasing public spending through the consumption tax increases average human capital by around 8.3% at the 100-year mark, whereas financing the increase through the labor tax increases it by around 7.8%. These differences are very small.

While the growth effects of financing higher public spending through the labor tax are slightly less than those when utilizing the consumption tax, inequality is expected to decrease by more under the labor tax mechanism. Less private spending disproportionately affects the

wealthy since the marginal product of their private spending is higher than that of the poor due to complementarity between the two composite inputs in human capital production. Figure 8 confirms this. However, the differences in the Gini coefficients are very small, so small as to be economically insignificant.

Finally, in comparing the consumption and labor tax policies, it is interesting to consider the effect on average consumption. While the consumption tax engenders higher economic growth, because it creates a substitution effect that puts downward pressure on consumption, we expect consumption growth under the consumption tax hike to be less than the gain in economic growth overall. Figure 9 displays the comparisons. Under the higher consumption tax, one hundred years out, average consumption is about 6.9% higher than the baseline and under the higher labor tax it is about 6.5% higher. The consumption tax depresses average consumption in the short term, but over the longer term increased public education spending stimulates higher growth of human capital, which eventually allows for higher average consumption relative to the benchmark.

5.3 Center-State Transfer Experiments

The increase in the transfer does not generate the same substitution effect as the consumption tax increase. For the state, it is a pure windfall. With this windfall, private education expenditures are expected to increase, and the growth rates of human capital and consumption to increase as well. As is evident from Figures 6, 7 and 9, this windfall does little to boost private education expenditure, nor does it substantially increase human capital accumulation. Most of this windfall ends up in consumption. This is a pure wealth effect.

Given the positive impact on private spending, at least in the first three model-periods (about 60 years), human capital accumulation is just slightly higher under the transfer hike than under the consumption tax hike. The transfer hike is essentially free resources to the state. However, these resources do not improve human capital accumulation much more than

a consumption tax levied at the state-level. The outlet for the net transfer is consumption. Figure 9 encapsulates this.

Finally, inequality is reduced when public education expenditures are increased through the transfer since higher public spending is more productive for families with lower private expenditures under this parameterization of α and ρ. However, due to the small effect on private spending of the transfer-financed spending increase, inequality as measured by the Gini coefficient is not much different under the transfer and consumption tax experiments.

5.4 Sensitivity Analysis: Elasticity of Substitution

The parameters of our model outnumber observed moments available for targeting. Therefore we conduct sensitivity analysis to check the robustness of our results. Throughout the discussion of the tax policy experiments, we alluded to the role of public and private education spending and the substitutability between them. Here we change this parameter, namely the elasticity of substitution between public and private education spending, and highlight how the effects of tax policy changes differ under these parameterizations.

In order to compare the results in sections 5.1, 5.2, and 5.3 we compute the percentage change of a variable when moving from the baseline level of public spending (3.42% of output) to the high level of spending (4.24% of output) under a given parameterization of the elasticity of substitution. Table 3 presents the effect on the private education spending share of output of raising public education spending through either the consumption tax, labor tax, or transfer. For example, the first three rows in the table represent a parameterization identical to the baseline, except that ρ is set to 0.01. In the first row, the consumption tax is calibrated to match a public education spending share of output of 3.42% and 4.24%. The percent difference in the private education spending share is calculated between these two public spending regimes and reported in this first row. For example, when ρ is 0.01, moving from the low (3.42%) to the high (4.24%) public spending regime through the consumption

tax alone decreases the private education spending share by 0.58%. If done so through the labor tax alone, the private spending share decreases by 1.39% and if done through the transfer alone it decreases by 0.08%.

Theoretically, we would expect that as the elasticity of substitution increases (ρ gets larger) the crowding out effect of higher public spending on private education spending would increase. For example, when these two inputs are more complementary, higher public spending increases the marginal product of private spending. Therefore, we expect more crowding out of private education spending under the higher public spending policy as ρ is increased. This is confirmed in Table 3.

This crowding out effect puts downward pressure on the growth rate of aggregate (or average) human capital as the tax regimes are implemented under larger cases of ρ. However, there is another force putting upward pressure on the growth rate. Consider the extreme case when ρ is unity and the two inputs are perfect substitutes. Aggregate crowding out of private spending is large: it falls by over 30%. However, because public education spending is perfect substitute for private spending, the effect of the reduction in private spending on human capital production is mitigated. On the other hand, when ρ is 0.01, the reduction in private spending, while small, is not as easily replaced by public spending.

As ρ is increased, the prevalence of corner solutions in the household's problem puts upward pressure on economic growth coming from higher public spending. Namely, when ρ is small, public and private spending on education are more complementary and few households exhibit zero private spending. For example, when the public spending share is 3.42% of output and ρ is 0.01, only about 12.40% of households choose zero private spending. However, when ρ is closer to or equal to unity, many households choose zero private spending. Under the 3.42% public spending share when ρ is unity, 77.20% of households choose zero private spending. Thus, higher public spending's crowding out effect on private spending is active for a smaller proportion of households when ρ is large because most households have

zero private spending with which to begin.

Thus, we expect the possibility of a non-monotonic effect of higher public spending on human capital growth. When ρ is small we expect public spending to generate less growth as ρ increases and when ρ is larger we expect the opposite. This is confirmed in Table 4.

Again in Table 4 immediate growth gains are highest when the transfer is utilized, second highest for the consumption tax, and lowest for the labor tax. The transfer does not engender the negative income effect that both the consumption and labor taxes bring. The consumption tax offsets some of the negative income effect through the substitution effect by making consumption effectively more expensive relative to private education spending. Thus, the labor tax generates the lowest growth gains.

It is also noteworthy to examine the effect of higher public spending on inequality under various parameterizations of ρ. For low values of ρ, public and private education spending are more complementary. The negative income effect reduces private spending on education for all households; however, for lower income households near the extensive margin of private education spending, their choice of private spending drops to zero. This happens in all cases of ρ; however, it has a more negative effect on human capital accumulation when public and private spending are more complementary. This translates into higher inequality as low-income households experience smaller gains in human capital production than richer households as public spending increases. This is shown in Table 5. Inequality actually increases with higher public spending for low values of ρ. For higher values of ρ, however, inequality decreases with higher public spending. This should not be surprising since under the higher values of ρ, crowding out only affects the richest households.

5.5 Sensitivity Analysis: Parental Human Capital Cutoff, ψ

In section 4, we chose the cutoff, $\bar{h}_t$ to equal the human capital level of the fifth percentile of the human capital distribution at time t. In other words, we let $\psi = 0.05$ and $\bar{h}_t = F_{h_t}^{-1}(\psi)$.

Here we perform sensitivity analysis, letting ψ take on the following values: 0, 0.1, 0.2, 0.3, and 0.4. The case $\bar{h}_t = 0$ serves as a useful comparison since it obviates the threshold effect below which parental human capital is ineffective in the child's learning.

Because the elasticity of substitution between the composite spending input and the composite ability input equals unity, whether or not parental human capital augments the child's ability does not affect the households choice of private education expenditures. Specifically, higher composite ability provides an "income effect" and a "substitution effect" which cancel out each other. Therefore, we highlight only the initial impact on human capital production of higher public education expenditures, and how this impact differs based on the value of ψ. These initial differences accumulate over time and translate into differences in private spending, inequality, and so on in later periods. Table 8 shows the effect of higher public spending through the various tax policies on human capital accumulation under various levels of ψ. Unsurprisingly, as ψ increases, fewer parents augment their child's human capital production and human capital growth increases by less and less under the higher public spending regime.

In every scenario of ψ, inequality falls as public education spending rises, as shown in Table 9. To understand this, consider the effect of the composite ability input on the marginal product of higher education spending. The larger the composite ability input, the larger the marginal product of higher spending. When ψ is zero, all parents augment their child's ability, making public spending more productive for all households. However, when ψ is 0.40, 40% of parents do not augment their child's ability and for these households, public education spending is much less productive than for the rest. This generates upward pressure on inequality of higher public spending. However, the crowding out effect remains and the net effect on inequality of higher spending is negative, albeit less so whenever fewer parents are able to intellectually contribute to their child's human capital production.

In section B.2 we also provide sensitivity analysis regarding the composite ability share

in human capital production, δ. In these parameterizations, we adjusted α throughout in order to maintain constant returns to scale. The direction of our results maintain throughout with the primary effect of a higher δ (and smaller α) being to reduce to the magnitude of the effects of increased public education spending.

6 Conclusion

In this paper we consider human capital accumulation at the state level in a developing country context with three important features: public and private education resources, non-homothetic preferences, and the potential for parental human capital being ineffective for some children's human capital production. In this model we consider raising public spending for human capital accumulation through three tax policies. In particular, we find that raising the consumption tax generates about as much economic growth as realizing an increase in the transfer from the federal level. We also find that financing this increase in public spending through the labor tax increases economic growth by less than utilizing the consumption tax; however, it reduces inequality by more than utilizing the consumption tax.

We carry out the same taxation experiments under various characterizations of the elasticity of substitution between public and private education spending. We find that raising public spending increases economic growth in every case considered. The growth rate of human capital is non-monotonic in the elasticity of substitution between public and private educational resources. We find that inequality is reduced more by the higher public education spending the larger is the degree of substitutability between public and private education spending.

We complete the analysis with similar tax experiments under various cases of the exogenous human capital cutoff determining whether a parent's human capital augments their child's ability in human capital production. We find that higher public spending yields

smaller growth gains and inequality reductions as this cutoff is increased.

Key features driving our results regarding increases in public education spending include the crowding out of private education spending and the human capital cutoff. In particular, higher public spending leads to less growth gains whenever public and private spending are neither perfect substitutes or complements and whenever fewer parents contribute intellectually to their child's human capital production.

The most important policy implication of this model is that relatively large changes in funding levels for education have relatively minor impacts both on growth of aggregate human capital and on the evolution of income inequality. Whether these increases are financed by consumption tax increases or income tax increases does not influence this finding much at all.

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Appendices

A Figures Comparing Baseline Calibration under Various Tax Policies

A.1 Consumption Tax Policies

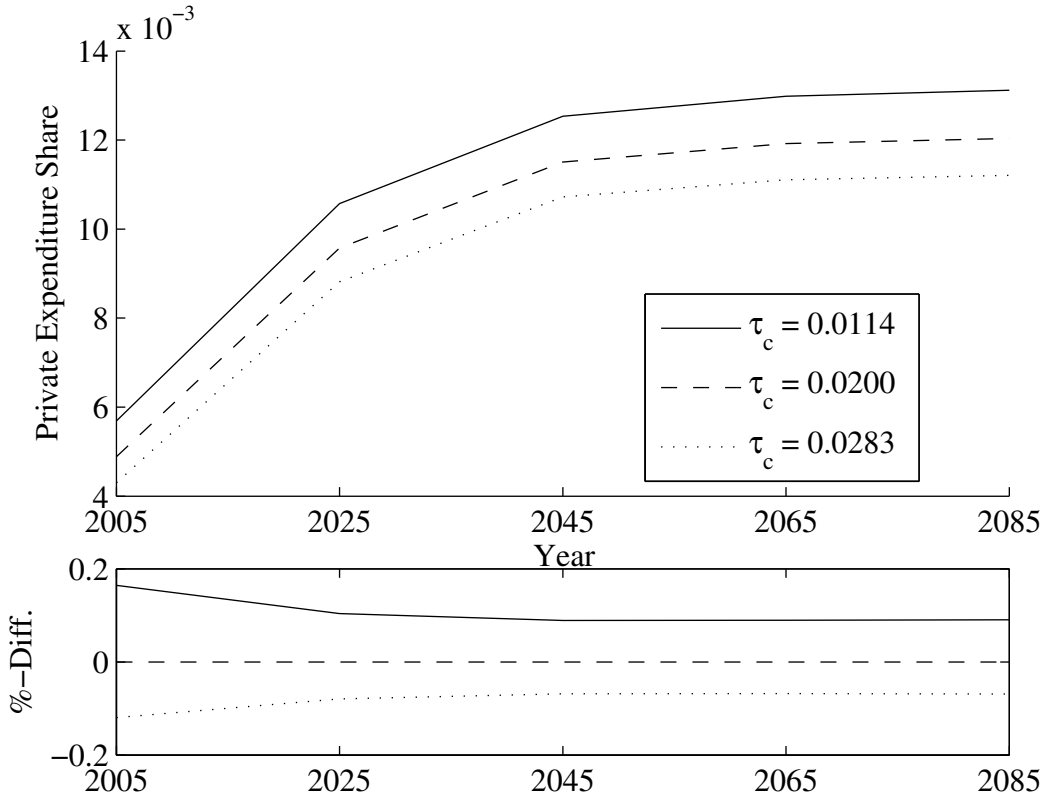

Figure 1: Private spending share of output under various consumption tax rates.

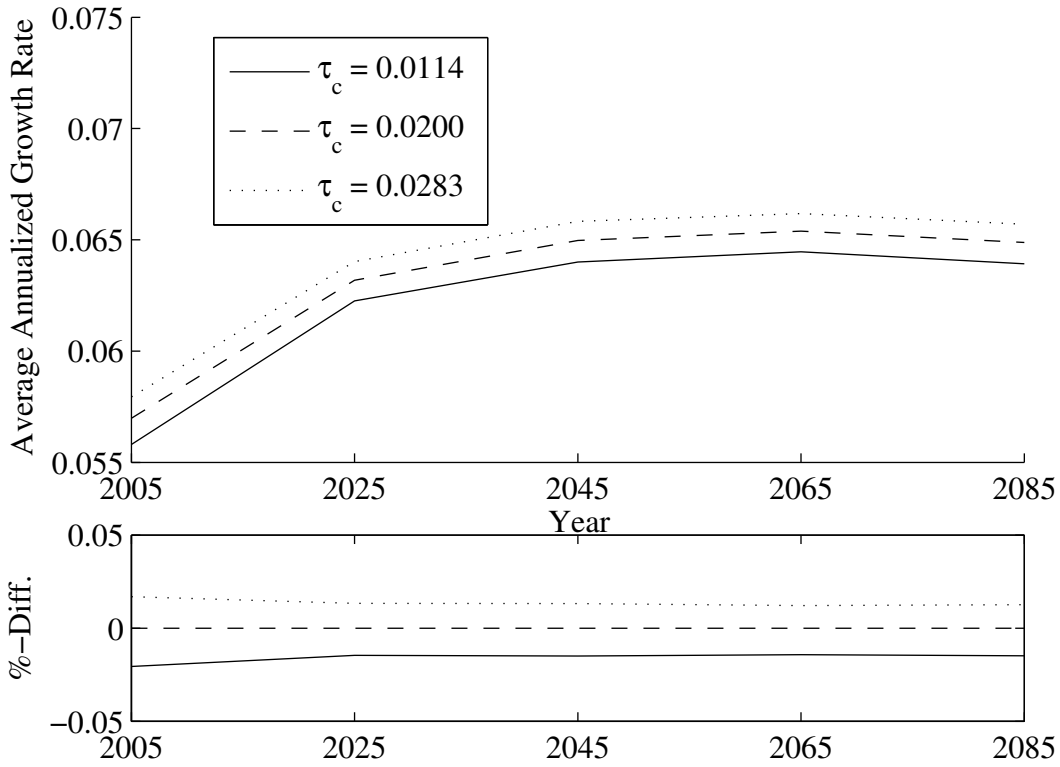

Figure 2: Annualized growth rate of aggregate human capital under various consumption tax rates.

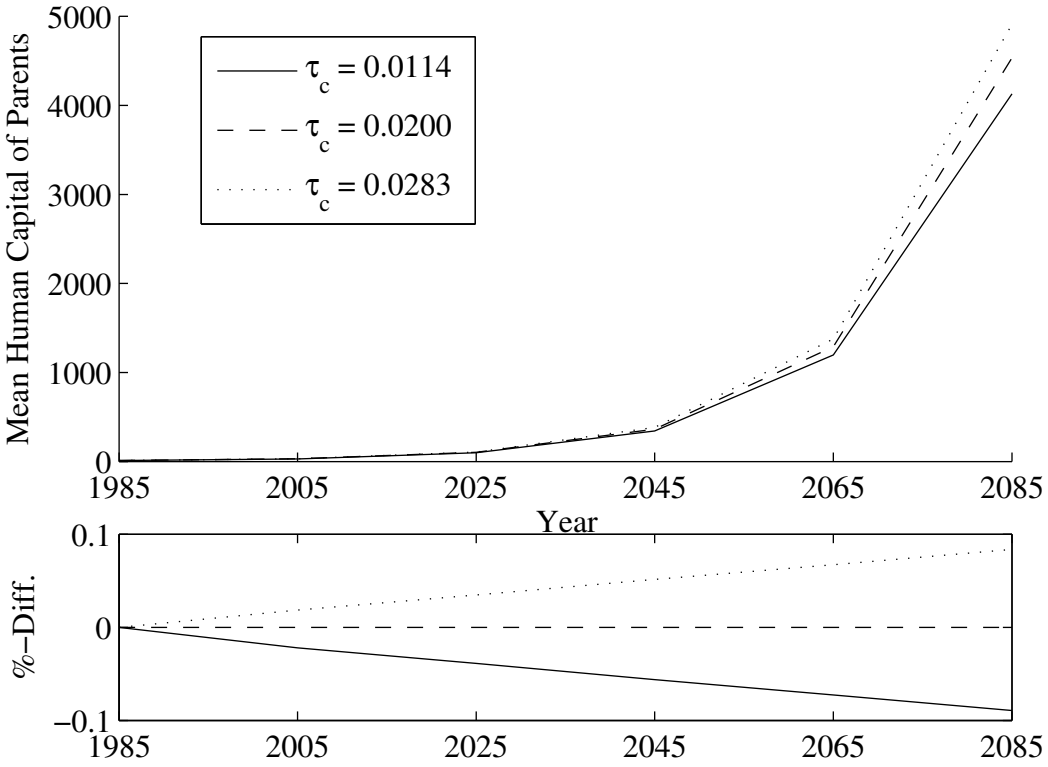

Figure 3: Average human capital of parents under various consumption tax rates.

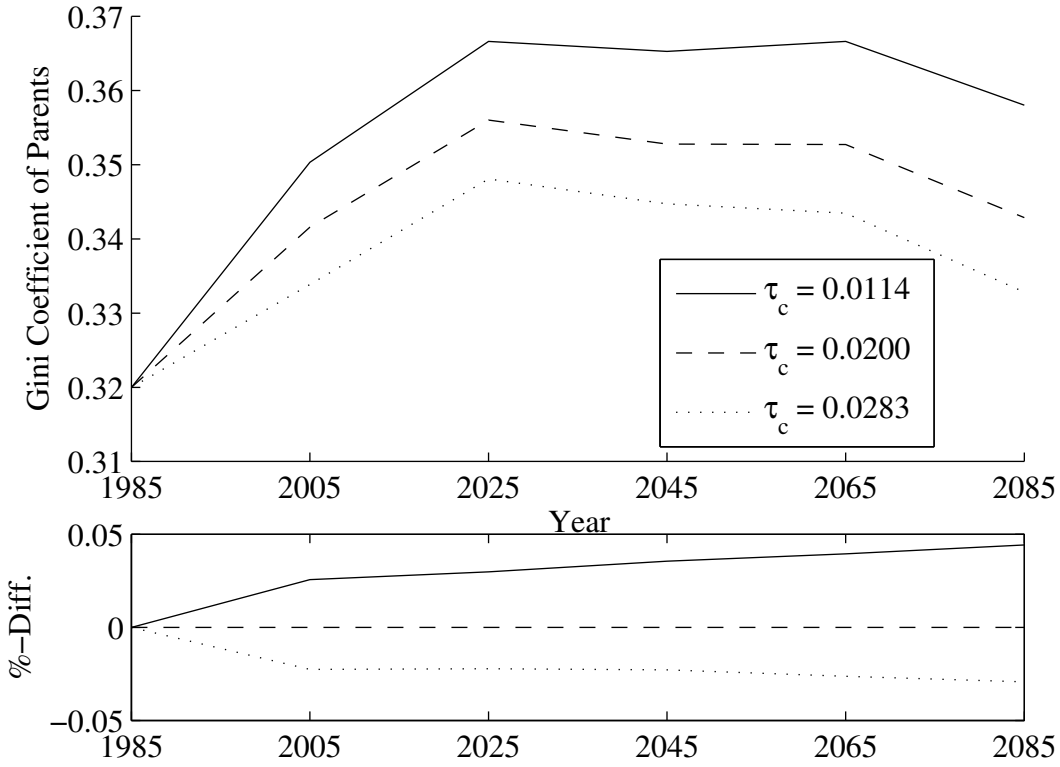

Figure 4: Gini coefficient of parents under various consumption taxes.

A.2 Comparing All Policies

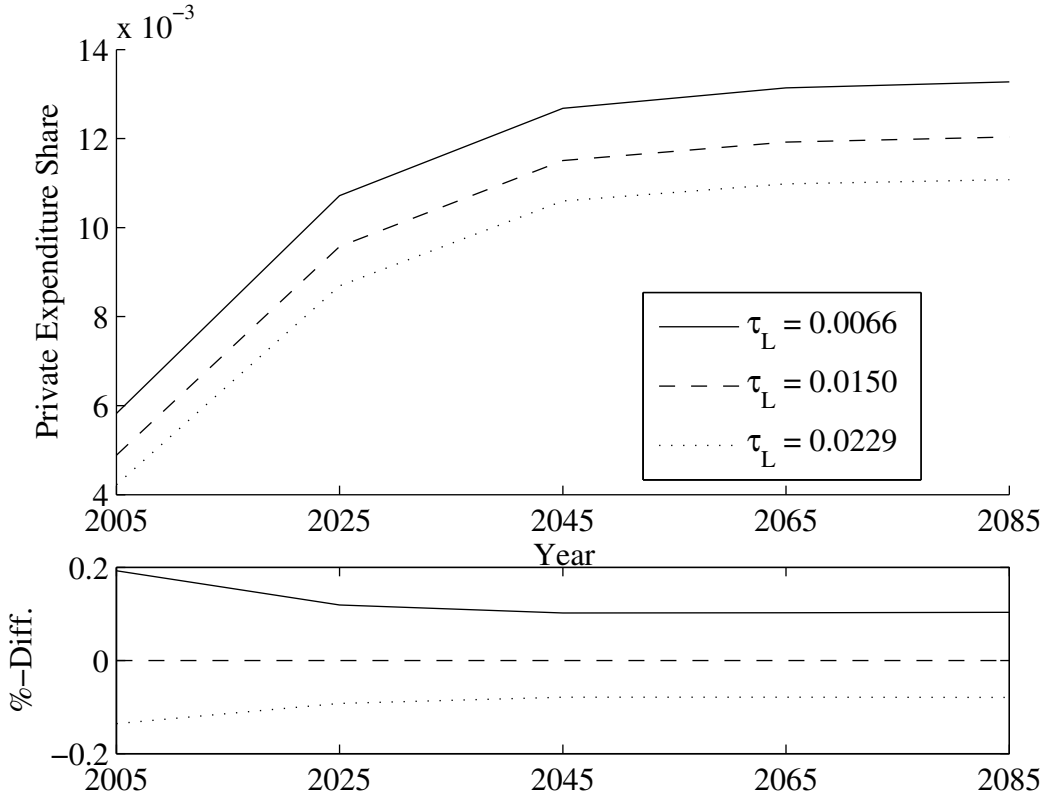

Figure 5: Private Spending Share of Output

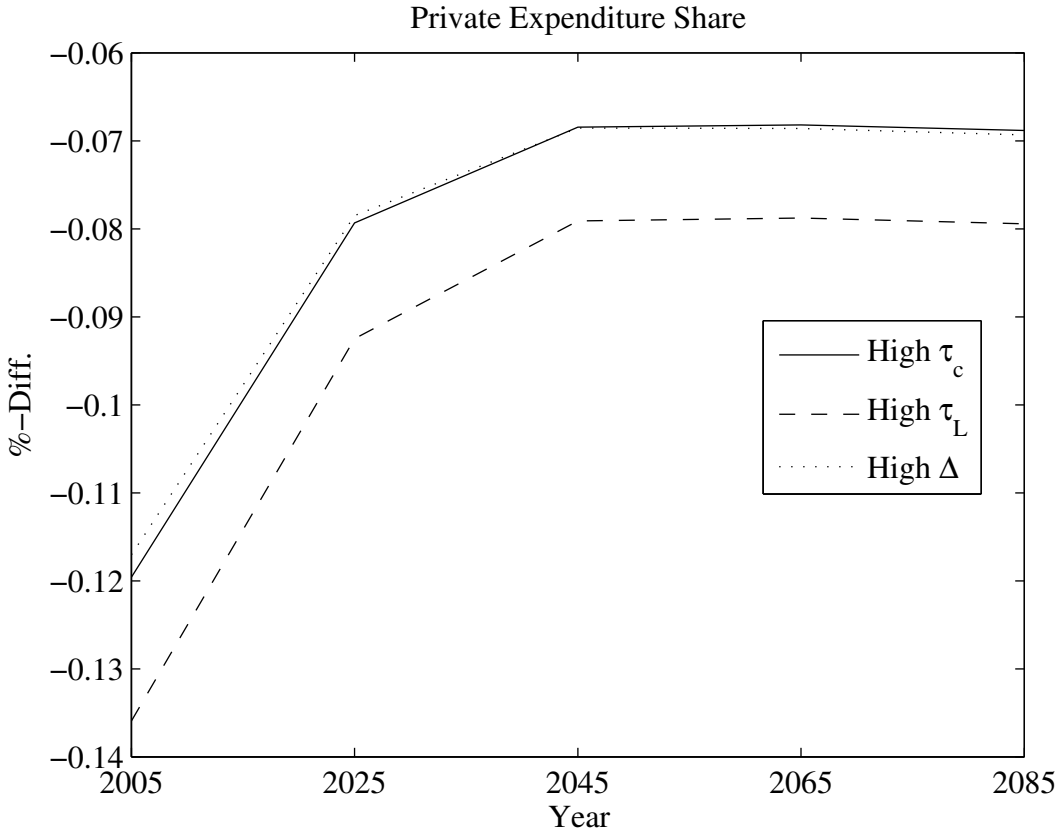

Figure 6: Private spending share of output under high public education spending regime achieved through various revenue sources.

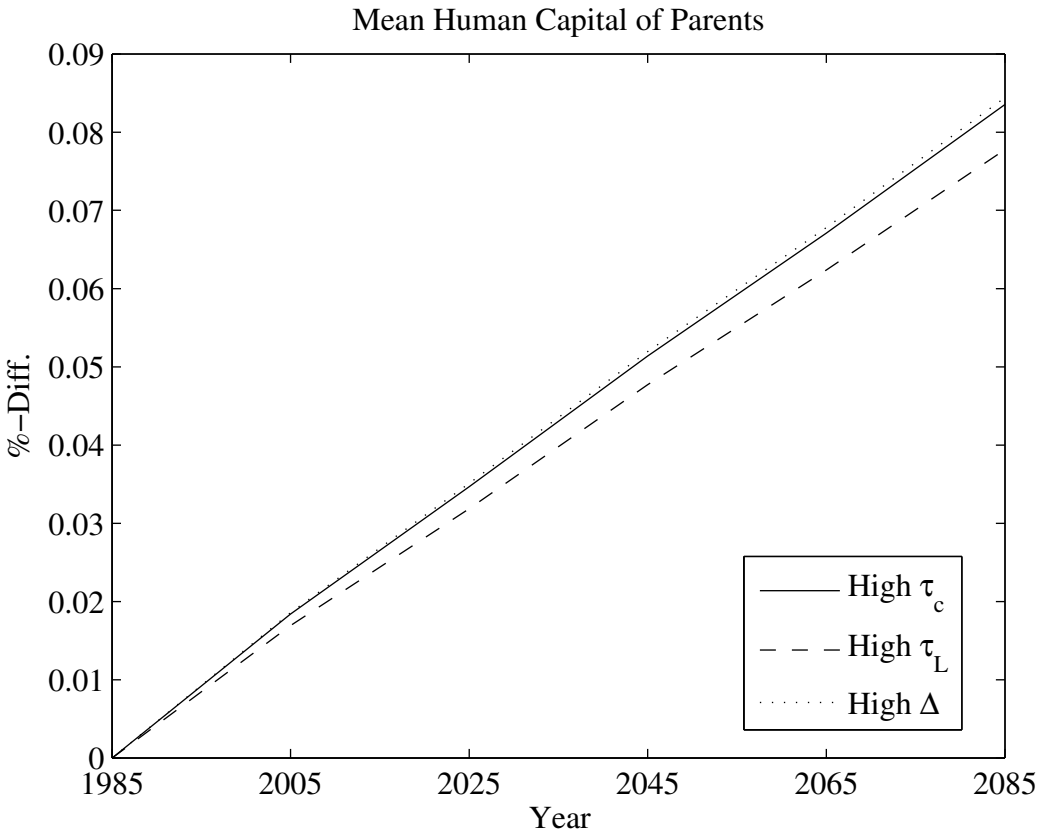

Figure 7: Mean human capital under high public education spending regime achieved through various revenue sources.

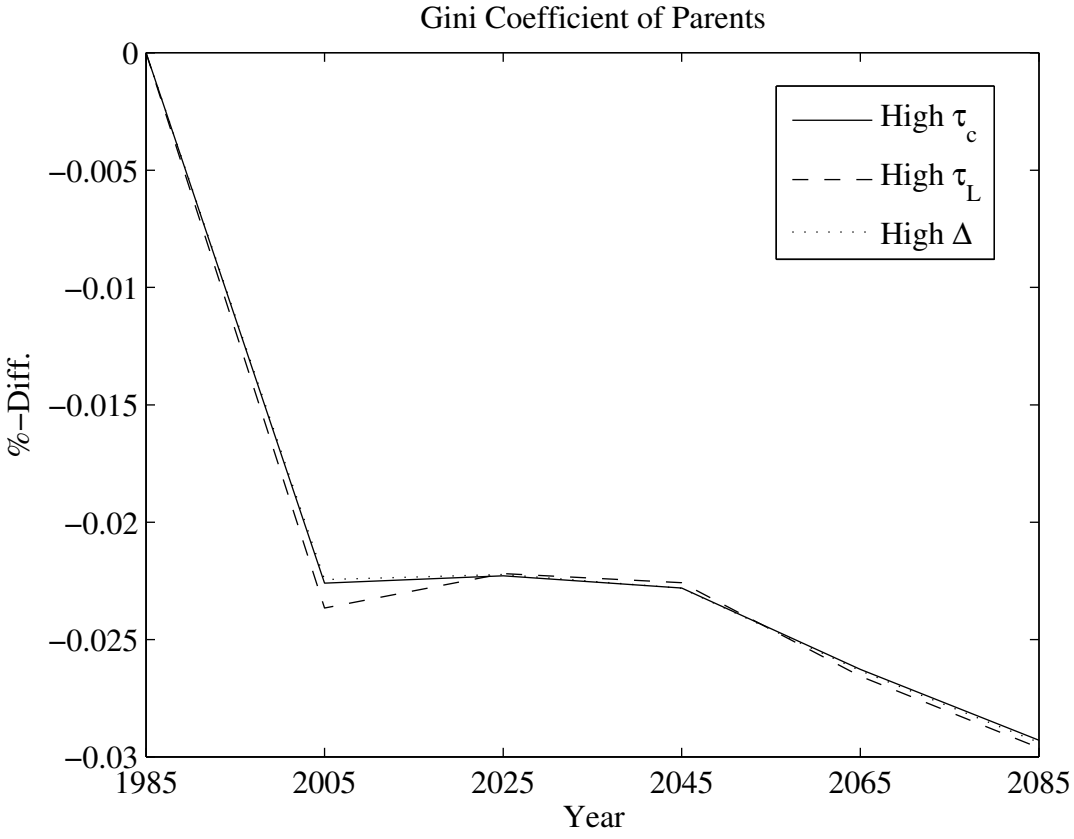

Figure 8: Gini coefficient of parents under high public education spending regime achieved through various revenue sources.

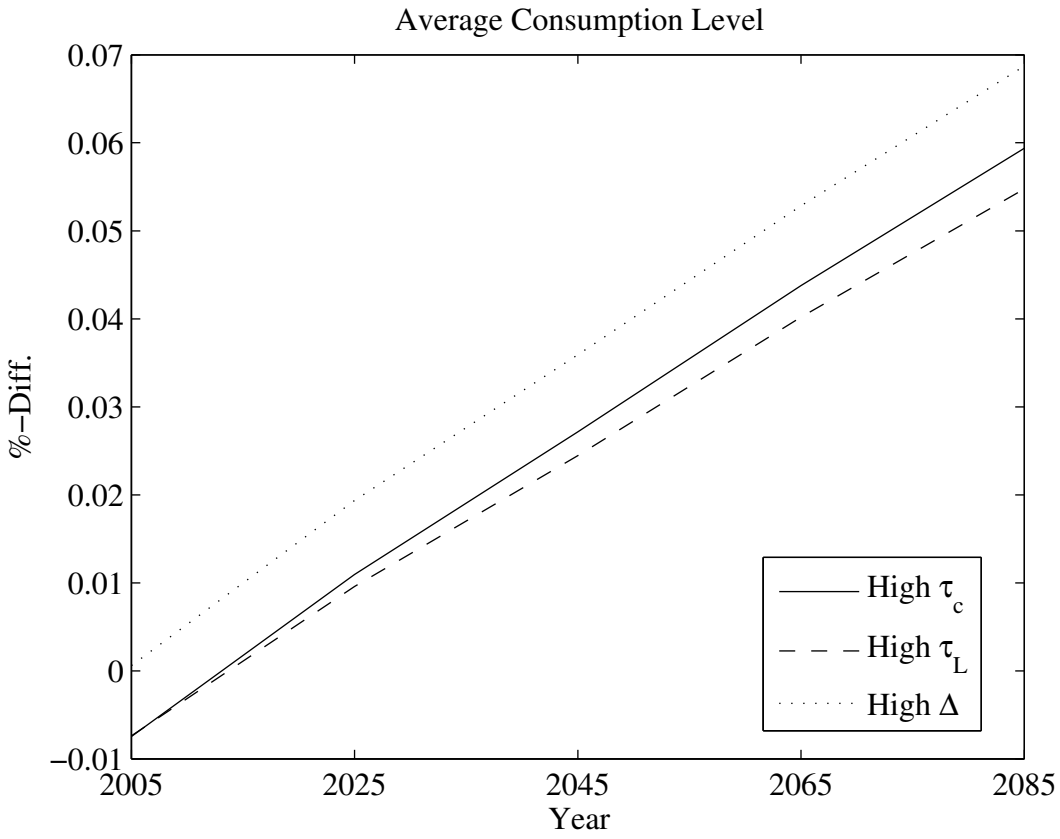

Figure 9: Average consumption level under high public education spending regime achieved through various revenue sources.

A.3 Sensitivity Analysis: Elasticity of Substitution

		1985	2005	2025	2045	2065
	$\boldsymbol{\tau_c}$	-0.0058	-0.0022	-0.0113	-0.0137	-0.0121
$\boldsymbol{\rho = 0.01}$	$\boldsymbol{\tau_l}$	-0.0139	-0.0098	-0.0439	-0.0736	-0.1016
	$\boldsymbol{\Delta}$	-0.0008	-0.0034	-0.0447	-0.0761	-0.1035
	$\boldsymbol{\tau_c}$	-0.0160	-0.0085	-0.0085	-0.0086	-0.0087
$\boldsymbol{\rho = 0.10}$	$\boldsymbol{\tau_l}$	-0.0258	-0.0169	-0.0168	-0.0169	-0.0170
	$\boldsymbol{\Delta}$	-0.0120	-0.0082	-0.0086	-0.0087	-0.0087
	$\boldsymbol{\tau_c}$	-0.0524	-0.0252	-0.0249	-0.0252	-0.0254
$\boldsymbol{\rho = 0.25}$	$\boldsymbol{\tau_l}$	-0.0647	-0.0345	-0.0339	-0.0342	-0.0344
	$\boldsymbol{\Delta}$	-0.0492	-0.0245	-0.0249	-0.0253	-0.0256
	$\boldsymbol{\tau_c}$	-0.1198	-0.0796	-0.0687	-0.0685	-0.0691
$\boldsymbol{\rho = 0.50}$	$\boldsymbol{\tau_l}$	-0.1362	-0.0928	-0.0794	-0.0791	-0.0797
	$\boldsymbol{\Delta}$	-0.1173	-0.0787	-0.0688	-0.0689	-0.0696
	$\boldsymbol{\tau_c}$	-0.2255	-0.1966	-0.1720	-0.1601	-0.1577
$\boldsymbol{\rho = 0.75}$	$\boldsymbol{\tau_l}$	-0.2396	-0.2116	-0.1864	-0.1742	-0.1716
	$\boldsymbol{\Delta}$	-0.2231	-0.1959	-0.1728	-0.1608	-0.1586
	$\boldsymbol{\tau_c}$	-0.3095	-0.3565	-0.3679	-0.3840	-0.3861
$\boldsymbol{\rho = 1.00}$	$\boldsymbol{\tau_l}$	-0.3263	-0.3748	-0.3873	-0.4031	-0.4056
	$\boldsymbol{\Delta}$	-0.3054	-0.3549	-0.3674	-0.3839	-0.3863

Table 3: Private Education Spending Share: Effect of raising public spending though either τ_c, τ_l, or Δ on the private spending share under various parameterizations of the elasticity of substitution ($\frac{1}{1-\rho}$). Values are percent deviations from the baseline calibration with only ρ different.

		1985	2005	2025	2045	2065	2085
	$\boldsymbol{\tau_c}$	0.0000	0.0156	0.0152	0.0139	0.0124	0.0111
$\boldsymbol{\rho = 0.01}$	$\boldsymbol{\tau_l}$	0.0000	0.0139	0.0474	0.0795	0.1134	0.1493
	$\boldsymbol{\Delta}$	0.0000	0.0166	0.0507	0.0824	0.1157	0.1513
	$\boldsymbol{\tau_c}$	0.0000	0.0117	0.0276	0.0444	0.0611	0.0791
$\boldsymbol{\rho = 0.10}$	$\boldsymbol{\tau_l}$	0.0000	0.0083	0.0229	0.0385	0.0545	0.0714
	$\boldsymbol{\Delta}$	0.0000	0.0123	0.0283	0.0451	0.0620	0.0802
	$\boldsymbol{\tau_c}$	0.0000	0.0111	0.0263	0.0435	0.0599	0.0776
$\boldsymbol{\rho = 0.25}$	$\boldsymbol{\tau_l}$	0.0000	0.0085	0.0229	0.0389	0.0542	0.0710
	$\boldsymbol{\Delta}$	0.0000	0.0114	0.0268	0.0441	0.0606	0.0784
	$\boldsymbol{\tau_c}$	0.0000	0.0185	0.0349	0.0516	0.0674	0.0839
$\boldsymbol{\rho = 0.50}$	$\boldsymbol{\tau_l}$	0.0000	0.0170	0.0321	0.0480	0.0627	0.0782
	$\boldsymbol{\Delta}$	0.0000	0.0187	0.0353	0.0522	0.0681	0.0848
	$\boldsymbol{\tau_c}$	0.0000	0.0220	0.0375	0.0525	0.0678	0.0833
$\boldsymbol{\rho = 0.75}$	$\boldsymbol{\tau_l}$	0.0000	0.0213	0.0359	0.0498	0.0641	0.0786
	$\boldsymbol{\Delta}$	0.0000	0.0222	0.0379	0.0529	0.0684	0.0840
	$\boldsymbol{\tau_c}$	0.0000	0.0273	0.0497	0.0694	0.0876	0.1062
$\boldsymbol{\rho = 1.00}$	$\boldsymbol{\tau_l}$	0.0000	0.0268	0.0486	0.0674	0.0848	0.1026
	$\boldsymbol{\Delta}$	0.0000	0.0274	0.0499	0.0697	0.0879	0.1066

Table 4: Average Human Capital: Effect of raising public spending though either τ_c, τ_l, or Δ on average human capital under various parameterizations of the elasticity of substitution ($\frac{1}{1-\rho}$). Values are percent deviations from the baseline calibration with only ρ different.

		1985	2005	2025	2045	2065	2085
	$\boldsymbol{\tau_c}$	0.0000	0.0014	0.0009	0.0008	0.0007	0.0006
$\boldsymbol{\rho = 0.01}$	$\boldsymbol{\tau_l}$	0.0000	0.0034	0.0037	0.0043	0.0043	0.0049
	$\boldsymbol{\Delta}$	0.0000	-0.0001	-0.0005	-0.0004	-0.0003	-0.0002
	$\boldsymbol{\tau_c}$	0.0000	0.0064	0.0057	0.0043	0.0033	0.0018
$\boldsymbol{\rho = 0.10}$	$\boldsymbol{\tau_l}$	0.0000	0.0104	0.0099	0.0083	0.0068	0.0052
	$\boldsymbol{\Delta}$	0.0000	0.0062	0.0056	0.0041	0.0032	0.0017
	$\boldsymbol{\tau_c}$	0.0000	-0.0024	-0.0056	-0.0073	-0.0097	-0.0106
$\boldsymbol{\rho = 0.25}$	$\boldsymbol{\tau_l}$	0.0000	-0.0017	-0.0049	-0.0069	-0.0097	-0.0105
	$\boldsymbol{\Delta}$	0.0000	-0.0023	-0.0056	-0.0073	-0.0097	-0.0107
	$\boldsymbol{\tau_c}$	0.0000	-0.0227	-0.0224	-0.0229	-0.0264	-0.0294
$\boldsymbol{\rho = 0.50}$	$\boldsymbol{\tau_l}$	0.0000	-0.0237	-0.0223	-0.0227	-0.0267	-0.0298
	$\boldsymbol{\Delta}$	0.0000	-0.0225	-0.0223	-0.0229	-0.0265	-0.0295
	$\boldsymbol{\tau_c}$	0.0000	-0.0245	-0.0364	-0.0391	-0.0412	-0.0473
$\boldsymbol{\rho = 0.75}$	$\boldsymbol{\tau_l}$	0.0000	-0.0256	-0.0379	-0.0408	-0.0429	-0.0491
	$\boldsymbol{\Delta}$	0.0000	-0.0244	-0.0364	-0.0389	-0.0412	-0.0473
	$\boldsymbol{\tau_c}$	0.0000	-0.0246	-0.0484	-0.0695	-0.0840	-0.0992
$\boldsymbol{\rho = 1.00}$	$\boldsymbol{\tau_l}$	0.0000	-0.0255	-0.0502	-0.0723	-0.0874	-0.1031
	$\boldsymbol{\Delta}$	0.0000	-0.0244	-0.0481	-0.0693	-0.0839	-0.0991

Table 5: Gini Coefficient of Parents: Effect of raising public spending though either τ_c, τ_l, or Δ on the Gini coefficient under various parameterizations of the elasticity of substitution ($\frac{1}{1-\rho}$). Values are percent deviations from the baseline calibration with only ρ different.

		1985	2005	2025	2045	2065
	$\boldsymbol{\tau_c}$	-0.0081	0.0073	0.0070	0.0056	0.0041
$\boldsymbol{\rho = 0.01}$	$\boldsymbol{\tau_l}$	-0.0080	0.0057	0.0389	0.0707	0.1044
	$\boldsymbol{\Delta}$	0.0000	0.0167	0.0507	0.0824	0.1157
	$\boldsymbol{\tau_c}$	-0.0080	0.0036	0.0194	0.0360	0.0526
$\boldsymbol{\rho = 0.10}$	$\boldsymbol{\tau_l}$	-0.0079	0.0003	0.0148	0.0302	0.0461
	$\boldsymbol{\Delta}$	0.0001	0.0124	0.0284	0.0453	0.0622
	$\boldsymbol{\tau_c}$	-0.0078	0.0032	0.0184	0.0354	0.0516
$\boldsymbol{\rho = 0.25}$	$\boldsymbol{\tau_l}$	-0.0077	0.0007	0.0150	0.0309	0.0461
	$\boldsymbol{\Delta}$	0.0003	0.0117	0.0272	0.0445	0.0610
	$\boldsymbol{\tau_c}$	-0.0075	0.0110	0.0273	0.0440	0.0597
$\boldsymbol{\rho = 0.50}$	$\boldsymbol{\tau_l}$	-0.0074	0.0097	0.0246	0.0404	0.0551
	$\boldsymbol{\Delta}$	0.0006	0.0195	0.0361	0.0531	0.0691
	$\boldsymbol{\tau_c}$	-0.0072	0.0152	0.0307	0.0456	0.0608
$\boldsymbol{\rho = 0.75}$	$\boldsymbol{\tau_l}$	-0.0071	0.0146	0.0292	0.0431	0.0573
	$\boldsymbol{\Delta}$	0.0009	0.0236	0.0395	0.0546	0.0701
	$\boldsymbol{\tau_c}$	-0.0071	0.0206	0.0433	0.0630	0.0813
$\boldsymbol{\rho = 1.00}$	$\boldsymbol{\tau_l}$	-0.0071	0.0202	0.0423	0.0612	0.0786
	$\boldsymbol{\Delta}$	0.0010	0.0290	0.0520	0.0720	0.0904

Table 6: Average Consumption: Effect of raising public spending though either τ_c, τ_l, or Δ on average consumption under various parameterizations of the elasticity of substitution ($\frac{1}{1-\rho}$). Values are percent deviations from the baseline calibration with only ρ different.

B Other Sensitivity Analysis

B.1 Sensitivity Analysis: Parental Human Capital Effectivity Cutoff

		1985	2005	2025	2045	2065
	$\boldsymbol{\tau_c}$	-0.1198	-0.0786	-0.0698	-0.0697	-0.0704
$\boldsymbol{\psi = 0.00}$	$\boldsymbol{\tau_l}$	-0.1362	-0.0926	-0.0804	-0.0803	-0.0811
	$\boldsymbol{\Delta}$	-0.1173	-0.0778	-0.0699	-0.0701	-0.0709
	$\boldsymbol{\tau_c}$	-0.1198	-0.0781	-0.0671	-0.0672	-0.0677
$\boldsymbol{\psi = 0.10}$	$\boldsymbol{\tau_l}$	-0.1362	-0.0904	-0.0781	-0.0778	-0.0783
	$\boldsymbol{\Delta}$	-0.1173	-0.0772	-0.0675	-0.0676	-0.0682
	$\boldsymbol{\tau_c}$	-0.1198	-0.0746	-0.0645	-0.0642	-0.0646
$\boldsymbol{\psi = 0.20}$	$\boldsymbol{\tau_l}$	-0.1362	-0.0869	-0.0751	-0.0747	-0.0752
	$\boldsymbol{\Delta}$	-0.1173	-0.0738	-0.0646	-0.0646	-0.0651
	$\boldsymbol{\tau_c}$	-0.1198	-0.0640	-0.0583	-0.0572	-0.0571
$\boldsymbol{\psi = 0.40}$	$\boldsymbol{\tau_l}$	-0.1362	-0.0747	-0.0688	-0.0676	-0.0674
	$\boldsymbol{\Delta}$	-0.1173	-0.0633	-0.0585	-0.0576	-0.0576

Table 7: Private Education Spending Share: Effect of raising public spending though either τ_c, τ_l, or Δ on the private spending share under various parameterizations of the parental human capital cutoff (ψ). Values are percent deviations from the baseline calibration with only ψ different.

		1985	2005	2025	2045	2065	2085
	$\boldsymbol{\tau_c}$	0.0000	0.0187	0.0360	0.0532	0.0694	0.0864
$\boldsymbol{\psi = 0.00}$	$\boldsymbol{\tau_l}$	0.0000	0.0172	0.0330	0.0494	0.0644	0.0805
	$\boldsymbol{\Delta}$	0.0000	0.0189	0.0364	0.0538	0.0701	0.0872
	$\boldsymbol{\tau_c}$	0.0000	0.0182	0.0341	0.0504	0.0658	0.0819
$\boldsymbol{\psi = 0.10}$	$\boldsymbol{\tau_l}$	0.0000	0.0167	0.0315	0.0469	0.0612	0.0764
	$\boldsymbol{\Delta}$	0.0000	0.0184	0.0345	0.0510	0.0665	0.0828
	$\boldsymbol{\tau_c}$	0.0000	0.0174	0.0321	0.0476	0.0621	0.0776
$\boldsymbol{\psi = 0.20}$	$\boldsymbol{\tau_l}$	0.0000	0.0158	0.0293	0.0439	0.0573	0.0717
	$\boldsymbol{\Delta}$	0.0000	0.0176	0.0325	0.0482	0.0629	0.0784
	$\boldsymbol{\tau_c}$	0.0000	0.0146	0.0276	0.0413	0.0537	0.0672
$\boldsymbol{\psi = 0.40}$	$\boldsymbol{\tau_l}$	0.0000	0.0128	0.0249	0.0376	0.0488	0.0613
	$\boldsymbol{\Delta}$	0.0000	0.0148	0.0281	0.0419	0.0545	0.0681

Table 8: Average Human Capital: Effect of raising public spending though either τ_c, τ_l, or Δ on average human capital under various parameterizations of the parental human capital cutoff (ψ). Values are percent deviations from the baseline calibration with only ψ different.

		1985	2005	2025	2045	2065	2085
	$\boldsymbol{\tau_c}$	0.0000	-0.0239	-0.0263	-0.0277	-0.0318	-0.0356
$\boldsymbol{\psi = 0.00}$	$\boldsymbol{\tau_l}$	0.0000	-0.0250	-0.0260	-0.0274	-0.0321	-0.0359
	$\boldsymbol{\Delta}$	0.0000	-0.0237	-0.0263	-0.0277	-0.0319	-0.0357
	$\boldsymbol{\tau_c}$	0.0000	-0.0211	-0.0194	-0.0193	-0.0221	-0.0244
$\boldsymbol{\psi = 0.10}$	$\boldsymbol{\tau_l}$	0.0000	-0.0220	-0.0195	-0.0191	-0.0223	-0.0245
	$\boldsymbol{\Delta}$	0.0000	-0.0209	-0.0193	-0.0192	-0.0220	-0.0244
	$\boldsymbol{\tau_c}$	0.0000	-0.0175	-0.0136	-0.0128	-0.0151	-0.0166
$\boldsymbol{\psi = 0.20}$	$\boldsymbol{\tau_l}$	0.0000	-0.0182	-0.0135	-0.0125	-0.0151	-0.0165
	$\boldsymbol{\Delta}$	0.0000	-0.0173	-0.0136	-0.0128	-0.0152	-0.0166
	$\boldsymbol{\tau_c}$	0.0000	-0.0112	-0.0070	-0.0055	-0.0065	-0.0073
$\boldsymbol{\psi = 0.40}$	$\boldsymbol{\tau_l}$	0.0000	-0.0115	-0.0071	-0.0054	-0.0065	-0.0072
	$\boldsymbol{\Delta}$	0.0000	-0.0111	-0.0070	-0.0055	-0.0065	-0.0073

Table 9: Gini Coefficient of Parents: Effect of raising public spending though either τ_c, τ_l, or Δ on the Gini coefficient under various parameterizations of the parental human capital cutoff (ψ). Values are percent deviations from the baseline calibration with only ψ different.

B.2 Sensitivity Analysis: Composite Ability Share in Human Capital Production

		1985	2005	2025	2045	2065
	$\boldsymbol{\tau_c}$	-0.1198	-0.0796	-0.0687	-0.0685	-0.0691
$\boldsymbol{\delta = 0.80}$	$\boldsymbol{\tau_l}$	-0.1362	-0.0928	-0.0794	-0.0791	-0.0797
	$\boldsymbol{\Delta}$	-0.1173	-0.0787	-0.0688	-0.0689	-0.0696
	$\boldsymbol{\tau_c}$	-0.1327	-0.0962	-0.0779	-0.0765	-0.0767
$\boldsymbol{\delta = 0.85}$	$\boldsymbol{\tau_l}$	-0.1611	-0.1140	-0.0889	-0.0876	-0.0876
	$\boldsymbol{\Delta}$	-0.1305	-0.0955	-0.0780	-0.0769	-0.0771
	$\boldsymbol{\tau_c}$	-0.2691	-0.1427	-0.0926	-0.0888	-0.0885
$\boldsymbol{\delta = 0.90}$	$\boldsymbol{\tau_l}$	-0.2771	-0.1568	-0.1045	-0.0998	-0.0996
	$\boldsymbol{\Delta}$	-0.2677	-0.1421	-0.0927	-0.0891	-0.0889

Table 10: Private Education Spending Share: Effect of raising public spending though either τ_c, τ_l, or Δ on the private spending share under various parameterizations of the composite ability share in human capital production (δ). Values are percent deviations from the baseline calibration with only δ and $\alpha = 1 - \delta$ different.

		1985	2005	2025	2045	2065	2085
	$\boldsymbol{\tau_c}$	0.0000	0.0185	0.0349	0.0516	0.0674	0.0839
$\boldsymbol{\delta = 0.80}$	$\boldsymbol{\tau_l}$	0.0000	0.0170	0.0321	0.0480	0.0627	0.0782
	$\boldsymbol{\Delta}$	0.0000	0.0187	0.0353	0.0522	0.0681	0.0848
	$\boldsymbol{\tau_c}$	0.0000	0.0185	0.0318	0.0451	0.0588	0.0724
$\boldsymbol{\delta = 0.85}$	$\boldsymbol{\tau_l}$	0.0000	0.0167	0.0284	0.0406	0.0538	0.0669
	$\boldsymbol{\Delta}$	0.0000	0.0186	0.0321	0.0455	0.0592	0.0729
	$\boldsymbol{\tau_c}$	0.0000	0.0133	0.0223	0.0325	0.0428	0.0535
$\boldsymbol{\delta = 0.90}$	$\boldsymbol{\tau_l}$	0.0000	0.0133	0.0217	0.0314	0.0413	0.0516
	$\boldsymbol{\Delta}$	0.0000	0.0134	0.0223	0.0327	0.0430	0.0537

Table 11: Average Human Capital: Effect of raising public spending though either τ_c, τ_l, or Δ on average human capital under various parameterizations of the composite ability share in human capital production (δ). Values are percent deviations from the baseline calibration with only δ and $\alpha = 1 - \delta$ different.

		1985	2005	2025	2045	2065	2085
	$\boldsymbol{\tau_c}$	0.0000	-0.0227	-0.0224	-0.0229	-0.0264	-0.0294
$\boldsymbol{\delta = 0.80}$	$\boldsymbol{\tau_l}$	0.0000	-0.0237	-0.0223	-0.0227	-0.0267	-0.0298
	$\boldsymbol{\Delta}$	0.0000	-0.0225	-0.0223	-0.0229	-0.0265	-0.0295
	$\boldsymbol{\tau_c}$	0.0000	-0.0172	-0.0174	-0.0183	-0.0189	-0.0219
$\boldsymbol{\delta = 0.85}$	$\boldsymbol{\tau_l}$	0.0000	-0.0194	-0.0186	-0.0204	-0.0204	-0.0227
	$\boldsymbol{\Delta}$	0.0000	-0.0171	-0.0174	-0.0183	-0.0190	-0.0219
	$\boldsymbol{\tau_c}$	0.0000	-0.0127	-0.0155	-0.0152	-0.0154	-0.0161
$\boldsymbol{\delta = 0.90}$	$\boldsymbol{\tau_l}$	0.0000	-0.0128	-0.0158	-0.0155	-0.0158	-0.0165
	$\boldsymbol{\Delta}$	0.0000	-0.0127	-0.0154	-0.0153	-0.0155	-0.0161

Table 12: Gini Coefficient of Parents: Effect of raising public spending though either τ_c, τ_l, or Δ on the Gini coefficient under various parameterizations of the composite ability share in human capital production (δ). Values are percent deviations from the baseline calibration with only δ and $\alpha = 1 - \delta$ different.

		1985	2005	2025	2045	2065
	$\boldsymbol{\tau_c}$	-0.0075	0.0110	0.0273	0.0440	0.0597
$\boldsymbol{\delta = 0.80}$	$\boldsymbol{\tau_l}$	-0.0074	0.0097	0.0246	0.0404	0.0551
	$\boldsymbol{\Delta}$	0.0006	0.0195	0.0361	0.0531	0.0691
	$\boldsymbol{\tau_c}$	-0.0077	0.0109	0.0241	0.0373	0.0509
$\boldsymbol{\delta = 0.85}$	$\boldsymbol{\tau_l}$	-0.0076	0.0092	0.0208	0.0329	0.0460
	$\boldsymbol{\Delta}$	0.0004	0.0192	0.0327	0.0461	0.0599
	$\boldsymbol{\tau_c}$	-0.0078	0.0056	0.0144	0.0246	0.0348
$\boldsymbol{\delta = 0.90}$	$\boldsymbol{\tau_l}$	-0.0078	0.0056	0.0139	0.0236	0.0333
	$\boldsymbol{\Delta}$	0.0003	0.0138	0.0228	0.0331	0.0434

Table 13: Average Consumption: Effect of raising public spending though either τ_c, τ_l, or Δ on average consumption under various parameterizations of the composite ability share in human capital production (δ). Values are percent deviations from the baseline calibration with only δ and $\alpha = 1 - \delta$ different.