WP/02/78

IMF Working Paper

Composition of Government Expenditures and Demand for Education in Developing Countries

Era Dabla-Norris and John M. Matovu

INTERNATIONAL MONETARY FUND

IMF Working Paper

IMF Institute

Composition of Government Expenditures and Demand for Education in Developing Countries

Prepared by Era Dabla-Norris and John M. Matovu[1]

Authorized for distribution by Eric V. Clifton

May 2002

Abstract

This paper addresses the potential effects on human capital accumulation and economic growth of the alternative compositions of public expenditures in the context of a computable dynamic general equilibrium model of overlapping generations and heterogeneous agents in which altruistic parents make schooling decisions for their children. In the presence of fixed and variable costs for different levels of schooling, we show that reducing household costs of primary education has the largest positive impact on growth and poverty reduction in the short run. Moreover, an increase in higher education spending increases long-run growth. These effects can be substantial even when increasing education spending comes at the expense of public infrastructure investment.

JEL Classification Numbers: E62; H53

Keywords: Government expenditures; education; growth

Author's E-Mail Address: edablanorris@imf.org; jmatovu@imf.org

[1] We would like to thank Andrew Feltenstein, Eric Clifton, Shanta Devarajan, Eric Thorbecke, Gerard Glomm, Kenneth Judd, Fabio Canova, and participants at the CEPR conference on Dynamic Aspects of Public Expenditures in Copenhagen for their comments. We would also like to thank George Korniotis for his research assistance.

Contents Page

I. Introduction ... 4
II. Theoretical Framework ... 7
A. Demographic Structure and Schooling Attainment ... 7
B. Preferences and Household Budget Constraints ... 8
C. Schooling Demand and Parental Income ... 11
D. Firms ... 13
E. Government ... 15
F. Equilibrium ... 15
G. Poverty Measures ... 16
III. Simulations ... 16
A. Calibration and Parameters ... 16
B. The Benchmark Equilibrium ... 18
C. Policy Experiments ... 20
1. Increase in government spending on primary, secondary, and tertiary education ... 20
2. Targeting transfers ... 22
3. Increasing infrastructure spending ... 23
4. Varying the composition of government spending ... 24
IV. Conclusion ... 25

Text Tables
1. Age of Child, Parent and Schooling Level ... 8
2. Parameters ... 18
3. Baseline ... 19
4. Steady-State Results ... 21
5. Trade-Offs between Various Types of Expenditures ... 24
6. Education Expenditures: Selected Sub-Saharan African Countries and Regions ... 27
7. Countries with Primary Gross School Enrollment Ratios Below 90 Percent, 1996 ... 28
8. Incidence of Child Labor and Education Across Age in Ghana, 1998 ... 29
9 Public Spending Per Student: Tertiary Education as a Multiple of Primary Education, 1980–90 ... 29

Appendices
I. Corner Solutions for Schooling ... 30
II. Estimation of Earnings-Age Profiles ... 32

Appendix Tables
A1. Description of Variables ... 33
A2. Age-Earning Profile Without Controls ... 33
A3. Benchmark Age-Earning Profile With Controls ... 34

Appendix Figures

A1. Baseline and Simulation Results 35
A2. Baseline Results 36
A3. Impact of Increasing Education Spending on Asset Accumulation by Skill Types in the Steady State 37
A4. Demand for Schooling by Age and Skills of Households in the Steady State 38
A5. Transition Effects 39
A6. Impact of Transfers on Asset Accumulation by Skill Type in the Steady State 40
A7. Transition Effects of Transfers 41
A8. Transition Effects of Infrastructure Spending and Quality of Government Education Spending 42
A9. Impact of Varying the Composition of Government Spending on Asset Accumulation of Agents by Skill Type 43
A10. Transition Effects from Varying the Composition of Government Spending 44

References 45

I. Introduction

There is wide consensus that expansion in the skills, knowledge, and capacities of individuals—increasing human capital—is critical for economic growth and poverty reduction.[2] Education or schooling within formal education systems plays a key role in creating human capital. Low educational attainment along with high estimated rates of returns to schooling in the developing world are often cited as justification for public investment in more and better quality schools. However, despite increases in government education spending in recent decades as shares of both GDP and total government spending (Table 6), human capital investments, particularly in Sub-Saharan Africa, are performing poorly with low school enrollments, high repetition and drop out rates, and child labor often performed at the expense of education (Tables 7 and 8).

Recent studies suggest that the allocation of investment in education matters for growth.[3] Public education spending in many developing countries, however, is often inefficient and inequitable with education outlays misallocated across sectors.[4] In sub-Saharan Africa, for instance, despite low primary school enrollments, spending per student in tertiary education is about forty times that per student in primary education, and the share of tertiary education in total public spending on education is one of the highest in the world (Table 9).

At the same time, given budgetary constraints, many developing countries face important tradeoffs between education and other types of expenditures, such as domestic infrastructure. For instance, fiscal austerity programs frequently require countries to make difficult choices regarding which components of public expenditures should be reduced or reallocated within the overall budget. The Fund-supported PRGF programs require that expenditure allocations be consistent with a country's poverty reduction strategies. This highlights the need for an assessment of the effects of each of these components on growth and poverty reduction.

This paper examines the differential impact on household schooling decisions and human capital accumulation of alternative uses of public spending, including spending for different levels of education, transfer payments, and infrastructure investment. In contrast to much of the literature on human capital accumulation through formal schooling where each individual

---

[2] For cross-country studies that emphasize the importance of schooling for economic growth see Barro and Lee (2000), Hanushek (1996), and Bosworth and Collins (1996). Some examples of studies that focus on connection between schooling, productivity, and earnings include Card and Krueger (1992) for the US and Behrman and Birdsall (1983) for Brazil.

[3] In a cross country study, Judson (1998) finds that countries whose allocations are inefficient gain little in output and growth from their investments in education.

[4] While country circumstances differ, in general in economies with less than universal basic education, most studies find that the rates of return to education are greatest for primary, followed by secondary and tertiary education (Psacharopolous (1993), World Bank (1995)).

makes his own educational decisions, we explicitly model the intertemporal trade-off in the contribution of the child to the household and the parental choice of schooling involved. Our analysis not only addresses the current policy debate on the characteristics of an optimal education policy in developing countries, but also allows us to quantify the effects on growth and poverty alleviation from altering the allocation of spending between infrastructure investment and human capital augmenting expenditures.

Empirical studies on the determinants of schooling decisions in developing countries indicate that distance to school, household income and wealth, credit constraints, demand for child labor, parental education, and monetary costs of schooling play important roles.[5] In this paper we focus on the impact of monetary costs of schooling on household schooling demand. Becker (1975) argues that individuals facing a higher marginal cost of funds for human capital investment choose less schooling and that marginal costs depend in part on parental resources. In many developing countries, despite basic education being obligatory and free, in practice, schools collect contributions from students to supplement government subsidies and parents bear costs for uniforms and books. Canagaragh and Coulombe (1997) find that per capita costs of publicly provided primary education in Ghana accounted for more than 15 percent of household mean per capita expenditures in 1994. For Uganda, Mackinnon and Reinikka (2000) note that parents on average contributed 60 percent of total primary education spending. In Kenya, households account for about 31 percent of the costs of primary education and 62 percent of secondary education (World Bank (1995)).

Our theoretical framework is a dynamic general equilibrium model of overlapping generations of long-lived and heterogeneous agents in the spirit of Auerbach and Kotlikoff (1987). We assume that parents make schooling decisions for children and there are fixed and varied costs to different levels of schooling which are partially financed by parents. As in Glomm (1997), all households value family consumption and the human capital of their offspring. When young, time is either allocated to working or to schooling and this time allocation is made by the parent. Parents choose between asset accumulation and child schooling to smooth their lifetime consumption. A child's time allocated to schooling increases its human capital at the end of the schooling phase and, given the intergenerational altruism in preferences, the utility of the parent. However, allocation of a child's time to schooling lowers household income and thus consumption.

We differentiate between types of agents on the basis of their human capital profiles and capture intra- as well as intergenerational inequality. Specifically, the model posits 17 different groups within each cohort, each with its own earnings ability (its own endowment of human capital).[6]

[5] See Jacoby and Skoufias (1997) and Sawada and Lokshin (2000) for Pakistan, and Canagaragh and Coulombe (1997) for Ghana.

[6] The 17 groups represent agents with no schooling up to a maximum of 16 years of primary, secondary and tertiary education.

For a given time spent in school, individuals differ in the amount of skills they have in adulthood. Household schooling decisions, by changing school enrollment rates in each period, affect the composition of the human capital stock and, hence, the educational composition of the work force over time.

The model also considers the potential benefits of productive government spending on both human and physical capital accumulation. In the context of a closed economy, the government in our model collects taxes and uses tax revenue to provide transfer payments, investment in different levels of education, and public infrastructure, which enters as an input in the production function for final output. Several papers have examined the growth and welfare implications of alternative public expenditure policies (Barro (1990), Turnovsky and Fisher (1995), Glomm and Ravikumar (1994), Baier and Glomm (2001)). However, our model differs from theirs in several ways. First, we explicitly focus on the implications of government spending on parental schooling decisions and educational attainment. In that respect our model is closest in spirit to Glomm (1997) but he treats human capital as a homogenous concept, and does not distinguish between government spending for primary, secondary and tertiary education. By ignoring the implications of shifting public resources from one type of education spending to another, these papers leave unexplored the pertinent question for developing countries of how best to allocate resources across different levels of education. Second, we introduce a potential choice between goods and human capital production and distinguish between public investment in final goods production and that in human capital accumulation, as in Baier, Bergstrand, and Glomm (2001).

In the paper, differential demand for schooling emerges as a result of increasing returns to human capital investment introduced by fixed schooling costs. We show that in environments where parents care about the future earnings of their children, wealthier households (with higher parental human capital) will optimally choose higher levels of schooling for their child. It is not the higher parental labor income itself that makes it easier for such groups to choose more schooling, but the availability of income to meet the opportunity costs of schooling while accumulating more assets for future consumption. Therefore, parental human capital, and hence income, plays an important role in determining the demand for schooling, consistent with the findings in the empirical literature.

Our model–calibrated to Ghana–yields important insights into the qualitative and quantitative effects of government education, transfer and public infrastructure investment policies.[7] For plausible parameters, we find that reducing private costs of primary education has the largest impact on growth and poverty reduction in the short run. Significant gains can be obtained even if the increased primary education spending comes at the expense of a reduction in infrastructure investment. In the context of our model this occurs because lower private costs of

[7] Ghana is used as an illustrative case and similar results can be derived by applying the model to other countries with less than universal basic education. Some parameters used in the simulations were estimated for other developing countries with characteristics similar to Ghana.

primary education affect household schooling decisions through two different channels: first, it allows low income (unskilled) households to increase investment in child human capital and given the sequencing of schooling decisions results in a higher demand for secondary and tertiary education. Second, lower schooling costs enable households of all skill types to accumulate more assets earlier in their working life, resulting in higher lifetime asset accumulation profiles, which, in turn, increases output.

The growth and poverty effects of a corresponding increase in secondary or tertiary spending are not so substantial, because of the larger fixed costs associated with them. Low income households increase investment in child human capital at the expense of asset accumulation, resulting in lower lifecycle asset accumulation. In addition, an increase in the subsidy for tertiary education has little impact on the marginal schooling decisions of low income households as their optimal schooling choices typically involve lower levels of schooling. However, our findings suggest that an increase in tertiary education spending is important for long run growth once universal basic education is achieved.

We also find that the impact of a targeted transfer on the lifecycle behavior of households and macroeconomic aggregates depends upon the relative magnitude of the transfer. Given increasing returns to human capital investment, if the transfer results in a substitution of human capital accumulation for physical asset accumulation, the effects on growth and poverty alleviation may be marginal. However, we find that sufficiently large transfers targeted to low income groups can have important consequences for growth and poverty reduction.

The paper proceeds as follows: Section II describes the theoretical model to which we calibrate our economy. Section III presents the simulation results. Section IV concludes.

II. Theoretical Framework

A. Demographic Structure and Schooling Attainment

The model economy is populated by sequences of distinct cohorts that are distinguished by their dates of birth and their lifetime labor-productivity endowments. Each j –type generation born at a specific date contains 17 lifetime earnings groups distinguished by their level of schooling. The first group refers to individuals with no schooling (unskilled). Groups for the primary skilled range from 1 to 6 years of education attainment, for secondary skills range from 7 to 12 years and tertiary education ranges from 13 to 16 years.[8]

Agents in the model live for 55 periods. At model age 23, each agent gives birth to one child. They also enter the formal work force on their 23rd birthday and work through age 50. There is

[8] Years of schooling attainment of adults in Ghana were obtained from Barro (2000). Enrollment rates for children at different levels of education were taken from Blunch and Verner (2000).

no uncertainty in the model. Agents are children during the first 22 periods of their life and consume as part of their parent's households between ages 1 through 22. Between the following ages, the child is expected to be at the schooling levels shown in the table below:

The fraction of each j-type agent in a given generation is updated by the schooling attainment of the population each period. Thus, we endogenize the fraction of the population falling in the 17 skill-types by taking into account household schooling decisions in each period. We assume stationary population growth with the number of births per period equaling the number of deaths.[9]

Table 1. Age of Child, Parent and Schooling Level

Age		Level of Schooling
Child	Parent	
7-12	30-35	Primary education
13-18	36-41	Secondary education
19-22	42-45	Tertiary education

Each household decides the fraction of time its child will spend in school each period, $s_{i,t}^{j} \in [0,1]$. Schooling decisions are sequential, and we assume that once a child leaves school, he cannot return.[10] To derive the aggregate schooling attainment, that is the total number of years spent in school, we sum over the per-period schooling time obtained from the household optimization decision. The total schooling attainment of a child of household j as of time t can then simply be written as:

$$S_{i,t}^{j} = \sum_{k=0}^{t} s_{i,k}^{j} \quad 0$$

B. Preferences and Household Budget Constraints

Each j-type agent beginning its economic life at calendar date t chooses a perfect-foresight consumption paths $c_{i,t}$ and child time in school $s_{i,t}^{j} \in [0,1]$ to maximize a time-separable utility function of the form

[9] While this assumption may be unrealistic for developing countries, particularly in sub-Saharan Africa, it is adopted for analytical tractability.

[10] This assumption rules out the widely observed phenomenon of grade repetition in developing countries, but is adopted for analytic tractability.

$$U_t^j = \sum_{i=23}^{55} \beta^{i-23} u(c_{i,t+i-23}^j) + \beta^{21} \mu(h_{45,t+21}^j) \tag{1}$$

where U is strictly concave and increasing and β is the subjective discount rate. At the end of the schooling phase, households leave a child human capital stock $h_{45,t+45}^j$, the value of which is given by an increasing concave function μ. Note that $s_{i,t}^j = 0$ for i = 23,...29 and i = 45,...50. We ignore leisure, both of the child and of the parent.

Define $a_{i,t}^j$ as the stock of physical capital held by an agent with schooling j, of age i, at time t. If children are not in the schooling phase, maximization of (1.1) is subject to a sequence of budget constraints given by[11]

$$a_{i+1,t+1}^j = (1+r_t-\delta)a_{i,t}^j + w_t^j H_i^j - (1-\tau_t^c)c_{i,t}^j + z_{i,t}^j \quad \text{for } s_{i,t}^j = 0 \tag{2}$$

If children are in the schooling phase, the relevant budget constraint is

$$a_{i+1,t+1}^j = (1+r_t-\delta)a_{i,t}^j + w_t^j H_i^{jP} - (1-\tau_t^c)c_{i,t}^j + [\overline{w}h_{i,t}^j(1-s_{i,t}^j) - s_{i,t}^j(1-\phi_{i,t}^1)e_i] + z_{i,t}^j$$
$$\text{for } 0 < s_{i,t}^j \leq 1 \tag{3}$$

where r_t is the pre-tax returns to savings, δ is the rate of depreciation of physical capital, $z_{s,t}^j$ are direct transfers received from government, τ_t^c is the tax rate on consumption, and $\phi_{i,t}^1$ is the proportion of government spending on education.[12]

---

[11] Note that this is the budget constraint faced by households for i = 23,...29 and i = 45,...50. The relevant schooling decisions are made between the ages of 30 and 44, the time at which the child first starts school to the point when the child can quit school permanently.

[12] We ignore the distortionary impact of financing higher public spending through taxes on capital or labor to in order to focus on the effects of alternative composition of government spending on demand for schooling. Moreover, Burgess and Stern (1993) note that developing countries typically rely more heavily on indirect taxes than do developed countries.

Household income has two components, parental income and child earnings. We assume that the labor income of a parent is the wage payment received, distributed according to the human capital efficiency levels of the parent (his human capital stock, H_i^{jP}). Thus, $w_t^j H_i^{jP}$ is total parental labor income at time *t*, where w_t^j is the rate of return for effective labor differentiated by skill level of the parent at time t.

The cost of attending school is foregone production or earnings and school fees, $s_{i,t}^j(1-\phi_{i,t}^1)e_i$.[13] The price of child time is assumed to be equivalent to the unskilled wage in the labor market, $\bar{w}$, multiplied by child human capital.[14] Education costs, e_i, are fixed for each level of schooling and the government subsidizes schooling costs at the rate $\phi_{i,t}^1$.[15] We assume that

$$e_t^{primary} < e_t^{secondary} < e_t^{tertiary}$$

that is, costs of schooling are increasing across levels of education.[16]

Schooling time $s_{i,t}^j$ augments the child's beginning of period stock of human capital $h_{i,t}^j$, where the superscript *j* denotes the schooling level of a child of a household of age *i*. Human capital of the child evolves according to

$$h_{i+1,t+1}^j = \gamma_0 h_{i,t}^{\gamma_1} s_{i,t}^{\gamma_2} (\phi_{i,t} e_i)^{\theta_1} + (1-\delta_h) h_{i,t}^j \tag{4}$$

where, δ_h is the rate of depreciation of human capital , $0 \le \gamma_1 \le 1$, $0 < \gamma_2 < 1$, which guarantee that the problem is concave in the control variable, and γ_0 captures the innate ability of the

---

[13] While it may be more realistic to assume that the same school fees are paid for full-time and part-time schooling, for analytical tractability, we assume that overall schooling costs are lower with part time schooling.

[14] Canagarajah and Coulombe (2000) note that, on average, children in Ghana earn one sixth of what adults earn.

[15] Note that the level of subsidy provided can vary with the age of the parent and the commensurate level of education of the child. Since schooling costs net of the subsidy vary across education levels, different cohorts face different environments.

[16] These costs include school fees, books and other related education materials such as school uniforms.

child.[17] The productivity of government spending on education is an increasing function of the parameter θ_1, and can be regarded as a measure of school quality or the effectiveness of government education spending. For $\theta_1 = 0$, public goods do not provide services that improve the productivity of human capital.

Specification (1.4) implies that all capital used in the human capital sector is publicly provided. This specification is plausible if the majority of human capital accumulation arises from schooling. For example, as a share of total Ghanaian primary school enrollment, the public sector accounts for more than 85 percent in 1997. In addition, private secondary school enrollment only accounted for 7 percent of total secondary enrollment.

The optimal consumption, schooling time and assets profile of individuals at different ages can be derived by reformulating the problem as a recursive structure via the value function

$$V_{i,t}^{j}(a_{i,t}^{j}, h_{i,t}^{j}) = \max_{a_{i+1,t+1}, a_{i,t}, s_{i,t}} U(c_{i,t}^{j}) + \beta V_{i+1,t+1}^{j}(a_{i+1,t+1}^{j}, h_{i+1,t+1}^{j}) \tag{5}$$

subject to the constraints (1.3) and (1.4) when children are in the schooling phase and subject to (1.2) before children start schooling ($i = 23, \ldots 29$) and when children quit schooling permanently ($i = 45, \ldots 55$). The agent solves a lifecycle optimization problem given initial stocks of human and physical capital.[18] At the end of terminal period, we assume that assets are zero. We can show that the optimal solution for schooling will be a corner one, either $s_{i,t}^{j} = 0$ or $s_{i,t}^{j} = 1$ (see Table 6). That is, the child never attends school part time.

C. Schooling Demand and Parental Income

In this section we examine the relationship between schooling demand and parental income. The value function associated with the decision to keep the child in school, $V_{i,t}^{S}(a_{i,t}, h_{i,t})$ (dropping cohort-specific superscripts j for notational ease) is given by:

---

[17] This functional form is used widely both in the empirical literature and the literature on human capital accumulation. See Ben-Porath (1967) and Heckman (1999), Heckman, Lochner and Taber (1998). Glomm and Ravikumar (1998) introduce a school quality argument in the human capital accumulation equation.

[18] The solution to the dynamic schooling problem is as follows. Working backward from T, the end of the lifecycle, the value of going to school for an additional year and the value of stopping schooling and entering the labor market can be characterized using backward recursions.

$$V_{i,t}^{S}(a_{i,t},h_{i,t}) = \max_{a_{i,t}} U(c_{i,t}) + \beta V_{i+1,t+1}\big|_{s_t=1} \tag{6}$$

where $V_{i+1,t+1}\big|_{s_t=1}$ denotes the value of following the optimal policy next period (either to keep the child in school or for the child to enter the labor market). The relevant constraints for the household are:

$$\begin{aligned} a_{i+1,t+1} &= (1+r_t-\delta)a_{i,t} + w_t H_i^P - (1-\tau_t^c)c_{i,t} - (1-\phi_{i,t})e_i + z_{i,t} \\ h_{i+1,t+1}^S &= \gamma_0 h_{i,t}^{\gamma_1}(\phi_{i,t}e_i)^{\theta_1} + (1-\delta_h)h_{i,t} \end{aligned} \tag{7}$$

Notice that by choosing $s_{i,t}=1$, the household reduces its current income (by $\overline{w}h_{i,t}$ + $(1-\phi_{i,t})e$) but enhances child human capital. This, in turn, increases labor income of the child and future household consumption if the child leaves school in subsequent periods as well as child human capital at the end of the schooling phase.

The value of stopping schooling in period *t*, $V_{i,t}^{NS}(a_{i,t},h_{i,t})$, is the value of the child entering the labor market this period and not accumulating any additional human capital in the future. That is,

$$V_{i,t}^{NS}(a_{i,t},h_{i,t}) = \max_{a_{i,t}} U(c_{i,t}) + \beta V_{i+1,t+1}\big|_{s_t=0} \tag{8}$$

The household now faces the constraints:

$$\begin{aligned} a_{i+1,t+1} &= (1+r_t-\delta)a_{i,t} + w_t H_i^P - (1-\tau_t^c)c_{i,t} + \overline{w}h_{i,t} + z_{i,t} \\ h_{i+1,t+1}^{NS} &= (1-\delta_h)h_{i,t} \end{aligned} \tag{9}$$

A household, therefore, chooses $s_{i,t}=1$ when $V_{i,t}^{S}(a_{i,t},h_{i,t}) > V_{i,t}^{NS}(a_{i,t},h_{i,t})$ and zero otherwise.

The trade-off between consumption today and asset accumulation is given by the Euler equation:

$$-u'(c_{i,t}) + \beta(1+r_{t+1}-\delta)u'(c_{i+1,t+1}) = 0 \tag{10}$$

This equation is standard: the household equates the cost of foregone consumption at time t to the benefit of acquiring an additional unit of capital at time t.

To examine the relationship between parental income and schooling decisions, we examine the relationship between two levels of schooling. Define a function $\Omega(H_i^P)$ as the difference between the expected lifetime utility of a household if it chooses schooling for the child, $V_{i,t}^S(H^P)$, and the $V(.)$ that solves problem (1.9). Differentiating $\Omega(H_i^P)$ with respect to H_i^P and using the Euler equation (1.10), we get

$$\frac{\partial\Omega(H_i^P)}{\partial H_i^P} = w_t[u'(c_{i,t}^S) - u'(c_{i,t}^{NS})] \tag{11}$$

For $(1-\phi_{i,t})e_i > 0$, the period t consumption of a household of age i that chooses schooling for its child must be lower than if the household chooses no schooling. That is, the marginal utility of period t consumption of a household that chooses schooling that period must be higher than if no schooling is chosen. Therefore, $\partial\Omega/\partial H_i^P > 0$. As parental human capital and income increases, households choose more schooling. This implies that the relative attractiveness of choosing schooling increases with the income of the household. The reason is that those households with higher parental income can afford to forego child contribution to household income and meet the lump sum cost to schooling in order to finance consumption. It is not the higher income itself that makes it easier for wealthier income groups to choose more schooling, but the availability of this income to meet the schooling costs while accumulating more assets for future consumption.

D. Firms

Output in the model economy is produced by identical competitive firms using a neoclassical, constant returns to scale production technology. Letting λ_t^j be the fraction of j-type agents in period t, aggregate capital K_t is obtained from household asset accumulation decisions as:

$$K_t = \sum_{j=1}^{17} \lambda_t^j \sum_{i=23}^{55} a_{i,t-1}^j \tag{12}$$

Labor types are differentiated by their years of schooling attained. For simplicity, we assume that the labor stock is composed of four education levels: unskilled, primary-educated, secondary-educated and higher-educated (or tertiary), where

$$L_t^U = \sum_{j=1}\lambda_t^j \sum_{i=23}^{50} H_{i,t}^{jP} + \sum_{j=1}^{17}\lambda_t^j \sum_{i=7}^{22} h_{i,t}^j \Big|_{s_{i,t}=0}$$
$$L_t^P = \sum_{j=2}^{8}\lambda_t^j \sum_{i=23}^{50} H_{i,t}^{jP}$$
$$L_t^S = \sum_{j=9}^{14}\lambda_t^j \sum_{i=23}^{50} H_{i,t}^{jP} \qquad (13)$$
$$L_t^T = \sum_{j=15}^{17}\lambda_t^j \sum_{i=23}^{50} H_{i,t}^{jP}$$

Note that the unskilled labor demanded, L_t^U, is simply the summation of the individual human capital stocks of unskilled parents and children who have dropped out of school as of period t[19]

Aggregate output y_t is produced by

$$y_t = F(K_t, L_t^U, L_t^P, L_t^S, L_t^T)G(\phi_{i,t}^2 g) \qquad (14)$$

where $F(.)$ is a neoclassical production function exhibiting positive but diminishing marginal productivity in its arguments. Government spending on infrastructure is of a multiplicatively separable form in the production process, with $\phi_{i,t}^2$ denoting the proportion of government expenditure spent on infrastructure. For simplicity, we assume that F(.) is a Cobb-Douglas production function of the form

$$y_t = \alpha_0 K_t^{\alpha} L_t^{\alpha_U} L_t^{\alpha_P} L_t^{\alpha_S} L_t^{\alpha_T} G$$

and that overall production is shifted upwards by a factor $G = (\phi_{i,t}^2 g)^{\theta_2}$. The productivity of public spending is increasing in the parameter θ_2. When $\theta_2 = 0$, public expenditure on infrastructure is not a required input in the production of the final good.

---

[19] The present model implicitly assumes that the labor markets for the four types of labor are segmented. In many developing countries, it is not unusual to find underemployment, whereby more educated workers decide to enter the market for less skilled activities. While this would result in a greater "crowding out" of unskilled workers and, hence a larger differential between skilled and unskilled wages, the basic thrust of our results will continue to hold.

Since households make the investment choices, the firm's problem is static and it chooses capital and effective labor to maximize profits. Physical capital evolves over time according to

$$K_{t+1} = (1-\delta_k)K_t + I_t \tag{15}$$

where δ_k is the depreciation rate.

E. Government

In order to sustain an equilibrium with steady growth, government expenditure is linked to the scale of the economy. The role of government in the model is to collect taxes and spend revenues on transfers, government consumption, education and public infrastructure, which are assumed to be a constant fraction of total output. As in Barro (1990), Lucas (1990), and Glomm and Ravikumar (1994, 1997), we assume that the government runs a balanced budget each period and tax rates to finance expenditures are determined endogenously. Total government expenditure in period t is given by

$$Gov_t = \sum_{j=1}^{17} \lambda_t^j \sum_{i=23}^{45} \phi_{i,t}^j e_{i,t} + \sum_{j=1}^{17} \lambda_t^j \sum_{i=23}^{55} z_{i,t}^j + \phi_t^2 g + \Gamma_t \tag{16}$$

where Γ_t is other government consumption.

The budget constraint of the government is given by

$$Gov_t = \sum_{j=1}^{17} \lambda_t^j \sum_{i=23}^{55} \tau_t^c c_{i,t}^j \tag{17}$$

F. Equilibrium

Given a fiscal policy, a competitive equilibrium under a balanced budget is a set of processes for individual allocations, $\{a_{i,t}^j, c_{i,t}^j, s_{i,t}^j\}$, aggregate inputs, $\{K_t, L_t^U, L_t^P, L_t^S, L_t^T\}$, prices for the factors of production, $\{w_t^j, r_t\}$ such that:

(i) $\{a_{i,t}^j, c_{i,t}^j, s_{i,t}^j\}$ solves the representative household's problem,

(ii) $\{K_t, L_t^U, L_t^P, L_t^S, L_t^T\}$ solves the firms' problem,

(iii) $L_t^U = \sum_{j=1}^{50} \lambda_t^j \sum_{i=23} H_{i,t}^{jP} + \sum_{j=1}^{17} \lambda_t^j \sum_{i=7}^{22} h_{i,t}^j \Big|_{s_{i,t}=0}$

$$L_t^P = \sum_{j=2}^{8} \lambda_t^j \sum_{i=23}^{50} H_{i,t}^{jP}$$

$$L_t^S = \sum_{j=9}^{14} \lambda_t^j \sum_{i=23}^{50} H_{i,t}^{jP}$$

$$L_t^T = \sum_{j=15}^{17} \lambda_t^j \sum_{i=23}^{50} H_{i,t}^{jP}$$

(iv) $$K_t = \sum_{j=1}^{17} \lambda_t^j \sum_{i=23}^{55} a_{i,t}^j$$

(v) $$a_{i,t}^j + c_{i,t}^j = (1 + r_t - \delta) a_{i-1,t-1}^j + w_{i,t}^j H_{i,t}^j - \tau_t^c c_{i,t}^j + z_{i,t}^j - (1 - \phi_{i,t}^j) e_{i,t}^j \quad \text{for } s_t = 1$$

(vi) $$a_{i,t}^j + c_{i,t}^j = (1 + r_t - \delta) a_{i-1,t-1}^j + w_{i,t}^j H_{i,t}^j - \tau_t^c c_{i,t}^j + z_{i,t}^j + \overline{w} h_{i,t}^j \quad \text{for } s_t = 0$$

(vii) policy arrangements $\{\tau, \phi_t^1, \phi_t^2, z_t\}$ solve the government's problem (1.17).

G. Poverty Measures

We extend the above model to consider poverty issues by adopting the Foster, Greer and Thorbecke poverty (1984) measures. We assume that $m = (m_1, m_2, ...m_n)$ is a vector of agents' incomes (asset and labor income) in increasing order, and assume that the poverty line given by $\Phi > 0$ is predetermined. If $g_i = \Phi - m_i$ is the income shortfall of the i^{th} household, q is number of households having income less than the poverty line, and the total number of households is N, the poverty measure used is given by

$$P_\alpha = \frac{1}{N} \sum_{i=1}^{q} \left[\frac{g_i}{\Phi} \right]^\kappa \qquad (18)$$

where P_0 is the headcount ratio while P_1 is the renormalization of the income-gap measure. The value of κ is a measure of poverty aversion and a higher value gives greater emphasis to the poor.

III. Simulations

A. Calibration and Parameters

The experiments reported in the next section share a common set of parameters and an initial steady state equilibrium (summarized in Table 2). The model parameters are chosen such that our model economy mimics as closely as possible the main Ghanaian economic statistics. For the most part, values used in other studies of human capital and government expenditures are relied on to specify the main model parameters. Where there is uncertainty about the size of the parameters, conservative values are chosen. The following functional form is imposed on household utility:

$$u(c_{i,t}^{j}) = \frac{(c_{i,t}^{1-\sigma} + h_{45,t+21}^{1-\sigma})}{1-\sigma} \qquad \sigma > 0$$

Both the factor shares α and the efficiency parameters α_0 are derived from a cross section study by Senhadji (1999). These parameters are obtained from a human capital index which is derived by weighting education levels attained using relative earnings of different groups. In an overlapping generations setting, economic theory does not impose any restriction on the size of the discount factor.[20] The value of the households' discount factor that implements the targeted rate of return is β=0.95.[21]

The human capital depreciation rate is assumed to be 0.03. Driffill and Rosen (1983) use a value of 0.01; while Lord (1989) employs values of 0.08 and 0.12; some empirical studies report values as high as 0.10 for certain categories of labor (Rosen (1976)). There is, however, very little econometric evidence on the parameters of the human capital production function. Previous estimates of the ability parameter, γ_0, in the literature lie in the range of 0.5–0.8 (Heckman (1975)). Empirical estimates of the elasticity of human capital investment with respect to government spending by Card and Krueger (1992) and Coleman (1966) suggest a range of 0 to 0.12. These estimates suggest a value of γ_1 between 0 and 0.7. We employ estimates of 0.67 for γ_0 and 0.15 for γ_1.

[20] See Deaton (1991) for a discussion of restrictions on the subjective discount factor in economies with infinitely lived agents.

[21] Recent empirical evidence on the value of β suggests that a subjective discount factor greater than unity is plausible (Hurd 1989).

Table 2. Parameters

α_0	Production efficiency	1.01
α	Capital factor	0.31
α_U	Unskilled labour factor	0.20
α_P	Primary labour factor	0.25
α_S	Secondary skilled labour factor	0.15
α_T	Tertiary skilled labour factor	0.09
δ_K	Physical capital	0.05
β	Discount	0.95
σ	Elasticity of	0.25
δ_h	Human capital	0.03
γ_0	Human capital investment	0.67
γ_1	Parameter on human capital	0.15
θ_1	Effectiveness of government education	0.50
θ_2	Efficiency of government infrastructure	0.05

The earnings ability profiles H_i^j are estimated using the following functional form:

$$H_i^{jP} = f(age, education, family, region) \quad (19)$$

Values for the parameters are based on regressions fitted to the 1999 Ghanaian Living Standard Measure Survey (LSMS). Using these estimates, we simulate earnings ability profiles for agents that vary by age, education background, family characteristics and regional dummies. Results of the above estimations are provided in Table 7.

B. The Benchmark Equilibrium

The benchmark steady state is calibrated to the 1999 Ghanaian National Accounts. Government expenditure as a share of GDP is 26 percent, which implies a tax rate of 15.5 percent. Government expenditure on education is 6.8 percent of GDP, while education expenditures as share of total government expenditure are set at 14.5 percent. The shares of education expenditures across different levels of schooling are 41 percent for primary education, 38 percent for secondary education, and 21 percent for tertiary education. The out of pocket primary education expenditures by the parents are assumed to be 15 percent of total household expenditures, 60 percent for secondary education, and 90 percent for tertiary education. Infrastructure spending is 1.6 percent of GDP and transfer payments are 1.5 percent of GDP.

Given our parameter choices, the model generates consumption and capital output ratios, wage rates and poverty indices described in Table 3. The tertiary wage rate is normalized to one and wages for various education categories are obtained relative to the tertiary wage.

Table 3. Baseline

Capital	5.6430
Output	1.5970
Consumption	1.1230
Aggregate Human Capital	1.3240
Return on Capital	0.0460
Unskilled Wage Rate	0.3650
Primary Wage Rate	0.7610
Secondary Wage Rate	0.9690
Tertiary Wage Rate	1.0000
Poverty (Head count ratio)	0.5350
Poverty (P1)	0.2431
Poverty (P2)	0.0832

Figures 1 and 2 (a-d) show the optimal life-cycle profiles of the selected variables for the benchmark case for different generations by lifetime-income groups. The human capital efficiency profiles shown in Figure 1a. start when an individual joins the labor force, and reach their peak at age 50. The shapes of the simulated age-earnings profiles for individuals with different skills are not very different from what is found in cross section household surveys, with incomes rising with age and starting to fall at about mid-working age.

Given the fixed costs for different levels of schooling, asset accumulation decisions of households vary with the parents' level of schooling attainment (and, therefore, their corresponding income profiles). The desire to smooth life cycle consumption entails a deaccumulation of assets (borrowing) at the beginning of each level of schooling for those households with sufficiently low initial incomes. As can be seen from Figure 2a, the rate of asset accumulation declines for most households during the schooling phase of the child. This decline is particularly marked for households in the lowest income class (unskilled). At the end of the schooling phase, asset profiles for all agents decline as agents deaccumulate their assets.

Given the higher opportunity costs of schooling, parents with lower skill levels demand less schooling for their child than more educated parents. In the steady state, given our choice of parameter values, in comparison to low income households, households in higher income classes choose some secondary as well as tertiary education for their children.

C. Policy Experiments

The policy experiments described below examine the growth and poverty effects of increases in government expenditures and changes in its composition. Table 4 provides a comparison of the various steady state macroeconomic aggregates relative to the baseline.

1. Increase in government spending on primary, secondary, and tertiary education

The first policy experiment examines the intertemporal effects on growth and poverty when education spending increases by 5 percent of GDP per year. As in Baeir and Glomm (2001), we increase τ and allocate the higher revenues to either primary, secondary or tertiary education.[22] In contrast with the baseline steady state, Table 4 indicates that output is significantly higher in all cases due to higher physical and human capital accumulation.

The increase in primary education spending results in the most significant increase in the physical and human capital stock and, hence, output. Two reasons account for this. First, a reduction in the costs for primary education affects households' marginal schooling decisions by lowering their opportunity costs of schooling. As a result, lower income households that previously had optimally chosen very little schooling for their child now increase their investment in child human capital. Given the sequencing of schooling decisions, this enables households to choose higher levels of secondary and tertiary schooling in subsequent periods, leading to a higher accumulation of human capital in the steady state.

Second, higher primary education spending serves to smoothen household life-time asset accumulation profiles. Figures 3 A-D illustrate the effects of such a policy on household asset accumulation decisions. Note that for all households, a reduction in primary schooling costs results in higher asset accumulation over their lifetime. Lower schooling costs during the beginning of the schooling phase (the early working years) enables low income (unskilled) households to forego child earnings and increase investment in child human capital while accumulating more assets in subsequent periods for future consumption.[23] For skilled households (with higher lifecycle earnings), a reduction in primary schooling costs also allows for a larger accumulation of assets earlier in life. Therefore, increasing primary education spending shifts the household lifecycle asset accumulation curve upwards for all skill types. This increase is more significant for primary education spending than for secondary and tertiary spending as in the latter cases, parents are already in their prime working years (between ages 36 to 45) when these policies comes into effect. The higher asset accumulation profiles translate into a larger aggregate capital stock and to higher levels of output.

---

[22] Since education costs are fixed, we assume that when government increases its contribution to education parents pay less in form of education expenses.

[23] In contrast with the baseline, unskilled parents do not have to deaccumulate assets (borrow) earlier in life to finance schooling for their child.

Table 4. Steady-State Results

Simulation	1	2	3	4	5	6	7
			(Percentage change from baseline)				
Capital	5.8553	3.0701	1.2567	1.8238	4.0823	1.9435	2.0134
Output	2.3267	1.2286	0.4910	0.7273	1.6317	0.5671	1.4356
Consumption	1.2435	0.8765	0.3541	0.5643	1.4220	0.7771	1.3211
Aggregate Human Capital	1.8954	1.2341	0.8932	0.5438	1.1011	0.6784	0.2134
Return on Capital	-3.3912	-1.8149	-0.7319	-1.1010	-2.3985	-1.2140	-1.6543
Unskilled Wage Rate	2.1324	1.2286	0.4910	0.7273	1.6317	1.2341	2.2987
Primary Wage Rate	2.5408	0.0012	0.0018	0.7942	1.7818	1.3304	2.5102
Secondary Wage Rate	1.5634	1.5026	0.0009	0.8895	1.9956	1.6101	2.8114
Tertiary Wage Rate	1.0932	1.0452	1.4354	0.9073	2.0355	1.6065	2.8676
Poverty (Head Count Ratio)	0.4321	0.5185	0.5272	0.4537	0.4235	0.4062	0.5142
Poverty (P1)	0.2212	0.2654	0.2699	0.2323	0.2168	0.2079	0.2632
Poverty (P2)	0.0612	0.0734	0.0747	0.0643	0.0600	0.0575	0.0728

Simulation
1 ==> Increasing primary education spending;
2 ==> Inncreasing secondary education spending;
3 ==> Increasing tertiary education spending;
4 ==> Lower direct transfer to households;
5 ==> Higher direct transfer to households;
6 ==> Higher quality of spending;
7 ==> Increasing infrastructure expenditure.

With a higher capital stock, the return to labor of all skill-types increases. In addition, the marginal product of labor is enhanced by more government spending in human capital production. The price of unskilled labor exhibits a significant increase relative to the baseline, by over 2.2 percent, as more parents choose to keep their children in school, thereby reducing the pool of unskilled labor in the economy. The large increase in the primary wage rate, of 2.5 percent, results from older cohorts (with higher age-earning profiles) demanding higher levels of secondary schooling for their children. Figures 4 A-D illustrate the demand for schooling by households of different ages. As a result, the supply of primary educated labor in the economy declines, which increases the price of such labor. The skilled-unskilled wage differential is reduced relative to the baseline as the supply of skilled human capital in the economy increases while the number of unskilled and primary-educated workers falls.

As discussed above, the growth effects of an increase in secondary education spending are dampened as households benefit from such a policy only in the middle of their working life. Moreover, as shown in Figure 3A, unskilled households increase investment in child human capital at the expense of asset accumulation, leading to lower lifetime asset accumulation profiles relative to the baseline. Therefore, aggregate physical and human capital stock are lower than in the previous case. Given the sequencing of schooling decisions, an increase in government subsidy on tertiary education only benefits those households which demanded secondary education in the baseline (the high income, skilled groups). This policy stance has no impact on the marginal schooling decisions of low income households as their optimal schooling choices typically involve much lower levels of schooling. As a result, an increase in government expenditure on tertiary education leads to lower physical and human capital accumulation, and, hence, output relative to increases in primary or secondary education spending.

Table 4 also reports the impact on poverty of alternative education policies. The decline in the head count ratio is most marked when primary education spending is increased relative to secondary or tertiary spending. Two reasons account for this: first is the higher household disposable income at the beginning of the schooling phase. Second, there is an increase in lifetime asset accumulation profiles of low income households in response to the policy change. As discussed above, the increase in aggregate human and physical capital accumulation is most significant for an increase in primary education spending, resulting in the sharpest reduction in the head count ratio. The severity of poverty is also shown to decline as indicated by the lower poverty indices, P_1 and P_2.

The transition effects of the policy changes on macroeconomic aggregates are illustrated in Figures 5 A-D. Notice that the growth effects of higher primary and secondary education spending are more important in the short run. However, in the long run, an increase in tertiary education results in the largest aggregate capital stock, and, hence, output, due to the sequencing of schooling decisions and the higher productivity of such labor. This result suggests countries should not ignore tertiary education given its importance for long run growth.

Notice, however, that the quality and effectiveness of government spending on education has significant incremental effects on human capital accumulation and the productivity of labor (column 6). However, to the extent that such a policy does not directly reduce private costs of education, households may be forced to substitute physical assets for human capital investment, resulting in a smaller increase in output. This suggests that improved prioritization of education spending accompanied by improvements in the quality and efficiency of such spending should be viewed as complementary activities.

2. Targeting transfers

The policy experiments reported in this section examine the implications of narrow targeting of government expenditures on household demand for schooling, growth and poverty reduction (columns 4 and 5 in Table 4). Households below the poverty line are assumed to be targeted through two types of transfers: a low type, equivalent to the costs of primary education, and a high type, equivalent to the costs of secondary education.[24] As expected, the actual impact of the transfers on the lifecycle behavior of households depends upon the relative size of the

---

[24] These transfers can take the form of transfers-in-kind (school lunches for the poor or directed subsidies for education in the form of free textbooks or school fees) or transfers in cash (social security and welfare payments).

transfer. The "low" transfer lowers the opportunity cost of schooling and results in a higher demand for primary schooling by low income (unskilled) households as households forego child earnings to increase investment in child human capital. In addition, this policy results in a higher lifecycle asset profile (Figure 6A). However, household's lifetime asset accumulation profile is not smoothened as parents are forced to substitute physical assets for investment in human capital at higher levels of schooling.

A higher transfer allows households to increase investment in child human capital and demand more primary as well as secondary schooling, leading to an increase in the aggregate human capital stock. Aggregate savings are also higher in this case as households of all types increase asset accumulation over their lifecycle. The impact on poverty in the steady state also depends on the magnitude of the transfer. If the transfer results in a substitution of human capital accumulation for asset accumulation, poverty levels may not be significantly improved relative to the baseline. With a sufficiently large transfer, however, poverty levels are significantly lower than in the baseline. As in the steady state, the transition paths of physical capital stock and output are higher the larger the transfer (Figures 7A-D).

3. Increasing infrastructure spending

This policy experiment examines the growth and poverty effects of higher public infrastructure investment. The literature outline two different channels through which an increase in infrastructure expenditures affects the capital accumulation process. The first channel is the "resource withdrawal" effect, whereby public spending crowds out domestic savings and investment. The second effect reflects the direct impact of infrastructure spending on the marginal productivity of physical and human capital. Our analysis focuses on the latter effect.

Table 4 (column 7) shows that an increase in infrastructure spending results in higher levels of capital stock and output relative to the baseline. The intuition behind this result is straightforward: increasing infrastructure spending raises the marginal product of physical and human capital, which, in turn, increases output. The higher return on labor of all skill types increases household incomes and causes demand for schooling to increase. Households forego child earnings to increase investment in child human capital as the higher parental wage income compensates for the loss of child earnings. Poverty levels fall relative to the baseline due to higher household incomes.

The growth effects of this policy are lower than those obtained from an increase in primary or secondary education spending because government education spending augments growth through two important effects. First, by lowering the opportunity costs of schooling, it directly increases schooling demand and allows for higher physical asset accumulation. Second, it raises the return to human capital accumulation as public education spending enters the human capital production function.

4. Varying the composition of government spending

The previous policy experiments indicated how an increase in different components of government spending, altered the optimal schooling and asset accumulation decisions of households, the marginal decision between child labor versus human capital accumulation, and various macroeconomic aggregates. The set of policy experiments considered in this section examine the trade-offs between different public policies. For a given tax rate and a fixed allocation of revenues to publicly provided goods and services, we examine the macroeconomic and poverty effects from increasing the fraction of the budget going to primary or secondary education at the expense of tertiary spending and increasing the allocation for overall education spending at the expense of infrastructure investment (Table 5).

Table 5. Trade-Offs between Various Types of Expenditures

Simulation	**8**	**9**	**10**
	(Percentage change from baseline)		
Capital	1.4638	0.7675	2.1113
Output	0.5817	0.3072	0.8249
Consumption	0.3109	0.2191	0.5949
Aggregate Human Capital	0.4739	0.3085	1.5006
Return on Capital	-0.8478	-0.4537	-1.2296
Unskilled Wage Rate	0.5331	0.3072	0.8249
Primary Wage Rate	0.6352	0.0003	1.0700
Secondary Wage Rate	0.3909	0.3757	0.5517
Tertiary Wage Rate	0.2733	0.2613	0.3711
	Poverty profiles		
Poverty (Head Count Ratio)	0.4105	0.4278	0.4019
Poverty (P1)	0.2101	0.2190	0.2057
Poverty (P2)	0.0581	0.0606	0.0569

8==> Increasing Primary and Reducing Tertiary Spending
9==> Increasing Secondary and Reducing Tertiary Spending
10==> Increasing all Education spending and Reducing Infrastructure Spending

Table 5 shows that a 3 percent of GDP increase in primary education spending at the expense of tertiary spending causes higher investment in child human capital and leads to larger aggregate human and physical capital stock in the steady state. The intuition for this is the same as in the section which considered the effects of an increase in primary education spending: low income households increase investment in child human capital as the policy reduces their opportunity costs as well as direct costs of schooling while allowing them to accumulate more assets for future consumption (Figures 9A-D). Poverty is significantly lowered as low income households benefit most from such a policy through higher wage and rental incomes. Notice, however, that the magnitude of changes in the aggregates are smaller than in previous policy experiment. This is because of the large fixed costs to tertiary education. Skilled households (with high lifecycle earnings), which optimally demand more years of schooling for their children are now forced to substitute physical asset accumulation for investment in human capital. This lowers the asset accumulation profiles over their lifetime and results in a lower demand for schooling.

The effect of an increase in secondary education is similar to the previous case. The aggregate physical capital stock, and, hence, output is lower than in the previous case because of the higher fixed costs to secondary schooling. As a result, households of all skill types can only increase investment in child human capital at the expense of asset accumulation over their lifecycle. Accordingly, households allocate less child time to human capital accumulation and the aggregate human capital stock in the economy is reduced.

The last policy experiment indicates that increasing expenditures on all levels of education proportionately at the expense of infrastructure spending has the most significant impact on macroeconomic aggregates and poverty both in the steady state and in the transition (Figures 10A-D). There are two reasons why output is higher with a higher rate of public investment in education. First, the allocation of funds to education raises the return to human capital accumulation and encourages more schooling as higher education spending directly enters into the human capital production function. Second, all income groups accumulate more assets over their lifecycle, resulting in a larger aggregate capital stock.

IV. Conclusion

In this paper we have presented a dynamic general equilibrium model of overlapping generations of long-lived people in which altruistic parents make schooling decisions for their children. We examine the effects of alternative composition of government expenditures on education, infrastructure investment and transfer payments on household schooling and asset accumulation decisions. In the presence of fixed and increasing schooling costs, we find that the macroeconomic and poverty reduction benefits of increasing primary and secondary education spending in countries with less than universal basic education can be substantial, even if these come at the expense of infrastructure investment. However, given the sequential nature of schooling decisions, tertiary education spending has the largest impact on long-run growth once universal basic education is achieved. Finally, we find that targeting of transfers to households below the poverty line can have non-trivial growth effects. The precise quantitative impact on growth and poverty alleviation, however, depends upon the magnitude of the transfer.

The current model assumes perfect credit markets, which by allowing households to smooth consumption through borrowing and lending, permit them to choose optimally higher levels of schooling for their child. This assumption may be unrealistic for many developing countries where poor households face credit constraints for financing human capital investments. In addition, our paper presents a very simplified model of the labor market and ignores the interaction between the formal and the informal economy. In many developing countries, the informal economy is the main avenue for employment. These extensions will be incorporated in future research.

Table 6. Education Expenditures
Selected Sub-Saharan African Countries and Regions

Country	Education Spending as share of GDP				Education Spending as share of Total Spending			
	1985	1990	1995	1998/99	1985	1990	1995	1998/99
Cameroon	2.8	3.3	2.1	1.9	20.6	16.6	14.6	9.9
Ethiopia	2.8	2.9	3.6	3.8	11.6	9.9	14.0	13.5
The Gambia	...	2.9	4.7	3.5	...	12.3	19.3	14.9
Ghana	2.4	3.2	4.2	4.5	18.0	25.5	...	...
Guinea	...	1.5	1.6	1.6	...	6.1	9.4	11.5
Kenya	5.0	5.5	5.8	6.9	19.6	19.9	20.6	25.6
Lesotho	4.8	5.6	9.1	10.4	16.0	18.5	25.4	25.9
Madagascar	2.7	2.4	1.9	2.0	15.7	14.1	10.5	10.7
Mozambique	2.6	2.6	2.4	2.5	10.4	7.2	7.9	10.1
Niger	2.5	3.3	2.9	2.0	12.9	14.6	19.2	7.7
Sierra Leone	1.7	1.5	2.4	3.7	12.5	7.4	12.2	18.5
Zambia	...	2.2	2.3	3.0	...	6.7	6.8	9.8
Regions[a,b]								
Middle East and North Africa	6.6	5.6	6.0	5.8	16.6	17.6	18.4	20.5
Sub-Saharan Africa	2.8	3.2	3.9	4.1	11.3	13.2	14.0	13.1
Latin America	3.5	2.1	2.8	3.1	10.0	11.0	11.4	11.3
South Asia	2.8	2.8	2.6	2.5	15.4	16.2	16.7	16.2
East Asia	2.7	2.8	2.9	3.5	15.0	10.0	13.5	14.9

Source: IMF and World Bank

a Regional averages are weighted by current GDP for the year

b Data coverage varies for the different variables

Table 7. Countries With Primary Gross School Enrollment Ratios Below 90 Percent, 1996

Region and country	Gross enrollment ratio	Region and country	Gross enrollment ratio
50-90 percent			
Sub-Saharan Africa		*Middle East and North Africa*	
Benin	78	Morocco	86
Burundi	51	Oman	76
Chad	57	Qatar	62
The Gambia	77	Yemen	79
Ghana	79		
Guinea-Bissau	62	*Latin America and Caribbean*	
Kenya	85	Guatemala	88
Mauritania	79		
Mozambique	60	**Below 50 percent**	
Senegal	71	*Sub-Saharan Africa*	
Tanzania	66	Burkina Faso	40
Uganda	74	Djibouti	39
		Ethiopia	43
East Asia and Pacific		Mali	49
Papua New Guinea	80	Niger	29
South Asia		*South Asia*	
Pakistan	82	Afghanistan	49

Source: UNESCO

Table 8. Incidence of Child Labor and Education Across Age in Ghana, 1998

Age	School	Work	Both	Neither
7	98.0	0.5	0.5	1.0
8	98.3	0.5	0.3	0.9
9	97.2	1.2	0.4	1.3
10	96.6	1.7	0.3	1.4
11	95.3	2.7	0.4	1.7
12	95.3	2.5	0.5	1.8
13	93.2	3.2	0.5	3.1
14	87	5.9	0.3	6.8
Total	96	1.8	0.4	1.9

Source: Blunch N-H, Verner D., *Revisiting the Link Between Poverty and Child Labor: The Ghanaian Experience*, World Bank, October 4, 2000.

Table 9. Public Spending Per Student: Tertiary Education as a Multiple of Primary Education, 1980–90

Region[a]	1980	1990
Low and middle income countries		
Sub-Saharan Africa	65.3	44.1
East Asia and the Pacifics and South Asia	30.8	14.1
Latin America and the Caribbean	8.0	7.4
Middle East and North Africa	14.6	8.2
OECD countries	3.0	2.5

Source: World Bank

a The data covers 8 Sub-Saharan African countries, 4 in East and South Asia, 4 in Latin America and the Caribbean and 2 in Middle East and North Africa.

Appendix I: Corner Solutions for Schooling

In this section we show that the optimal per period solution for schooling is a corner one. Given that schooling time does not enter into the utility function of households, schooling decisions can be separated from consumption decisions, and we can simply examine the maximization of discounted life cycle wealth.

$$\mathcal{L} = \sum_{i=23}^{45} \beta^{t-23} U([\overline{w}h_{i,t}(1-s_{i,t}) - s_{i,t}(1-\phi_{i,t})e_i] + z_{i,t}) + \beta^{14}\mu(h_{45,t+15})$$
$$+\lambda_t \left[h_{i+1,t+1} - \gamma_0 h_{i,t}^{\gamma_1} s_{i,t}^{\gamma_2} - (1-\delta_h)h_{i,t} \right] \qquad \text{(A1)}$$

The following first order conditions hold:

$$u'_{i,t}\left[\overline{w}h_{i,t} + (1-\phi_{i,t})e_i\right] + \lambda_t \gamma_o \gamma_2 h_{i,t}^{\gamma_1} s_{i,t}^{\gamma_2} \geq 0 \;\; \text{for } s_{i,t} = 0$$
$$u'_{i,t}\left[\overline{w}h_{i,t} + (1-\phi_{i,t})e_i\right] + \lambda_t \gamma_o \gamma_2 h_{i,t}^{\gamma_1} s_{i,t}^{\gamma_2} = 0 \;\; \text{for } 0 < s_{i,t} < 1$$
$$u'_{i,t}\left[\overline{w}h_{i,t} + (1-\phi_{i,t})e_i\right] + \lambda_t \gamma_o \gamma_2 h_{i,t}^{\gamma_1} s_{i,t}^{\gamma_2} \leq 0 \;\; \text{for } s_{i,t} = 1 \qquad \text{(A2)}$$

and

$$u'_{i,t}\overline{w}(1-s_{i,t}) = \lambda_t \left[\gamma_0 \gamma_1 h_{i,t}^{\gamma_1 - 1} s_{i,t}^{\gamma_2} + (1-\delta_h) \right] \;\; \text{for } h_{i,t} > 0 \qquad \text{(A3)}$$

$$h_{i+1,t+1} = \gamma_0 h_{i,t}^{\gamma_1} s_{i,t}^{\gamma_2} + (1-\delta_h) h_{i,t} \;\;\; \lambda_t > 0 \qquad \text{(A4)}$$

Suppose $0 < s_{i,t} < 1$, solving for λ_t in (A1) and substituting into Langragian function, we get

$$\left[\overline{w}h_{i,t} + (1-\phi_{i,t})e_i\right] s_{i,t} = -\frac{\overline{w}(1-s_{i,t})\left[\gamma_0 \gamma_2 h_{i,t}^{\gamma_1} s_{i,t}^{\gamma_2}\right]}{\left[\gamma_0 \gamma_1 h_{i,t}^{\gamma_1 - 1} s_{i,t}^{\gamma_2} + (1-\delta_h)\right]} \qquad \text{(A5)}$$

Using A4 and solving for $s_{i,t}$, we get

$$s_{i,t} = -\frac{\gamma_2 \overline{w} h_{i,t}\left[h_{i+1,t+1} - (1-\delta_h)h_{i,t}\right]}{\gamma_2 \overline{w} h_{i,t}\left[h_{i+1,t+1} - (1-\delta_h)h_{i,t}\right] - \left[\overline{w} h_{i,t} + (1-\phi_{i,t})e_i\right]\left[\gamma_1 h_{i+1,t+1} + (1-\gamma_1)(1-\delta_h)h_{i,t}\right]}$$

Given that $\left[\overline{w} h_{i,t} + (1-\phi_{i,t})e_i\right]>0$, the denominator is smaller than the numerator, such that $s_{i,t} > 1$. Thus, it is never the case that $0 < s_{i,t} < 1$.

Appendix II: Estimation of Earnings-Age Profiles

Becker (1975) and Mincer (1974) introduced the age-earning estimation framework to estimate the returns to human capital. Since human capital is unobservable, they suggested the use of years of schooling as an appropriate proxy for it. The following log-linear form is commonly used in the literature:

$$\ln EARN_{it} = \alpha_0 + \alpha_1 SCHOOL_{it} + \alpha_3 AGE_{it} + \alpha_4 (AGE_{it})^2 + X_{it}\beta + \varepsilon_{it}$$

where i is the index for the individual, t is the time period of the cross-section in hand, ε_{it} is the error term capturing any unobserved factors, *lnEARN* is the natural logarithm of total earnings, *SCHOOL* is the years of schooling, *AGE* is the age of the individual approximating her years of experience, X is a set of controls and β is a set of parameters. The controls include demographics and reference characteristics of the individual.

Our estimations use data from the LMSM survey for Ghana contacted by the World Bank in the period 1998–99. A general-to-specific methodology is adopted to define a benchmark model (Spanos 1986, 1999). Such a model, is one with a relative good fit where all the explanatory variables are statically significant (see Table A1 with the description of controls). The estimation process used is simple OLS with the standard errors being heteroscedasticity consistent or robust.

Table A1. Description of Variables

Variable	*Description*
lnEARN	Natural logarithm of total earnings from main job
Years of Schooling	Constructed by the information supplied in HEDU and HEDUq. Also, the two educational reforms in Ghana in mid-1970s and in 1990 were taken into account.
HEDU Highest Educational Level achieved	Highest educational level completed: 1 None, 2 Kindergarten, 3 Primary, 4 Middle, 5 JSS, 6 SSS, 7 Vocational/Commercial, 8 Secondary (O'level), 9 Sixth Form, 10 Teachers Training, 11 Technical, 12 Post Secondary T/T, 13 Nursing, 14 P/Sec Nursing, 15 Polytechnic, 16 University, 17 Koranic Stage, 96 Others
HEDUq Highest Educational Qualification Acquired	Highest educational qualification, 1 None, 2 MSLC/BECE, 3 Voc/Comm, 4 "O" Level, 5 SSS, 6 "A" level, 7 T/T Cert. B, 8 T/T Cert. A, 9 Nursing, 10 Tech/Prof Cert., 11 Tech/Prof Dipl., 12 Bachelor, 13 Masters, 14 Doctorate, 96 Others
Age	Age in years
Age^2	Age in years squared
Marital Status	Marital Status: 1 Married, 2 Informal Union, 3 Divorced, 4 Widowed, 5 Never married
Female	Dummy variable for female.
Accra	Dummy variable for Accra district
Rural	Dummy variable for rural areas

The results of the estimations are in Tables 7 and 8. In the first table, a simple regression without any controls is shown and in the second one the benchmark regression is presented. The estimation results in Table 8 are close to those of the existing literature. The impact of years of schooling is found to be 6.8 percent, near to the 8.5 percent reported by Glewwe (1996), with an adjusted R^2 of 25 percent, higher than the 18.6 percent reported by the same author in a comparable regression. Also, we find a positive wage premium with respect to the Accra district as in Verner's paper. Finally, the coefficients for years of schooling, age and age^2 are not substantially influenced by the inclusion of the various controls (compare results in Tables 7 and 8).

Table A2. Age-Earning Profile Without Controls

Dependent Variable: lnEARN	*Coefficient Estimates*	*Robust Standard Errors*	*t-statistics**	*P-values**	*95% Confidence Intervals for coefficient estimates*	
Years of Schooling	.0656108	.0070991	9.24	0.000	.0516826	.079539
Age	.127157	.017905	7.10	0.000	.0920283	.1622857
Age^2	-.0013239	.0002208	-6.00	0.000	-.0017571	.-0008908
Constant	10.67973	.3484317	30.65	0.000	9.996119	1.36333
Number of observations = 1197		F(3, 1193) = 78.57		Prob > F = 0.0000		
Adjusted R^2 = 0.1986		Root Mean Square Error = .86303				

* The underlying test is H_0: Parameter = 0

Table A3. Benchmark Age-Earning Profile with Controls

Dependent Variable: lnEARN	*Coefficient Estimates*	*Robust Standard Errors*	*t-statistics**	*P-values**	*95 Percent Confidence Intervals for coefficient estimates*	
Years of Schooling	.0680011	.0069356	9.80	0.000	.0543937	.0816086
Age	.105986	.0204022	5.19	0.000	.0659576	.1460145
Age^2	-.0011258	.0002453	-4.59	0.000	-.0016071	-.0006445
Accra	.3257569	.0606969	5.37	0.000	.2066715	.4448423
Rural	-.1351177	.0560755	-2.41	0.016	-.245136	-.0250993
Female	-.2960351	.0535535	-5.53	0.000	-.4011053	-.1909649
Marital Status	-.0739339	.022698	-3.26	0.001	-.1184666	-.0294011
Constant	11.35104	.4332792	26.20	0.000	10.50096	12.20112
Number of observations = 1193		F(7, 1185) = 47.88		Prob > F = 0.0000		
Adjusted R^2 = 0.2522		Root Mean Square Error = .83207				

* The underlying test is H_0: Parameter = 0

Figure A1. Baseline and Simulation Results

Figure 1a Assets accumulated by parents

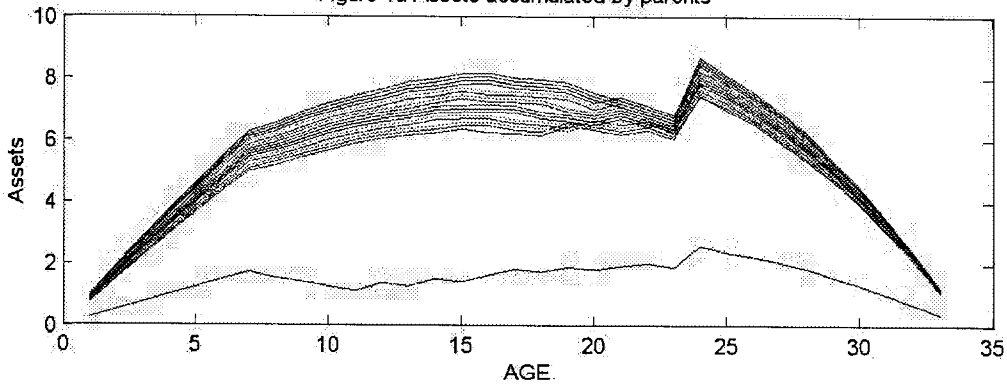


Figure 1b Schooling Demanded by Parents

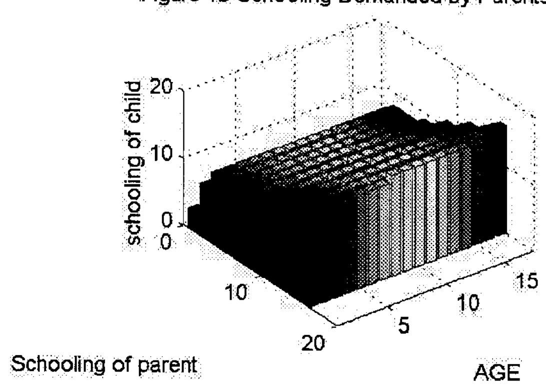


Figure A2. Baseline Results

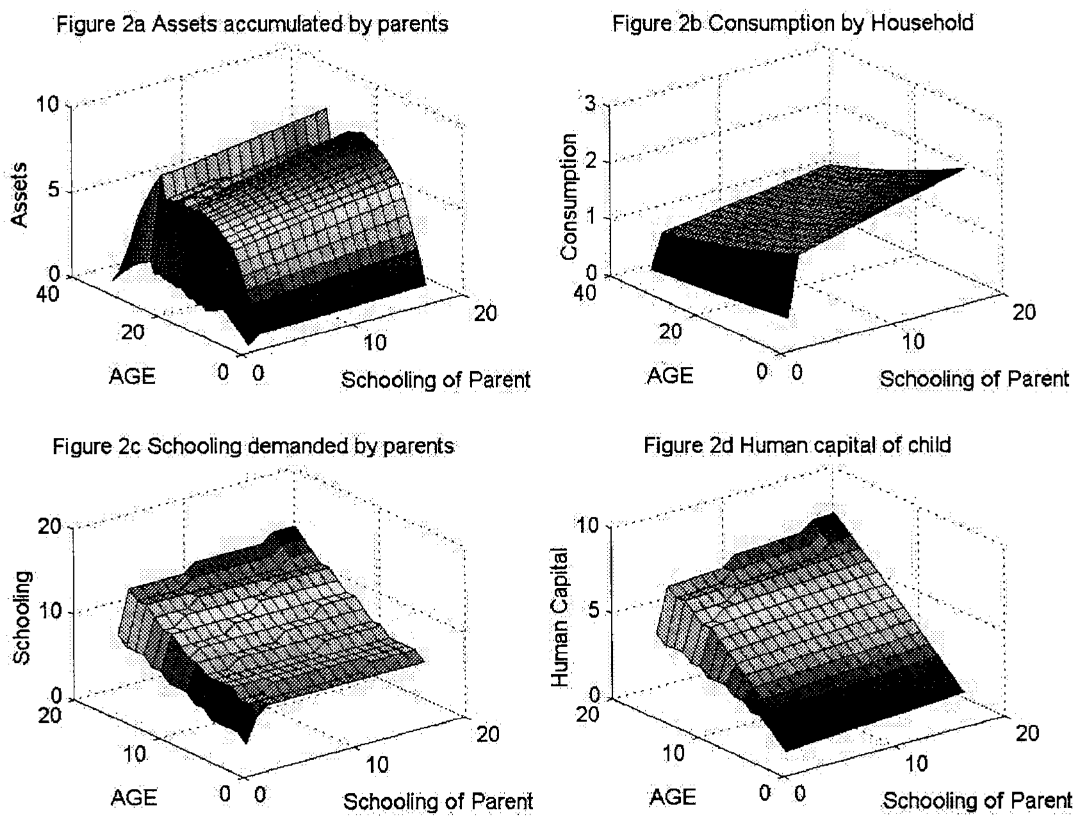


Figure A3. Impact of Increasing Education Spending on Asset Accumulation by Skill Types in the Steady State

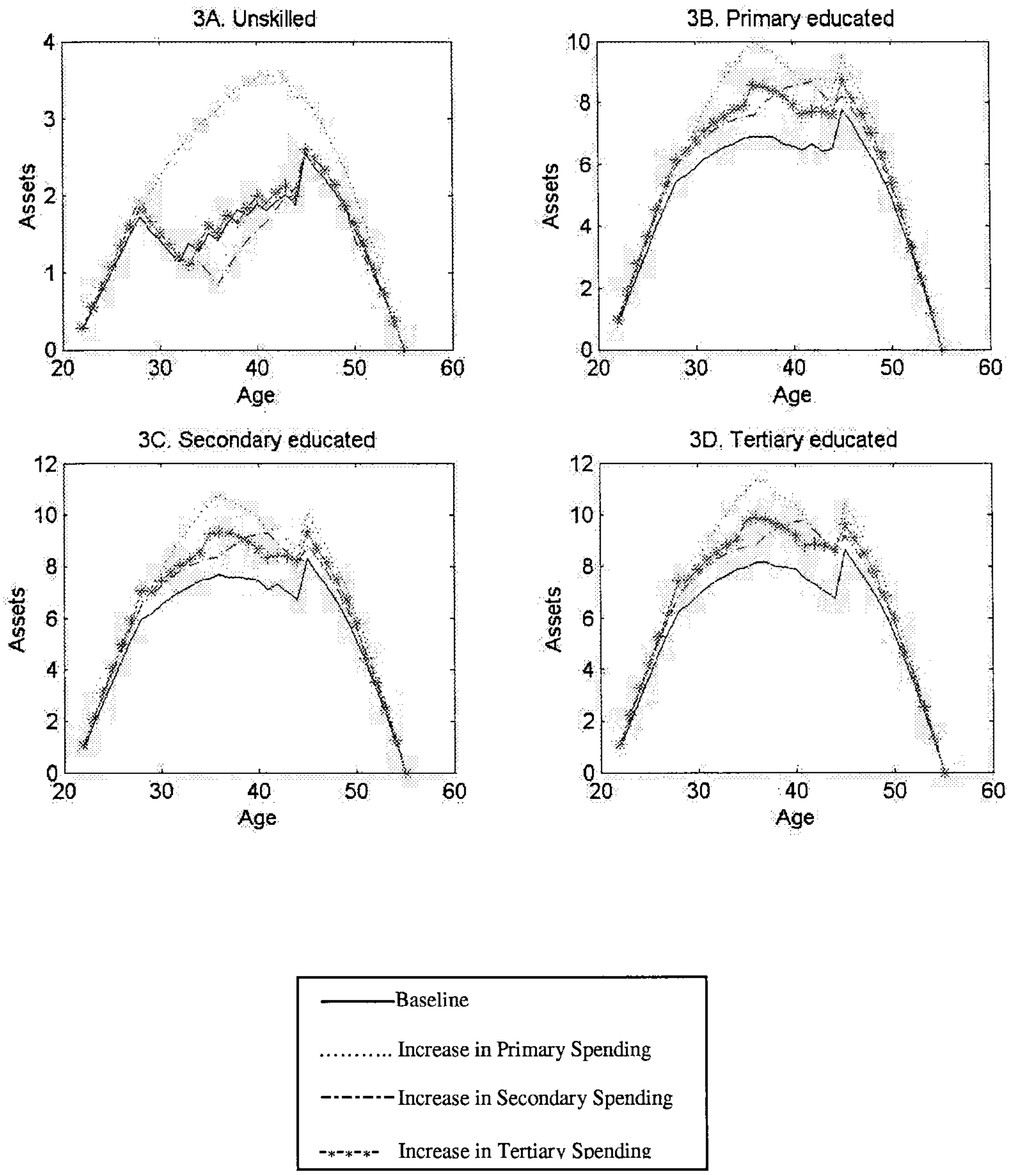
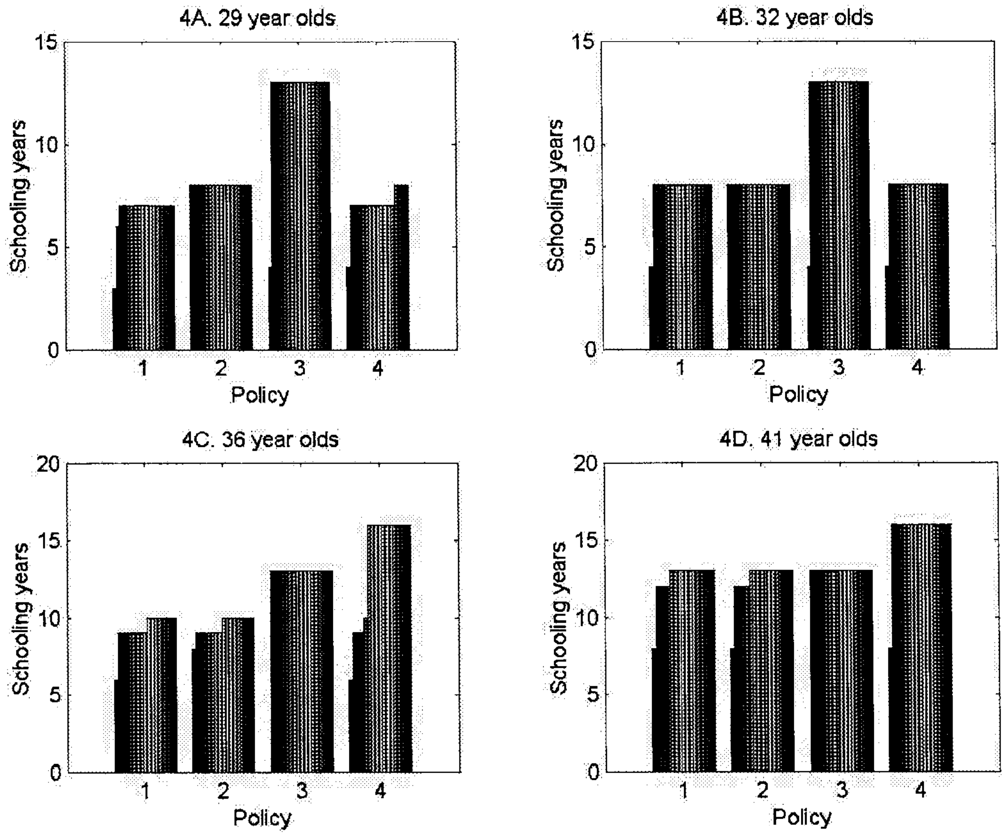


Figure A4. Demand for Schooling by Age and Skills of Households in the Steady State



1	Baseline
2	Increase in Primary Spending
3	Increase in Secondary Spending
4	Increase in Tertiary Spending

Figure A5. Transition Effects

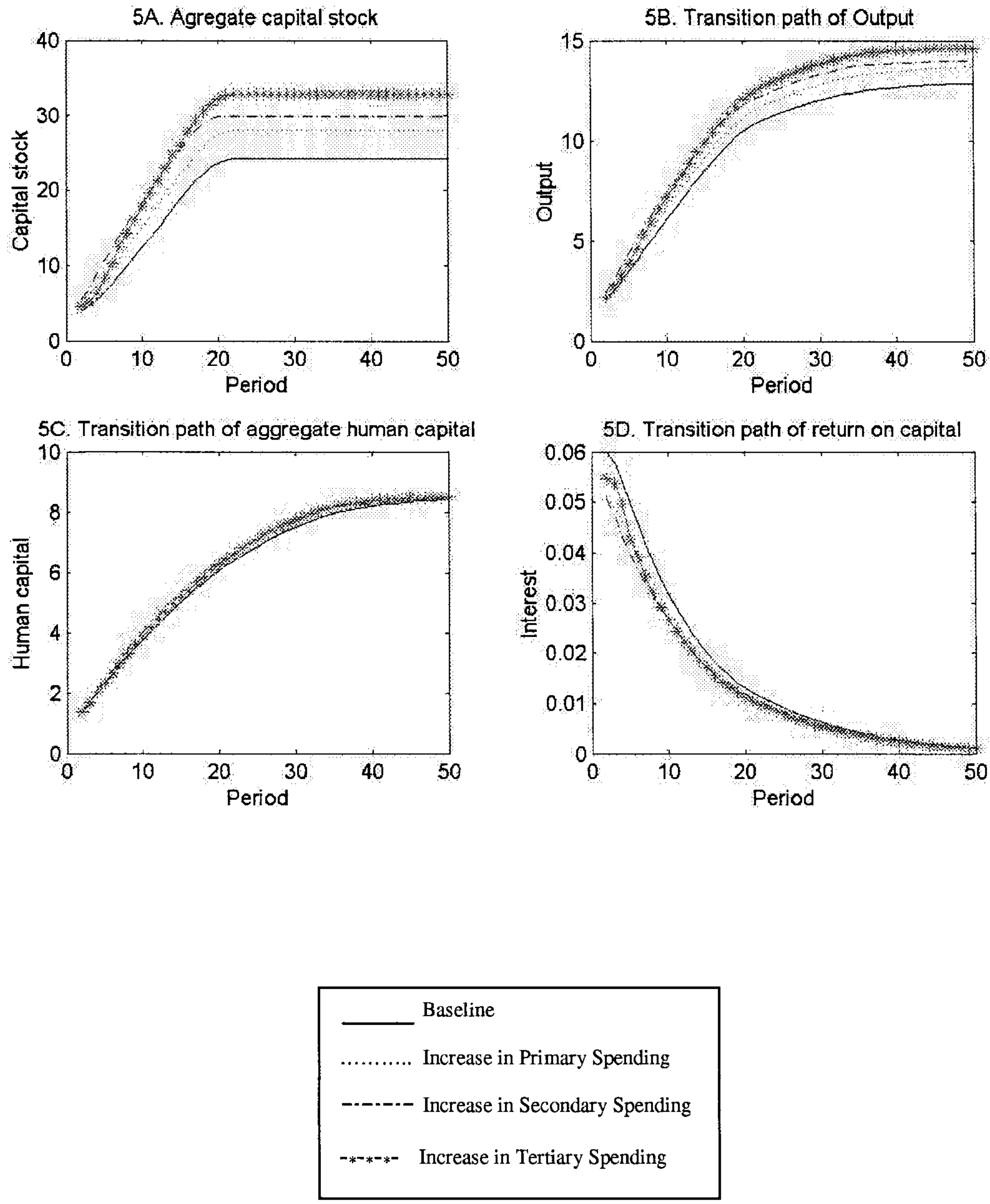


Figure A6. Impact of Transfers on Asset Accumulation by Skill Type in the Steady State

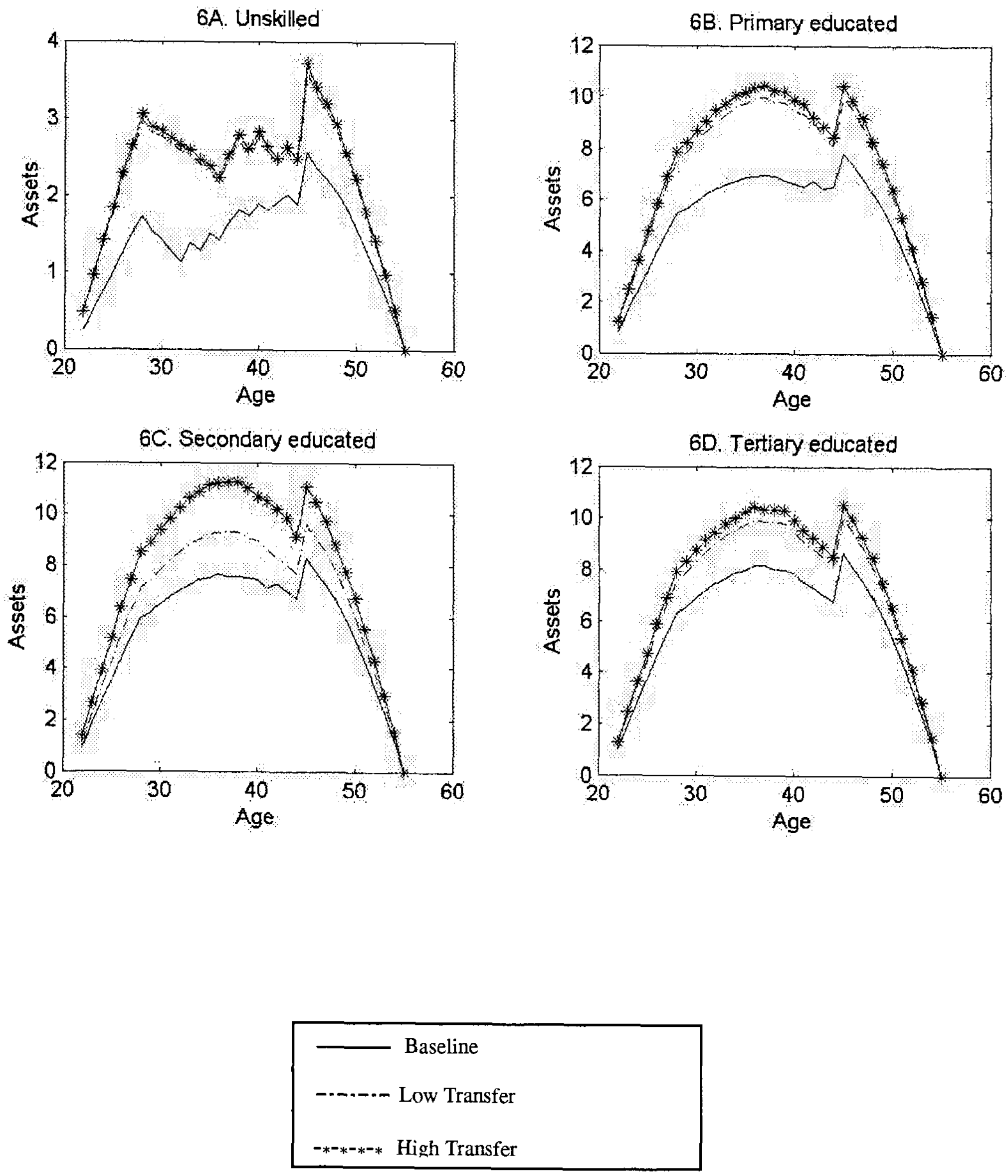


Figure A7. Transition Effects of Transfers

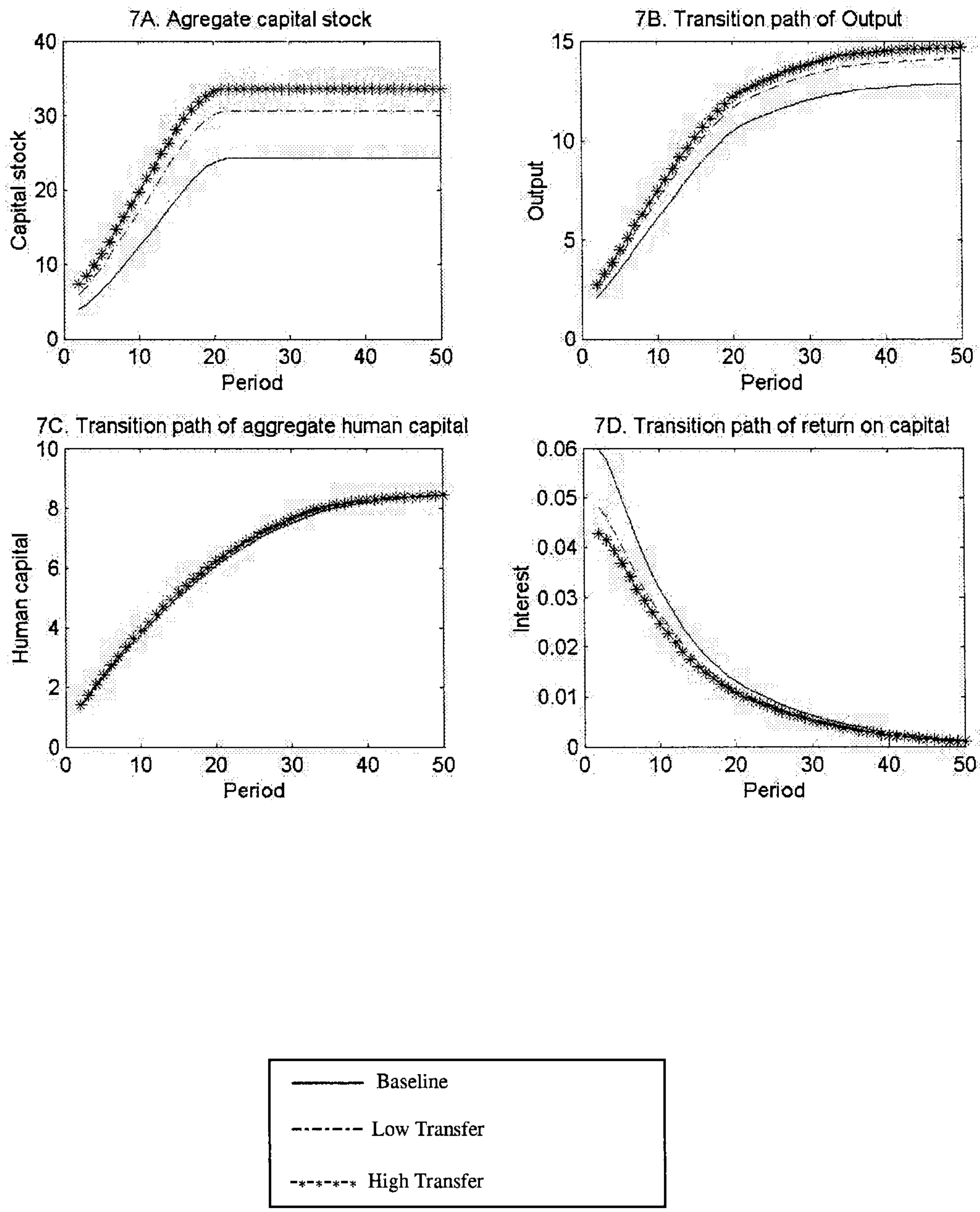


Figure A8. Transition Effects of Infrastructure Spending
and Quality of Government Education Spending

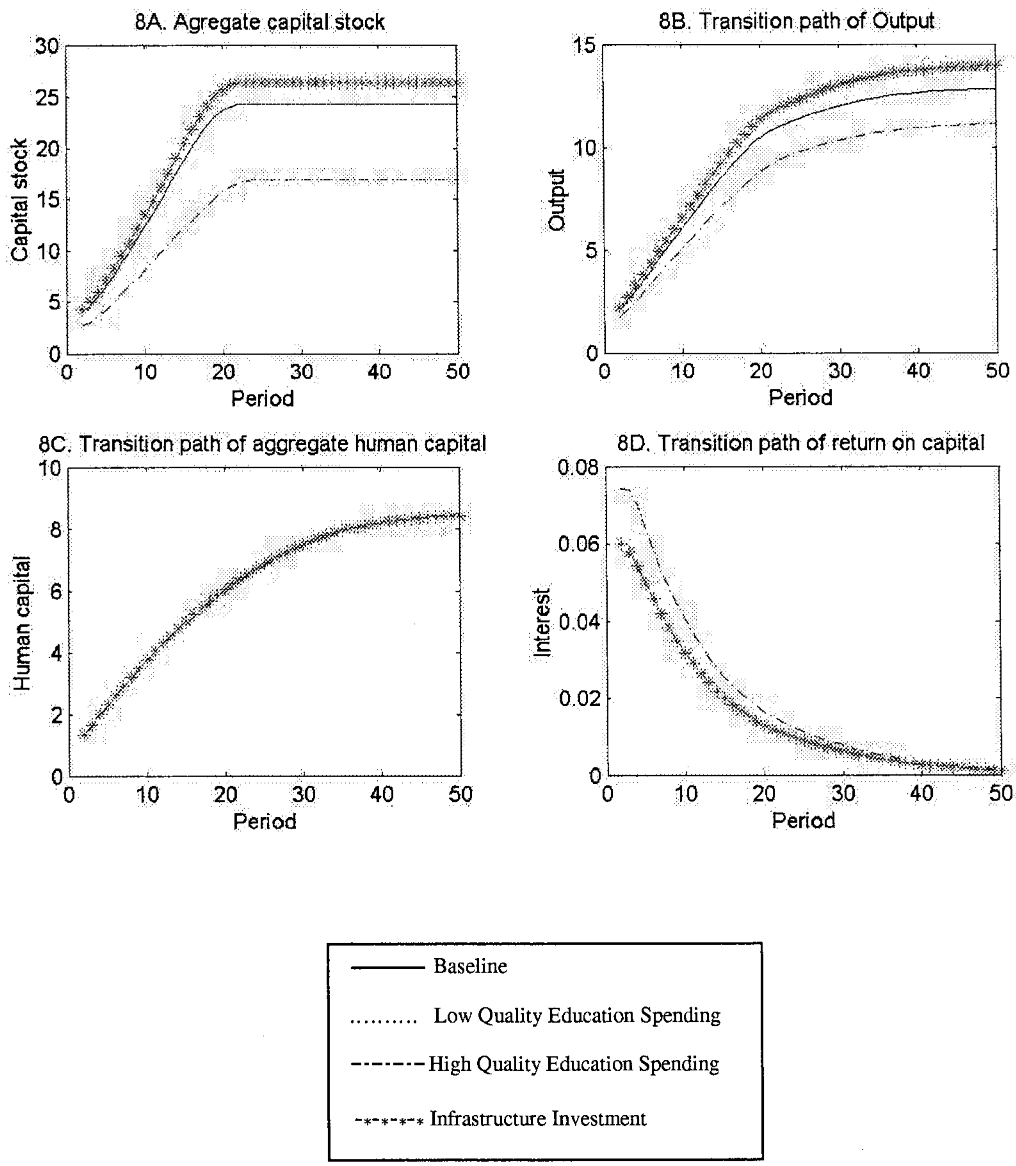


Figure A9. Impact of Varying the Composition of Government Spending on Asset Accumulation of Agents by Skill Type

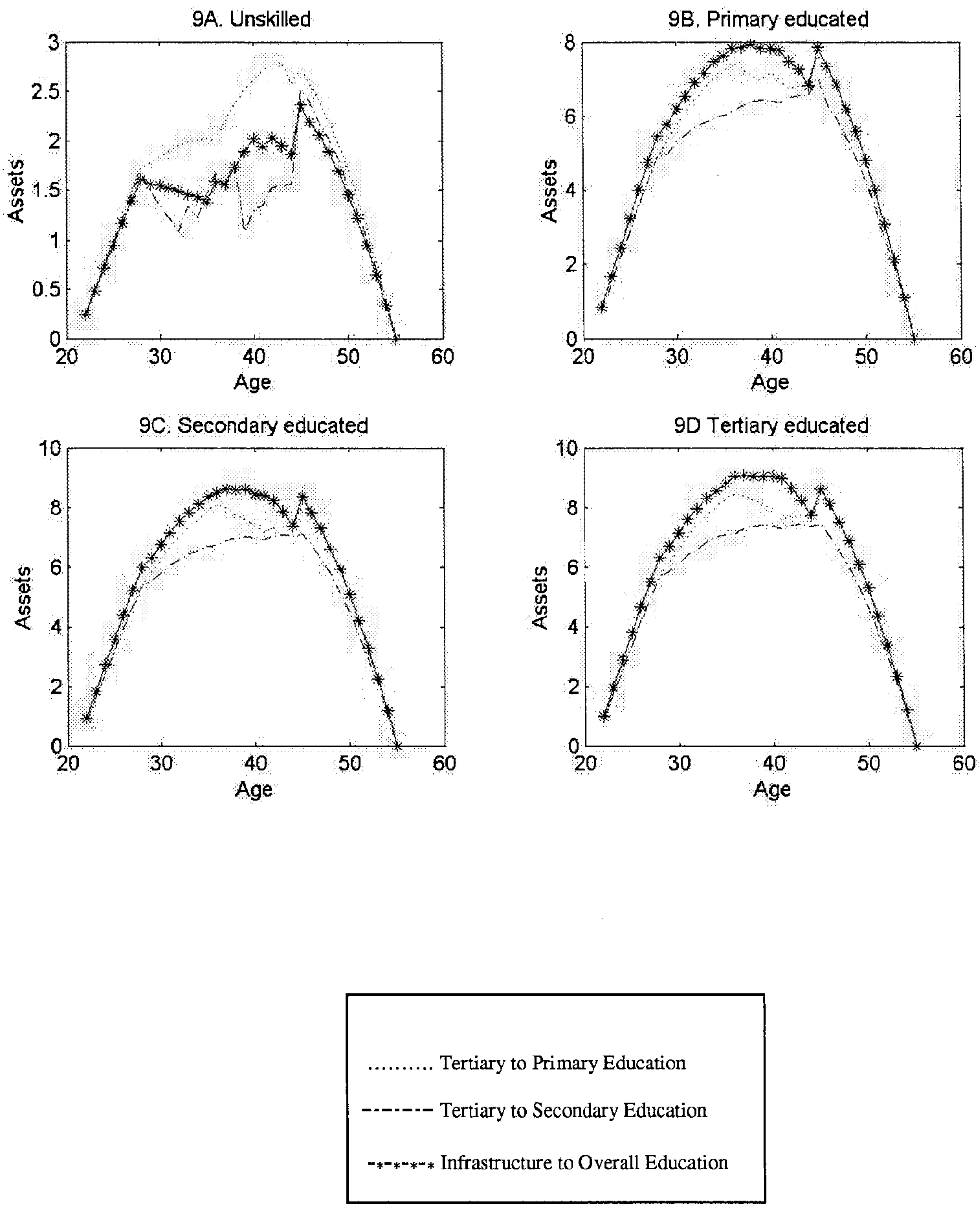
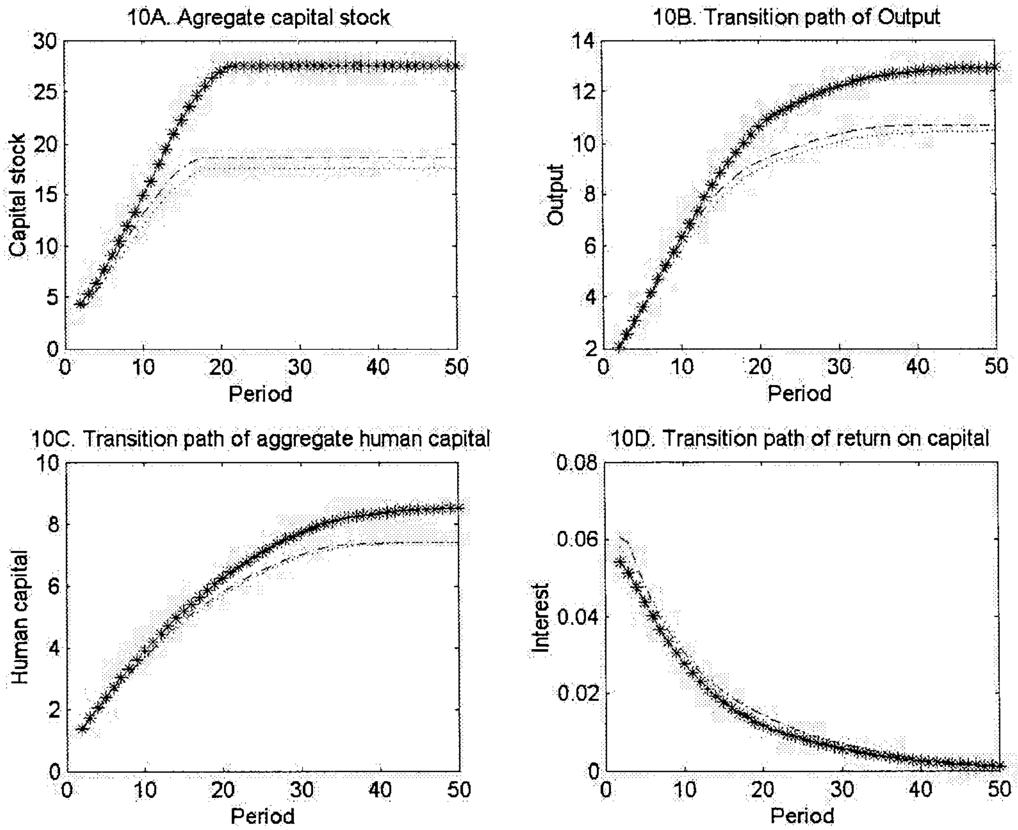


Figure A10. Transition Effects from Varying the Composition of Government Spending



.... Tertiary to Primary Education

———Tertiary to Secondary Education

-*-*-*-* Infrastructure to Overall Education

REFERENCES

Auerbach, A.J., and L. Kotlikoff, eds., 1987, *Dynamic Fiscal Policy* (Cambridge: Cambridge University Press).

Barro, R., 1991, "Economic Growth in a Cross Section of Countries," *Quarterly Journal of Economics,* Vol. 106 (May), pp. 407–43.

———, and J. Lee, 2000, "International Data on Educational Attainment: Updates and Implications," NBER Working Paper No. 7911 (Cambridge, Massachusetts: MIT Press).

Becker, G.S, 1975, *Human Capital,* 2nd Edition, University of Chicago Press.

Ben-Porath, Y., 1967, "The Production of Human Capital and the Life Cycle of Earnings," *Journal of Political Economy,* Vol. 84, pp. 449–72.

Behrman, J.R., and N. Birdsall, 1983, "The Quality of Schooling: Quantity Alone is Misleading," *American Economic Review*, Vol. 73, pp. 928–46.

Bosworth, B., and S. Collins, 1996, "Economic Growth in East Asia: Accumulation Versus Assimilation," *Brookings Papers on Economic Activity: 2,* Brookings Institution, pp. 135–203.

Canagarajah, S., and H. Coulombe, 1997, "Child Labor and Schooling in Ghana," World Bank Policy Research Working Paper No. 1844 (Washington: World Bank).

Card, D., and A. Krueger, 1992, "Does School Quality Matter? Returns to Education and the Characteristics of Public Schools in the United States," *Journal of Political Economy,* Vol. 100 (February), pp. 1–40.

Davies, J., and J. Whalley, 1989, "Taxes and Capital Formation: How Important is Human Capital?" NBER Working Paper No. 2899 (Cambridge, Massachusetts: MIT Press).

Driffill, E.J., and H.S. Rosen, 1983, "Taxation and Excess Burden: A Life-Cycle Perspective," *International Economic Review,* Vol. 24, pp. 671–83.

Glewwe, P., 1996, "The Relevance of Standard Estimates of Rates of Return to Schooling for Educational Policy: A Critical Assessment," *Journal of Development Economics,* Vol. 51, pp. 267–90.

Glomm, G., 1997, "Parental Choice of Human Capital Investment," *Journal of Development Economics*; Vol. 53 (June), pp. 99–114.

———, and B. Ravikumar, 1992, "Public Versus Private Investment in Human Capital: Endogenous Growth and Income Inequality," *Journal of Political Economy,* Vol. 100, pp. 818–34.

———, 1998, "Flat-Rate Taxes, Government Spending on Education, and Growth," *Review of Economic Dynamics*, Vol. 1 (January), pp. 306–25.

Hanushek, E., 1996, "Schooling, Labor Force Quality and Economic Growth," NBER Working Paper No. 5399 (Cambridge, Massachusetts: MIT Press).

Heckman, J.J., 1999, "Accounting for Heterogeneity, Diversity and General Equilibrium in Evaluating Social Programs," NBER Working Paper No. 6230 (Cambridge, Massachusetts: MIT Press).

———, L. Lochner, and C. Taber, 1998, "Explaining Rising Wage Inequality: Explorations with a Dynamic General Equilibrium Model of Labor Earnings with Heterogeneous Agents," NBER Working Paper No. 6384 (Cambridge, Massachusetts: MIT Press).

Jacoby, H., and E. Skoufias, 1997, "Risk, Financial Markets, and Human Capital in a Developing Country," *Review of Economic Studies,* Vol. 64 (3), pp. 311–35.

Judson, R., 1998, "Economic Growth and Investment in Education: How Allocation Matters," *Journal of Economic Growth,* Vol. 3 (December), pp. 337–59.

Mincer, J., 1974, *Schooling, Experience and Earnings*, (New York: National Bureau of Economic Research).

Psacharopoulos, G., 1993, "Returns to Investment in Education: A Global Update," World Bank Policy Research Paper No. 1067 (Washington: World Bank).

———, 1995, "The Profitability of Investment in Education: Concepts and Methods," World Bank Human Capital Development and Operations Policy Working Paper No. 63 (Washington: World Bank).

Sawada, Y., and M. Lokshin, 2000, "Household Schooling Decisions in Rural Pakistan," World Bank Policy Research Paper No. 2541 (Washington: World Bank).

Spanos, A., 1986, *Statistical Foundations of Econometric Modelling* (New York: Cambridge University Press).

———, 1999, *Probability Theory and Statistical Inference: Econometric Modelling with Observational Data* (New York: Cambridge University Press).

Trostel, P., 1993, "Effect of Taxation on Human Capital," *Journal of Political Economy,* Vol. 101 (April), pp. 327–50.

Verner, D., 1999, "Wage and Productivity Gaps: Evidence from Ghana," World Bank Policy Research Working Papers No. 2168 (Washington: World Bank).