

Government Bias in Education, Schooling Attainment and Long-run Growth*

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JEL Code: I25, O41

Forthcoming in Southern Economic Journal. Must not be reproduced

January 2, 2012

*Acknowledgement: We have greatly benefitted from the insightful comments of two referees and the co-editor John Pepper of this journal. We also gratefully acknowledge William Blankenau, B. Ravikumar and the workshop participants at University of Iowa, Concordia University and Growth Conference at the Indian Statistical Institute in New Delhi in 2009 for comments on an earlier version of this paper. Basu gratefully acknowledges a research leave from Durham University in 2009 to complete this project. The usual disclaimer applies.

Abstract

A surprising cross-country stylized fact is that higher public spending on education tends to lower the long run growth rate of per capita GDP and the returns to schooling. This is contrary to the conventional wisdom that education is a major driver of growth. In this paper, we revisit this issue and try to understand these puzzling facts in terms of an endogenous growth model. Our cross-country calibration of the growth model predicts that countries with a greater government involvement in education experience lower schooling efforts and lower growth.

1 Introduction

How public spending on education influences educational attainment and economic growth is an unresolved issue. A recent flow of literature questions the effect of government involvement in education on educational attainment of pupils. Based on U.S. and international data, Hanushek (2003) persuasively argues that a resource based policy of the government has little effect on the educational attainment of pupils. In the majority of cases, an active involvement of government in the education sector is deemed to be a failure. Blankenau and Camera (2009) show that in a strategic environment when a government spends more on the education sector, students may underinvest in their efforts. If government involvement in education has such a questionable effect on educational attainment of pupils, the spillover effect of this on economic growth also becomes debatable.¹

The objective of this paper is to ask why a resource based public education policy can be counterproductive. There is a growing literature that explores the link between public expenditure on education and growth (Glomm and Ravikumar 1992, 1997, 1998). Our paper is closely related to Blankenau and Simpson (2004) and Blankenau, Simpson and Tomljanovich (2007) who address the relationship between growth and public education spending. However, our model differs from both these papers in several important ways. First, we focus on household's time allocation between schooling and work as an important determinant of long run growth and public education spending. Blankenau, Simpson and Tomljanovich (2007) do not model time allocation to schooling. Second, unlike Blankenau and Simpson (2004) and Blankenau, Simpson and Tomljanovich (2007), we focus on the proactive role of the government as a factor determining public education spending behavior. Third, we analyze the relationship between public education spending and schooling returns while Blankenau and Simpson (2004) and Blankenau, Simpson and Tomljanovich (2007) do not explore any such relationship. Fourth, Blankenau, Simpson and Tomljanovich (2007) use an overlapping generations model while we use an infinite horizon model making the model more naturally amenable to calibration using the cross-

country data. Finally, for model calibration we use a bigger sample of countries than Blankenau, Simpson and Tomljanovich (2007).

The principal insight from our endogenous growth model is that when the government spends more on intermediate inputs such as teachers and pupils for production of human capital, two opposing effects are at work. First is a positive complementarity effect because of greater governmental provision of such intermediate inputs. Second, there is a negative distortionary effect due to the tax on the non-education sector (goods sector) to finance such education spending. Since the goods sector uses both physical and human capital, such a tax on goods to finance education directly depresses the investment in both. Given that the goods sector is more physical capital intensive than the education sector, a tax on the goods sector immediately lowers the investment in physical capital more than investment in human capital. As a result, the ratio of physical to human capital declines which raises the marginal product of the physical capital. Households respond to this by reallocating more time to the goods sector and less time to schooling to rebalance the return on physical capital and human capital. This depresses investment in human capital further. The long run growth thus suffers because of the decline in investment in both physical and human capital. The overall effect on growth depends on the relative strengths of these two opposing forces. While the former complementarity channel promotes growth, the latter distortionary effect lowers growth.

The overall effect of a greater government education spending on long run growth depends critically on how *proactive* the government is in the education sector. Such government involvement can take various forms which include designing a national curriculum and implementing compulsory schooling for children. There are numerous determinants of this proactive role of the government which include economic and sociological factors. Friedman (1962) in his classic article succinctly lays out two broad principles of government intervention in education: (i) externality or "neighborhood effects," and (ii) "paternalistic concern" of the government in the society.² The intensity of (i) and (ii) could differ from one country to another depending on social norms and customs which

could give rise to varying degrees of government intervention in education in different societies. For example, in England compulsory schooling for children was implemented in 1880 much later than in many continental countries (Sanderson 1991).

In view of this complexity in measuring the degree of government involvement in education, we envisage this proactive role of the government as an exogenous parameter in the schooling technology. This parameter determines the relative importance of public service as an intermediate input in the human capital technology. Hereafter, we call this parameter the *government bias in education*. Countries may differ in this government bias which makes their schooling technologies different. Our central question is to understand how this government bias in education influences public education spending propensity, pupils' incentive to learn, schooling returns and ultimately the long run growth of a nation.

Our approach is novel because we highlight the role of this government bias in education as a central determinant of the cross-country relationship between growth and public spending on education. The role of government bias in determining the cross-country variation in growth and education spending has so far been overlooked in the literature. Using our calibrated growth model, we estimate this government bias for a wide range of countries. The basic principles followed in this calibration are non-standard. We assume that governments in all countries set the tax on output optimally to finance education spending. This optimal tax rate maximizes the long run growth and welfare of the society. Our steady state optimal tax formula shows a tight relationship between government bias and the tax rate. Everything else equal, countries with a greater government bias in education tax a higher fraction of output to finance education. Assuming that all our 166 countries in the sample had already arrived at various steady states, we back out the government bias parameter as well as schooling efforts using only two observables, namely historical average share of public education spending in GDP and growth rate of all countries in our sample. The advantage of this reverse engineering procedure is that by simply exploiting the balanced growth properties of the model we can identify two crucial unknowns, namely government bias in education and schooling efforts which are

of central interest in this paper.

Our calibration experiment shows that nations with a larger government bias have a higher tax on output to finance higher education spending. This has a positive effect on growth. However, on the negative side, a higher tax on output gives rise to the distortionary effect which crowds out private schooling efforts and depresses growth for the reasons mentioned earlier. The latter negative effect depresses growth. For our sample of countries in the calibration experiment, the latter distortionary effect dominates, and we find an inverse relation between growth and public spending on education consistent with the stylized facts. Thus, even though there is a technological complementarity between private and public inputs in human capital production, a greater government bias in the education sector crowds out private schooling efforts for the majority of countries in our sample.

Our model also provides lessons for an optimal public spending policy for education. A benevolent government that aims to promote societal welfare should spend more on education in an economy where considerable government bias in education is already present in terms of prior actions of the government to promote educational endowment and infrastructure.³ More spending on education through taxes in countries without sufficient infrastructure creates larger distortions and lowers growth. Thus contrary to conventional wisdom, a blanket increase in government spending on education may not necessarily promote growth and welfare in all countries.

The paper is organized as follows. The following section presents some key development facts to motivate our growth model. Section 3 lays out an endogenous growth model and characterizes the balanced growth properties of model variables. Section 4 reports the quantitative implications of the model based on cross-country calibration. Section 5 discusses welfare and policy implications. Section 6 concludes. Construction of data and details on derivation of equilibrium conditions and solution procedure of the model are given in the Appendix.

2 Some Development Facts

In this section, we present some stylized facts about the cross-country relationship between growth rates, rate of return on education and share of public education spending in GDP. Figure 1 plots the average per capita growth rate (1970-2005) against the public education spending ratio for 166 countries. Despite the well known cross-country volatility of growth rate, a negative relationship holds. The correlation coefficient is -0.18.

[Figure 1 about here]

A clearer relationship emerges if countries are broadly grouped. Figure 2 plots the cross-country per capita growth rate and education spending ratio averaged over the period 1970-2005 for 18 groups of countries sorted by per capita income. The correlation coefficient is -0.38. A higher spending ratio is associated with lower growth except for countries that have very high education spending ratios. At this very top end, a higher spending ratio tends to be correlated with a higher per capita output growth. The relationship between education spending ratio and growth resembles the nonlinearity pointed out by Blankenau, Simpson and Tomljanovich (2007).

[Figure 2 about here]

Figure 3 plots the rate of return on education against the education spending ratio for 48 countries for which the rate of return data are available.⁴ The correlation coefficient is -0.15 and statistically significant at the 5% level.

The essence of these cross-country stylized facts can be summarized as follows. The growth rate and return on education are generally lower in countries where the government spends more on education. The following section presents a growth model to understand these stylized facts.

[Figure 3 about here]

3 The Model

The model is an adaptation of the Lucas-Uzawa (Lucas 1988) model. We set up a growth model of a prototype country in the world economy. There are two sectors, goods and education. A fixed time (normalized at unity) is allocated between schooling and goods production. Time l_{Ht} allocated to schooling at date t creates effective labour or human capital (h_{t+1}) in the following period using similar schooling technology as in Glomm and Ravikumar (1997) and Blankenau, Simpson and Tomljanovich (2007):

$$h_{t+1} = (1 - \delta_h)h_t + A_H g_t^\eta (l_{Ht} h_t)^{1-\eta} \quad (1)$$

where $\delta_h \in (0, 1)$ is the rate of depreciation of human capital and $\eta \in (0, 1)$ is a schooling technology parameter. The productivity of schooling effort thus depends on (i) the education productivity parameter (A_H) and (ii) the public spending on education (g_t) which differs from one country to another.⁵

The schooling technology (1) is actually a production function for new human capital. In a similar vein as in Barro (1990), the inputs in the production function are public spending on education g_t and private spending $l_{Ht} h_t$. The latter is the imputed (opportunity) cost of diverting time from goods production to human capital production.⁶

The schooling technology parameter η is of central interest in this paper. Note that η is simply the elasticity of the flow of knowledge with respect to government spending on intermediate input to human capital production (e.g. teacher salary). For example, a one percent increase in teacher salary creates higher than one percent increase in pupil attainment in an economy with a better educational infrastructure (e.g. school library, internet facility). Viewed from this perspective, η can be interpreted as the infrastructural role of the government in the education sector. In other words, η is higher in countries where the government had already taken a proactive role in the past by investing resources to build a rich educational infrastructure. Rather than explicitly modelling the government's infrastructural investment in education, we treat this infrastructural role of the government as a country-specific technology parameter. Absent such a government role

in education (η equals zero), the schooling technology reverts to the Lucas (1988) form. Given this interpretation, hereafter we label the schooling technology parameter (η) as the *government bias in the education sector*. We find that this government bias parameter is quite fundamental in determining the cross-country relationship between public spending on education and growth.

Final goods (y_t) are produced with the help of human and physical capital via the Cobb-Douglas production technology:

$$y_t = A_G k_t^\alpha (l_{Gt} h_t)^{1-\alpha} \quad (2)$$

where l_{Gt} (that equals $1 - l_{Ht}$) is the remaining time allocated to the production of goods and A_G is a constant total factor productivity (TFP) in the goods sector.⁷

The investment goods technology is specified as follows:

$$k_{t+1} = (1 - \delta_k)k_t + i_t^k \quad (3)$$

where i_t^k is the gross investment in physical capital and δ_k is the fixed rate of depreciation of physical capital.

The government finances education spending (g_t) by levying a proportional tax (τ_t) on the goods sector output, y_t . In other words, the government budget constraint is:

$$g_t = \tau_t y_t \quad (4)$$

The representative household takes the sequence of tax rates $\{\tau_t\}$ as given and chooses the sequences $\{c_t\}, \{i_t\}, \{l_{Ht}\}$, that maximize utility

$$Max \sum_{t=0}^{\infty} \beta^t \ln(c_t)$$

subject to the resource constraint:

$$c_t + i_t^k = (1 - \tau_t)y_t \quad (5)$$

and the schooling technology (1).

Given that the private sector behaves optimally, the government sets the tax rates $\{\tau_t\}$ to maximize societal welfare.

Balanced Growth Properties

Since the central goal of the paper is to understand the cross-country long run relationship between public education spending and growth, we assume that each country has already arrived at a balanced growth path. We thus focus on the balanced growth property of our proposed economy. We have the following proposition.

Proposition 1 *Along the balanced growth path, the welfare maximizing share of public spending in GDP is given by:*

$$\tau = \frac{\frac{1-\alpha}{1-\eta} \cdot \frac{\eta l_H}{l_G}}{1 + \frac{1-\alpha}{1-\eta} \cdot \frac{\eta l_H}{l_G}} \quad (6)$$

Proof. Appendix. ■

Along the balanced growth path, the time allocations to goods and schooling sectors are stationary which we denote as l_H and l_G dropping the time subscripts. The ratios of output to capital (y_t/k_t) and the physical to human capital (k_t/h_t) are also constants. Proposition 1 establishes that the share of education in GDP is also constant. In other words, the steady state government spending share in GDP is given by:

$$\frac{g_t}{y_t} = \tau \quad (7)$$

Define the gross balanced growth rate as γ . There are three key balanced growth equations. Based on the first order condition for the physical capital stock (A.2) in the appendix, we get:

$$\gamma = \beta [(1 - \tau)(\alpha y_t/k_t) + 1 - \delta_k] \quad (8)$$

Based on the first order condition for the human capital stock (A.3) in the appendix, we get:

$$\gamma = \beta[1 - \delta_h + A_H(1 - \eta)\tau^\eta l_H^{-\eta}(y_t/h_t)^\eta] \quad (9)$$

Finally, using the human capital technology (1), we get a third balanced growth equation:

$$\gamma = 1 - \delta_h + A_H\tau^\eta l_H^{1-\eta} A_G^\eta l_G^{(1-\alpha)\eta} (k_t/h_t)^{\alpha\eta} \quad (10)$$

Given the production function (2), these three equations solve for three unknowns, namely k_t/h_t , l_H and γ . The appendix provides details of the derivation.

4 Cross-country calibration of the government bias in education

In this section, we report the results of a cross-country calibration experiment. Our basic premise is that all countries share the same world technology of goods production. However, they differ in the technology of human capital production due to differences in two parameters, namely government bias η and education productivity A_H . The assumption that η differs across countries is motivated by the evidence that the education spending ratio differs substantially across countries (see Figure 1). The second assumption about cross-country difference in the education productivity parameter A_H is motivated by the finding of Hanushek and Woessmann (2008) who document that the quality of schooling, and hence education quality differs across countries.⁸ Other structural parameters are fixed at baseline levels specified as follows. The capital share parameter α and the rate of depreciation of physical capital, δ_k are fixed at the conventional levels 0.36 and 0.1 (Prescott 1986) respectively. The remaining parameters are fixed at $\beta = 0.94$, $A_G = 3.9$ and $\delta_h = 0.05$ with a goal to arrive at reasonable cross-country steady state distribution for time allocation between work and schooling (l_H), the education productivity A_H and the government bias in the education η . Table 1 summarizes the baseline parameter

values.

[Table 1 about here]

In order to get cross-country estimates of the two crucial educational technology parameters, η and A_H , we follow a method of reverse engineering. We focus on four key steady state equations; (6), (8), (9) and (10). We fix $\alpha, \beta, A_G, \delta_k, \delta_H$ at their baseline levels. We assume that all 166 countries in our sample are already on various steady states. This means that for each country, γ and τ are equal to the historical average growth rate of GDP and education share in GDP. Given that all countries share the same baseline estimates of the structural parameters as shown in Table 1, it means that for each country in our sample, we have four equations, (6), (8), (9) and (10) in four unknowns, namely η, A_H, l_H and k/y . These four unknowns can be thus backed out from the model.

It is important to mention that the reverse engineering procedure of backing out these four unknowns is novel in our paper. There are, of course, other ways of doing this. The advantage of our procedure is that our growth model could perfectly match the cross-country growth rates and education shares. We then back out the two crucial education technology parameters, η, A_H as well as the time to schooling l_H and the capital-output ratio (k/y) for each of the countries in our sample.⁹

Table 2 reports the mean and standard deviation of the cross-country distribution of the four key steady state variables. The average time to schooling l_H is 0.47 which is similar to the estimate of Gomme and Rupert (2007). A cross-country average A_H of 0.15 is in the vicinity of the value calibrated by Basu, Gillman and Pearlman (2010) and an average $\eta = 0.07$ is close to the cross-country average share of public spending on education in GDP (which is 0.05) for our sample. The cross-country average capital to output ratio of 1.91 is in line with the estimate of capital to output ratio for the US based on a Solow growth model (Mankiw 2003). The cross-country dispersion is highest for the capital-output ratio which is not surprising given the enormous disparity in the per capita output across countries.

[Table 2 about here]

Table 3 reports the summary description of η for broad groups of countries classified in regions. The range of regional variation of η is from 0.036 to 0.096 which is substantial. The government bias is highest in the North American region where Canada provides the lead (0.12). Next to North America are the OECD countries. The government bias is lowest in the South Asian region. The bottom row of the table reports the historical average growth rate of GDP for each region over the sample period 1980-2008. A sharp negative regional relationship emerges between government bias in education and long run average growth rates. (see Figure 4).

[Table 3 about here]

Table 4 summarizes the cross correlations of the key macroeconomic variables of interest based on our calibrated growth model for the full sample of 166 countries. The correlation between growth and government bias is -0.46 which further confirms the negative relation reported in Figure 4.¹⁰

Our model also establishes a tight link between private schooling efforts, growth rates and returns to schooling. Along the balanced growth path, the return to human capital (R^h) is given by gross marginal product of human capital:

$$R^h = 1 - \delta_h + MPH^E \tag{11}$$

where MPH^E denotes the marginal product of human capital in the education sector. Since schooling return is proportional to growth rate (see equation (9)) and growth rate negatively varies with η , the immediate implication is that returns to schooling also covary negatively with η and the correlation between growth and schooling return is perfect. This is shown on the last row of Table 4. The model thus reflects the stylized facts reported in section 2 that there is a negative cross-country correlation between the growth rate and spending ratio as well as schooling return and spending ratio.

[Figure 4 about here]

[Table 4 about here]

Government bias in education and schooling efforts

The cross-country correlation between η and l_H is -0.64 significant at the 5% level. Figure 5 plots l_H against η for all 166 countries in the sample. The scatter plot also confirms the strong negative relationship between η and l_H . Countries with a greater government bias in education experience crowding out of private schooling efforts.

[Figure 5 about here]

[Figure 6 about here]

Not surprisingly, the model predicts that the cross-country correlation between education share τ and government bias, η is strongly positive (correlation coefficient is 0.81). Figure 6 plots the government bias in the education sector against the education share. Governments in countries with a greater government bias in education spend more on education as a fraction of GDP.

These two cross-country plots shed light on the finding of Hanushek (2003) that greater public resources in education do not help promote pupils' learning incentive. In fact, our model shows that a greater government involvement in education crowds out private schooling efforts. Although this crowding out effect is apparently counterintuitive, a closer examination reveals that a fundamental arbitrage condition explains this effect. To see it note that along the balanced growth path, private agents allocate time between goods production and schooling to equate the post tax marginal returns to physical and human capital. In other words, we have the following arbitrage condition:

$$R^h = (1 - \tau)(\alpha y/k) + 1 - \delta_k \tag{12}$$

Everything else equal, an increase in η raises the optimal tax rate τ to finance education spending. Since the goods sector is more capital intensive than the education sector, this increase in tax lowers the physical to human capital ratio in the economy. This in turn

raises the marginal product of physical capital. If agents can alter the time allocation, they will allocate more time to work and less to schooling to preserve the arbitrage condition (12).

For 100% depreciation of human capital ($\delta_h = 1$), an analytical expression for l_H exists and it confirms this intuition. Use (9) and (10) to get:

$$l_H = \beta(1 - \eta) \tag{13}$$

which upon substitution in (6) yields

$$\tau = \frac{\beta(1 - \alpha)}{(1 - \beta)\eta^{-1} + \beta + (1 - \alpha)\beta} \tag{14}$$

It is straightforward to verify from (13) and (14) that countries with a greater government bias in education (higher η) experience a crowding out of private schooling effort, l_H and a greater share of GDP in education, τ .

5 Welfare Implications

Does an increase in public spending on education necessarily make the society worse off in the long run? In the appendix, we have shown in proposition 2 that the education spending share τ that maximizes welfare also maximizes long run growth. Thus, growth can be a sufficient statistic of a country's welfare in our representative agent growth model.

Given this connection between growth and welfare, the first question that we ask is: Do countries with a greater government bias in education (η) necessarily experience lower welfare? Our calibrated model based on cross-country evidence suggests that this is indeed the case. A higher η lowers long run per capita growth rate of a country and thus lowers welfare.

One has to be careful to generalize this result. An increase in η has two opposing effects on growth: (i) a negative effect via crowding out of schooling effort, and (ii) a

positive effect via a richer educational infrastructure. In our cross-country calibration, we find that (i) is stronger than (ii). However, if one allows a large range of variation of η , it is possible that for countries with a very high η , greater government involvement could be beneficial for growth. Figure 7 plots gross growth rate (γ) against education share (g/y) when η is allowed to vary from 0.05 to 0.40 while setting the other parameters at the baseline levels.¹¹ The relationship is U shaped. The implication is that countries which already have a very a high government bias in education, growth and public spending on education could show a positive correlation. This nonlinear relationship between growth and education spending is also consistent with Blankenau and Simpson (2007).

[Figure 7 about here]

In our model, the government bias parameter η is determined by the prior actions of the government. Since over the observed range of countries, an increase in government bias lowers growth and welfare, this gives rise to a puzzle why a country should opt for greater government bias in education when it could be potentially worse off. In this paper, we do not have a theory of optimal government bias in education. One possible hypothesis is that past governments in our sample of countries followed a flawed educational policy which makes the distortionary effect dominate the complementarity effect. This could be due to the fact that the government may have goals different from the representative agent. For example, a government driven by redistributive objectives may spend substantial public funds on university infrastructure to promote higher education. This could create unproductive bureaucrats (Pritchett 2001) at the expense of lower investment in both physical and human capital and thus could have a drag on long run growth. On the other hand, if a government spends more on vocational and professional schooling, it is conceivable that the complementarity effect of public spending could dominate the distortionary effect.¹² The optimal composition of educational infrastructure needed to maximize societal welfare is a subject matter of future research which is beyond the scope of this paper.

6 Conclusion

The effect of public education spending on growth is an empirically unsettled issue. A plethora of studies document that public education spending does not help promote growth. Our cross-country stylized facts also support this finding. Growth and schooling returns are in fact lower in countries with a higher ratio of public spending to GDP except for very high education spenders. In this paper, we reopen this issue and investigate this within an endogenous growth framework. In our model, public spending on education appears directly in the human capital technology. The relative intensity of public and private education spending, which we call government bias in education, appears to be a fundamental driver of cross-country dispersion in long run growth and public spending on education. A higher government bias has conflicting effects on growth. On the one hand, it lowers growth by crowding out private schooling efforts. On the other hand, it promotes growth through the complementarity channel. The latter effect is stronger in countries which have historically a greater government bias in education. Based on our growth model, we estimate this government bias parameter for a wide range of countries and find that countries with a higher government bias in education experience lower schooling effort, schooling returns and growth.

The policy implication of our analysis is that an increase in public spending on education without an adequate infrastructural support may not necessarily be beneficial for the society. Currently 80 percent of education spending is allocated to teacher salaries¹³ which is likely to be spent more on consumption than in investment. For the complementarity effect of public spending to dominate, a nation may need a greater educational infrastructure. This infrastructural role of the government in education is an area worth exploring in future research.

Our model gives rise to deeper questions about the determinants of government bias in education. This requires a richer model that could endogenize the government bias parameter η . This is a topic that warrants future work. A useful starting point for endogenizing the government bias is to assume that η is a function of the past government

spending ratio on education. Each country would take its history of past government intervention in education as given and solve its own optimal tax rate. In a steady state equilibrium, the optimal tax must be history consistent. The computation of such a history dependent steady state could possibly give rise to multiple equilibria where countries may end up at varying degrees of government biases in the steady state.

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Notes

¹Pritchett (2001) shows significant skepticism about the positive effect of education spending on growth. Sylwester (2000) demonstrates that the contemporaneous education expenditure has a negative effect on growth. Temple (2001) revisits the empirical evidence and shows with alternative statistical procedures that the link between education expenditure and growth is tenuous. Blankenau, Simpson and Tomljanovich (2007) argue that government spending on education has insignificant effect on growth for low and middle income countries while it has a positive effect on rich countries.

²Although Friedman (1962) lays out these two basic motive forces for government intervention, he advocates minimal government intervention in education in a free democratic society. In reality, one observes varying degrees of government intervention in different societies depending on social and cultural ethos.

³Greater involvement of the government in education in the UK was preceded by an increase in public spending on education in various forms which boosted educational infrastructure. Public spending rose by more than 20 fold (Sanderson (1991), Carpentier (2003)) during the period 1833-1897 following a series of reforms including Reform Act (1867), Foster's Act (1870), Elementary Education Act (1880), Elementary School Attendance Act (1893), which not only brought education under state responsibility but also made attendance compulsory to improve the quality of the work force.

⁴Psacharopoulos and Patrinos (2004) and Pritchett (2001) compiled the rate of return on education series for 48 countries based on Mincer (1974) type analysis. We use their dataset. Details of all the data sources are discussed in the appendix.

⁵Without any loss of generality we avoid putting country suffix at this stage just for economy of notations. The growth model thus refers to a prototype i^{th} country. In section 4, we discuss the motivation for assuming the country heterogeneity in respect of these two schooling technology parameters.

⁶If an explicit labour market is in place, this opportunity cost will be measured by the foregone wages due to spending time at school.

⁷We assume that leisure time is fixed.

⁸Basu and Bhattacharai (2011) interpret A_H as cognitive skills and explain the cross-country relationship between openness and education spending propensity in terms of an open economy endogenous growth model.

⁹Although some cross country data are available for time to schooling (e.g. Lee and Barro 2001), we use our model to generate cross country estimates of l_H . The reason is that the variable l_H in our model more accurately represents schooling efforts which cannot be fully reflected by the cross-country data on schooling time. For example, parents might spend a significant amount of time in tutoring their children which means a lot of schooling efforts. It is hard to find cross country data for this kind of

efforts. In a similar vein, Blankenau and Camera (2009) argue that schooling attendance may be the same across countries but efforts may differ. We also rely on the model to generate cross country series for capital/output ratio (k/y) and education productivity parameter (A_H) because reliable cross-country series for capital stock are hard to get. About education productivity, the closest series available are Hanushek and Weissman (2006). These estimates are, however, based on standardized test scores which are the end results of pupils' learning ability and even a debatable proxy for it.

¹⁰We have also performed sensitivity analysis by changing α and δ in the neighborhood of their baseline values which we do not report here for brevity. The signs of the correlations are robust to such changes.

¹¹The parameter A_H is fixed at 0.15 as in Table 2. The U shaped relationship is robust to alternative choices of A_H and other parameters in the neighbourhood of the baseline values.

¹²Murphy, Schliefer and Vishny (1991) provide evidence that countries with a greater fraction of engineering students grow faster, while countries with a higher proportion of law graduates have low growth performances.

¹³This is based on UNESCO database on education available at <http://www.uis.unesco.org/>.

Table 1: Baseline estimates of structural parameters common to all countries

α	β	δ_k	δ_h	A_G
0.36	0.94	0.1	0.05	3.9

Table 2: Cross country steady state distribution of the education technology

	l_H	A_H	η	k/y
Mean	0.47	0.15	0.07	1.91
Std Deviation	0.07	0.02	0.03	0.21

Table 3: Regional Features of the Government Bias in Education

	Asia	Europe	Latin America and Caribbean	Mideast and N. Africa	OECD	North America	South Asia	Africa
η	0.057	0.078	0.068	0.063	0.08	0.096	0.036	0.077
g (%)	2.830	2.111	1.478	1.518	2.259	1.756	3.811	0.731

Table 4: Cross country correlations of the key macroeconomic variables

	l_H	A_H	η	k/y	τ	γ	R^h
l_H	1						
A_H	0.92	1					
η	-0.64	-0.39	1				
k/y	-0.94	-0.96	0.35	1			
τ	-0.14	0.12	0.81	-0.19	1		
γ	0.93	0.99	-0.46	-0.95	0.01	1	
R^h	0.93	0.99	-0.46	-0.95	0.01	1	1

Figure Captions

Figure 1: Cross Country Growth Rate and Education Spending

Figure 2: Growth and Education Spending in 18 Groups of Countries

Figure 3: Rate of Return to Public Spending on Education

Figure 4: Government Bias in Education and Growth Rates by Regions

Figure 5: Government Bias in Education and the Time Spent in Education

Figure 6: Government Bias in Education and the Education Share in GDP

Figure 7: Variation in Growth and Education-Spending by η

Figure 1

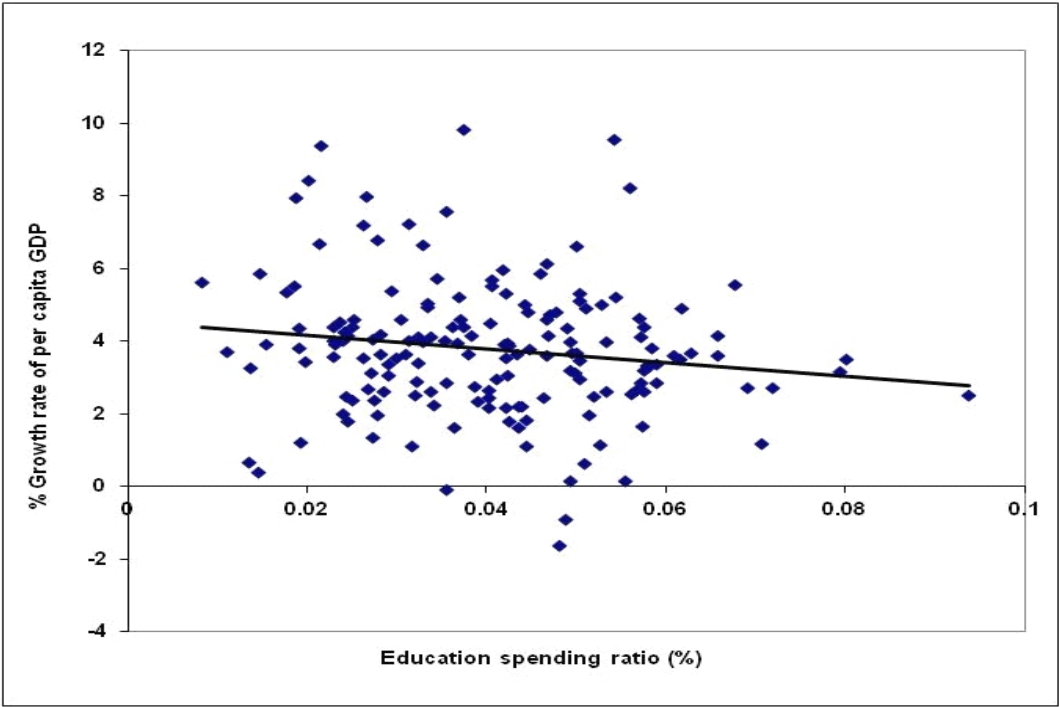


Figure 2

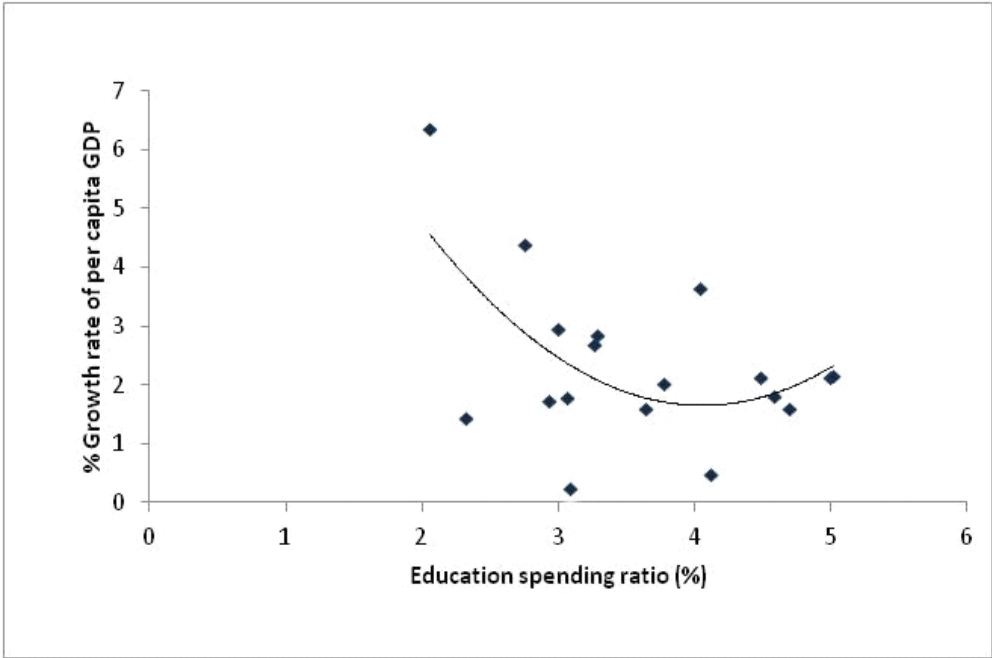


Figure 3

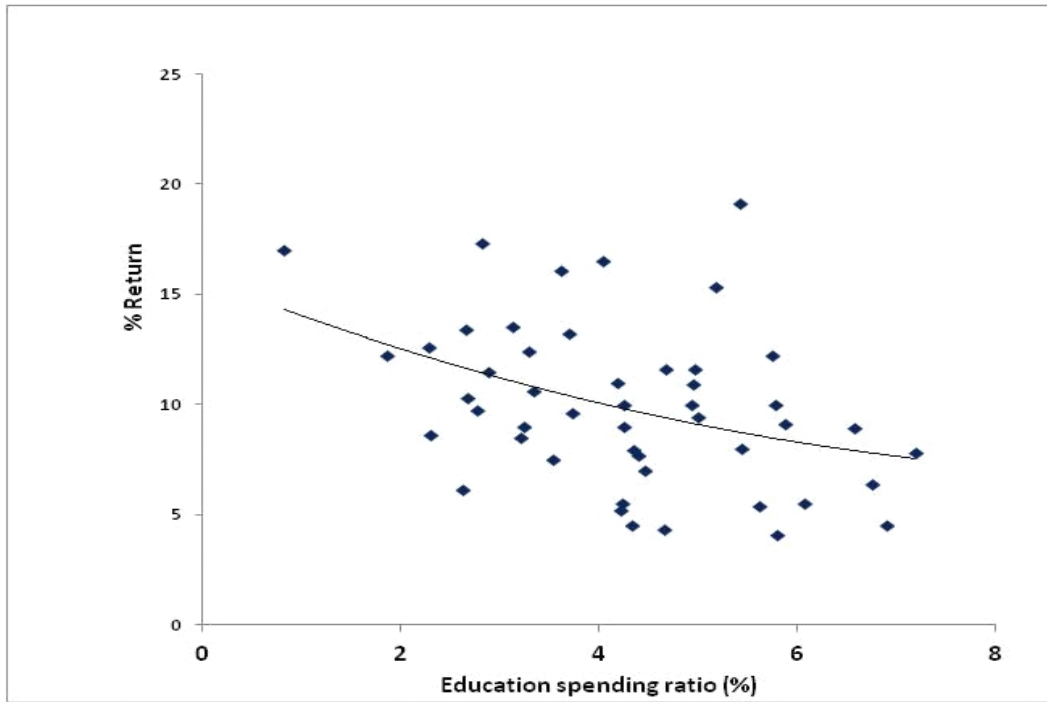


Figure 4

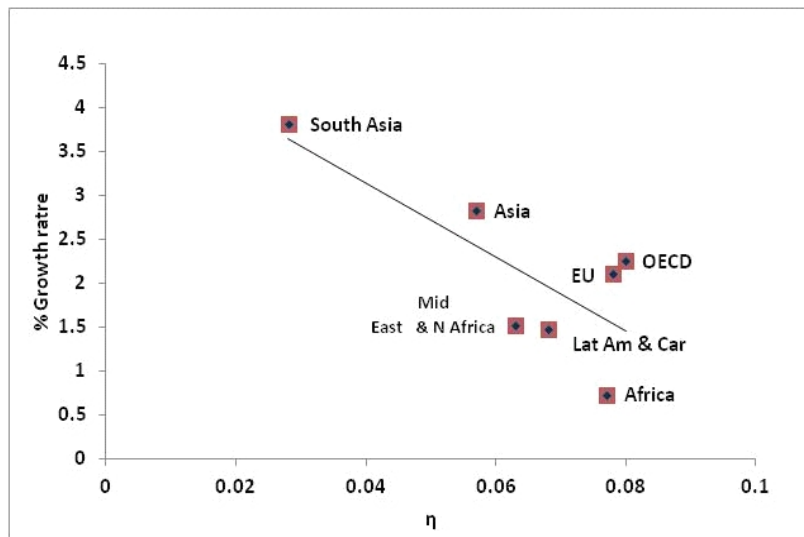


Figure 5

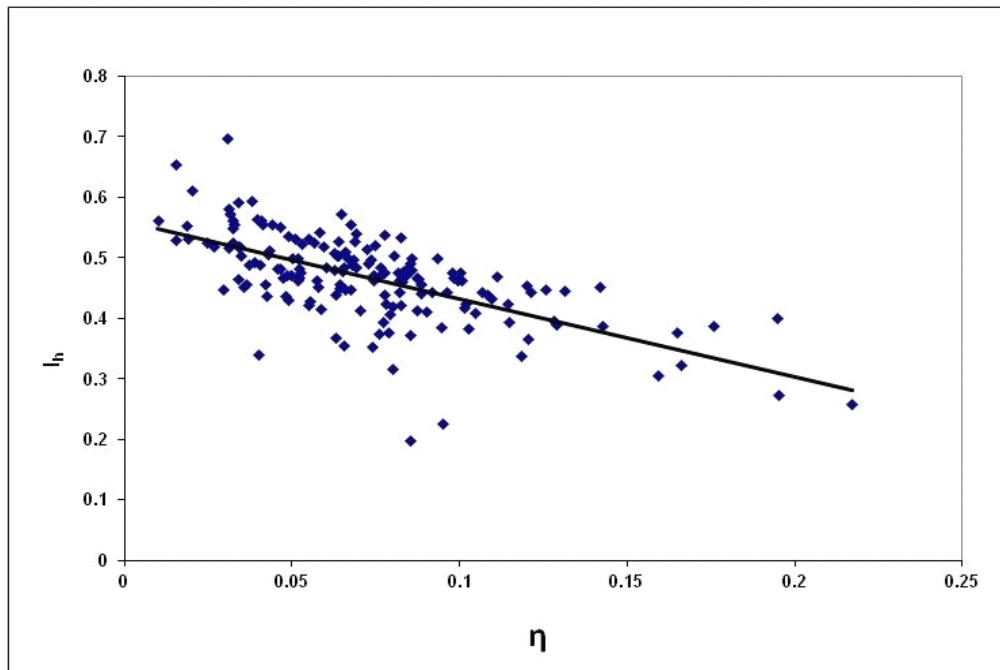


Figure 6

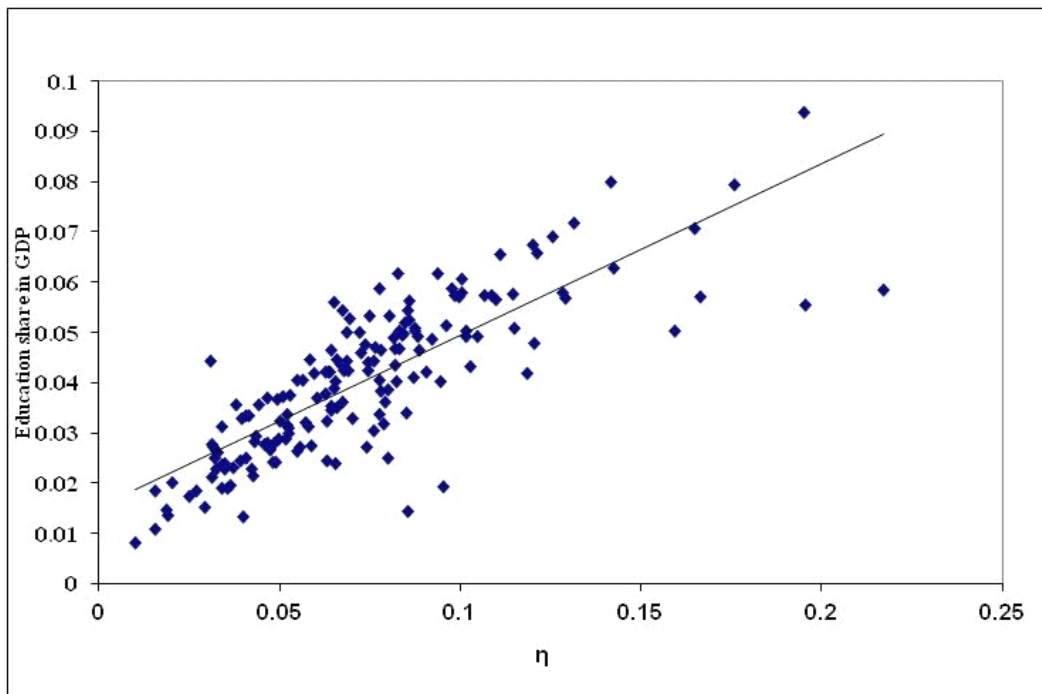
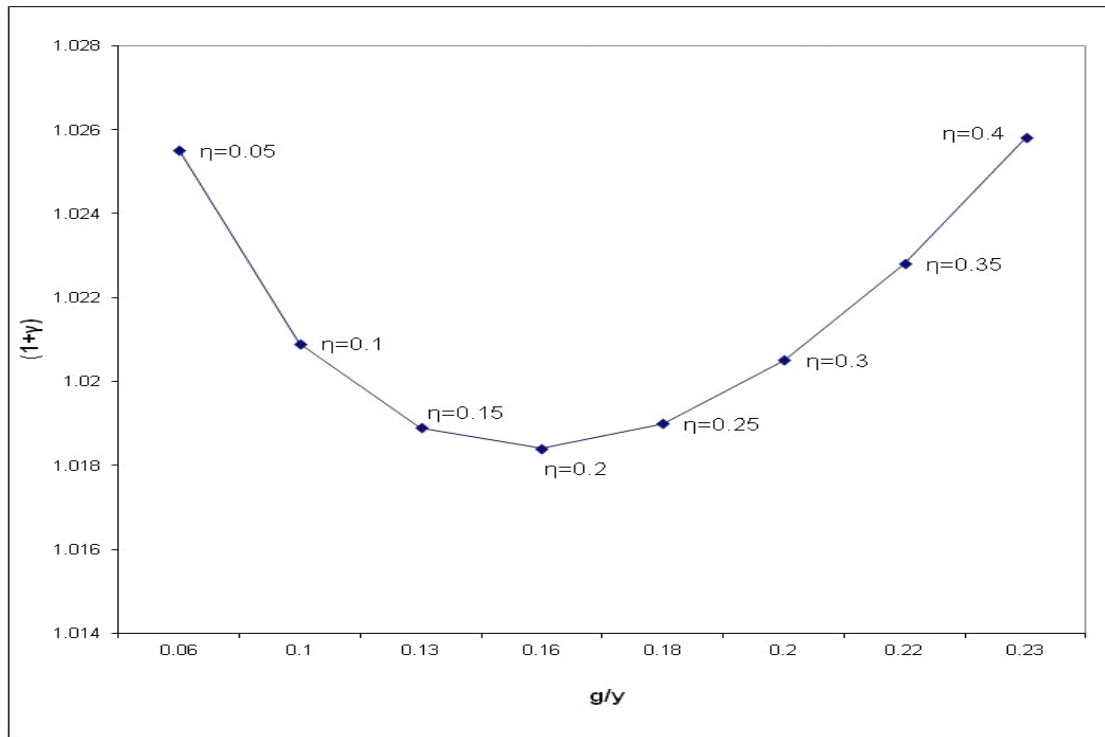


Figure 7



A Appendix

Data Sources

Data on PPP adjusted growth of GDP per capita (γ) and education spending ratios (g/y) were taken from the World Development Indicators (WDI), 2010. Education expenditure (% of GNI) includes the current operating expenditures in education, including wages and salaries and excluding capital investments in buildings and equipment. This database was accessed from the archive of the international data in the UK (www.esds.ac.uk/international/). Our sample period generally ranges from 1970 to 2008. We changed the sample period from 1980 onwards for some countries that did not have data. The time average of the annual growth rate of per capita GDP, share of public spending in education to GDP, as shown in Figures 1 and 2, were constructed for each country in our sample of 166 countries. Data on the rate of return on education (R^h) were taken from the World Bank web site (go.worldbank.org/W0WKLRECX0) but were available only for 48 countries which are namely: Argentina, Australia, Austria, Botswana, Brazil, Canada, Chile, China, Colombia, Cyprus, Czech Republic, Denmark, Egypt, Arab Rep., Estonia, Finland, France, Germany, Ghana, Greece, Hong Kong, Hungary, India, Indonesia, Iran, Islamic Rep., Israel, Italy, Japan, Korea, Rep., Kuwait, Malaysia, Mexico, Netherlands, Norway, Peru, Philippines, Poland, Portugal, Russian Federation, Singapore, South Africa, Spain, Sweden, Switzerland, Thailand, Tunisia, United Kingdom, United States, Uruguay. We have used these rates of return on schooling for these 48 countries, along with the average of g/y from the WDI, as shown in Figure 3.

First order conditions

Let λ_t, μ_t , be the Lagrangian multipliers associated with the flow budget constraint (5) and human capital technology (1) respectively.

The Lagrange is:

$$L = \sum_{t=0}^{\infty} \beta^t U(c_t) + \sum_{t=0}^{\infty} \lambda_t [A_G (1 - \tau_t) k_t^\alpha (l_{Gt} h_t)^{1-\alpha} + (1 - \delta_k) k_t - c_t - k_{t+1}] \\ + \sum_{t=0}^{\infty} \mu_t [(1 - \delta_h) h_t + A_H g_t^\eta (l_{Ht} h_t)^{1-\eta} - h_{t+1}]$$

First order conditions are:

$$c_t : \beta^t U'(c_t) = \lambda_t \quad (\text{A.1})$$

$$k_{t+1} : -\lambda_t + \lambda_{t+1}[(1 - \tau_{t+1})\alpha \frac{y_{t+1}}{k_{t+1}} + 1 - \delta_k] = 0 \quad (\text{A.2})$$

$$\begin{aligned} h_{t+1} : \mu_t = \mu_{t+1}[1 - \delta_h + A_H g_{t+1}^\eta (1 - \eta) h_{t+1}^{-\eta} l_{Ht+1}^{1-\eta}] \\ + \lambda_{t+1}[A_G (1 - \tau_{t+1})(1 - \alpha) k_{t+1}^\alpha h_{t+1}^{-\alpha} l_{Gt+1}^{1-\alpha}] \end{aligned} \quad (\text{A.3})$$

$$l_{Gt} : \lambda_t (1 - \alpha)(1 - \tau_t) A_G l_{Gt}^{-\alpha} k_t^\alpha h_t^{1-\alpha} - \mu_t (1 - \eta) g_t^\eta A_H h_t^{1-\eta} l_{Ht}^{-\eta} = 0 \quad (\text{A.4})$$

$$\tau_t : \lambda_t y_t = \mu_t A_H \eta \tau_t^{\eta-1} (h_t l_{Ht})^{1-\eta} y_t^\eta \quad (\text{A.5})$$

Proof of Proposition 1

The expression for the optimal tax rate in proposition 1 immediately follows after substituting out λ_t/μ_t from (A.4) and (A.5). One gets the optimal tax rate:

$$\tau_t = \frac{\frac{1-\alpha}{1-\eta} \cdot \frac{\eta l_{Ht}}{l_{Gt}}}{1 + \frac{1-\alpha}{1-\eta} \cdot \frac{\eta l_{Ht}}{l_{Gt}}}$$

Next, we exploit the fact that along the balanced growth path, the time allocations to goods and schooling (l_{Gt} and l_{Ht}) are constants. Unless the time allocations are constant, a constant balanced growth rate does not exist because the marginal product of capital will be time varying (see (A.2)). Since l_{Gt} is a constant, this means that the optimal tax rate τ_t is also stationary.

Derivation of the Balanced Growth Equations

Hereafter, we drop time subscripts for variables which are stationary along the balanced growth path. To prove (8), use (A.1) and (A.2).

To get (9), rewrite (A.3) as:

$$\begin{aligned} \frac{\mu_t}{\lambda_t} &= \frac{\mu_{t+1}}{\lambda_{t+1}} \cdot \frac{\lambda_{t+1}}{\lambda_t} [1 - \delta_h + A_H g_{t+1}^\eta (1 - \eta) (1 - l_{Gt+1})^{1-\eta} h_{t+1}^{-\eta}] \\ &\quad + \frac{\lambda_{t+1}}{\lambda_t} \{A_G (1 - \alpha) (1 - \tau_{t+1}) k_{t+1}^\alpha h_{t+1}^{-\alpha} l_{Gt+1}^{1-\alpha}\} \end{aligned} \quad (\text{A.6})$$

Using (A.1), check that $\frac{\lambda_{t+1}}{\lambda_t} = \frac{\beta c_t}{c_{t+1}}$. Use (A.5) to substitute out $\frac{\mu_t}{\lambda_t}$ and also use the balanced growth condition $\frac{\lambda_{t+1}}{\lambda_t} = \beta/(1 + g)$ which upon substitution in (A.6) yields:

$$\gamma = \beta [1 - \delta_h + A_H (1 - \eta) \tau^\eta l_H^{-\eta} (y_t/h_t)^\eta] \quad (\text{A.7})$$

To get (10) use (1), (2) and (4).

Proposition 2 *The tax rate that maximizes welfare also maximizes the long run growth.*

Proof. The steady state welfare can be written as:

$$\begin{aligned} W_t &= \sum_{j=0}^{\infty} \beta^j \ln c_{t+j} \\ &= \frac{\ln c_t}{1 - \beta} + \frac{\beta}{(1 - \beta)^2} \ln \gamma \\ &= \frac{\ln k_t}{1 - \beta} + \frac{\ln(c_t/k_t)}{1 - \beta} + \frac{\beta}{(1 - \beta)^2} \ln \gamma \end{aligned} \quad (\text{A.8})$$

Use the resource constraint (5) and the balanced growth condition to verify that

$$\frac{c_t}{k_t} = \frac{(1 - \tau)y_t}{k_t} + (1 - \delta_k) - \gamma \quad (\text{A.9})$$

Next plug (8) into (A.9) to find

$$\frac{c_t}{k_t} = \frac{1 - \alpha\beta}{\alpha\beta} \gamma - \frac{(1 - \delta_k)(1 - \alpha)}{\alpha} \quad (\text{A.10})$$

which upon substitution in (A.8) yields

$$W_t = \frac{\ln k_t}{1 - \beta} + \ln \left[\gamma - \frac{\beta(1 - \delta_k)(1 - \alpha)}{1 - \alpha\beta} \right] + \frac{\beta}{(1 - \beta)^2} \ln \gamma + \ln \left(\frac{1 - \alpha\beta}{\alpha\beta} \right) \quad (\text{A.11})$$

This shows that the steady state welfare is positively related to growth rate.

Thus the welfare maximizer tax rate is also a growth maximizer. ■