

WP/01/106

# IMF Working Paper

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The Impact of Public Education  
Expenditure on Human Capital, Growth,  
and Poverty in Tanzania and Zambia:  
A General Equilibrium Approach

*Hong-Sang Jung and Erik Thorbecke*

**IMF Working Paper**

Fiscal Affairs Department

**The Impact of Public Education Expenditure on Human Capital, Growth, and Poverty  
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Authorized for distribution by Sanjeev Gupta

August 2001

**Abstract**

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The impact of public education expenditure on human capital, the supply of different labor skills, and its macroeconomic and distributional consequences is appraised within a multisector CGE model. The model is applied to and calibrated for two Heavily Indebted Poor Countries (HIPC)s, Tanzania and Zambia. The simulation results suggest that education expenditure can raise economic growth. However, to maximize benefits from education expenditure, a sufficiently high level of physical investment is needed, as are measures that improve the match between the pattern of educational output and the structure of effective demand for labor. An important result of the simulation experiments is that a well-targeted pattern of education expenditure can be effective for poverty alleviation.

JEL Classification Numbers: H5, I2

Keywords: Public expenditure, CGE, education, poverty, Tanzania, Zambia

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## **I. INTRODUCTION**

In most poor countries, education is considered a priority to reduce poverty, and several studies have emphasized its importance. Barro (1991), Chu and others (1995), and Tanzi and Chu (1998) argue that public expenditure allocations for education can improve economic growth while promoting equity. Gupta and Verhoeven (2001) and Gupta, Verhoeven, and Tiongson (1999) suggest that both the size and the efficiency of public education expenditure are important in improving socioeconomic performance.

Promoting the education sector normally entails increasing public expenditure on education. A macroeconomic policymaker would question the economic consequences: how much would the supply of different educational skill groups and corresponding wage levels change, and what would be the impact on economic growth, macroeconomic stability, and poverty alleviation? In order to answer these questions, a computable general equilibrium (CGE) model was specified and calibrated for each Tanzania and Zambia. A novel feature of this model is that it specifies the mechanism through which public expenditure on education affects the production of human capital. In particular, education expenditure is viewed as providing additional human capital to those who are in the educational pipeline. As these individuals come out of the pipeline, they contribute to the stock of human capital of their households in the form of improved labor skills. In this context, the pattern of education expenditure influences the distribution of this additional stock among different socioeconomic household groups. This paper presents the simulation results of different education expenditure policies, to gain some insights into these issues.

In the next section, the economic structures of Tanzania and Zambia and the frameworks for their Poverty Reduction Strategy Papers (PRSPs) are reviewed. In the third section, the education-focused CGE model and its calibration are presented and explained. In the fourth section, three alternative counterfactual scenarios are simulated, and their respective impacts on the macroeconomic conditions, the labor market, income distribution, and poverty alleviation are analyzed. The final section offers conclusions.

## **II. ECONOMIC STRUCTURE AND THE PRSPs OF TANZANIA AND ZAMBIA**

### **A. Economic Structure**

The model was calibrated on early or mid-90s data (i.e., the Tanzanian 1992 Social Accounting Matrix (SAM) and the Zambian 1995 SAM). We believe that those SAMs reflect relatively well the present structures of the two economies, summarized in Table 1. In general, macroeconomic performance has been better in Tanzania than in Zambia: the GDP growth rate has been higher and the inflation rate has been lower. During the mid-1990s, GDP growth in Zambia was barely equal to its population growth. The better growth performance of Tanzania was partly due to a higher investment ratio in past years. In recent years, however, the trend has been for this ratio to decline in Tanzania, while in Zambia it has increased.

Table 1. Economic Structure of Tanzania and Zambia

	Tanzania			Zambia		
	1992	1995	1999 1/	1992	1995	1999 1/
GDP growth (annual change, in percent)	1.8	3.6	4.7	2.1	-2.5	2.4
Inflation	21.8	15.8	7.0	65.7	34.9	26.8
Investment (in percent of GDP)	27.0	19.6	15.2	11.9	15.9	17.5
Public	9.2	3.4	3.1	4.0	6.6	7.1
Private	17.8	16.2	12.1	7.9	9.3	8.8
Domestic savings (in percent of GDP)	-2.4	0.8	6.2	-0.7	12.2	-1.1
Production structure (in percent of GDP)	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture	48.1	46.2	44.8	21.3	16.2	24.6
Industry	16.5	14.8	15.4	43.7	31.6	24.5
Services	35.4	39.0	39.8	35.0	52.2	50.9
Budget balance (in percent of GDP)	-1.7	-5.9	-3.4	-4.2	-4.3	-3.6
Total revenue	14.1	12.5	11.3	33.0	29.0	25.6
of which: grants	2.7	2.0	3.9	14.7	9.2	7.9
Total expenditure and net lending	15.9	18.3	14.7	37.2	33.4	29.2
Current account balance (in percent of GDP) 2/	-26.7	-21.1	-14.8	-16.0	-7.0	-16.1
Population growth (annual change, in percent)	3.1	2.9	2.4	-7.5	2.7	2.2

Sources: Country authorities; and World Bank, World Development Indicators 2000.

1/ Most data for 1999 are preliminary.

2/ Excluding government transfers.

Tanzania's production structure is heavily dependent on agriculture, while its industry relies mostly on processing agricultural products and light consumer goods. On the other hand, Zambia's structure is dominated by copper and other mining products. Both countries suffer from fiscal and external deficits, with Zambia depending more on grants than Tanzania. Population growth is around 2.5 percent a year in the two countries.

## B. PRSPs and Education

Each country was considered eligible by the Bank and the Fund to receive debt relief under the enhanced HIPC Initiative in 2000, and each formulated its PRSP or IPRSP. The papers emphasize poverty reduction and the need to sustain macroeconomic stability, as summarized in Table 2. To maintain macroeconomic stability, government expenditure and the current account deficit are to be contained. Regarding education, both countries plan to expand expenditure within a sustainable macroeconomic framework.

Table 2. Macroeconomic Frameworks of the PRSPs and the Education Sectors of Tanzania and Zambia

	Tanzania			Zambia		
	2000	2001	2002	2000	2001	2002
Real GDP growth (annual change, in percent)	5.2	5.6	6.0	4.0	5.0	5.0
Consumer price index (annual change, in percent)	5.6	4.5	4.0	19.0	10.0	7.0
Budget balance (in percent of GDP)	-0.4	-1.0	-0.4	-2.3	-1.0	-0.2
Total revenue	16.1	16.3	16.4	28.0	28.4	27.7
of which: grants	4.8	4.5	4.4	8.0	4.9	4.7
Total expenditure and net lending	16.5	17.3	16.8	30.3	29.4	27.9
of which: education	2.5	2.6	2.6	4.5 1/	7.2 1/	-
Current account balance (in percent of GDP) 2/	-15.9	-15.4	-14.8	-13.6	-13.3	-12.8

Sources: Tanzania PRSP, Decision Point Document, and Zambia IPRSP.

1/ Total social expenditure.

2/ Excluding government grants.

Presently, both the school enrollment rates and the quality of schooling are quite low in the two countries. In Tanzania, the gross enrollment rate for primary schools was estimated at 78 percent in 1997. The net enrollment rate, however, was much lower at 57 percent.<sup>2</sup> In Zambia, the net enrollment rate in 1995 was higher at 75.2 percent. However, the quality of schooling is questionable: only three percent of fifth-grade students had attained the desired level of mastery of their subjects and only 26 percent had reached the minimum mastery level.<sup>3</sup>

The two countries emphasize education in their poverty reduction strategies. The Tanzanian government has prepared a Basic Education Master Plan and is preparing a Secondary Education Master Plan, to improve school facilities, textbooks, school management, and the quality of teachers, and to rationalize a number of underutilized and inefficient tertiary education institutions. To support these policy measures, the government intends to adopt a medium-term expenditure framework (MTEF) emphasizing primary education. In a similar vein, the Zambian government has launched a Basic Education Subsector Investment Program (BESSIP). A major objective of this program is to increase enrollment and improve the overall performance of basic education. To achieve these goals, the government plans to

<sup>2</sup> Tanzania PRSP. An electronic version is available at <http://www.imf.org/external/np/prsp/2000/tza/02/index.htm>.

<sup>3</sup> Zambia IPRSP. An electronic version is available at <http://www.imf.org/external/country/ZMB/index.htm>.

recruit and retain qualified teachers, improve teaching conditions, and correct the imbalance in teaching staff between urban and rural areas.

### III. AN EDUCATION-FOCUSED CGE MODEL AND ITS CALIBRATION<sup>4</sup>

#### A. Model Structure

A neoclassical multisector CGE modeling approach with optimizing agents and flexible prices has been adopted for this study.<sup>5</sup> Educated labor supply is determined as a function of education expenditure and other macroeconomic variables. The model has four types of institutions: households, firms, the government, and the rest of the world. Households are again classified into four groups by region and income level (i.e., urban poor, urban nonpoor, rural poor, and rural nonpoor). The model categorizes three production sectors: agriculture, industry (including mining, manufacturing, and construction), and services.

At the beginning of a period, the economy is endowed with a certain level of physical capital and human capital (in the form of stocks of different labor skills). The allocation of capital across production sectors is fixed during the period; labor, however, is mobile across the sectors. Economic agents maximize their objectives: households seek utility through consumption, and firms seek profits through production. Firms optimize factor use according to factor prices, equalizing the value of the marginal product of labor with its wage rate. Production factors distribute their income to households according to each group's factor (resource) endowment, and households save some of their income and consume the remainder. Agents' optimizing behavior adjusts to changing product and factor prices, to let the economy achieve a new general equilibrium. The savings determine investment.<sup>6</sup> The model captures the interaction of economic activities and the circular flow of incomes within the socioeconomic system. The government collects taxes (income, domestic indirect, and tariffs), purchases goods and services, and provides transfers to household groups or firms. Firms, households, and the government are also involved in transactions with the rest of the world: exporting or importing goods and services, receiving or sending transfers and grants.

Imperfect substitution is depicted with respective CES-type Armington functions between factors (capital and labor), among products of domestic supplies and exports, and between

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<sup>4</sup> For detailed equations of the model, see Appendix II.

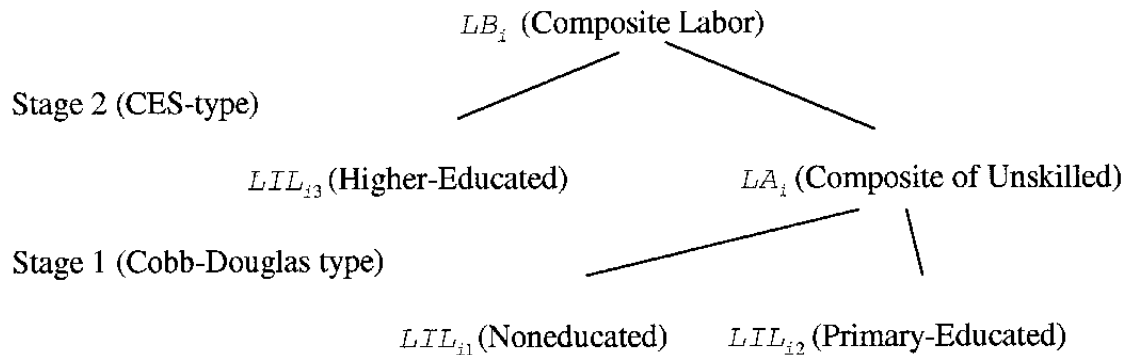
<sup>5</sup> The basic structure of the model follows Robinson and others (1999).

<sup>6</sup> Savings are determined by income, and investment by the interest rate (in the savings equation in the model we assume that savings are insensitive to changes in the interest rate, consistent with observed trends in the two economies). External sector equilibrium is achieved through a flexible exchange rate. The interest rate and exchange rate are endogenously determined within the model. Money supply and demand are not included in the model, and only relative prices are determined.



domestic demand and imports. Different labor types are combined in two stages, reflecting two different levels of substitutability. The less-skilled types of labor (the noneducated and the primary-educated) are combined within a Cobb-Douglas-type Armington aggregation ( $LA_i$ ). This aggregate of less-skilled labor is combined again with the skilled (the higher-educated) labor within a CES-type Armington aggregation to yield a composite labor measure, assuming a smaller elasticity of substitution. This aggregation is depicted in Figure 1.<sup>7</sup> Consumption is specified as a Cobb-Douglas function.

Figure 1. Aggregation of Different Labor Types

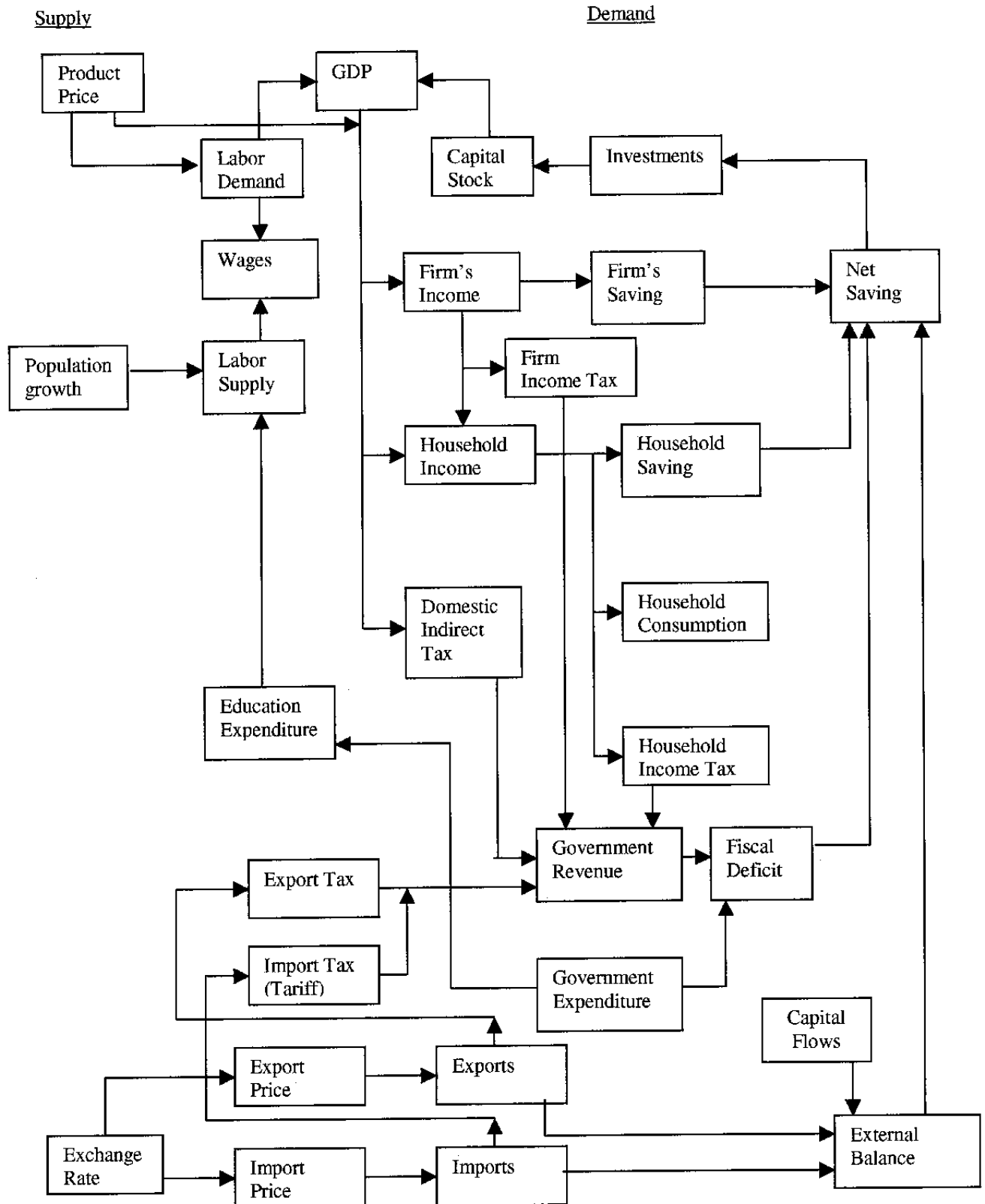


Given the labor supply for a period, employment levels are determined by flexible wages through the operation of the labor market, given firms' profit maximization conditions. Firms employ the optimal amount of labor ( $LB_i$ ), considering their first order condition of profit maximization, which in turn leads to the optimization of each labor type ( $LIL_{ij}$ ), given technical constraints and wage rates. The main structure of the model is depicted in Figure 2.

Intertemporally, the model adjusts through changes in the stock of physical capital and the stock of human capital. Physical capital is increased by investment, which is determined by domestic and foreign savings. Human capital is determined by population growth (given exogenously) and the pattern of educational expenditures, a variable partially under the control of the government.

<sup>7</sup> This aggregation scheme enables the model to depict productivity growth under the scenario that the economy be endowed with more education. An educated or skilled worker is provided with a higher share parameter in the Cobb-Douglas or CES function, due to its higher initial wage level in the calibration (thus contributing more to the composite labor). Hence, an increase in the supply of educated labor leads to a higher value for composite labor and results in higher production, compared with a similar increase in the supply of noneducated workers.

Figure 2. Structure of the Education-Focused CGE Model



## B. Supply of Educated Labor

Educational output—in terms of the supply of different types of labor, which contain different levels of human capital—is determined by the government’s expenditure on education and agents’ schooling efforts, expressed in terms of the agents’ opportunity cost for schooling. Schooling efforts are again determined through a representative agent’s maximization of its lifetime income. A representative agent compares the benefits (i.e., the present value of future income flows obtainable by finishing higher level education) with its opportunity cost (i.e., the income lost by the time spent on schooling). Assuming myopic expectations, schooling is formulated as a function of the wage differences among different educational levels, the economic growth rate, and the interest rate.

### Flow structure of educated labor

The labor stock is composed of three educational levels: noneducated, primary-educated, and higher-educated. Flows of new entrants into and retirees from the labor force during a period determine the next period’s stock of the three types of labor.<sup>8</sup> In the initial state, the total number of new entrants is assumed to increase by the fixed population growth rate of 2.5 percent. Assuming a 30-year working life, the oldest cohort retires and a new cohort joins the labor force, each canceling out the other and leaving a net (demographic) addition of 2.5 percent.<sup>9</sup>

The flow structure of the labor force is represented graphically in a simplified form in Figure 3. From the pool of population growth, some proceed to primary school, while others remain as noneducated, and from primary school, some advance to higher education while others directly enter the labor market as primary-educated. Finally, higher-educated workers are produced and supplied. With the total increase of the labor force constrained to a fixed population growth rate, the supply of noneducated labor is determined residually.

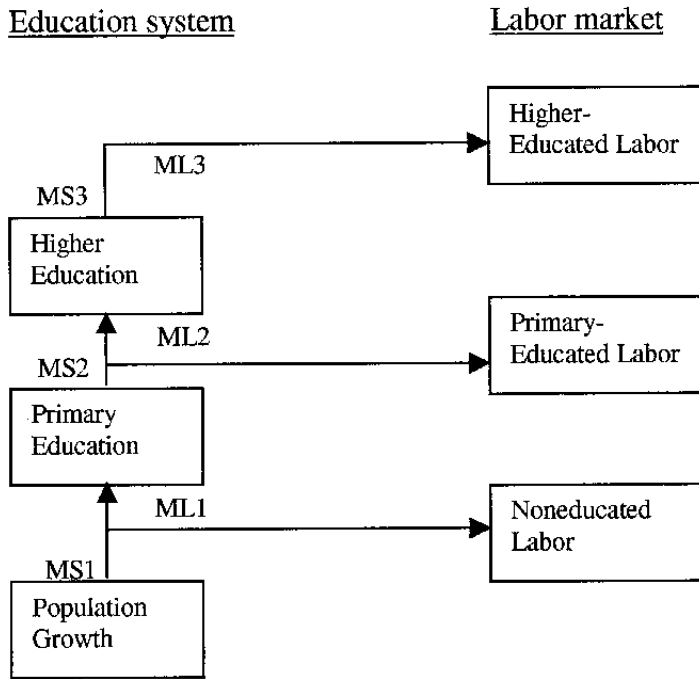
The linkage is specified as  $MS_3 = ML_3$ ,  $MS_2 = ML_2 + MS_3$ ,  $MS_1 = ML_1 + MS_2$ , where  $MS_l$  is the output flow of education level  $l$  that includes  $ML_l$ , the new labor supply of education level  $l$ , and  $MS_{l+1}$  for  $l=1, 2$ , those proceeding onward to the next higher level of education. Alternatively,  $MS_1 = ML_1 + ML_2 + ML_3$ ,  $MS_2 = ML_2 + ML_3$ , and  $MS_3 = ML_3$ .

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<sup>8</sup> Each level of educated labor includes not only graduates but also dropouts.

<sup>9</sup> Under the assumption of 2.5 percent population growth and a 30-year working life, the oldest cohort and the new cohort are calculated as 2.3 and 4.8 percent of the stock (of the three types of labor) respectively.

Figure 3. Structure of Labor Flow



### Specification of educated labor supply

In the initial state, the labor supply of each education level is assumed to increase by a fixed population growth rate. However, an increase of public expenditure devoted to education, with corresponding schooling efforts of individuals, increases the flow of educated labor supplied to the labor market.

The supply of educated labor is assumed to be determined by two factors: the level of the government's education expenditure and individuals' schooling effort, which is specified as the opportunity cost of schooling. Public expenditure on education provides the capacity for accommodating an expansion of human capital, which needs to be met by a corresponding increase in individuals' schooling efforts, to realize the desired outcome (i.e., an increase in the number of educated workers). Its functional form is assumed to be exponential in the two determinants. The production function of educated labor of level  $m$  is specified as

$$MS_m = AS_m \cdot EG^{\beta_{m1}} \cdot EP^{\beta_{m2}} \text{ or } MS_m = AS_m \cdot EG^{\beta_{m1}} \cdot (s_l \cdot W_{l0})^{\beta_{m2}} \quad (1)$$

where  $MS_m$  is the outflow of education level  $m$  for a given period (year),  $AS_m$  is a scale parameter,  $EG$  is the government's education expenditure, and  $EP$  is the individual's

opportunity cost for schooling, which can be specified as the product of the share of schooling time ( $s_t$ ) and the present wage income of the next lower level  $l$  ( $W_l$ ).<sup>10</sup>

The agent's schooling effort  $s_t$  is determined through the agent's maximization of his/her lifetime income.<sup>11</sup> In the present period 0, a representative agent of educated level  $l$  determines what fraction of his/her time or effort he/she will put into education to ascend to the next higher level  $m$ , which in the future will provide higher income. Thus, the agent's decision can be described as

$$\text{Maximize } W_{l0} \cdot (1 - u_l) \cdot (1 - s_t) + \sum_t^T (W_{mt}(s_t) - W_{lt}) \cdot (1 - u_m) \cdot \left( \frac{1}{(1 + r_t)^t} \right) \quad (2)$$

where  $W_{l0}$  is the present wage rate of educated level  $l$ ,  $W_{mt}$  is the wage rate of the next higher level  $m$  in period  $t$  that can be achieved by more schooling,  $u_l$  and  $u_m$  are unemployment rates of level  $l$  and  $m$  respectively,  $s$  is the fraction of time devoted to schooling,  $T$  is average working years, and  $r_t$  is the discount rate in period  $t$ .

We assume that the agent has the myopic expectations that the rate of increase of the future wage rates  $W_{mt}$  and  $W_{lt}$  will be at its present growth rate  $g$  and the discount rate will be constant at its present interest rate  $r$ , and that the functional form of  $W_{mt}(s_t)$  is

$W_{m0} \cdot \left( \frac{s_t}{\bar{s}_l} \right)^\gamma \cdot (1 + g)^t$ , satisfying  $W'_m > 0$  and  $W''_m < 0$ , where  $\bar{s}_l$  is the initial level of schooling effort in the economy. Then we obtain the following first-order condition with respect to  $s_t$ :<sup>12</sup>

$$W_{l0} \cdot (1 - u_l) = \gamma \cdot (W_{m0} - W_{l0}) \cdot \left( \frac{s_t}{\bar{s}_l} \right)^{\gamma-1} \cdot (1 - u_m) \cdot \left( \frac{1 + g}{r - g} \right). \quad (3)$$

The left-hand side represents the marginal opportunity cost of schooling efforts, and the right-hand side represents the marginal benefit of schooling efforts, that is, the present value

<sup>10</sup> The specification reflects the income effects of education. As wage income increases, the supply of educated workers increases.

<sup>11</sup> A representative agent wants to maximize lifetime utility from consumption. Assuming that he/she cannot hold liabilities at the time of death and can access credit markets efficiently, maximizing utility is equivalent to maximizing his/her lifetime income.

<sup>12</sup> If an agent undertakes more schooling effort than the initial level, he/she can achieve a higher wage level. We assume  $r > g$ . Otherwise, the agent will choose  $s=1$ , which is clearly unsustainable. Also, for a large  $T$ , the

term  $\left( \frac{1 + g}{1 + r} \right)^T$  diminishes to 0.

of future additional income. The growth rate represents future wage growth, and the interest rate represents the discount rate of future wages. Solving the above equation (3) for  $s$ , we obtain<sup>13</sup>

$$s_t = ASL_t \cdot \left( \frac{(W_{m0} - W_{t0}) \cdot (1 + g)}{W_{t0} \cdot (r - g)} \right)^{\frac{1}{(1-\gamma)}} \quad (4)$$

The agent's optimization is depicted in Figure 4. An initial endowment is given as point A. The agent can remain at point A with no further schooling or can proceed to a higher education level with schooling, as represented by the earnings possibility frontier, arc ABC. The agent maximizes his/her lifetime income at point B, at which the relative wage increase corresponds to the net discount factor, line DE, provided by the market. At point B, the agent chooses schooling of HI in terms of the present wage.

If the interest rate  $r$  decreases or the growth rate  $g$  increases, this reduces the net discount factor and increases the net present value of future income, and thus schooling efforts increase. In Figure 3, the slope of the net discount factor DE becomes flatter, and the tangency point moves left. If the wage rate for the higher level increases, resulting in higher expected future income, schooling efforts also increase. In the figure, the possibility frontier shifts upward, achieving a tangency point located to the left. The higher the wage rate for workers with a higher level of education, the more schooling the agent chooses.

### C. Calibration

The model is calibrated to the countries' most recent SAMs: Wobst's (2001) Tanzanian 1992 SAM, and Hausner's (1999) Zambian 1995 SAM. Both SAMs were reaggregated by the authors to conform to the classification scheme adopted in the model (i.e., three production sectors (agriculture, industry, and services), three labor categories (noneducated, primary-educated, and higher-educated), and four socioeconomic (urban poor, urban nonpoor, rural poor, and rural nonpoor) household groups).<sup>14</sup> The reaggregated SAMs of Tanzania and Zambia are shown in the Appendix.<sup>15</sup>

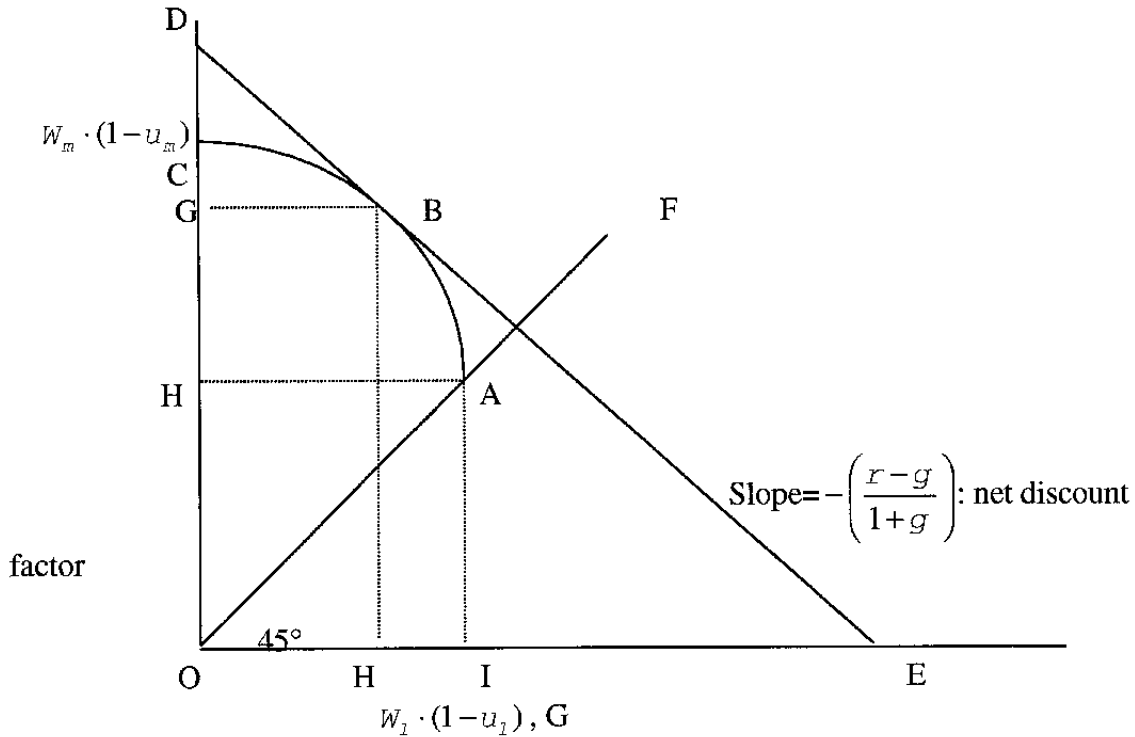
The capital stocks were estimated by discounting the capital incomes with each country's current interest rate, and a depreciation rate of 10 percent was applied for both countries.

<sup>13</sup> Flexible wages clear the labor market, while unemployment rates are fixed in the model.

<sup>14</sup> The Zambian SAM classifies labor by education level; however, the Tanzanian SAM classifies labor by employment status (e.g., professional, white collar, blue collar). Thus, in the case of the Tanzanian SAM, we estimated the cells for the labor groups by education level, applying the same labor structure as in Zambia.

<sup>15</sup> In Zambia, copper mining is important. Mining is included in industry. The Tanzanian SAM and Zambian SAM do not include income transfers between household groups. They do, however, include transfers to and from the rest of the world.

Figure 4. An Agent's Optimization of Schooling



Considering life expectancy in each country, a working life of 30 years was assumed.<sup>16</sup> Other parameters, such as elasticities, are adopted from previous relevant CGE studies.<sup>17</sup>

The labor supply of educated workers is assumed to display constant returns to scale for education expenditure and schooling efforts, with both elasticities assumed to be set at 0.5, with the remaining constants calibrated on the basis of SAM data. The supplies of primary-educated and higher-educated labor types are first determined with these estimated equations, and the supply of noneducated labor is determined residually, assuming that the total work force grows at the population growth rate of 2.5 percent.

Labor income is allocated to each household group based on the prevailing factor (resource) endowment structures in the two countries, as revealed in their respective SAMs. That is, we assume that the flow of new labor types is distributed across household groups in the same

<sup>16</sup> Labor stocks are estimated with household survey results as provided in World Bank country documents. Life expectancies at birth and at age 15 are projected at 44.1 and 38.0 years in Tanzania and 40.2 and 37.5 years in Zambia, respectively, for 2000–05 (World Bank, World Development Indicators 2000).

<sup>17</sup> As in the studies by Devarajan, Go, and Li (1999), Dorosh and Sahn (2000), and Dorosh (1994), we assumed elasticities of substitution for production factors in the range of 0.3–0.8, while those for consumption (with imports) and transformation (with exports) ranged between 0.6–1.2.

way as that of the whole labor stock. Factor endowments of household groups are calibrated from the SAMs, which reveal major differences between the two countries. In Tanzania poor households (both rural and urban) are largely endowed with noneducated labor, while nonpoor households are mainly endowed with educated labor. In contrast, in Zambia, we find that poor households include significant proportions of educated workers and, conversely, that nonpoor households include many noneducated workers. In that sense, Zambia appears to suffer more than Tanzania from “educated unemployment.”

#### **D. Methodological Caveats**

The study focuses on the impact on the labor market and macroeconomy of an increase in public education expenditure, assuming the qualitative aspect of education and other expenditures (including health) remains unchanged under different policy experiments. Compared with previous partial-equilibrium research, the study can contribute to the reduction of specification errors generated by closely related but omitted variables. Even more importantly, it can help shed light on the interlinkages among education expenditure and other macroeconomic and distributional variables.

The results should be interpreted in light of the methodological limitations of our approach. First, we assume that increased public education expenditure will result in improved education outcomes; several studies, however, caution that improvements in the quality of spending may also be needed to ensure that higher spending translates into better educational outcomes.<sup>18</sup> Second, we assume that the technology and resource endowment shares of different household groups are fixed, without any significant dynamic changes during the time span of the policy experiments (except in our third scenario, where better targeting of education expenditure affects the human capital endowment of the poor alone). This can be justified on the grounds that our simulations involve relatively moderate policy changes, which are unlikely to lead to significant changes in the resource endowment matrix.

### **IV. POLICY EXPERIMENTS**

In our policy experiments, we presume two policy options: (1) an increase in real education spending of 15 percent; (2) an increase in real education spending of 30 percent.<sup>19</sup> The results of these two policy options are, in turn, compared with those of the base run that has no increase in real education expenditures. In the base run, even without any education expenditure expansion in real terms, the economy accumulates both physical capital and

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<sup>18</sup> See for example, Gupta, Verhoeven, and Tiongson (1999); Hanushek (1996); and Behrman and Birdsall (1983).

<sup>19</sup> Based on data from nineteen HIPC countries, education expenditure will increase on average from 3.9 percent of GDP in 1999/2000 to 4.8 percent of GDP in 2000/01, which is an almost 20 percent increase. This appears consistent with the range of a 15 to 30 percent increase adopted in our policy experiments.



human capital (through an increase in the labor stock), and we assume that each type of labor grows at the population growth rate of 2.5 percent. Once there is an increase in real education expenditure, the supply of educated labor grows by more than 2.5 percent.<sup>20</sup> For simplicity, we assume that all other exogenous variables remain constant in real or dollar terms, including total government expenditure and foreign financing.<sup>21</sup> That is, we assume that the economies maintain sound macroeconomic frameworks, as envisioned in their PRSPs.

We assume that the adjustments required to reach a new equilibrium take place within one period, even though in reality education output is produced over a long gestation period. The enrollment ratios in the two countries are quite low, implying that an increase in human capital can be achieved rapidly (e.g., through the reenrollment of students who had previously dropped out). Also, it is not unrealistic to assume that the stock of human capital would increase not only quantitatively, but also qualitatively, following a rise in public expenditures on education. Although our model, as such, cannot capture these qualitative effects, positive results can be achieved in the short run, and further contribute to the creation of human capital.

It should be noted that the present model assumes that the labor markets for the three types of labor are segmented, although firms choose an optimal mix of labor types, depending on relative wages. The model assumes that higher-educated workers do not enter the market for primary-educated or noneducated workers, and that primary-educated workers do not enter the market for noneducated workers. In the real world, it is not unusual that unemployed educated workers, after searching unsuccessfully for a job in the formal sector, decide to enter the market for less-skilled labor in the informal sector. This process could lead to some crowding out of less-educated workers and a corresponding decline in their wage rates, as well as a rise in the wage rate of the more educated labor categories. We do not believe that the magnitude of the above “downscaling” would be large enough to alter significantly the results we obtain with segmented markets. Finally, it should be noted that the impact of educational expenditure affects only the annual flow, which constitutes about 3.3 percent of the labor stock, assuming a 30-year working life.

Three different counterfactual scenarios are simulated within the model. In the first scenario, we examine the results under the extreme assumption that the total labor supply would rise at the population growth rate of 2.5 percent. This assumption would be reasonable whenever effective demand for labor were constrained in the short run. However, in general, it might be more realistic to assume that additional unskilled (noneducated) labor—presently unemployed—would reenter the labor force if their wage rate were to increase. Thus, in the

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<sup>20</sup> We assume that public education expenditure amounts to 4 percent of GDP in both countries in the base run.

<sup>21</sup> That is, we suppose only a reallocation of government resources to education from other sectors, maintaining a total government expenditure constant in real terms. We also assume that government spending on public investment remains constant: thus, an increase in education spending does not crowd out growth-enhancing public investment projects.

second scenario, we assume that previously unemployed noneducated workers would flow into the market as they observed a rise in the wage rate of noneducated workers, and this flow would stop when the wage rate for this type of labor returned to its normally expected level, which is equal to the level in the base run (the case with no real education expenditure increase). In the final scenario, we assume, furthermore, that the increase in real education expenditure would be perfectly targeted to poor household groups, implying that any additional educated labor supply over and above the population growth rate (2.5 percent) would originate exclusively from poor groups. In this case, the endowment of human capital of the poor groups would increase relative to that of the nonpoor household groups.

#### **A. Scenario 1—Fixed Total Labor Supply**

The growth of total labor supply is assumed to be fixed at the population growth rate of 2.5 percent. Under this assumption, as the supply of educated labor rises by more than the natural growth rate as a result of larger education expenditure, the supply of noneducated labor, which is determined residually, grows by less.

##### **Labor market**

The growth rate of the educated labor supply, which was initially 2.5 percent, now ranges between 2.9–3.3 percent, increasing by 0.4 percentage point for each 15 percent rise in real education expenditure (Table 3). The labor supply of the noneducated workers must grow at a lower rate than 2.5 percent, since it is determined residually. Regarding wage levels, the relative improvement of the noneducated wage level (compared to the other labor types) is significant in both countries, while the rate of growth of the wage rate of educated workers is falling. As primary- and higher-educated workers are supplied more abundantly, the noneducated become relatively more scarce and see their wages go up.

Under this scenario the growth rate of the average wage of the whole economy in Tanzania improves following an expansion in education expenditure, while that of Zambia worsens. The lower elasticity of demand for skilled labor in Zambia, relative to unskilled labor, contributes to the reduction of average wages as education levels increase. The likely reason for this is related to the lower physical capital accumulation in Zambia compared to Tanzania. The rise in the number of skilled workers is not matched with a sufficient increase in physical capital, limiting thereby the labor productivity and thus the wage rate in the model.<sup>22</sup>

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<sup>22</sup> Due to low savings ratios, the capital stock is estimated to increase by only 2.2 percent in Zambia, while that in Tanzania increases by 13.7 percent in the base run.

Table 3. Labor Supply and Wage Levels (Scenario 1)

	Tanzania			Zambia		
	Base	15%	30%	Base	15%	30%
Labor supply (increase rate, %)	2.5	2.5	2.5	2.5	2.5	2.5
- Noneducated	2.5	0.4	-1.5	2.5	0.6	-1.2
- Primary-educated	2.5	2.9	3.3	2.5	2.9	3.3
- Higher-educated	2.5	2.9	3.3	2.5	2.9	3.3
Wage rates (increase rate, real, %)	4.6	4.6	4.7	-2.3	-2.4	-2.5
- Noneducated	3.9	6.2	8.5	-1.5	0.5	2.4
- Primary-educated	4.7	4.4	4.2	-1.1	-1.5	-1.8
- Higher-educated	4.6	4.0	3.3	-4.2	-4.9	-5.6

### Macroeconomic consequences

The GDP growth rate is improved in both countries by around 0.1 percentage point for each 15 percent increase in education expenditure (Table 4). The savings and investment ratios remain almost constant. The interest rate remains constant or decreases slightly.<sup>23</sup> However, as previously noted, the savings and investment ratios of Zambia are much lower than in Tanzania in the baseline scenario: 29.3 percent in Tanzania and 14.5 percent in Zambia.<sup>24</sup>

Table 4. Growth, Interest, Exchange Rates (Scenario 1)

	Tanzania			Zambia		
	Base	15%	30%	Base	15%	30%
GDP growth (real, increase rate, %)	4.4	4.5	4.5	2.2	2.2	2.3
Investment (in percent of GDP)	29.9	30.0	30.0	15.8	15.8	15.8
Interest rate (%)	28.9	28.9	28.8	31.2	31.1	31.0
Real exchange rate (increase rate, %)	-4.3	-4.2	-4.1	4.3	4.5	4.6

<sup>23</sup> The equations specify both savings and investment as depending on the interest rate. However, considering the trends in the countries, the elasticity of savings to the interest rate is assumed to be 0, specifying savings only as a function of income. The elasticity of investment to the interest rate is assumed to be 1.0.

<sup>24</sup> In the present experiments, Tanzania (1992) represents a high-investing economy and Zambia (1995) represents a low-investing economy. The model was calibrated on the SAMs of Tanzania 1992 and Zambia 1995. However, the PRSPs of the two countries plan investment ratios of 17 percent in Tanzania and 20.7 percent in Zambia for 2002.

The exchange rate increases (depreciates) in both countries. A greater exchange rate depreciation is required to achieve a greater amount of exports that can balance the external sector in the model, since the increased domestic absorption induces a greater amount of imports.

### Income distribution

In both countries the relative increase in capital income is greater than that of the wage rate consequent to an expansion in public expenditure on education (Table 5). As the supply of educated labor increases and capital becomes relatively more scarce, capital income grows faster than labor income. This trend is more prominent in Zambia, where savings and capital accumulation are relatively low, making capital more scarce and valued.<sup>25</sup> However, this fact does not appear to affect in any significant way the simulated changes in household incomes.<sup>26</sup> One reason is that land is included as part of the capital stock. Some poor groups, especially rural poor, own land and receive rental (mainly imputed) income. In both countries, education spending raises the income of the rural poor, but only by a small amount. One interesting result of the experiment is that higher education spending under this scenario could reduce the income growth of the urban poor in Zambia. This owes to the heavy reliance of this group on income from educated labor. Thus, an increase in education spending—by increasing the supply of educated labor—actually leaves the urban poor group worse off. The rural poor, meanwhile, benefit from higher education spending and the concomitant increase in wages of the unskilled.

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<sup>25</sup> In this context, it should be noted that the baseline results for the growth in household and wage income were sensitive to assumptions regarding the growth rate of the capital stock. Under the assumption that the capital stock increased by 5 percent in real terms in Zambia, for example, real wages were estimated to rise by 0.9 percent, and household incomes by 3.0 percent.

<sup>26</sup> The classifications of household categories used in the SAMs of Tanzania and Zambia do not correspond exactly to the classification adopted in our model. Based on locational, occupational, and income characteristics the following conversion was adopted:

	<u>Urban Poor</u>	<u>Urban Nonpoor</u>	<u>Rural Poor</u>	<u>Rural Nonpoor</u>
Tanzania	Urban farmers	Urban nonfarmers	Rural farmers	Rural nonfarmers
Zambia	Metropolitan low income	Metropolitan high income	Nonmetropolitan rural	Nonmetropolitan urban

These different definitions of poor vs. nonpoor household categories might matter if the intent were to make poverty comparisons between these two countries in the base year. However, our objective is to explore the impact of alternative counterfactual (policy) scenarios on the *change* in income distribution and the magnitude of poverty in the two countries.

Table 5. Income Distribution (Scenario 1)

	Tanzania			Zambia		
	Base	15%	30%	Base	15%	30%
Wage income (real, increase rate, %)	8.4	8.4	8.5	-0.2	-0.3	-0.3
Capital income (real, increase rate, %)	1.4	1.5	1.6	3.7	3.9	4.0
Household income (real, increase rate, %) 1/	5.5	5.5	5.6	1.3	1.4	1.4
- Urban poor	4.2	4.3	4.4	0.7	0.6	0.6
- Urban nonpoor	8.6	8.5	8.4	2.1	2.2	2.2
- Rural poor	4.3	4.5	4.6	1.3	1.4	1.4
- Rural nonpoor	6.4	6.5	6.6	2.0	2.1	2.2

1/ Household income includes not only labor and capital income but also includes government and foreign transfers.

### B. Scenario 2—Excess Supply of Unskilled (Noneducated)

In this case we assume that previously unemployed noneducated workers flow back into the labor market as they observe the wage rate of their labor type go up, and this flow of new entrants stops when their wage rate returns to the level in the base run (no education expenditure increase).

#### Labor market

Under this assumption of a very elastic labor supply of unskilled workers, the labor supply of educated workers rises at the same rate as in the first scenario; however, the labor supply of noneducated workers rises more than that in the first scenario (Table 6). The supply of noneducated workers is estimated to grow at 2.7–2.8 percent in Tanzania, and 2.3–2.4 percent in Zambia, leading to a growth of the total labor supply ranging between 2.8 and 3.2 percent.

Table 6. Labor Supply and Wage Levels (Scenario 2)

	Tanzania			Zambia		
	Base	15%	30%	Base	15%	30%
Labor supply (increase rate, in percent)	2.5	2.9	3.2	2.5	2.8	3.1
- Noneducated	2.5	2.7	2.8	2.5	2.4	2.3
- Primary-educated	2.5	2.9	3.3	2.5	2.9	3.3
- Higher-educated	2.5	2.9	3.3	2.5	2.9	3.3
Wage rates (increase rate, real, in percent)	4.5	4.3	4.1	-3.0	-3.4	-3.9
- Noneducated	3.9	3.9	3.9	-1.5	-1.5	-1.5
- Primary-educated	4.7	4.4	4.1	-1.1	-1.6	-2.1
- Higher-educated	4.6	4.3	4.1	-4.2	-4.8	-5.4

The supply response of unskilled (noneducated) workers in both countries has a moderating effect on their wage rates. Compared with the results under the Scenario 1, as education expenditures increase, the wage rates of primary-educated workers worsen to a greater degree than those of higher-educated workers in both countries. This can be explained by their different degrees of labor substitutability with the unskilled (higher for primary-educated, lower for higher-educated).<sup>27</sup> It should be noted that, in comparing the two countries, the wage rates of educated workers worsen to a greater degree in Zambia. This can be explained by the fact that the production structures are very different in the two countries. Zambia possesses a relatively larger share of industry and services, which rely more on educated labor, while Tanzania has a relatively larger share of agriculture, which depends more on unskilled workers.

### Macroeconomic consequences

The GDP growth rate improves by 0.1–0.3 percentage point with each 15 percent increase in education expenditure in both countries (Table 7). Compared with the results of the previous scenario, savings and investment ratios are almost similar, while the real exchange rate shows less appreciation in Tanzania and more depreciation in Zambia. The economies both grow at a higher rate with increased domestic absorption.

Table 7. Growth, Interest, Exchange Rates (Scenario 2)

	Tanzania			Zambia		
	Base	15%	30%	Base	15%	30%
GDP growth (real, increase rate, in percent)	4.4	4.6	4.9	2.2	2.3	2.5
Investment (in percent of GDP)	29.9	30.0	30.0	15.8	15.8	15.8
Interest rate (in percent)	28.9	28.9	28.9	31.2	31.2	31.2
Real exchange rate (increase rate, in percent)	-4.3	-4.2	-4.0	4.3	4.7	5.0

### Income distribution

As the economies grow faster, household incomes also grow faster in both countries (Table 8). All household groups benefit from the higher income growth in both countries, as the increase in labor supply (employment) more than compensates for the declining growth

<sup>27</sup> Wage rates of educated workers are affected by two elements: higher economic growth results in higher wage rates, and a larger supply of unskilled workers and their lower wage rate cause greater substitution of educated workers. Primary-educated workers, who are more substitutable with the unskilled, are more affected by the latter, while higher-educated workers, who are less substitutable with the unskilled, are more affected by the former.

of wage rates. However, the poor benefit more than the nonpoor from the expansion in education expenditure in Tanzania, with the opposite result in Zambia. As previously mentioned, the endowment of human capital of poor households in Zambia differs from that of Tanzania, including a larger proportion of educated individuals within those poor households.

Table 8. Income Distribution (Scenario 2)

	Tanzania			Zambia		
	Base	15%	30%	Base	15%	30%
Wage income (real, increase rate, in percent)	8.4	8.5	8.6	-0.2	-0.4	-0.5
Capital income (real, increase rate, in percent)	1.4	1.8	2.2	3.7	4.1	4.5
Household income (real, increase rate, in percent) 1/	5.5	5.7	5.9	1.3	1.4	1.5
- Urban poor	4.2	4.5	4.7	0.7	0.7	0.7
- Urban nonpoor	8.6	8.7	8.8	2.1	2.4	2.6
- Rural poor	4.3	4.6	4.8	1.3	1.4	1.4
- Rural nonpoor	6.4	6.5	6.7	2.0	2.2	2.4

1/ Household income includes not only labor and capital income but also includes government and foreign transfers.

### C. Scenario 3—Targeted Education Expenditure

Under this scenario, we assume that education expenditure is perfectly targeted to poor household groups. The increase in educated labor supply in excess of the initial 2.5 percent growth is assumed to originate exclusively from urban poor or rural poor household groups. This increased supply of educated labor is then incorporated in the factor endowment matrix of those household groups.

#### Labor market and macroeconomic consequences

Under this setting, the labor supply is the same as in scenario 2, and wage levels remain almost unchanged (Table 9). As for the macroeconomic consequences, the poor household groups receive more income, and spend more on food products, benefiting the agricultural sector. Hence, that sector is observed to grow marginally faster than in the prior cases. The economic growth and macro variables remain almost constant under this scenario compared with scenario 2.

#### Income distribution

Poor household groups' incomes improve significantly in both countries under this scenario, while nonpoor groups' incomes increase relatively less, resulting in a more equal income distribution. However, the impact is smaller in Zambia than in Tanzania: both poor and nonpoor households benefit relatively equally, with a smaller impact on income distribution.

The main reason for this result is the dispersion of educated workers among nonpoor and poor household groups in Zambia, while in Tanzania, educated workers are more concentrated within nonpoor household groups.<sup>28</sup> That is, the educated poor are more common in Zambia, implying that the effective demand for educated labor (job opportunities) is quite limited.

Table 9. Income Distribution (Scenario 3)

	Tanzania			Zambia		
	Base	15%	30%	Base	15%	30%
Wage income (real, increase rate, in percent)	8.4	8.5	8.7	-0.2	-0.4	-0.5
Capital income (real, increase rate, in percent)	1.4	1.8	2.2	3.7	4.1	4.5
Household income (real, increase rate, in percent) 1/	5.5	5.7	5.9	1.3	1.4	1.5
- Urban poor	4.2	4.7	5.2	0.7	0.7	0.8
- Urban nonpoor	8.6	8.3	8.0	2.1	2.3	2.4
- Rural poor	4.3	4.7	5.0	1.3	1.4	1.5
- Rural nonpoor	6.4	6.3	6.2	2.0	2.1	2.1

1/ Household income includes not only labor and capital income but also includes government and foreign transfers.

## V. SUMMARY AND POLICY IMPLICATIONS

Our results suggest that an increase in public expenditure on education can contribute to economic growth and poverty alleviation. In this context, it should be noted that all simulation experiments presumed sound macroeconomic policies, as total government expenditure and capital inflows were kept constant in real or dollar terms. The policy experiment results also imply that the poverty and growth effects of education expenditure will differ across countries. This suggests that poverty reduction strategies should be closely tailored to each country's technology and factor endowment structures; similar policies in different countries may, in practice, lead to different outcomes. Nevertheless, an important implication of the experimental results is that, to maximize their beneficial impact, increases in education expenditure should be supported by appropriate policy measures, as explained below:

**Significant poverty alleviation can be achieved most effectively through better targeting of educational expenditure to poor households.** Under most scenarios, higher public expenditure on education provides higher economic growth and higher incomes for the poor.

<sup>28</sup> To test how significant the factor endowments are, we experimented in the Zambian case with the Tanzanian endowment matrix of factors to household groups. The income distribution result was similar to that of Tanzania, assuring us that the pattern of factor endowments has an important impact on the distribution results.



However, without better targeting, the impact on poverty reduction remains marginal, as a comparison of the results of the three simulation scenarios reveals. To achieve better targeting, the government could, for example build more schools in and attract more teachers to rural areas.

**The government should implement policies that enhance the demand for labor through an appropriate pattern of economic growth.** In Zambia, many educated workers are poor, in large part because of low growth in the past and few job opportunities. Because of this mismatch between skilled labor supply and demand, the expansion of the education system has had a limited effect in alleviating poverty.

**To enhance the value of educated labor, the mix of education output should conform better to the economy's prevailing production structure and effective demand for labor.** The educational system should produce the type of human capital—in terms of different labor skills—that correspond to the pattern of labor demand.

**Employment increases are essential for poverty reduction.** The results indicate that the growth and poverty consequences of education expenditure are more favorable under conditions of excess labor supply, which in turn are associated with higher employment growth (and lower wage growth) than the in scenario with rising wages. This implies that poverty reduction can be facilitated by labor market flexibility and a reduction in barriers to employment growth.

The results also suggest that future research could fruitfully examine the link among other determinants of labor supply, employment, and income distribution. In particular, it would be useful to examine the linkage between health expenditure and labor supply, especially in light of the high incidence of HIV/AIDS in both Tanzania and Zambia.

**Sufficient investment is necessary to improve labor productivity.** When baseline scenarios are compared across countries, one striking result is the effect of investment on the rate of growth of wages and capital incomes. When investment rates were low, as in Zambia, wage increases were limited, and the relative value of capital and capital income increased relatively more, worsening income distribution. This result should be interpreted with caution, however, given the sensitivity of the results to assumptions regarding the rate of growth of the capital stock, the difficulty in estimating an initial capital stock, and the fact that current investment-to-GDP ratios differ somewhat from those incorporated in the Zambian SAM. Nevertheless, the results imply that poverty reduction strategies should ensure that efforts to strengthen human capital are complemented by sufficient levels of public and private investment.

## Social Accounting Matrices (SAMs)

### 1. Tanzania: 1992 SAM

	Agriculture	Industry	Service	Commodity-Agriculture	Commodity-Industry	Commodity-Service	Non-educated	Primary-educated	Higher-educated	Capital income	Urban poor	Urban non-poor	Rural poor	Rural non-poor	Company	Govt. recurrent	Govt. investment	Indirect tax	Tariff	Capital	World	Total	
Agriculture	0.000	0.000	0.000	0.844	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.042	0.886	
Industry	0.000	0.000	0.000	0.000	1.057	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.051	1.107
Service	0.000	0.000	0.000	0.000	0.000	1.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.073	1.098
Commodity-Agriculture	0.086	0.180	0.119	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.082	0.299	0.017	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.854
Commodity-Industry	0.076	0.280	0.159	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.081	0.148	0.355	0.028	0.000	0.000	0.053	0.000	0.000	0.404	0.000	1.584	
Commodity-Service	0.157	0.323	0.230	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.031	0.051	0.010	0.000	0.279	0.000	0.000	0.011	0.000	0.000	1.108	
Noneducated	0.052	0.021	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.106	
Primary-educated	0.396	0.049	0.083	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.244	
Higher-educated	0.045	0.063	0.136	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.244	
Capital income	0.069	0.178	0.332	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.578	
Urban poor	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.067	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.078	0.000	0.000	0.000	0.000	0.023	0.203	
Urban non-poor	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.134	0.181	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.001	0.331	
Rural poor	0.000	0.000	0.000	0.000	0.000	0.000	0.079	0.293	0.030	0.000	0.000	0.000	0.000	0.000	0.224	0.000	0.000	0.000	0.000	0.000	0.099	0.726	
Rural non-poor	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.034	0.005	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.003	0.061	
Company	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.578	0.000	0.000	0.000	0.000	0.000	0.000	0.028	0.000	0.000	0.000	0.000	0.000	0.606	
Government recurrent	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.011	0.002	0.065	0.000	0.000	0.071	0.023	0.018	0.173	0.366	
Government investment	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.035	0.000	0.000	0.000	0.000	0.018	0.553	
Indirect tax	0.006	0.015	0.006	0.002	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.071	
Tariff	0.000	0.000	0.000	0.001	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.023	
Capital	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.036	0.034	0.009	0.004	0.195	0.000	0.000	0.000	0.000	0.004	0.158	0.441	
World	0.000	0.000	0.000	0.008	0.462	0.083	0.000	0.000	0.000	0.000	0.000	0.034	0.000	0.000	0.030	0.024	0.000	0.000	0.000	0.000	0.000	0.641	
Total	0.886	1.107	1.098	0.854	1.584	1.108	0.106	0.528	0.244	0.578	0.203	0.331	0.726	0.061	0.606	0.366	0.053	0.071	0.023	0.441	0.641	11.61	

### 2. Zambia: 1995 SAM

	Agriculture	Industry	Service	Commodity-Agriculture	Commodity-Industry	Commodity-Service	Non-educated	Primary-educated	Higher-educated	Capital income	Urban poor	Urban non-poor	Rural poor	Rural non-poor	Company	Government recurrent	Direct tax	Indirect tax	Tariff	World	Capital	Total
Agriculture	0.000	0.000	0.000	1.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.030	0.000	1.07
Industry	0.000	0.000	0.000	0.000	2.381	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.999	0.000	3.38
Service	0.000	0.000	0.000	0.000	0.000	3.278	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.054	0.000	3.33
Commodity-Agriculture	0.039	0.390	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.130	0.036	0.439	0.066	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.10
Commodity-Industry	0.227	0.947	0.607	0.000	0.000	0.000	0.000	0.000	0.000	0.420	0.201	0.520	0.071	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.478	3.47
Commodity-Service	0.199	0.998	1.622	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.088	0.065	0.148	0.018	0.000	0.464	0.000	0.000	0.000	0.000	0.000	3.60
Noneducated	0.047	0.039	0.084	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.17
Primary-educated	0.358	0.094	0.212	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.66
Higher-educated	0.040	0.120	0.349	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.50
Capital income	0.155	0.706	0.435	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.29
Urban poor	0.000	0.000	0.000	0.000	0.000	0.000	0.022	0.165	0.228	0.000	0.000	0.000	0.000	0.000	0.194	0.062	0.000	0.000	0.000	0.000	0.000	0.67
Urban non-poor	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.024	0.108	0.000	0.000	0.000	0.000	0.000	0.317	0.013	0.000	0.000	0.000	0.000	0.000	0.46
Rural poor	0.000	0.000	0.000	0.000	0.000	0.000	0.136	0.437	0.153	0.000	0.000	0.000	0.000	0.000	0.360	0.029	0.000	0.000	0.000	0.000	0.000	1.11
Rural non-poor	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.038	0.019	0.000	0.000	0.000	0.000	0.000	0.086	0.003	0.000	0.000	0.000	0.000	0.000	0.15
Company	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.296	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.29
Government recurrent	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.190	0.194	0.165	0.000	0.295	0.84
Direct tax	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.134	0.000	0.000	0.000	0.056	0.000	0.000	0.000	0.000	0.000	0.000	0.19
Indirect tax	0.005	0.086	0.018	0.001	0.051	0.034	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.19
Tariff	0.000	0.000	0.000	0.004	0.126	0.034	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.16
World	0.000	0.000	0.000	0.059	0.913	0.257	0.000	0.000	0.000	0.000	0.000	0.018	0.000	0.000	0.235	0.000	0.000	0.000	0.000	0.000	0.000	1.48
Capital	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.033	0.010	0.009	0.002	0.048	0.273	0.000	0.000	0.000	0.399	0.000	0.77
Total	1.070	3.380	3.332	1.104	3.471	3.602	0.171	0.664	0.509	1.296	0.671	0.464	1.116	0.156	1.296	0.845	0.190	0.194	0.165	1.481	0.773	25.9

### List of Equations and Notations

#### Equations

##### Prices

- (1)  $PE_i = ER \cdot \overline{PWE}_i / (1 + te_i)$
- (2)  $PM_i = ER \cdot \overline{PWM}_i \cdot (1 + tm_i)$
- (3)  $PD_i = (PX_i \cdot X_i - PE_i \cdot E_i) / D_i$
- (4)  $P_i = (PD_i \cdot D_i + M_i \cdot PM_i) / Q_i$
- (5)  $PVA_i = PX_i \cdot (1 - ti_i) - \sum_j v_{ji} \cdot PX_j$
- (6)  $PK_i = \sum_j kp_{ij} \cdot P_j / \sum_j kp_{ij}$
- (7)  $PIND = \sum_i P_i \cdot \omega_i$

##### Products

- (8)  $X_i = A_i [\lambda_i LB_i^{\rho_i} + (1 - \lambda_i) \overline{K}_i^{\rho_i}]^{\frac{1}{\rho_i}}$
- (9)  $X_i = AT_i [\lambda_i E_i^{\rho_i} + (1 - \lambda_i) D_i^{\rho_i}]^{\frac{1}{\rho_i}}$
- (10)  $Q_i = AC_i [\lambda_c M_i^{\rho_c} + (1 - \lambda_c) D_i^{\rho_c}]^{\frac{1}{\rho_c}}$
- (11)  $E_i = D_i \left[ \left( \frac{PD_i}{PE_i} \right) \left( \frac{\lambda_i}{1 - \lambda_i} \right) \right]^{\frac{1}{1 - \rho_i}}$
- (12)  $M_i = D_i \left[ \left( \frac{PD_i}{PM_i} \right) \left( \frac{\lambda_c}{1 - \lambda_c} \right) \right]^{\frac{1}{1 - \rho_c}}$

##### Labor markets

- (13)  $WB_i LB_i = X_i PVA_i (\lambda_i LB_i^{\rho_i} / (\lambda_i LB_i^{\rho_i} + (1 - \lambda_i) \overline{K}_i^{\rho_i}))$
- (14)  $LA_i = ALA_i \cdot \prod_{i=1}^2 LIL_{i1}^{lf_{i1}}$
- (15)  $\left( \frac{LIL_{i2}}{LIL_{i1}} \right) = \left( \frac{lf_{i2}}{lf_{i1}} \right) \cdot \left( \frac{wd_{i1} \cdot W_1}{wd_{i2} \cdot W_2} \right)$
- (16)  $LB_i = ALB_i (\lambda_i LA_i^{\rho_i} + (1 - \lambda_i) LIL_{i3}^{\rho_i})^{\frac{1}{\rho_i}}$

$$(17) \quad LIL_{i3} = LA_i \left[ \left( \frac{WA_i}{wd_{i3} \cdot W_3} \right) \left( \frac{1 - \lambda_i}{\lambda_i} \right) \right]^{\frac{1}{1 - \rho_i}}$$

$$(18) \quad WA_i = \left( \frac{1}{AL_i} \right) \cdot \prod_{l=1}^2 \left( \frac{wd_{il} W_l}{lf_{il}} \right)^{f_{il}}$$

$$(19) \quad WB_i = (wd_{i3} \cdot W_3 \cdot LIL_{i3} + WA_i \cdot LA_i) / LB_i$$

$$(20) \quad \bar{L} \bar{S}_i \cdot (1 - \bar{u}_i) = \sum_i LIL_{ii}$$

**Incomes**

$$(21) \quad YL_i = \sum_i wd_{ii} \cdot W_i \cdot LIL_{ii}$$

$$(22) \quad KINC_i = PVA_i X_i - WA_i \cdot LA_i$$

$$(23) \quad YN = \sum_i KINC_i + fgn \cdot \overline{GCT}$$

$$(24) \quad YDN = (1 - tn - fsn - fwn) \cdot YN$$

$$(25) \quad Y_h = \sum_i fl_{hi} \cdot (1 - s_i) \cdot YL_i + fk_h \cdot YDN + fg_h \cdot \overline{GCT} + \overline{TRW}_h \cdot ER$$

$$(26) \quad YD_h = (1 - th_h - fw_h) \cdot Y_h$$

$$(27) \quad TET = \sum_i te_i \cdot E_i \cdot ER \cdot \overline{PWE}_i$$

$$(28) \quad TMT = \sum_i tm_i \cdot M_i \cdot ER \cdot \overline{PWM}_i$$

$$(29) \quad TIT = \sum_i ti_i \cdot D_i \cdot PD_i$$

$$(30) \quad THT = \sum_h th_h \cdot Y_h$$

$$(31) \quad TNT = \sum_i tn \cdot YN$$

$$(32) \quad GR = TMT + TET + TIT + THT + TNT$$

**Expenditures**

$$(33) \quad P_i C_i = \sum_h [\alpha_{ih} \cdot (YD_h - SH_h)] \text{ where } \sum_i \alpha_{ih} = 1$$

$$(34) \quad GC_i = fgc_i \cdot \overline{GCT}$$

$$(35) \quad GI_i = fgi_i \cdot \overline{GIT}$$

$$(36) \quad GE = \sum_i P_i \cdot GC_i + \sum_i PK_i \cdot GI_i + \sum_h PIND \cdot fg_h \cdot \overline{GCT} + PIND \cdot fgn \cdot \overline{GCT}$$

### *Savings and investment*

$$(37) \quad SN = fsn \cdot YN$$

$$(38) \quad SH_h = s_h \cdot (1+r)^{\beta s_h} \cdot YD_h$$

$$(39) \quad SG = GR - GE$$

$$(40) \quad TS = \sum_h SH_h + SG + SN + \overline{FSV} \cdot ER$$

$$(41) \quad \frac{INV_i}{K_i} = ai_i \cdot \left( \frac{KINC_i}{PK_i \cdot K_i \cdot r} \right)^{\beta i}$$

$$(42) \quad INV_i = \sum_j kp_{ij} \cdot IVD_j$$

### *Market equilibrium*

$$(43) \quad Q_i = \sum_j v_{ij} X_j + C_i + IVD_i + GC_i + GI_i$$

$$(44) \quad \sum_i (\overline{PWE}_i \cdot ER \cdot E_i - \overline{PWM}_i \cdot ER \cdot M_i) + \sum_h (\overline{TRW}_h \cdot ER - fw_h \cdot Y_h) - fwn \cdot YN + \overline{FSV} \cdot ER = 0$$

$$(45) \quad RGDP = \left( \sum_i PVA_i \cdot X_i + TI + TM + TE \right) / PIND$$

### *Intertemporal adjustments*

$$(46) \quad \overline{K}_i(t+1) = \overline{K}_i(t) \cdot (1 - dp_i) + INV_i(t)$$

$$(47) \quad s_l = ASL_l \cdot \left( \frac{(W_{m0} - W_{l0}) \cdot (1+g)}{W_{l0} \cdot (r-g)} \right)^{\frac{1}{(1-\gamma)}}$$

$$(48) \quad MS_m = AS_m \cdot (s_l \cdot W_{l0})^{\beta m_1} \cdot EG^{\beta m_2}$$

$$(49) \quad ML_3 = MS_3, \quad ML_2 = MS_2 - MS_3, \quad \sum_i (ML_i(t) - LS_i(t) \cdot dh_i) = n \cdot EAP(t)$$

$$(50) \quad LS_i(t+1) = LS_i(t) \cdot (1 - dh_i) + ML_i$$

**Notations**

**Parameters**

$A_i$	Production shift parameter
$AC_i$	Composite good supply shift parameter
$AT_i$	CET shift parameter
$dh_i$	Depreciation rate of human capital
$dp_i$	Depreciation rate of physical capital
$fg_h$	Share of government transfer to household group h
$fgn$	Share of government transfer to company
$fk_h$	Share of capital income to household group h
$fw_h$	Share of capital income to rest of world (row)
$fl_{hl}$	Share of labor income of level l to household group h
$gc_i$	Share of government consumption in total expenditure
$gi_i$	Share of government investment in total expenditure
$kp_{ij}$	Coefficient transforming investments from origin j to destination i
$lf_{il}$	Share of a level of labor l in sector i
$s_h$	Marginal propensity to save
$te_i$	Tax (= -subsidy) rate on export
$th_h$	Tax rate on household income of group h
$ti_i$	Tax rate of indirect tax on domestic goods
$tm_i$	Tax rate on imports including tariff
$tn$	Tax rate on company income
$u_i$	Unemployment rate of level l
$v_{ji}$	Input-output coefficient
$wd_{il}$	Wage difference between industries
$\alpha_{ih}$	Share of the consumption on good i
$\lambda_i$	Factor share parameter
$\lambda c_i$	Composite good supply share parameter
$\lambda l_i$	Labor share parameter
$\lambda t_i$	Output (CET) share parameter
$\rho_i$	Substitutability parameter in production
$\rho c_i$	Substitutability parameter in total demand
$\rho l_i$	Substitutability parameter in labor
$\rho t_i$	Substitutability parameter in output
$\omega_i$	Share of value added of product i

**Variables**

$C_i$	Consumption demand
$D_i$	Domestic sales of domestic output
$E_i$	Exports
$EAP$	Economically active population
$ER$	Exchange rate
$EG$	Total expenditure on education
$g$	Growth rate

<i>GC</i>	Total government consumption
<i>GDPVA</i>	Nominal GDP in market price
<i>GE</i>	Total government expenditure
<i>GI</i>	Total government investment
<i>GR</i>	Government revenue
<i>INV<sub>i</sub></i>	Investment by destination
<i>IV</i>	Aggregate investment
<i>IVD<sub>i</sub></i>	Investment by origin
$\overline{K}_i$	Capital stock of sector i
<i>KINC<sub>i</sub></i>	Capital income
<i>LA<sub>i</sub></i>	Composite of unskilled labor
<i>LB<sub>i</sub></i>	Composite labor
<i>LIL<sub>il</sub></i>	Labor demand of sector i for level l
<i>LS<sub>i</sub></i>	Labor supply
<i>M<sub>i</sub></i>	Imports
<i>ML<sub>l</sub></i>	New incomers of level l to labor market
<i>MS<sub>m</sub></i>	Total supply of education level m
<i>P<sub>i</sub></i>	Price of composite good
<i>PD<sub>i</sub></i>	Domestic sales price
<i>PE<sub>i</sub></i>	Domestic price of exports
<i>PIND</i>	Price index (GDP deflator)
<i>PK<sub>i</sub></i>	Price of capital good for investment in sector i
<i>PM<sub>i</sub></i>	Domestic price of imports
<i>PVA<sub>i</sub></i>	Value-added price
$\overline{PWE}_i$	World price of exports
$\overline{PWE}_i$	World price of imports
<i>PX<sub>i</sub></i>	Output price
<i>Q<sub>i</sub></i>	Composite goods supply
<i>RGDP</i>	Real GDP
<i>SF</i>	Savings in the external sector
<i>SG</i>	Government saving
<i>SH<sub>h</sub></i>	Savings of household group h
<i>SN</i>	Savings of company
<i>TET</i>	Revenue of export tax (or subsidy)
<i>THI</i>	Tax revenue on household income
<i>TII</i>	Indirect tax revenue
<i>TMT</i>	Tax on imports including tariff
<i>TNT</i>	Tax revenue on company income
<i>TRW<sub>h</sub></i>	Foreign transfer to household group h
<i>TS</i>	Total savings
<i>W<sub>l</sub></i>	Wage rate of level l
<i>WA<sub>i</sub></i>	Wage for the composite unskilled labor ( $LA_i$ )
<i>WB<sub>i</sub></i>	Wage for the composite labor ( $LB_i$ )

$X_i$	Domestic output
$D_i$	Output
$Y_h$	Total income of household group h
$YD_h$	Disposable income of household group h
$YDN$	Total disposable company income
$YL_i$	Total labor income of level l
$YN$	Total gross company income



## Applied Parameters for CGE Model

### 1. Elasticities of Substitution (Tanzania and Zambia)

	Agriculture	Industry	Services
$\rho_i$ (substitutability between capital and labor)	0.3	0.5	0.8
$\rho c_i$ (substitutability between domestic sales and imports)	1.2	0.8	0.6
$\rho t_i$ (substitutability between domestic sales and exports)	-1.2	-0.8	-0.6
$\rho l_i$ (substitutability between unskilled and higher-educated)	0.5	0.5	0.5

Source: Authors' assumptions. Similar figures can be found in Devarajan, Go, and Li (1999) and Dorosh and Sahn (2000).

### 2. Wage Differentials

	Tanzania			Zambia		
	Noneducated	Primary-educated	Higher-educated	Noneducated	Primary-educated	Higher-educated
Agriculture	0.755	0.944	0.984	0.498	0.691	0.610
Industry	0.975	0.861	0.736	1.495	1.970	1.124
Services	2.141	1.614	1.205	1.694	2.149	1.037

1/ Each figure represents the ratio of the wage rate for a specific education level in each sector to the average for that education level. The figures cannot be compared across education levels.

Sources: Authors' estimates based on Tanzanian 1992 SAM, Zambian 1995 SAM, and World Bank (1994, 1996, 1999).

### 3. Endowment Coefficients of Human Capital (Initial Values)

	Tanzania			Zambia		
	Noneducated	Primary-educated	Higher-educated	Noneducated	Primary-educated	Higher-educated
Urban poor	0.074	0.127	0.113	0.013	0.036	0.212
Urban nonpoor	0.102	0.254	0.741	0.130	0.248	0.449
Rural poor	0.748	0.554	0.125	0.060	0.057	0.037
Rural nonpoor	0.076	0.065	0.021	0.797	0.659	0.302
Total	1.000	1.000	1.000	1.000	1.000	1.000

Sources: Tanzanian 1992 SAM and Zambian 1995 SAM.

#### 4. Consumption Shares

##### Tanzania

	Urban poor	Urban nonpoor	Rural poor	Rural nonpoor
Agriculture	0.406	0.316	0.424	0.302
Industry	0.493	0.566	0.504	0.511
Services	0.101	0.118	0.073	0.188
Total	1.000	1.000	1.000	1.000

Source: Tanzanian 1992 SAM.

##### Zambia

	Urban poor	Urban nonpoor	Rural poor	Rural nonpoor
Agriculture	0.204	0.118	0.397	0.428
Industry	0.658	0.665	0.469	0.458
Services	0.137	0.217	0.134	0.113
Total	1.000	1.000	1.000	1.000

Source: Zambian 1995 SAM.

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