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Impact of increased public education spending on growth and poverty in Uganda

An integrated micro-macro approach

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Preamble

In recent years, UNICEF has increasingly called on the unique and versatile expertise of PEP-affiliated researchers and world-leading experts to assist in its advocacy work, by producing reliable and comprehensive bases of evidence on the situation of children and the impact of various policy options/interventions in favor of child welfare in developing countries. In some cases, UNICEF's commissions to PEP also involved the development of specific methodologies and tools to be used on a long-term basis as a source of reliable and renewable data on child welfare, either at the national or international levels.

This project stems from the desire expressed by UNICEF-Uganda to assess the impact of fiscal policies on the well-being of Ugandan children. From the outset, the authors and representatives of UNICEF-Uganda agreed that the policies to be analyzed should reflect the knowledge and concerns of local experts affiliated with MoFPED, UBOS, EPRC, Development Research and Training, UNDP, World Bank and UNICEF. A meeting was thus held in Kampala in February 2013 to validate the assumptions made by the authors in the development of the methodology, and to determine the scenarios to be studied.

The work presented below is thus reflective of the discussions with Ugandan experts. Although the well-being of children depends on multiple factors, the workshop participants agreed that the low quality of education received by children today remains the main concern in order to ensure them greater opportunities for the future, and thus, a better quality of life for their own children.

Executive summary

- The decreasing budget share allocated to education resulted in poor quality of services provided to the students and thus disappointing results in terms of primary education completion; close to 70% of the labor force did not complete primary school.
- Hence, workers have limited opportunity to participate in more productive activities as wage earners; therefore, workers are confined into low value-added sectors such as subsistence agriculture.
- Consequently, regional disparities remain, with rural living conditions below those of in urban areas, rural poverty being more than three times more prevalent than poverty in urban areas.
- Besides, children's poverty headcount continues to be greater than that of adults and poverty reduction has been less for the former.
- With that context in mind, a group of local experts met in Kampala in February 2013.
    - They agreed that the low quality of education received by children today remains the main concern in order to ensure them greater opportunities.
    - They also suggested that budget shares should meet stated policies, i.e., 18% of total budget.
    - They established that a major share of additional spending should be devoted to primary education.
    - They recommended spending increased to be financed either through increased indirect taxes, or by using the funds to be generated by the exploitation of oil resources.
    - They also recommended that the reference scenario should be based on the latest IMF projections and thus should include both the development and operation of oil extraction and refinement sectors.
- The consultants built an integrated micro-macro model, which is the best suited tool to evaluate the impact of such policies. Compared to the reference scenario, results show:
    - Better education performances:
        - Increasing the share of public spending on education by 3 percentage points leads to an increase in the number of children enrolled in primary schools by up to 6% (more than 8% if the entire amount is dedicated to primary education).
        - Improved participation and graduation rates, coupled with fewer dropouts, increase the number of children who complete primary education by up to 13%.
        - In 2025, these percentages correspond to 960,000 to 1,400,000 additional children enrolled in primary schools and to about 110,000 additional children completing primary education each year.
    - Increased number of skilled workers:
        - The number of workers who complete at least primary school is greater than what it would have been and this increase intensifies over time. In 2025, there would be between 340,000 and 540,000 additional skilled workers, depending on the scenario.
        - The number of skilled salaried employees thus increases, whereas the supply of other type of workers decreases.
    - Higher GDP growth rates in medium/long run:
        - In the short run, GDP growth rates are slightly below their reference level, due to students' increased and prolonged participation in school, but higher in the medium/long run.
        - GDP growth exceeds its reference level starting in 2017 when financed using the oil fund, and in 2021 if financed through indirect taxes.
        - Spending the entire extra budget in primary education generates higher GDP growth rates.
    - Poverty indicators improve in the long run:
        - In the short run, child poverty rates are slightly higher than in the reference scenario.
        - Poverty rates are statistically lower only in the long run, with a reduction by up to 99,000 poor children in 2023 compared with the reference scenario.

    - In the long run, slow absorption into the labor market of new skilled workers together with the price increase does not allow faster improvement in children's monetary well-being with respect to the reference scenario.
- From this analysis, it thus appears that increased public spending on education should prioritize primary education and that using oil funds would further improve overall economic indicators.
- Caveats:
  - Better participation and completion of primary education may have other important impacts both on the economy and on children's present and future wellbeing. For instance, it is well documented that better education positively affects nutrition and health indicators, which in turn positively affect both education and productivity. Education also impacts fertility rates.
  - The development of oil sectors in the economy might also generate spillover effects that could impact the labor market as well as economic indicators. Such effects are, however, highly speculative.
  - These impacts are beyond the scope of this project, and thus the results presented here should be seen as conservative.

1. Introduction

Over the past decades, Uganda has experienced impressive economic growth rates, far above the average among Sub-Saharan African countries. Indeed, on average, GDP grew by more than 6% annually since the 1990s, increasing per capita income by 4% yearly over the period (World Bank, 2012). Economic growth has been led mainly by strong private consumption growth rates and great performance of the export sectors (Matovu et al., 2011).

The structure of the economy has changed over time. The contribution of agriculture to GDP has steadily decreased, whereas the share of services increased markedly. However, as can be seen in the figure below, most of the labor force remains engaged in agriculture activities, mainly as family/self-employed workers. Hence, despite outstanding economic achievements, the economy remains highly dependent on agriculture (predominantly subsistence), which accounts for more than 75% of the labor force, while these sectors only account for 26% of GDP.

FIGURE 1: SECTORAL CONTRIBUTION TO THE WORKFORCE AND TO GDP

Source: Authors' calculation based on UNPS09/10 and SAM 2009

At the same time, it appears that the economic performance failed to benefit to all, thus increasing income inequality. Although poverty headcounts have decreased significantly since the early 1990s, regional disparities remain, with rural poverty being more than three times higher than that in urban areas (Benin et al., 2008). Moreover, children's poverty headcount continues to be greater than that of adults and poverty reduction has been smaller for the former.

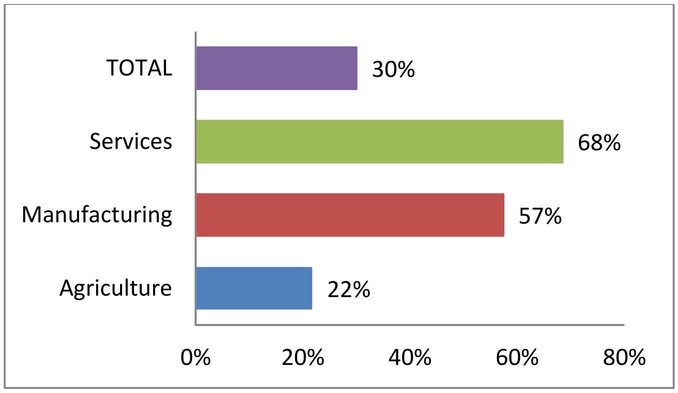
TABLE 1: MONETARY POVERTY HEADCOUNT

	Children		Adults	
	2006	2009	2006	2009
National	34.2	28.3	29.5	23.4
Rural	*36.7*	*30.5*	*32.7*	*26.2*
Urban	*17.8*	*12.4*	*13.8*	*8.6*

Source: Batana et al. (2012)

There seems to be some connection between the poor performances of the subsistence agricultural sector and the high poverty rates in rural areas. With close to 70% of the labor force not having completed primary school, the opportunities for workers to move from low-value-added activities, such as subsistence agriculture, to a better-paying occupation remain very small. One of the biggest challenges for Uganda thus appears to be improvement of the basic skill level of its workers in order to empower them to access wage-earning jobs in more productive activities. Additional challenges, such as mismatches between the needs of industry in terms of skills and skills being developed during post-primary education, arise for workers who have achieved more advanced skills. However, the low level of primary education completion remains the most preoccupying issue.

FIGURE 2: PERCENTAGE OF THE WORKFORCE WHO HAVE COMPLETED PRIMARY SCHOOL



Source: Authors' calculation based on UNHS09/10

> *"Uganda's past growth generated jobs, but with a fast-growing labor force, only a small fraction got into productive employment, leaving the bulk of labor in low value-added activities, particularly in agriculture and the informal and household enterprise sectors. Poor skills, given that* ***the majority of new labor market entrants have not completed primary school****, remain a key obstacle to productive employment and decent wages. Looking forward, job creation will become an even greater social and demographic challenge as more youth enter the labor market. (...) Education plays an important role in allocating labor among sectors and in the different market segments. An additional year of education increases the likelihood of participation in the wage and self-employment sectors, while it decreases the likelihood*

The Government of Uganda introduced universal primary education (UPE) in 1997. As a result, enrolment in primary schools increased markedly in the following years. Table 2 shows that the net primary enrolment ratio has indeed increased since 2000/2001, but new cohorts face a higher repeat rate and their survival rate up to the last grade of primary school is less than what it was for their predecessors. There may be several factors behind these disappointing performances. The greater number of children enrolled in primary education resulted in crowded classes, as public (current and investment) expenditures in education did not match greater demand (see Table 2). In fact, education budgets, both as a percentage of total public spending and as a percentage of GDP, declined over the last few years, and remained roughly constant in real terms (I&D, 2012). These factors contributed to the deterioration of the quality of the education received: in 2010, more than one-third of primary school pupils did not have adequate sitting and writing space, with an average of 58 pupils per classroom and 49 pupils per teacher (MoES, 2010). These factors affect the repetition and dropout rates, which remain high and lead to deterioration of the completion rate. In other terms, more children go to primary school, but a smaller proportion of them actually successfully complete the cycle.

TABLE 2: EDUCATION STATISTICS

	2000/01	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13
Education budget[1]	n.a.	16.6%	15.5%	15.0%	15.5%	14.0%	13.1%	14.9%
Net enrolment ratio[2]	85.5	92.0	93.3	95.0	96.1	96.0	97.5	95.7
Repetition rate[2]	10.1	15.7	14.8	11	11.7	10.9	10.2	10.6
Survival rate to grade 7[2]	74	30	29	29	29	30	31	32

[1] Share of education spending in total budget (source: I&D, 2012);
[2] Primary education statistics
http://www.education.go.ug/files/downloads/Fact%20Sheet%202012%20final.pdf

A recent report on education (I&D, 2012) shows that despite an ambitious education sector strategic plan (ESSP), budgets for education did not match the projections, which were anticipated to grow continuously and reach more than 17% of the budget in 2013/2014 (ESSP, 2010). Bringing education budgets in line with stated policies may seem challenging, especially given the difficulties encountered by the government in collecting domestic taxes. With a narrow tax base, given the predominance of the informal sector in the economy, widespread tax evasion and smuggling, taxes end up being paid by a very small fraction of the population (AfDB, 2010). Finding new sources of funding for additional expenditures thus appears challenging for the government.

However, the recent discovery of oil reserves appears to be a great opportunity, both economically and fiscally. It might be hazardous to try to predict oil extraction and refinement profitability, as it will depend on the oil price on world markets, the volume of production and the revenue sharing agreement between foreign firms and the government (Wiebelt et al., 2011). Nonetheless, this new source of income for the government could be used to set out measures targeted to reduce inequality, poverty and offer children better living conditions and prospects for the future.

The objective of this paper is to assess the impact of increased public expenditures in education on school participation, skill level of the workforce, occupational choices between self-employed and wage earners, economic performance, poverty reduction and income distribution. These additional expenditures in education are financed either through increased indirect taxes, or using the funds to be generated by the exploitation of oil resources.

The best suited tool to evaluate the impact of such policies and financing mechanisms on the economy is a computable general equilibrium model (CGE) as this type of tool takes into account the interactions between all of the actors of an economy in a consistent framework. Impacts on prices, volumes and school performance will affect differently the households and thus, in order to compute how these results will affect the income distribution and poverty, a micro model is needed as well. Standard CGE models do not explicitly set out the relationship between education spending, school performance, skill level of workers and their choices on the labor market. Hence, we suggest using an integrated macro-micro approach that models those important linkages.

A brief review of similar studies that have been done in Uganda is provided in the next section, while section 3 presents the methodology. Section 4 describes the results of the different scenarios that were simulated.

2. Literature review

There have been numerous studies done on Uganda in recent years. In particular, literature investigating linkages between public expenditures and poverty reduction has been relatively abundant (see for example Williamson and Canagarajah, 2003; Sennoga and Matovu, 2010; Sennoga et al., 2009; Fan and Zhang, 2008; Deininger and Okidi, 2003; Gelb and Majerowicz, 2011; and Benin et al., 2008). Although methodologies used differ across these studies, the overall conclusions seem to be the following: (i) the most efficient way to reduce poverty appears to be through targeted cash transfers; (ii) investment in agriculture would reduce regional disparities; (iii) investment in infrastructure would stimulate growth; and, (iv) financing extra expenditures through taxes would mitigate the positive impact on poverty.

Rural development generated also some interest. Benin et al. (2008) evaluate the impact of public investment in agriculture on rural development, while Blake et al. (2001) also focus on agriculture but the issues tackled relate more to trade policies. Dorosh and Thurlow (2011) focus on rural development through reduction of transportation costs (better infrastructure) and investment in agriculture.

Also, and given the relative importance of foreign aid in the total budget, other studies focused on the impact of different utilization of external funding (see for example Twimukye et al., 2009; Adam and Bevan, 2006; and Hisali and Ddumba-Ssemtamu, 2013).

Conversely, public spending in education generated less research. Batega and Matovu (2011) and Wiebelt et al. (2011) use standard CGE models in which a productivity factor that captures the spillover effect of public spending is introduced. Hence, increased education spending directly raises this productivity factor and consequently economic performance. The education process is not systematically introduced, and thus, the impact of education spending on pupil enrolment is not captured.

Matovu et al. (2011) apply the Maquette for MDG Simulations (MAMS) to the Ugandan economy to portray the evolution of the MDG indicators and their potential achievement by 2015 under different scenarios. They further use a micro-simulation module to assess the impact on poverty reduction and income distribution. The MAMS model presents, among other things, detailed modeling of the education choices and thus enables tracking education behavior and its dynamic impact on labor supply disaggregated according to the level of education achieved. The objective of the paper is, however, not so much focused on occupational choices or on children' wellbeing, but rather on the overall achievement of MDGs.

To our knowledge, there has not been any attempt to systematically combine CGE and micro econometric models to capture the linkages between public spending in education, education behavior, occupational choices of the workers on the labor market and children' welfare.

3. Methodology

We believe that the best suited tool to evaluate the impact of increased education spending on the economy is a computable general equilibrium model (CGE), as this type of tool takes into account the interactions between all of the actors of an economy in a consistent framework. Besides, impacts on prices, volumes and school performance will affect households differently and thus, to analyze how these results will affect income distribution and poverty, a micro model is needed as well. Subsection 3.1 describes the CGE model, while section 3.2 covers the micro side.

3.1 Macroeconomic model[1]

Computable general equilibrium (CGE) models are a class of economic models that use actual economic data to estimate how an economy might react to changes in policy, technology or other external factors. A CGE model consists of (a) equations describing model variables and (b) a database consistent with the model equations. The equations tend to be neo-classical, assuming cost-minimizing behavior by producers and household demand based on optimizing behavior. CGE modeling can be broadly used to simulate impact of macro policy change and external shocks.

The CGE model that we develop for this study is based on the PEP 1-t standard model (Decaluwé et al., 2010). In order to tackle the linkages between education levels, workers' skills and their occupational choices, we need to modify the standard model. Only changes from PEP 1-t are discussed below; the interested reader may refer to Decaluwé et al. (2010) for a complete description of the model.

Education behavior

To model the education behavior we follow the approach suggested in the MAMS model (Lofgren and Diaz-Bonilla, 2006) and used by Matovu et al. (2011). Although we intend to use similar modeling assumptions, given that more than 70% of the workforce did not complete primary cycle, we suggest having only two labor categories: those who failed to complete primary school and those who completed at least this first cycle. Thus, education is split between two cycles: primary school and post-primary education.

The determinants of the different behaviors also slightly differ from Matovu et al. (2011). As the MDGs are not the focus of our study, and as we therefore do not run simulations that would affect the health-related indicators, we do not include them as an argument in the education functions. However we include consumption per capita (which is not included in Matovu et al., 2011). The rest is quite similar to their approach and we use the same elasticities.[2]

The labor market

Assume there are two categories of workers based on their skill levels:

---

[1] All variables, parameters, sets and equations are presented in Annex 1. The CGE model was developed by Véronique Robichaud.

[2] See Annex 2, prepared by Hélène Maisonnave, for a description of the database.

$WKR_{USK,t}$ (unskilled, i.e. not completed primary education)

$WKR_{SK,t}$ (skilled, i.e. completed primary education or more)

In each period, the number of unskilled workers evolves according to retirement and to the new entrants on the labor market, that is a proportion[3] of those who dropped out of primary school before completing the cycle, or did not enter primary school. Similarly, the number of skilled workers in each period is equal to what it was in the preceding period, less those who retired, plus a share of the ones who completed at least primary school.

Mathematically:

$$WRK_{usk,t} = WRK_{usk,t-1}\left(1-ret_{usk}\right)+\psi_{usk}\left\{\begin{matrix} NST_{primary,t-1}\cdot SHR_{primary,dropout,t-1} \\ +POP_{t-1}^{H6}\cdot\left(1-SHR_{primary,entry,t-1}\right)\end{matrix}\right\}$$

and

$$WRK_{sk,t} = WRK_{sk,t-1}\left(1-ret_{sk}\right)+\psi_{sk}\left\{\begin{matrix} NST_{primary,t-1}\cdot SHR_{primary,prom\_grd,t-1}\cdot SHR_{primary,grd\_fin,t-1} \\ +NST_{secter,t-1}\cdot SHR_{secter,prom\_grd,t-1}\cdot SHR_{secter,grd\_fin,t-1} \\ +NST_{secter,t-1}\cdot SHR_{secter,dropout,t-1}\end{matrix}\right\}$$

where:

ψ_{skl}	Share of new workers entering the labor market	
ret_{skl}	Retirement rate	
$NST_{cyc,t}$	Total number of students enrolled in cycle *cyc*	
POP_t^{H6}	Population of six year olds	
$SHR_{cyc,sb,t}$	Share of students in cycle *cyc* with behavior *sb*	
cyc	Education cycles:	
	primary	Primary cycle
	sector	Secondary and tertiary cycles
sb	Students' behavior:	
	entry	Proportion of children aged 6 entering grade 1 in primary school
	dropout	The grade is not passed and the student drops out
	prom_grd	The grade is passed and it is the last year of a cycle (graduation)
	grd_fin	Graduation and end of studies
skl	Skill levels:	
	usk	Less than completed primary education
	sk	Completed primary education or more

Both types of workers, skilled and unskilled, may choose either to work as a salaried employee or to be self-employed (either as a farmer or in activities other than agriculture). The main advantage of working as a salaried employee is greater mobility and higher wages. Indeed, farmers are forced to work in the agricultural sector, and other self-employed workers are essentially confined to the services sector, construction and manufacturing. In addition, salaried employees receive higher remuneration, especially if the worker has completed his/her primary education.

Mathematically, skilled and unskilled workers choose their occupation in order to maximize income subject to imperfect substitutability between the labor categories (CET):

[3] In fact, when looking at the data, not all school graduates and dropouts end up on the labor market. This observation may be explained by several factors: the former students may be too young to enter the labor market, or might have left school because of pregnancy or to enter a marital relationship. Of course, other factors can explain this outcome, but as these cannot be modeled explicitly, this share is fixed throughout the simulation and is calibrated based on household survey data.

$$\text{Max} \sum_{l} W_{l,t} LST_{skl,l,t}$$

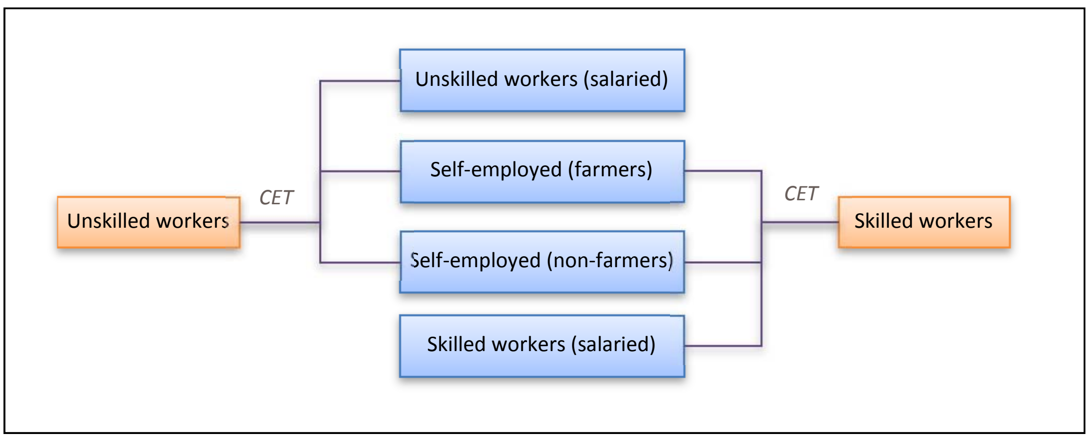
Subject to:

$$WRK_{skl,t} = B_{skl}^{LS} \cdot \left[\sum_{l} \beta_{skl,l}^{LS} \cdot LST_{skl,l,t}^{\rho_{skl}^{LS}} \right]^{\frac{1}{\rho_{skl}^{LS}}}$$

Where

$W_{l,t}$	Wage rate of type *l* labor
$LST_{skl,l,t}$	Labor supply of type *l* with skill *skl*
B_{skl}^{LS}	Scale parameter (CET – labor supply)
$\beta_{skl,l}^{LS}$	Share parameter (CET – labor supply)
ρ_{skl}^{LS}	Elasticity parameter (CET – labor supply)
l	Labor categories: *swusk* Salaried unskilled workers (less than completed primary education) *swsk* Salaried skilled workers (completed primary education or more) *seag* Self-employed farmer *senag* Self-employed non-farmer

FIGURE 3: LABOR MARKET



To represent the fact that higher education increases the opportunities for the worker to move from one occupation to another, we assume that the elasticity is greater for skilled workers than it is for unskilled ones. Of course, only those workers who have completed at least the primary cycle can enter the market for skilled salaried employees.

Total supply of each category of occupation is then given by the sum of workers by skill. In other words, total self-employed labor includes both skilled and unskilled workers, whereas salaried workers are characterized according to their skill level.

Production

Consistently with household survey data and the SAM, we then assume that farmers can only work in the agricultural sector, whereas salaried workers are mobile across all sectors. Self-employed non-farm workers are employed in non-agricultural private sectors, mainly services, construction and manufacturing. It is assumed that workers are paid at their marginal productivity, and that the rate of remuneration obtained for each type of labor is determined by equilibrium between total supply and total demand. The structure of production is quite standard and follows PEP 1-t assumptions. However, given that each sector does not necessarily use the same factors of production, we distinguish the structure for the agricultural sectors, other private sectors and for the public services sectors. The three following figures describe the nested production function for each group and equations in annex describe the mathematical representation.

FIGURE 4: STRUCTURE OF PRODUCTION IN AGRICULTURAL SECTORS

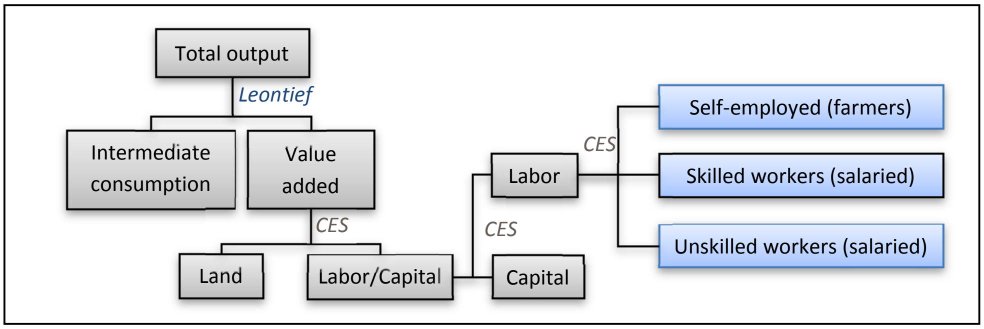


FIGURE 5: STRUCTURE OF PRODUCTION IN NON-AGRICULTURAL BUSINESS SECTORS

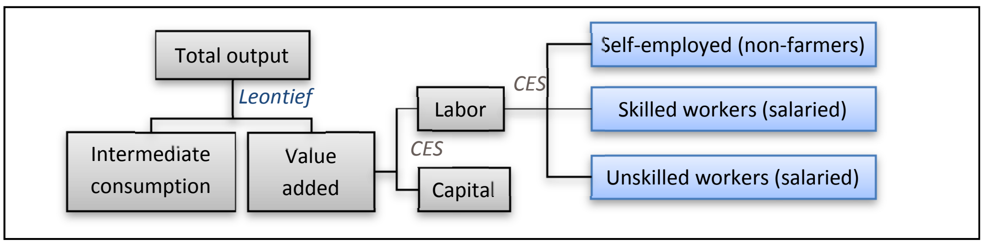
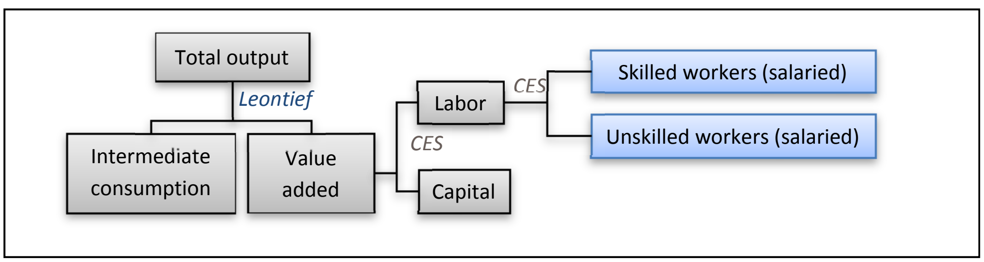


FIGURE 6: STRUCTURE OF PRODUCTION IN PUBLIC SERVICES SECTORS



Data[4]

The CGE is based on a SAM for the fiscal year 2009/2010 developed by the Development Policy and Analysis Division of the United Nations Department of Economic and Social Affairs (UN-DESA/DPAD) and the United Nations Development Programme (UNDP). Based on the 2009/2010 UNPS, we modified the labor categories to fit those presented in the previous section. Furthermore, given the scope of our project, we disaggregated the agricultural commodities based on the 2007 SAM developed at IFPRI (Thurlow, 2008). Finally, in order to account for oil extraction and refinement, we followed the methodology used in Wiebelt et al. (2011).

The modified 2009/2010 SAM thus presents four labor categories (self-employed farmers, other self-employed, skilled salaried employees and unskilled salaried employees), 25 productive activities (including oil extraction and petroleum refinement), and 32 commodities (of which 11 agricultural products). A complete list of accounts appears in Annex 2.

3.2 Microeconomic model[5]

The distributive and welfare effects of social policies are estimated by the microsimulation component, which was combined with the CGE model. This is particularly relevant as the main focus of our analysis is a

[4] Annex 2 fully describes the data used in the CGE model.
[5] The microeconomic model was developed by Luca Tiberti.

specific sub-group of the population, children, and because the CGE alone cannot look at the evolution of within-group inequality.

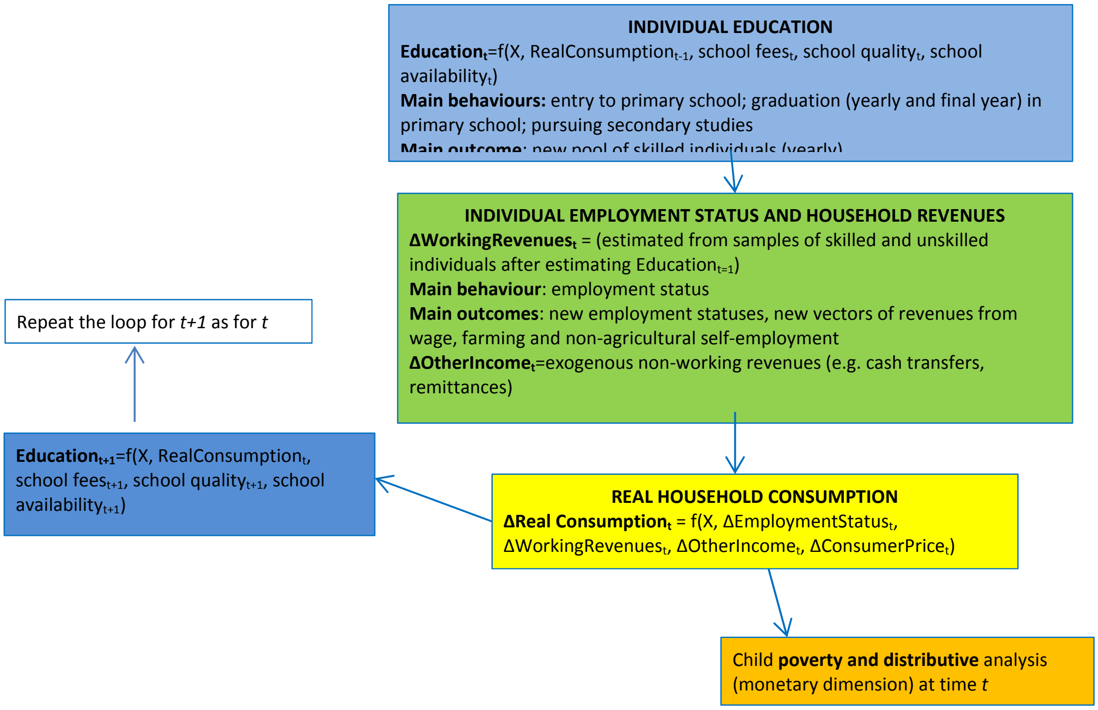
To do that, we followed a top-down macro-micro simulation framework with microeconomic behaviour. Some behaviours are indeed likely to be affected by the policy and to change over time (notably, labour force participation and employment status, and schooling).

The microsimulation component then makes it possible to identify which individuals are most likely to be affected by macroeconomic changes. As is well known for such approaches, the relevant (i.e. affected by policy changes) variables in the microsimulation modules evolve along with the CGE results. In fact, macro results on prices, employment, revenues and schooling outcomes serve as inputs into the microeconomic analysis. The ultimate objective of the microsimulation model is to conduct poverty and distributive analysis of the simulation scenarios.

Hereafter we provide a brief description of the microsimulation component. A fully detailed description of the methodology developed for the microsimulation models, as well as how the CGE results are integrated in a consistent manner, is provided in annex.

For this project we developed three main modules for: education, income generation and real consumption (see Figure 7). Of course, all these modules contribute to the new real household income for each simulation period. We start from the education module which updates year by year the education status (both for primary and secondary education) of each sampled school-age individual. This module also updates the overall skilled and unskilled labor force. We then move to the income generation module, aiming first at selecting those individuals migrating across different occupational choices, and then at estimating the new vectors of wages and revenues. At the end of this module, we obtain the new total household income for each year of simulation. The absolute change in household income relative to the base year is added to total household consumption. After some necessary adjustments (household composition and regional and temporal differences in prices), we use the real per adult equivalent household consumption for poverty and distributive analysis.

FIGURE 7: SCHEMA FOLLOWED FOR THE ESTIMATION OF THE MICRO COMPONENT (FOR EXAMPLE, AT TIME T=1)



Source: Authors' elaboration.

The data used for the micro analysis are the 2009/2010 Ugandan National Panel Survey (UNPS), which includes 2970 households and 18730 individuals. The survey also provides the sampling weights, which are used to extrapolate the sampled population to the national totals. As in the CGE model, the population evolves over the simulation period according to forecasts by the UN Population Division. This is done by following a common "static ageing" technique as proposed by Deville and Särndal (1992).[6] These authors developed a linear algorithm that helps, in our specific case, in modifying year by year the sampling weights in a way that the total population represented in the sample corresponds exactly to the macro projections. Dynamic ageing approaches would have required the development of additional (and more complex) modules to update different individual real life events (e.g. birth, marriage, divorce, migration, death). However, the quality of micro data and macro projections for these events is not sufficiently good (and such a development would have gone well beyond the purpose of this study). Note that the microsimulation analysis stops at 2023, as we made the hypothesis that a child has 14 years from birth to complete the primary cycle of education and become a skilled worker (the focus of our analysis). The youngest children in 2009 (that is, those aged zero), will be 14 years old by 2023. Since we have not introduced a fertility model, after 14 years we would not have new children to follow.

4 Scenarios and results

4.1 Reference scenario

The reference scenario represents the evolution of the Ugandan economy without additional public education expenditures. It was agreed with local experts that this scenario should account for the foreign investment made to develop the oil sectors, which, on average, reaches about 1,260 billion UGX per year up until 2016/2017 when these sectors should become fully operational. It was also agreed that the

[6] For this purpose, we used the STATA command *calibrate*.

methodology used in Wiebelt et al. (2011) should be followed and that all oil revenues generated for the government be set aside in a fund. In other words, it is as if the extra income for the government arising from oil production is sterilized since it is not injected in the economy. Of course, both the investment and operational phases in the oil sector lead to higher GDP and this is factored in the latest IMF projections. IMF projections regarding GDP evolution were further used in order to account for productivity improvement. Overall, the reference scenario thus replicates the average growth anticipated in IMF (2013) and the oil production capacity in Wiebelt et al. (2011).

Based on these projections, real GDP growth under the reference scenario reaches 7% on average for the simulation period. Given declining projected population growth rates, this implies that real GDP per capita would grow one percentage point faster in the decade to come (2013 to 2022) compared to the last decade (2003 to 2012). In other words, the reference scenario depicts strong economic performance, which translates into better living conditions for Ugandans. Hence, poverty headcount and depth under the reference scenario decrease significantly over the simulation period. More specifically, the poverty headcounts for children falls from 26.9% in 2009 to 17.8% in 2023, and the poverty gap decreases from 7.3% to 5.6% over the same period.

4.2 Simulations

The scenarios that were selected reflect the concern of local experts regarding the poor quality of the supply of education. It was therefore agreed that the scenarios should simulate an increase in current and investment spending so that the share of education in total public expenditure increases by three percentage points in 2013, and that this share is then maintained throughout the simulation period. In fact, the education budget represented roughly 15% of the government budget over recent years (see Table 2) while official targets are about 18%. The simulated increase thus fills the gap so that the education budget reaches the target. The table below shows the value of this new spending and the share it represents in the total government budget and in the baseline GDP.

As the government finances both primary and post-primary education, local experts suggested allocating 70% of the additional expenditure to primary education and the rest to the other cycles. The split between current and investment expenditures is proportional to the shares in the government 2009/2010 budget. A second set of simulations consider focusing all of the additional expenditure on primary education.

The local experts also suggested various financing mechanisms for these additional expenditures. Given that the government will be receiving new revenues from oil production, the first financing source identified is the oil fund. The second mechanism that was suggested reflects the intention of the government to increase its tax base. A new indirect tax that would not apply to agricultural commodities and food products is thus introduced as a second financing mechanism.

TABLE 3: INCREASE IN EDUCATION SPENDING COMPARED TO THE REFERENCE SCENARIO

	Billion UGX	% Budget	%GDP
2013	225	3%	0.5%
2014	232	3%	0.5%
2015	240	3%	0.5%
2016	248	3%	0.5%
2017	255	3%	0.5%
2018	264	3%	0.4%
2019	272	3%	0.4%
2020	281	3%	0.4%
2021	289	3%	0.4%
2022	297	3%	0.4%
2023	306	3%	0.4%
2024	315	3%	0.3%
2025	324	3%	0.3%

Source: Authors' calculations.

In summary, we simulate four scenarios with the education spending increases presented in Table 3 kept the same.

TABLE 4: DESCRIPTION OF SIMULATIONS

Simulation	Share dedicated to primary education	Financing mechanism
SIM1	70%	Oil fund
SIM2	70%	New tax
SIM3	100%	Oil fund
SIM4	100%	New tax

4.3 Results

IMPACT ON EDUCATION

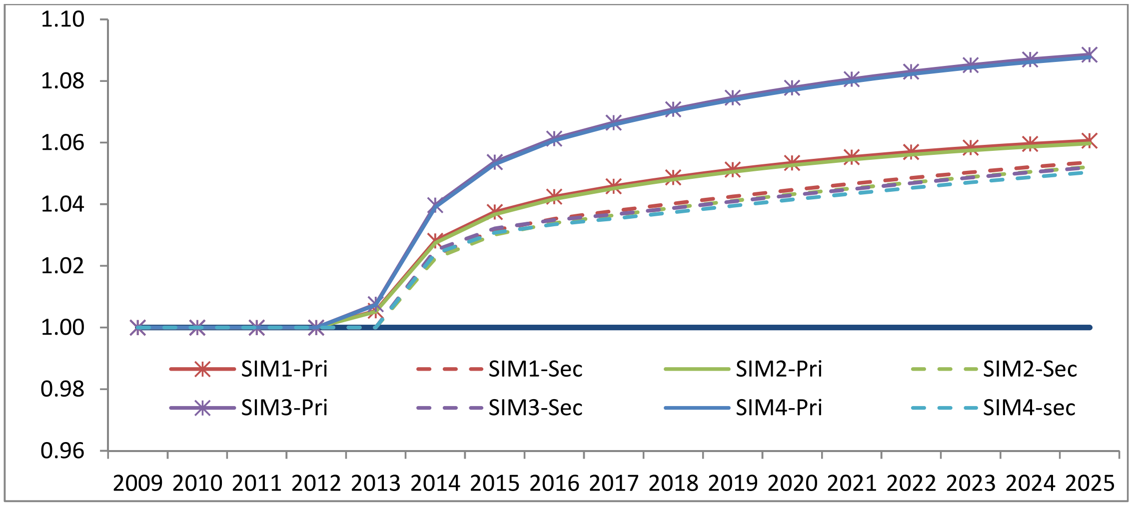
- Increasing the share of public spending on education by 3 percentage points increases the number of children enrolled in primary schools by up to 6% (more than 8% if the entire amount is dedicated to primary education).
- Improved participation and graduate rates, coupled with fewer drop-outs, increases the number of children who complete primary education by up to 13%.
- In 2025, these percentages correspond to 960,000 to 1,400,000 additional children enrolled in primary schools and to about 110,000 additional children completing primary education each year.
- Participation in post-primary cycles increases by up to 4 percentage points.

It is important to note that, although private and public education constitute two separate sectors in the model, the results presented here cover the entire education system. In other words, spending on public education translates into a greater number of teachers in the public sector and thus the overall student-to-teacher ratio diminishes. This is reflective of the fact that if the public education improves, some students may switch from private to public schools, thus reducing the student-to-teacher ratio in the private sector as well. The model however does not allow for a distinction between the outcomes in each sector separately.

The first impact of increased spending in education is improving the quality indicator, which is measured by the amount of education services available per student and which affects positively all education behaviors:[7] participation and graduation rates increase while the drop-out rate decreases. As a result, a greater number of students successfully complete primary education.

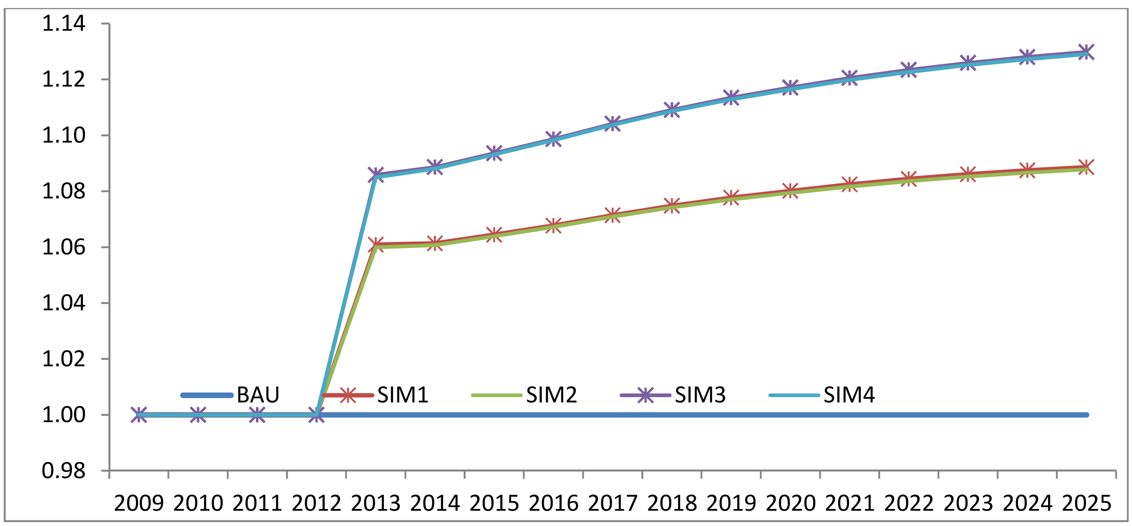
[7] See equations 91 to 102 in Annex 1.

Figure 8: Number of students per cycle compared to the reference scenario (BAU=1)



Source: Authors' calculations based on simulation results.

Figure 9: Number of graduates from primary school compared to the reference scenario (BAU=1)



Source: Authors' calculations based on simulation results.

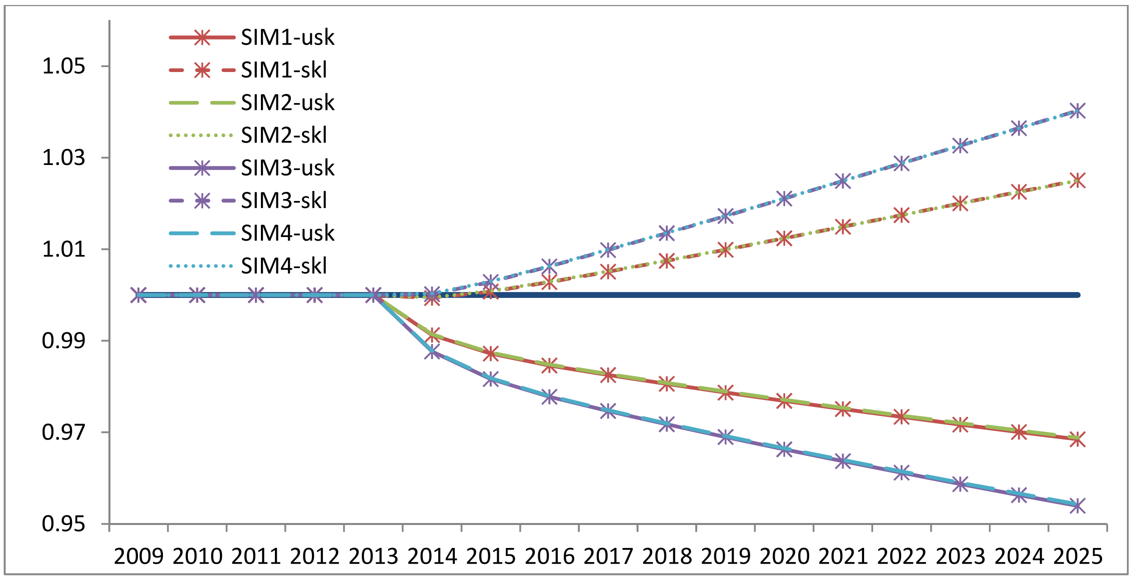
If the entire additional budget is allocated to primary education (simulations 3 and 4), these indicators improve much more for primary education without significantly affecting post-primary participation. This result can be explained by the fact that the number of public secondary schools represent less than one-third of all secondary schools. Hence, although increased spending in post-primary cycles does positively impact the quality of public education, this effect does not have a major impact on total services available for post-primary students. Therefore, the increased number of students in the post-primary cycle mostly results from better graduation rates from primary school, and not so much from increased public supply of services. As can be seen in the two figures above, the financing mechanism does not significantly influence these results.

IMPACT ON THE LABOR MARKET

- The number of workers who complete at least primary school is greater than what it would have been and this increase intensifies over time.
- In 2025, there would be between 340,000 and 540,000 additional skilled workers, depending on the scenario.
- The number of skilled salaried employees thus increases, whereas the supply of other type of workers decreases.

In the short run, increased school participation reduces the number of workers compared to the reference scenario as students stay in school for a longer period. In the medium and long run, though, the number of workers who complete at least primary education increases and thus, the proportion of unskilled workers decreases. The impact is accentuated if the entire additional budget is allocated to primary education, since the number of graduates from primary school is improved.

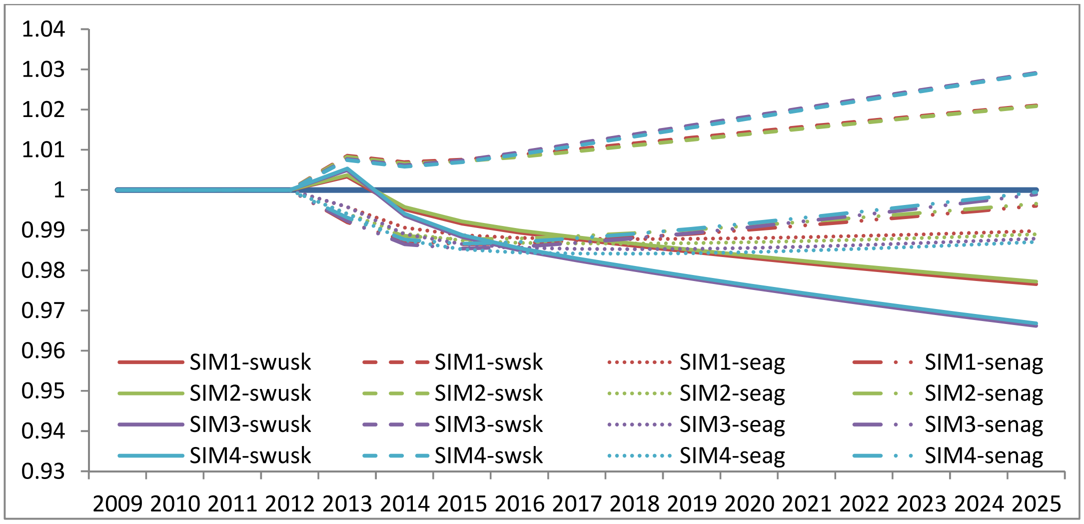
FIGURE 10: NUMBER OF WORKERS PER SKILL LEVEL COMPARED TO THE REFERENCE SCENARIO (BAU=1)



Source: Authors' calculations based on simulation results.

As presented in the methodology section, skilled workers can either enter the skilled wage salaried labor market (*swsk*) or be self-employed in the agricultural sectors (*seag*) or in other sectors (*senag*). Similarly, unskilled workers can work as unskilled wage laborers (*swusk*), or be self-employed in agriculture or non-agricultural sectors. In each case, the choice depends on the relative wage received on each market and on the ease with which they can switch from one type of work to the other. As there are more skilled workers, it is not surprising to see that the supply of salaried skilled workers increases compare to the BAU, whereas the supply of other types of labor is below what it would have been. Indeed, as the wage rate for skilled workers is greater than all other categories, workers who graduate from primary school will prefer working as skilled wage laborers. Again, all results are accentuated when the entire budget increase is devoted to primary education.

Figure 11: Labor supply (by category) compared to the reference scenario (BAU = 1)



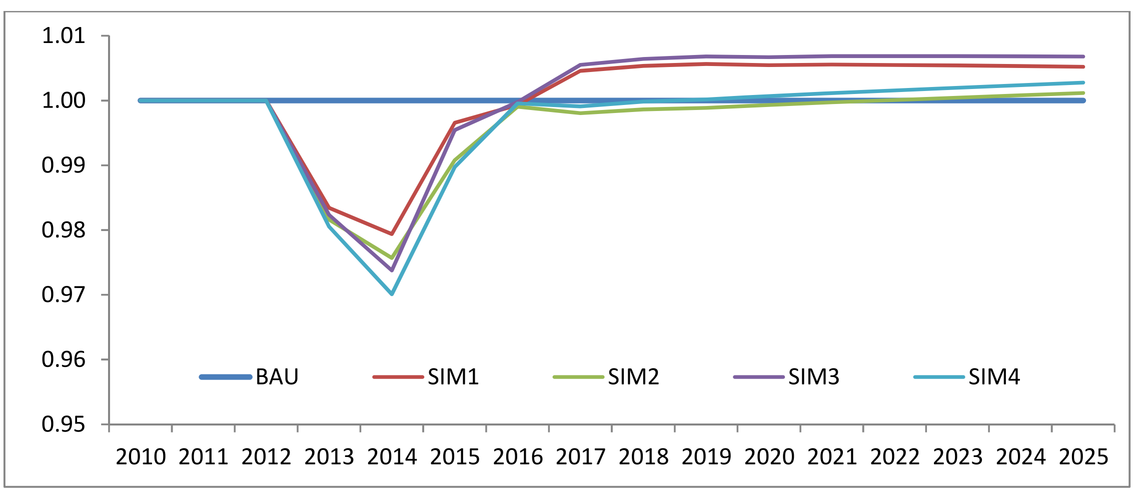
Source: Authors' calculations based on simulation results.

IMPACT ON GDP

- In the short run, GDP growth rates are slightly below their reference level, due to students' increased and prolonged participation in school.
- GDP growth rate exceeds its reference level starting in 2017 when financed using the oil fund, and in 2021 if financed through indirect taxes.
- Spending all extra budget in primary education generates higher GDP growth rates.

In the short run, the real GDP growth rate is slightly below what it would have been in the reference case. As students are more numerous and since they stay in school for longer, the total labor force is below reference levels and hence, so is GDP. Since the impact on school participation is greater when the government spends the entire additional budget on primary education, this short run impact on GDP is accentuated under these scenarios.

Figure 12: Real GDP growth rate as proportion of reference scenario (BAU = 1)



Source: Authors' calculations based on simulation results.

Furthermore, if the government finances extra spending through indirect taxation, the negative effect on the GDP growth rate persists over a longer period, but tends towards above its BAU value in the medium/long run. In fact, as it has been shown in previous studies, financing extra spending through taxation simply transfers purchasing power from consumers to the government, introducing additional distortions and a slight negative impact on GDP.

Conversely, funding new expenditures using the oil fund is akin to using external financing, as government revenues from oil were put aside in the reference scenario. The observed positive impact on real GDP in the long run is consistent with studies showing similar results when public expenditures are partly financed through foreign aid. When comparing the way the additional budget is allocated, long-run GDP growth rates are better when all is spent on primary education.

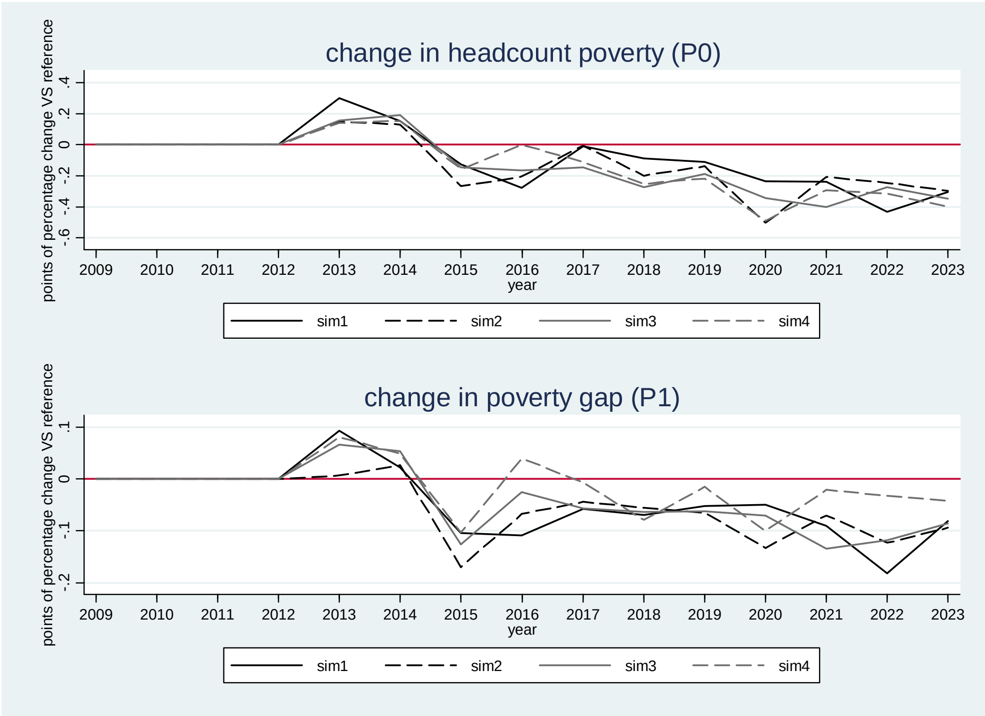
IMPACT ON POVERTY

- The reference scenario shows large reductions in child poverty rates.
- In the short run, child poverty rates under the simulation scenarios are slightly higher than in the reference scenario.
- Poverty rates are statistically lower only in the long run, which translates into a reduction by up to 99,000 of poor children in 2023 compared with the reference scenario.
- In the long run, a slow absorption into the labor market of new skilled workers and the price increase do not allow a faster improvement in children's monetary well-being with respect to the reference scenario.

In line with the macro results, poverty increases in the short term as students delay their entry into the labor market to pursue schooling. As shown in Figure 13, in 2013 and 2014, poverty rates under simulation scenarios are higher by up to 0.3 and 0.1 percentage points for P0 and P1, respectively. Poverty rates under the simulated scenarios are lower than in the reference scenario. A similar trend is observed for P1, with a few interesting exceptions. For example, in 2013, P1 under sim1 is larger than the benchmark situation (as in the other simulations). In 2015, under sim2 and sim3 P1 is statistically lower than in the reference scenario. In the long run, however, poverty indicators are lower in the simulations than in the reference scenario. Moreover, the long-run poverty headcount declines by more when the entire budget increase is devoted to primary education. Hence, in 2023, there would be up to 99,000 less poor children.

As discussed in the previous sections, in the first years after the reforms, the total labor supply is smaller. This, together with a general higher level of prices (under the oil-financed scenarios), contributes to push poverty rates higher than in the reference scenario. In the medium-to-long run, the positive effects on household welfare deriving from a larger skilled labor force and higher productivity are likely to be mitigated by some factors. First of all, the number of unskilled workers decreases and, since a greater proportion of them live in poorer households, their welfare deteriorates relative to the baseline scenario. Then, due to different labor market rigidities and skills mismatches with labor demand, the absorption of new skilled entrants in the labor market is slow. Also, some years after the beginning of the reforms, a relatively long period span exists between the exit of the school system and the entry at the labor force. Finally, under the oil-financed scenarios (sim1 and sim3) the relatively higher level of prices decreases the purchasing power under the simulation scenarios.

FIGURE 13: CHANGE IN P0 AND P1 RELATIVE TO THE REFERENCE SCENARIO, PERCENTAGE POINTS (CHILDREN)

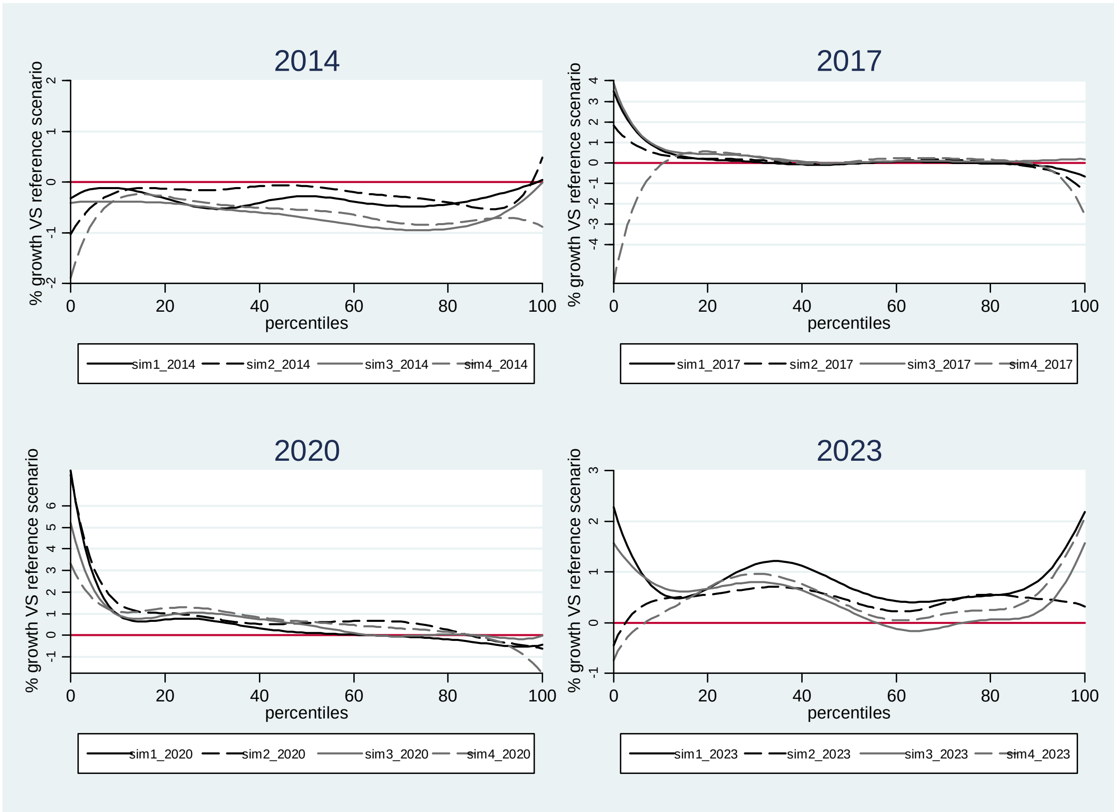


Source: Authors' calculations based on simulation results.

Figure 14 presents the incidence curves of real consumption of children for the various simulations for 2014 (the first year where the scenarios and the baseline differ), 2017, 2020 and 2023 (the final year of the microsimulation analysis). In each panel, the curves plot the difference in logarithms of the predicted average consumption in each percentile of the distribution under the simulation and reference scenarios. This difference is a very close approximation to the real consumption growth in each simulation scenario relative to the benchmark. Note that the changes for the first percentiles are often affected by the variation in the share of individuals with zero consumption, and so not too much attention should be paid to this part of the distribution. Generally, the figure shows that the proposed scenarios have little effect on inequality, although some relative changes in the distribution are observed in the long run. However, the differences in the Gini inequality index between the reference and simulation scenarios are not statistically significant (figures not shown here).

These curves are consistent with the poverty results discussed above. In the short term (2014), all percentiles suffer a decrease in their welfare. This deterioration is as high as about -1% for the 70th-80th percentiles. In the medium term (2017), there is practically no impact. In the long run (2020 and, more markedly, 2023), the monetary well-being of children improves significantly. At the official poverty line (which, in 2023, is associated with a headcount poverty of about 17%), real consumption increased by 0.5% in comparison with the reference scenario (see the growth rate at around the 17th percentile). As clearly shown by this panel, the variation is even greater if higher poverty lines are chosen. If this is set at the 40th percentile, the improvement in the poverty headcount rate would be larger (especially when sim1 is adopted).

FIGURE 14: GROWTH OF REAL CONSUMPTION RELATIVE TO THE REFERENCE SCENARIO, % (CHILDREN)



Source: Authors' calculations based on simulation results.

5. Conclusion

The decreasing budgets share allocated to education led to poor quality of the services provided to the students and thus to disappointing results in terms of primary education completion. With close to 70% of the labor force not having completed primary school, the opportunities for the workers to move from low-value-added activities, such as subsistence agriculture, to a better-paying occupation remain very small. One of the biggest challenges for Uganda thus appears to be improvement of the basic skill level of its workers in order to empower them to access wage-earning jobs in more productive activities.

Bringing education budgets in line with stated policies may seem challenging, especially given the difficulties encountered by the government in collecting domestic taxes. The recent discovery of oil reserves thus appears as a great opportunity, both economically and fiscally, and this new source of income for the government could be used to set out measures targeted to reduce inequality, poverty and offer children better living conditions and prospects for the future.

Through discussions with local experts, the low quality of education received by children was identified as the main concern in ensuring them with greater opportunities, and so, the scenarios described in this paper were designed with that priority in mind and consist in bringing the education budget in line with stated policies. Increased spending is either entirely devoted to primary education (scenarios 3 and 4) or split between the primary and post-primary cycles in 70%-30% proportions, respectively (scenarios 1 and 2). Furthermore, this additional spending is financed either through increased indirect taxes (simulation 2 and 4), or using the funds to be generated by the exploitation of oil resources (scenarios 1 and 3).

The best suited tool to evaluate the impact of such policies and financing mechanisms on the economy is a computable general equilibrium model (CGE) as this type of tool takes into account the interactions between all of the actors of an economy in a consistent framework. Impacts on prices, volumes and school performance will differently affect the households and thus, to compute how these results will affect income distribution and poverty, a micro model is needed as well. Hence, an integrated macro-micro approach is used.

Results show that increasing the share of public spending on education by 3 percentage points increases the number of children enrolled in primary schools by up to 8%, improves participation and graduate rates and reduces dropout rates; consequently the number of children who complete primary education increases by up to 13%. In 2025, these percentages correspond to 1,400,000 additional children enrolled in primary schools and to about 110,000 additional children completing primary education each year. Accordingly, the number of workers who complete at least primary school is greater than what it would have been and this increase intensifies over time. In 2025, there would be between 340,000 and 540,000 additional skilled workers, depending on the scenario.

In the short run, GDP growth rates are slightly below their reference levels, due to students' increased and prolonged participation in school, but higher in the medium/long run. Furthermore, spending the entire extra budget in primary education generates higher GDP growth rates. Likewise, in the short run, child poverty rates are slightly higher than in the reference scenario, but are lower only in the long run, leading to a reduction by up to 99,000 in the number of poor children in 2023 compared to the reference scenario.

From this analysis, it thus appears that increased public spending on education should prioritize primary education and that using oil funds would further improve overall economic indicators.

Of course, this analysis does not account for all the positive effects a better education would have, and thus, results presented here should be seen as conservative. Indeed, better participation and completion of primary education may have other important impact both on the economy and on children's present and future wellbeing. For instance, better education affects positively nutrition and health indicators, which in turn positively affects both education and productivity. Education also impacts fertility rates. Furthermore, the development of oil sectors in the economy might generate spillover effects that could impact the labor market as well as economic indicators. Such effects are, however, highly speculative.

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Annex 1: Variables, parameters, sets and equations

Sets

Activities	
j, jj	All activities: agriculture, flowers, coffee, tea, fishing, mining, crude oil, other food, beverages and tobacco, textiles, refined petroleum, other chemicals, other manufactures, electricity, water and sanitation, construction, public administration, primary education (private), secondary and tertiary education (private), primary education (public), secondary and tertiary education (public), health (private), health (public), other infrastructure, other services.
$pub \subset j$	Public activities: water and sanitation, public administration, primary education (public), secondary and tertiary education (public), health (public), other infrastructure.
$bus \subset j$	Private activities: agriculture, flowers, coffee, tea, fishing, mining, crude oil, other food, beverages and tobacco, textiles, refined petroleum, other chemicals, other manufactures, electricity, construction, primary education (private), secondary and tertiary education (private), health (private), other services.
$agr \subset bus$	Agriculture activities: agriculture, flowers, coffee, tea.
$nag \subset bus$	Non-agriculture activities: fishing, mining, other food, beverages and tobacco, textiles, petrochemical, other manufactures, electricity, construction, primary education (private), secondary and tertiary education (private), health (private), other services.
$oil \subset bus$	Oil activities: crude oil, refined petroleum.
$noil \subset bus$	Non-oil activities: agriculture, flowers, coffee, tea, fishing, mining, other food, beverages and tobacco, textiles, other chemicals, other manufactures, electricity, construction, primary education (private), secondary and tertiary education (private), health (private), other services.
Commodities	
i, ij	All commodities: coffee, tea, flowers, maize, rice, other cereals, cassava, roots, pulses and oilseeds, matoke, other agricultural products, fishing, crude oil, mining, other food, beverages and tobacco, textiles, refined petroleum, other chemicals, other manufactures, electricity, water and sanitation, construction, public administration, primary education (private), secondary and tertiary education (private), primary education (public), secondary and tertiary education (public), health (private), health (public), other infrastructure, other services.
Agents	
ag, agj	All agents: *hhd* (household); *gvt* (government); *row* (rest of the world)
$agng \subset ag$	Non-governmental agents: *hhd, row*
$agd \subset ag$	Domestic agents: *hhd, gvt.*
Labor	
l, lj	Labor categories: *swusk* Salaried unskilled workers (less than completed primary education) *swsk* Salaried skilled workers (completed primary education or more) *seag* Self-employed farmer *senag* Self-employed not farmer
skl	Skill levels: *usk* Less than completed primary education *sk* Completed primary education or more

Education	
cyc	Education cycles: *primary* Primary cycle *secter* Secondary and tertiary cycles
sb	Students' behavior: *entry* Proportion of children aged 6 entering grade 1 in primary school *rep* The grade is not passed and the student repeats it *dropout* The grade is not passed and the student drops out *prom* The grade is passed *prom_ctn* The grade is passed and it is not the last year of a cycle *prom_grd* The grade is passed and it is the last year of a cycle (graduation) *grd_fin* Graduation and end of studies *grd_csup* Graduation and continue on to the next education cycle
$lg \subset sb$	Students behavior in the logistic function: *entry* Proportion of children aged 6 entering grade 1 in primary school *prom* The grade is passed *grd_csup* Graduation and continue on to the next education cycle
Periods	
t	Simulation period: 2009-2025

Parameters and variables

Parameters	
$aij_{i,j}$	Input coefficient
$\alpha_{cyc,lg}^{ED}$	Parameter (logistic education function)
A^{K_PRI}	Scale parameter (private investment function)
A^{K_PUB}	Scale parameter (public investment function)
B_j^{LD}	Scale parameter (CES - composite labor)
B_{agr}^{LKD}	Scale parameter (CES – aggregate labor-capital)
B_{skl}^{LS}	Scale parameter (CET – labor supply)
B_i^{M}	Scale parameter (CES – composite commodity)
B_j^{VA}	Scale parameter (CES – value added)
$B_{j,i}^{X}$	Scale parameter (CET – exports and local sales)
B_j^{XT}	Scale parameter (CET – total output)
$\beta_{cyc,lg}^{ED}$	Parameter (logistic education function)
$\beta_{l,j}^{LD}$	Share parameter (CES - composite labor)
β_{agr}^{LKD}	Share parameter (CES – aggregate labor-capital)
$\beta_{skl,l}^{LS}$	Share parameter (CET – labor supply)
β_i^{M}	Share parameter (CES – composite commodity)
β_j^{VA}	Share parameter (CES – value added)
$\beta_{j,i}^{X}$	Share parameter (CET – exports and local sales)
$\beta_{j,i}^{XT}$	Share parameter (CET – total output)
δ_j	Depreciation rate of capital in industry j
$ext_{cyc,lg}$	Extreme value (logistic education function)
g_t^{LAND}	Growth (land)

$\gamma_{cyc,lg}^{ED}$	Parameter (logistic education function)
γ_{i}^{GVT}	Share of commodity i in total current public expenditures
γ_{i}^{INVPRI}	Share of commodity i in total private investment expenditures
γ_{i}^{INVPUB}	Share of commodity i in total public investment expenditures
γ_{i}^{LES}	Marginal share of commodity i in household consumption budget
io_{j}	Coefficient (Leontief - intermediate consumption)
λ_{ag}^{RK}	Share of capital income received by agent ag
$\lambda_{ag,agj}^{TR}$	Share parameter (transfer functions)
n_{t}	Population growth rate
ny_{cyc}	Number of years by education cycle
ϕ_{bus}	Scale parameter (allocation of investment to industries)
pop_{t}	Population index (equals 1 at the first period)
ψ_{skl}	Share of new workers entering the labor market
ret_{skl}	Retirement rate
ρ_{j}^{LD}	Elasticity parameter (CES – composite labor)
ρ_{agr}^{LKD}	Elasticity parameter (CES – aggregate labor-capital)
ρ_{skl}^{LS}	Elasticity parameter (CET – labor supply)
ρ_{i}^{M}	Elasticity parameter (CES – composite commodity)
ρ_{j}^{VA}	Elasticity parameter (CES – value added)
$\rho_{j,i}^{X}$	Elasticity parameter (CET – exports and local sales)
ρ_{j}^{XT}	Elasticity parameter (CET – total output)
$\sigma_{cyc,lg}^{ECH}$	Elasticity - consumption per capita (intermediate function for education)
$\sigma_{cyc,lg}^{EDQ}$	Elasticity - education quality index (intermediate function for education)
$\sigma_{cyc,lg}^{EKDI}$	Elasticity - other infrastructures (intermediate function for education)
$\sigma_{cyc,lg}^{EWP}$	Elasticity - wage premium (intermediate function for education)
σ_{bus}^{INV}	Elasticity (investment demand)
σ_{j}^{INF}	Elasticity (productivity to infrastructures)
σ_{j}^{LD}	Elasticity (CES – composite labor)
σ_{agr}^{LKD}	Elasticity (CES – aggregate labor-capital)
σ_{skl}^{LS}	Elasticity (CET – labor supply)
σ_{i}^{M}	Elasticity (CES – composite commodity)
σ_{j}^{VA}	Elasticity (CES – value added)
$\sigma_{j,i}^{X}$	Elasticity (CET – exports and local sales)
σ_{j}^{XT}	Elasticity (CET – total output)
TFP_{t}	Total factor productivity
v_{j}	Coefficient (Leontief - value added)
Variables – volumes	
$C_{i,t}$	Households consumption of commodity i

$CG_{i,t}$	Public final consumption of commodity I (exogenous)
$CI_{j,t}$	Total intermediate consumption of industry j
$C_{i,t}^{MIN}$	Households minimum consumption of commodity i
$DD_{i,t}$	Domestic demand for commodity i produced locally
$DI_{i,j,t}$	Intermediate consumption of commodity i by industry j
$DIT_{i,t}$	Total intermediate demand for commodity i
$DS_{j,i,t}$	Supply of commodity i by industry j to the domestic market
$EX_{j,i,t}$	Quantity of product i exported by industry j
$EXD_{i,t}$	World demand for exports of product i
$IND_{j,t}$	Investment in capital by industry j
$INV_{i,t}$	Total final demand of commodity i for investment purposes (GFCF)
$INV_{i,t}^{PRI}$	Final demand of commodity i for private investment purposes
$INV_{i,t}^{PUB}$	Final demand of commodity i for public investment purposes
$IM_{i,t}$	Quantity of product i imported
$KD_{j,t}$	Demand for capital by industry j
KD_{t}^{INF}	Stock of infrastructures
KS_{t}	Total supply of capital
$LD_{l,j,t}$	Demand for type l labor by industry j
$LAND_{agr,t}$	Demand for land by industry agr
$LKD_{agr,t}$	Industry agr demand for capital-labor composite
$LDC_{j,t}$	Industry j demand for composite labor
$LS_{l,t}$	Supply of type l labor
$LST_{skl,l,t}$	Labor supply of work l with skill skl
$Q_{i,t}$	Quantity demanded of composite commodity i
$VA_{j,t}$	Value added of industry j
$VSTK_{i,t}$	Inventory change of commodity i
$XS_{j,i,t}$	Industry j production of commodity i
$XST_{j,t}$	Total aggregate output of industry j
$NST_{cyc,t}$	Total number of students enrolled in cycle cyc
$NST_{cyc,t}^{N}$	New students entering cycle cyc
$NST_{cyc,t}^{N\_OTH}$	Number of other new students
$NST_{cyc,t}^{O}$	Old students in cycle cyc
POP_{t}^{H}	Population
POP_{t}^{H6}	Population of six year olds
$WRK_{skl,t}$	Number of workers of skill skl
Variables – prices	
e_{t}	Exchange rate (price of foreign currency in local currency; *numeraire*)
$P_{j,i,t}$	Basic price of industry j's production of commodity i

$PC_{i,t}$	Purchaser price of composite commodity i (including taxes)
$PCI_{j,t}$	Intermediate consumption price index of industry j
$PD_{i,t}$	Price of local product i sold on the domestic market (including taxes)
$PE_{i,t}$	Price received for exported commodity i (excluding export taxes)
$PIXCON_t$	Consumer price index
$PIXGDP_t$	GDP deflator
$PIXGVT_t$	Public expenditures price index
$PIXINV_t^{PRI}$	Private investment price index
$PIXINV_t^{PUB}$	Public investment price index
PK_t^{PRI}	Price of new private capital
PK_t^{PUB}	Price of new public capital
$PL_{i,t}$	Price of local product i (excluding taxes on products)
$PM_{i,t}$	Price of imported product i (including taxes and tariffs)
$PT_{j,t}$	Basic price of industry j's output
$PVA_{j,t}$	Price of industry j value added
$PWM_{i,t}$	World price of imported product i (expressed in foreign currency, exogenous)
$PWX_{i,t}$	World price of exported product i (expressed in foreign currency, exogenous)
$R_{bus,t}$	Rental rate of capital in industry bus
$RL_{agr,t}$	Rental rate of land in industry agr
$U_{bus,t}$	User cost of capital in industry bus
$W_{l,t}$	Wage rate of type l labor
$WC_{j,t}$	Wage rate of industry j composite labor
$WK_{agr,t}$	Price for capital-labor composite
$WWRK_{skl,t}$	Composite wage by skill
Variables – nominal values	
CAB_t	Current account balance
CTH_t	Household consumption budget
CPC_t	Real per capita consumption
$DEBT_t^{DOM}$	Domestic public debt
$DEBT_t^{ROW}$	Foreign public debt
$DEBT_t^{TOT}$	Total public debt
FDI_t	Foreign direct investment in oil sectors
G_t	Current government expenditures on goods and services
GDP_t^{BP}	GDP at basic prices
$GDP_t^{BP\_REAL}$	Real GDP at basic prices
GDP_t^{MP}	GDP at market prices
$GFCF_t$	Gross fixed capital formation
INT_t^{DOM}	Interest paid on domestic debt
INT_t^{ROW}	Interest paid on foreign debt

IT_t	Total investment expenditures
IT_t^{PRI}	Total private investment expenditures
IT_t^{PUB}	Total public investment expenditures
SG_t	Government savings
SH_t	Household savings
$SROW_t$	Rest-of-the-world savings
TDH_t	Household income taxes
$TIC_{i,t}$	Government revenue from indirect taxes on product i
$TICT_t$	Total government receipts of indirect taxes on commodities
$TIM_{i,t}$	Government revenue from import duties on product i
$TIMT_t$	Total government revenues from import duties
$TPRCTS_t$	Total government revenues from taxes on products and imports
$TR_{ag,agj,t}$	Transfers from agent agj to agent ag
YDH_t	Household disposable income
YG_t	Total government income
YGK_t	Government capital income
$YGOIL_t$	Government oil income
$YGTR_t$	Government transfer income
YH_t	Household total income
YHK_t	Household capital income
YHL_t	Household labor income
$YHTR_t$	Household transfer income
$YROW_t$	Rest-of-the-world income
Variables – rates and intercepts	
$EDQ_{cyc,t}$	Education quality index in cycle cyc
EDW_t	Wage premium
IR_t	Interest rate
ir_t^{DOM}	Interest rate on public domestic debt (exogenous)
ir_t^{ROW}	Interest rate on public foreign debt (exogenous)
$sh0_t$	Intercept (household savings)
$sh1_t$	Slope (household savings)
$SHR_{cyc,sb,t}$	Share of students in cycle cyc with behavior sb
$SHR_{cyc,sb,t}^{I}$	Intermediate share of students in cycle cyc with behavior sb
$tr0_t$	Intercept (household transfers to government)
$tr1_t$	Marginal rate of household transfers to government
$ttdh0_t$	Intercept (household income taxes)
$ttdh1_t$	Marginal household income tax rate
$ttic_{i,t}$	Tax rate on commodity i
$ttim_{i,t}$	Rate of taxes and duties on imports of commodity i

Equations

Production	
1.	$VA_{j,t} = v_j \cdot XST_{j,t}$
2.	$CI_{j,t} = io_j \cdot XST_{j,t}$
3.	$VA_{agr,t} = TFP_t \cdot \left[\frac{KD_t^{INF} / pop_t}{KD^{INF0}}\right]^{\sigma_{agr}^{INF}} \cdot B_{agr}^{VA} \cdot \left[\beta_{agr}^{VA} \cdot LKD_{agr,t}^{-\rho_{agr}^{VA}} + \left(1-\beta_{agr}^{VA}\right) \cdot LAND_{agr,t}^{-\rho_{agr}^{VA}}\right]^{\frac{-1}{\rho_{agr}^{VA}}}$
4.	$\frac{LKD_{agr,t}}{LAND_{agr,t}} = \left[\frac{\beta_{agr}^{VA}}{1-\beta_{agr}^{VA}} \cdot \frac{RL_{agr,t}}{WK_{agr,t}}\right]^{\sigma_{agr}^{VA}}$
5.	$LKD_{agr,t} = B_{agr}^{LKD} \cdot \left[\beta_{agr}^{LKD} \cdot LDC_{agr,t}^{-\rho_{agr}^{LKD}} + \left(1-\beta_{agr}^{LKD}\right) \cdot KD_{agr,t}^{-\rho_{agr}^{LKD}}\right]^{\frac{-1}{\rho_{agr}^{LKD}}}$
6.	$\frac{LDC_{agr,t}}{KD_{agr,t}} = \left[\frac{\beta_{agr}^{LKD}}{1-\beta_{agr}^{LKD}} \cdot \frac{R_{agr,t}}{WC_{agr,t}}\right]^{\sigma_{agr}^{LKD}}$
7.	$VA_{nag,t} = TFP_t \cdot \left[\frac{KD_t^{INF} / pop_t}{KD^{INF0}}\right]^{\sigma_{nag}^{INF}} \cdot B_{nag}^{VA} \cdot \left[\beta_{nag}^{VA} \cdot LDC_{nag,t}^{-\rho_{nag}^{VA}} + \left(1-\beta_{nag}^{VA}\right) \cdot KD_{nag,t}^{-\rho_{nag}^{VA}}\right]^{\frac{-1}{\rho_{nag}^{VA}}}$
8.	$\frac{LDC_{nag,t}}{KD_{nag,t}} = \left[\frac{\beta_{nag}^{VA}}{1-\beta_{nag}^{VA}} \cdot \frac{R_{nag,t}}{WC_{nag,t}}\right]^{\sigma_{nag}^{VA}}$
9.	$VA_{pub,t} = TFP_t \cdot \left[\frac{KD_t^{INF} / pop_t}{KD^{INF0}}\right]^{\sigma_{pub}^{INF}} \cdot B_{pub}^{VA} \left[\beta_{pub}^{VA} \cdot LDC_{pub,t}^{-\rho_{pub}^{VA}} + \left(1-\beta_{pub}^{VA}\right) \cdot KD_{pub,t}^{-\rho_{pub}^{VA}}\right]^{-\frac{1}{\rho_{pub}^{VA}}}$
10.	$LDC_{j,t} = B_j^{LD} \cdot \left[\sum_{l} \beta_{l,j}^{LD} \cdot LD_{l,j,t}^{-\rho_j^{LD}}\right]^{-\frac{1}{\rho_j^{LD}}}$
11.	$LD_{l,j,t} = \left[\beta_{l,j}^{LD} \cdot \frac{WC_{j,t}}{W_{l,t}}\right]^{\sigma_j^{LD}} \cdot \left(B_j^{LD}\right)^{\sigma_j^{LD}-1} \cdot LDC_{j,t}$
12.	$DI_{i,j,t} = aij_{i,j} \cdot CI_{j,t}$
Households	
13.	$YH_t = YHL_t + YHK_t + YHTR_t + INT_t^{DOM}$
14.	$YHL_t = \sum_{l,j} W_{l,t} \cdot LD_{l,j,t}$
15.	$YHK_t = \lambda_{hhd}^{RK} \cdot \sum_{noil} R_{noil,t} \cdot KD_{noil,t} + \sum_{agr} RL_{agr,t} \cdot LAND_{agr,t}$
16.	$YHTR_t = \sum_{ag} TR_{hhd,ag,t}$
17.	$YDH_t = YH_t - TDH_t - TR_{gvt,hhd,t}$
18.	$CTH_t = YDH_t - SH_t - \sum_{agng} TR_{agng,hhd,t}$
19.	$SH_t = PIXCON_t \cdot sh0_t + sh1_t \cdot YDH_t$

Government	
20.	$YG_t = YGK_t + TDH_t + TPRCTS_t + YGTR_t$
21.	$YGK_t = \lambda_{gvt}^{RK} \cdot \sum_{noil} R_{noil,t} \cdot KD_{noil,t}$
22.	$YOIL_t = \lambda_{gvt}^{RKOIL} \cdot \sum_{oil} R_{oil,t} \cdot KD_{oil,t}$
23.	$TDH_t = PIXCON_t \cdot ttdh0_t + ttdh1_t \cdot YH_t$
24.	$TPRCTS_t = TICT_t + TIMT_t$
25.	$TICT_t = \sum_i TIC_{i,t}$
26.	$TIC_{i,t} = ttic_{i,t} \cdot \left[PL_{i,t} \cdot DD_{i,t} + \left(1 + ttim_{i,t}\right) \cdot PWM_{i,t} \cdot e_t \cdot IM_{i,t}\right]$
27.	$TIMT_t = \sum_i TIM_{i,t}$
28.	$TIM_{i,t} = ttim_{i,t} \cdot PWM_{i,t} \cdot e_t \cdot IM_{i,t}$
29.	$YGTR_t = \sum_{agna} TR_{gvt,agng,t}$
30.	$INT_t^{DOM} = ir_t^{DOM} \cdot DEBT_t^{DOM}$
31.	$INT_t^{ROW} = ir_t^{ROW} \cdot DEBT_t^{ROW}$
32.	$DEDT_t^{TOT} = DEBT_t^{ROW} + DEBT_t^{DOM}$
33.	$SG_t = YG_t - \sum_{agng} TR_{agng,gvt,t} - G_t - INT_t^{DOM} - INT_t^{ROW} - \sum_{pub} PK_t^{PUB} \cdot IND_{pub,t}$
Rest of the world	
34.	$YROW_t = e_t \cdot \sum_i PWM_{i,t} \cdot IM_{i,t} + \lambda_{row}^{RK} \sum_{noil} R_{noil,t} \cdot KD_{noil,t} + \lambda_{row}^{RKOIL} \sum_{oil} R_{oil,t} \cdot KD_{oil,t} + \sum_{agd} TR_{row,agd,t} + INT_t^{ROW} + YGOIL_t$
35.	$SROW_t = YROW_t - \sum_i PE_{i,t} \cdot EXD_{i,t} - \sum_{agd} TR_{agd,row,t} - FDI_t$
36.	$SROW_t = -CAB_t - FDI_t$
Transfers	
37.	$TR_{agng,hhd,t} = \lambda_{agng,hhd}^{TR} \cdot YDH_t$
38.	$TR_{gvt,hhd,t} = PIXCON_t \cdot tr0_t + tr1_t \cdot YH_t$
39.	$TR_{agng,gvt,t} = PIXCON_t \cdot TR_{agng,gvt}^{O} \cdot pop_t$
40.	$TR_{agd,row,t} = PIXCON_t \cdot TR_{agd,row}^{O} \; pop_t$
Demand	
41.	$PC_{i,t} \cdot C_{i,t} = PC_{i,t} \cdot C_{i,t}^{MIN} + \gamma_i^{LES} \cdot \left(CTH_t - \sum_{ij} PC_{ij,t} \cdot C_{ij,t}^{MIN}\right)$
42.	$GFCF_t = IT_t - \sum_i PC_{i,t} \cdot VSTK_{i,t}$
43.	$PC_{i,t} \cdot INV_{i,t}^{PRI} = \gamma_i^{INVPRI} \cdot IT_t^{PRI}$
44.	$PC_{i,t} \cdot INV_{i,t}^{PUB} = \gamma_i^{INVPUB} \cdot IT_t^{PUB}$

45.	$INV_{i,t} = INV_{i,t}^{PRI} + INV_{i,t}^{PUB}$
46.	$G_t = \sum_i PC_{i,t} \cdot CG_{i,t}$
47.	$DIT_{i,t} = \sum_j DI_{i,j,t}$
Supply and international trade	
48.	$XST_{j,t} = B_j^{XT} \cdot \left[\sum_i \beta_{j,i}^{XT} \cdot XS_{j,i,t}^{\rho_j^{XT}} \right]^{\frac{1}{\rho_j^{XT}}}$
49.	$XS_{j,i,t} = \frac{XST_{j,t}}{\left(B_j^{XT}\right)^{1+\sigma_j^{XT}}} \cdot \left[\frac{P_{j,i,t}}{\beta_{j,i}^{XT} \cdot PT_{j,t}} \right]^{\sigma_j^{XT}}$
50.	$XS_{j,i,t} = B_{j,i}^{X} \cdot \left[\beta_{j,i}^{X} \cdot EX_{j,i,t}^{\rho_{j,i}^{X}} + \left(1-\beta_{j,i}^{X}\right) \cdot DS_{j,i,t}^{\rho_{j,x}^{X}} \right]^{\frac{1}{\rho_{j,i}^{X}}}$
51.	$\frac{EX_{j,i,t}}{DS_{j,i,t}} = \left[\frac{1-\beta_{j,i}^{X}}{\beta_{j,i}^{X}} \cdot \frac{PE_{i,t}}{PL_{i,t}} \right]^{\sigma_{j,i}^{X}}$
52.	$Q_{i,t} = B_i^{M} \cdot \left[\beta_i^{M} \cdot IM_{i,t}^{-\rho_i^{M}} + \left(1-\beta_i^{M}\right) \cdot DD_{i,t}^{-\rho_i^{M}} \right]^{\frac{-1}{\rho_i^{M}}}$
53.	$\frac{IM_{i,t}}{DD_{i,t}} = \left[\frac{\beta_i^{M}}{1-\beta_i^{M}} \cdot \frac{PD_{i,t}}{PM_{i,t}} \right]^{\sigma_i^{M}}$
Prices	
54.	$PT_{j,t} \cdot XST_{j,t} = PVA_{j,t} \cdot VA_{j,t} + PCI_{j,t} \cdot CI_{j,t}$
55.	$PCI_{j,t} \cdot CI_{j,t} = \sum_i PC_{i,t} \cdot DI_{i,j,t}$
56.	$PVA_{agr,t} \cdot VA_{agr,t} = WK_{agr,t} \cdot LKD_{agr,t} + RL_{agr,t} \cdot LAND_{agr,t}$
57.	$PVA_{nag,t} \cdot VA_{nag,t} = WC_{nag,t} \cdot LDC_{nag,t} + R_{nag,t} \cdot KD_{nag,t}$
58.	$PVA_{pub,t} \cdot VA_{pub,t} = WC_{pub,t} \cdot LDC_{pub,t}$
59.	$WK_{agr,t} \cdot LKD_{agr,t} = WC_{agr,t} \cdot LDC_{agr,t} + R_{agr,t} \cdot KD_{agr,t}$
60.	$PT_{j,t} \cdot XST_{j,t} = \sum_i P_{j,i,t} \cdot XS_{j,i,t}$
61.	$P_{j,i,t} \cdot XS_{j,i,t} = PE_{i,t} \cdot EX_{j,i,t} + PL_{i,t} \cdot DS_{j,i,t}$
62.	$PE_{i,t} = e_t \cdot PWX_{i,t}$
63.	$PD_{i,t} = \left(1 + ttic_{i,t}\right) \cdot PL_{i,t}$
64.	$PM_{i,t} = \left(1 + ttic_{i,t}\right) \cdot \left(1 + ttim_{i,t}\right) \cdot e_t \cdot PWM_{i,t}$
65.	$PC_{i,t} \cdot Q_{i,t} = PM_{i,t} \cdot IM_{i,t} + PD_{i,t} \cdot DD_{i,t}$
66.	$PIXGDP_t = \sqrt{\frac{\sum_j PVA_{j,t} \cdot VA_j^{O}}{\sum_j PVA_j^{O} \cdot VA_j^{O}} \frac{\sum_j PVA_{j,t} \cdot VA_{j,t}}{\sum_j PVA_j^{O} \cdot VA_{j,t}}}$
67.	$PIXCON_t = \frac{\sum_i PC_{i,t} \cdot C_i^{O}}{\sum_{ij} PC_{ij}^{O} \cdot C_{ij}^{O}}$

68.	$PIXINV_t^{PRI} = \prod_i \left(\frac{PC_{i,t}}{PC_i^O} \right)^{\gamma_i^{INVPRI}}$
69.	$PIXINV_t^{PUB} = \prod_i \left(\frac{PC_{i,t}}{PC_i^O} \right)^{\gamma_i^{INVPUB}}$
70.	$PIXGVT_t = \prod_i \left(\frac{PC_{i,t}}{PC_i^O} \right)^{\gamma_i^{GVT}}$
Labor supply	
71.	$WRK_{skl,t} = B_{skl}^{LS} \cdot \left[\sum_l \beta_{skl,l}^{LS} \cdot LST_{skl,l,t}^{\rho_{skl}^{LS}} \right]^{\frac{1}{\rho_{skl}^{LS}}}$
72.	$LST_{skl,l,t} = \frac{WRK_{skl,t}}{\left(B_{skl}^{LS}\right)^{1+\sigma_{skl}^{LS}}} \cdot \left[\frac{W_{l,t}}{\beta_{skl,l}^{LS} \cdot WWKR_{skl,t}} \right]^{\sigma_{skl}^{LS}}$
73.	$LS_{l,t} = \sum_{skl} LST_{skl,l,t}$
Equilibrium	
74.	$Q_{i,t} = C_{i,t} + CG_{i,t} + INV_{i,t} + VSTK_{i,t} + DIT_{i,t}$
75.	$LS_{l,t} = \sum_j LD_{l,j,t}$
76.	$KS_t = \sum_j KD_{j,t}$
77.	$IT_t = SH_h + SG_t + \sum_{pub} PK_t^{PUB} \cdot IND_{pub,t} + SROW_t + FDI_t$
78.	$IT_t^{PRI} = IT_t - IT_t^{PUB} - \sum_i PC_{i,t} \cdot VSTK_{i,t}$
79.	$\sum_j DS_{j,i,t} = DD_{i,t}$
80.	$\sum_j EX_{j,i,t} = EXD_{i,t}$
Gross domestic product	
81.	$GDP_t^{BP} = \sum_j PVA_{j,t} \cdot VA_{j,t}$ t
82.	$GDP_t^{BP\_REAL} = \frac{GDP_t^{BP}}{PIXGDP_t}$
83.	$GDP_t^{MP} = GDP_t^{BP} + TPRCTS_t$
Dynamic equations	
84.	$IT_t^{PUB} = PK_t^{PUB} \cdot \sum_{pub} IND_{pub,t}$
85.	$IT_t^{PRI} = PK_t^{PRI} \cdot \sum_{bus} IND_{bus,t}$
86.	$PK_t^{PRI} = \frac{1}{A^{K\_PRI}} \cdot \prod_i \left[\frac{PC_{i,t}}{\gamma_i^{INVPRI}} \right]^{\gamma_i^{INVPRI}}$

87.	$PK_t^{PUB} = \frac{1}{A^{K\_PUB}} \cdot \prod_i \left[\frac{PC_{i,t}}{\gamma_i^{INVPUB}} \right]^{\gamma_i^{INVPUB}}$
88.	$IND_{noil,t} = \phi_{noil} \cdot \left[\frac{R_{noil,t}}{U_{noil,t}} \right]^{\sigma_{bus}^{INV}} \cdot KD_{noil,t}$
89.	$IND_{oil,t} = \left[\frac{FDI_t}{PK_t^{PRI}} \right] \cdot \left[\frac{KD_{oil}^O}{\sum_{oilj} KD_{oilj}^O} \right]$
90.	$U_{noil,t} = PK_t^{PRI} \cdot \left(\delta_{noil} + IR_t \right)$
Education	
91.	$SHR_{cyc,lg,t} = ext_{cyc,lg} + \frac{\alpha_{cyc,lg}^{ED}}{1 + \exp\left\{ \gamma_{cyc,lg}^{ED} + \beta_{cyc,lg}^{ED} \cdot \left(SHR_{cyc,lg,t}^I - SHR_{cyc,lg}^O \right) \right\}}$
92.	$SHR_{cyc,lg,t}^I = SHR_{cyc,lg}^O \left[\begin{array}{l} \left(\frac{EDQ_{cyc,t}}{EDQ_{cyc}^O} \right)^{\sigma_{cyc,lg}^{EDQ}} \cdot \left(\frac{EDW_{cyc,t}}{EDW_{cyc}^O} \right)^{\sigma_{cyc,lg}^{EWP}} \\ \left(\frac{KD_t^{INF}}{pop_t KD^{INF\,O}} \right)^{\sigma_{cyc,lg}^{EKDI}} \cdot \left(\frac{CPC_t}{CPC^O} \right)^{\sigma_{cyc,lg}^{ECH}} \end{array} \right]$
93.	$EDQ_{primary,t} = \frac{XST_{eduprv,t} + XST_{edugov,t}}{NST_{primary,t}}$; $EDQ_{secter,t} = \frac{XST_{edustprv,t} + XST_{edustgov,t}}{NST_{secter,t}}$
94.	$EDW_t = \frac{WWRK_{sk,t}}{WWRK_{usk,t}}$
95.	$CPC_t = \frac{\sum_i PC_i^O \cdot C_{i,t}}{POP_t^H}$
96.	$SHR_{cyc,prom\_grd,t} = \left[\frac{SHR_{cyc,prom\_grd}^O}{SHR_{cyc,prom}^O} \right] \cdot SHR_{cyc,prom,t}$
97.	$SHR_{cyc,prom\_ctn,t} = SHR_{cyc,prom,t} - SHR_{cyc,prom\_grd,t}$
98.	$SHR_{cyc,grd\_fin,t} = 1 - SHR_{cyc,grd\_csup,t}$
99.	$SHR_{cyc,rep,t} = \left[\frac{SHR_{cyc,rep}^O}{1 - SHR_{cyc,prom}^O} \right] \cdot \left(1 - SHR_{cyc,prom,t} \right)$
100.	$SHR_{cyc,dropout,t} = 1 - SHR_{cyc,prom,t} - SHR_{cyc,rep,t}$
101.	$NST_{cyc,t} = NST_{cyc,t}^N + NST_{cyc,t}^O$
102.	$NST_{primary,t}^N = SHR_{primary,entry,t} \cdot POP_t^{H6} + NST_{primary,t}^{N\_OTH}$
Inter-period behavior	
103.	$KD_{j,t} = KD_{j,t-1} \left(1 - \delta_j \right) + IND_{j,t-1}$
104.	$LAND_{agr,t} = LAND_{agr,t-1} \left(1 + g_{t-1}^{LAND} \right)$
105.	$WRK_{usk,t} = WRK_{usk,t-1} \left(1 - ret_{usk} \right) + \psi_{usk} \left\{ \begin{array}{l} NST_{primary,t-1} \cdot SHR_{primary,dropout,t-1} \\ + POP_{t-1}^{H6} \cdot \left(1 - SHR_{primary,entry,t-1} \right) \end{array} \right\}$
106.	$WRK_{sk,t} = WRK_{sk,t-1} \left(1 - ret_{sk} \right) + \psi_{sk} \left\{ \begin{array}{l} NST_{primary,t-1} \cdot SHR_{primary,prom\_grd,t-1} \cdot SHR_{primary,grd\_fin,t-1} \\ + NST_{secter,t-1} \cdot SHR_{secter,prom\_grd,t-1} \cdot SHR_{secter,grd\_fin,t-1} \\ + NST_{secter,t-1} \cdot SHR_{secter,dropout,t-1} \end{array} \right\}$

107.	$NST^{O}_{cyc,t} = NST_{cyc,t-1}\{SHR_{cyc,grd\_ctn,t-1} + SHR_{cyc,rep,t-1}\}$
108.	$NST^{N}_{secter,t} = NST_{primary,t-1} \cdot SHR_{primary,prom\_grd,t-1} \cdot SHR_{primary,grd\_csup,t-1} + NST^{N\_OTH}_{secter,t}$
109.	$DEBT^{TOT}_{t} = DEBT^{TOT}_{t-1} - SG_{t-1}$
110.	$OILFUND_{t} = OILFUND_{t-1} + YGOIL_{t-1}$

Exogenous variable

$C^{MIN}_{i,t} = C^{MIN\ O}_{i} \cdot pop_t$	$CAB_t = CAB^{O} \cdot pop_t$
$CG_{i,t} = CG^{O}_{i} \cdot pop_t$	$DEBT^{DOM}_{t} = DEBT^{DOM\ O} \cdot pop_t$
$IND_{pub,t} = IND^{O}_{pub} \cdot pop_t$	$VSTK_{i,t} = VSTK^{O}_{i} \cdot pop_t$
$POP^{H}_{t} = POP^{H\ O} \cdot pop_t$	$POP^{H6}_{t} = POP^{H6O} \cdot pop_t$
$NST^{N\_OTH}_{cyc,t} = NST^{N\_OTH\ O}_{cyc} \cdot pop_t$	$sh0_t = sh0^{O} \cdot pop_t$
$tr0_t = tr0^{O} \cdot pop_t$	$ttdh0_t = ttdh0^{O} \cdot pop_t$
$ir^{DOM}_{t} = ir^{DOM\ O}$	$ir^{ROW}_{t} = ir^{ROW\ O}$
$PWM_{i,t} = PWM^{O}$	$PWX_{i,t} = PWX^{O}$
$sh1_t = sh1^{O}$	$tr1_t = tr1^{O}$
$ttdh1_t = ttdh1^{O}$	$ttic_{i,t} = ttic^{O}_{i}$
$ttim_{i,t} = ttim^{O}_{i}$	$ttip_{j,t} = ttip^{O}_{j}$
$ttix_{i,t} = ttix^{O}_{i}$	$e_t = e^{O}$ *(numeraire)*

Annex 2: Sources of data[8]

A2.1 The Social Accounting Matrix

The original Social Accounting Matrix (SAM) used in this project was elaborated in the framework of the Project "Strengthening Macro-Micro Modelling Capacities to Assess Development Support Measures and Strategies", which is being coordinated by the Development Policy and Analysis Division of the United Nations Department of Economic and Social Affairs (UN-DESA/DPAD) and the United Nations Development Programme (UNDP) in Uganda.[9] To better take into account the specificities of our study, we introduced some changes in the SAM. We will therefore present the different changes made, and then we will present the structure of the SAM.

A2.1.1 Changes added to the initial SAM

The original SAM is based on 2009/10 data. We introduced 3 main changes in this SAM. The first one is related to agricultural commodities, the second one to the labor market and the third one to the introduction of the petroleum sector.

A2.1.1.1 Agricultural commodities

In the original SAM, there were four agricultural commodities: (*agric, flowers, coffee and tea*). In our project, we are interested in the impacts of two specific policies on child poverty. We know that households spend most of their income on agricultural products. We are therefore very interested in splitting the commodity "c-agric" further. Moreover, it allows us to have the same categories of agricultural products in the SAM and in the micro-module. To proceed, we use the SAM developed by Thurlow (2008), based on 2007 data. This SAM, as shown in the table below, is very detailed for agricultural commodities.

TABLE 5: AGRICULTURAL COMMODITIES IN THE 2007 SAM

Labels in the SAM	Definitions
cmaiz	Maize
Crice	Rice
cocer	Other cereals
ccass	Cassava
croot	Roots
cpuls	Pulses and oilseeds
chort	Horticulture
cmato	Matoke

Labels in the SAM	Definitions
ctoba	Tobacco
ccott	Cotton
ccoff	Coffee
cocrp	Other crops
clive	Livestock
cfore	Forestry
cfish	Fishing

TABLE 6: AGRICULTURAL COMMODITIES IN THE 2009 SAM

Labels in the SAM	Definitions
c-agric	Agriculture
c-flowers	Flowers
c-coffee	Coffee
c-tea	Tea
c-fish	Fish

Source: UN-DESA/DPAD SAM

From the 2007 SAM, first we create a new category "other agriculture" (*othagr*) that includes the commodities other crops, livestock, forestry, tobacco and cotton. Coffee and horticulture are common to both SAMs, but tea is not in the 2007 SAM. We will thus assume that it is included in "other crops" in the 2007 SAM.

We need to split the commodity "c-agric" from the 2009 SAM between the following agricultural commodities: maize, rice, cassava, roots, pulses and oilseeds, matoke and other agriculture. To estimate

[8] This section was prepared by Hélène Maisonnave

[9] We are very grateful to Martin Cicowiez for sharing all the data with us.

the supply, we keep the 2009 values for coffee, tea and flowers, and then, to split the value of "c-agr", we keep the same division as in the 2007 SAM for exports, local sales, and imports. For import duties and indirect taxes, we keep the same tax rate as in 2007.

Then, to estimate the domestic absorption, we keep the 2007 shares for consumption and total intermediate demand. In the 2007 SAM, there was no consumption for investment purposes. To split the value of investment purposes for the commodity "cagric" between the different agricultural commodities, we use the same shares as the ones used for production. It turns out that domestic absorption (consumption plus total intermediate consumption plus consumption for investment purposes) does not exactly match the sum of local sales, imports and taxes (indirect plus import duties), so we use the RAS method to balance the demand.

The supply table: in the 2007 SAM, the supply table is a diagonal, whereas it is not in 2009. We had to rebalance the supply table in order to avoid assigning a production of agricultural products to a non-agricultural sector. Then the production was split, keeping the 2007 shares. Finally, for intermediate consumption, we used the same division as in the 2007 SAM.

A2.1.1.2 Labor market

The SAM from MAMS splits labor into three categories (unskilled, skilled and highly skilled). Unskilled labor refers to workers who did not complete their secondary education, skilled labor refers to workers who completed secondary education, and finally highly skilled workers refers to workers who completed tertiary education. Given the distribution of skills in the labor market in Uganda (almost 70 % of the labor force has not complete primary education), we wish to distinguish labor differently. Moreover, we know that most workers in Uganda are self-employed, and this is another specificity that we want to take into account. We will therefore have four different types of labor: salaried unskilled workers (swusk), salaried skilled workers (swsk), self-employed farmers (seag), and self-employed non-farmers (senag).

Salaried unskilled workers will refer to wage workers who did not complete primary school. Salaried skilled workers refers to wage workers who have completed at least primary education. To obtain these categories, we need to modify the SAM with the help of the household survey. First, the total values in the SAM are split proportionally to the values from the household survey. According to the household survey, the total wage bill is shown in Table 7. In the 2009 SAM, the total wage bill for agriculture is 1,580. Applying the same breakdown as in the household survey, we find the new breakdown for the agricultural sector as in the Table 8.

TABLE 7: WAGE BILL BY TYPE OF WORKERS IN THE HOUSEHOLD SURVEY (UGX BILLIONS)

Type of workers	Wage bill
Salaried unskilled	1,124
Salaried skilled	3,178
Self-employed agriculture	3,016
Self-employed non-agriculture	6,359
TOTAL	**13,677**

Source: Authors' calculation from the household survey

TABLE 8: DISTRIBUTION OF THE WAGE BILL IN THE AGRICULTURAL SECTOR (UGX BILLIONS)

Type of workers	Survey	AGRIC
Salaried unskilled	125	62
Salaried skilled	53	26
Self-employed agriculture	3,016	1,492
TOTAL	**3,194**	**1,580**

Source: Authors' calculation

For the other sectors, we made some modifications in the data coming from the survey. Indeed, some of the data seemed to be out of line with what one would expect. The first hypothesis taken is that we extracted the income of the self-employed from the following sectors: electricity, private secondary and tertiary education, and private health. The second hypothesis taken is related to the public secondary and tertiary education sector. Indeed, in the data, the breakdown of salaries was way greater for unskilled (though one would expect more skilled workers). The data from private secondary and tertiary education was used. Finally, self-employed salaries for electricity were placed into the construction sector, as well as the one representing workers who do not know which sector they belong to. Computing the shares with the data obtained, we find the following shares from the survey.

TABLE 9: SHARES OF THE WAGE BILL OBTAINED IN THE HOUSEHOLD SURVEY, PER ACTIVITY (IN %)

Activities	swusk	swsk	seag	senag
Flowers	35	15	0	50
Coffee	35	15	0	50
Tea	35	15	0	50
Fish	6	2.8	0	91.2
Mining	0.7	4.6	0	94.7
Other food	14.2	9.4	0	76.4
Beverages tobacco	9.0	21.3	0	69.7
Textile	10.8	9.3	0	79.9
Petrochemical	79.6	20.4	0	0
Other manufactories	10.8	15.4	0	73.8
Electricity	64.8	35.2	0	0
Water and sanitation	1.6	98.4	0	0
Construction	7.8	60.1	0	32.1
Public administration	1.6	98.4	0	0
Primary education, private	2.8	97.2	0	0
Secondary and tertiary education, private	1.7	98.3	0	0
Primary education, public	10.4	89.6	0	0
Secondary and tertiary education, public	1.7	98.3	0	0
Health, private	14.1	85.9	0	0
Health, public	3.3	96.7	0	0
Other infrastructure	1.6	98.4	0	0
Other services	4.7	14.2	0	81.1

Source: Authors' calculations

Applying these shares and after using the RAS method, we find the following values for the wage bill in the SAM.

TABLE 10: WAGE BILL BY ACTIVITY AND TYPE OF WORKERS (UGX BILLIONS)

Activities	swusk	swsk	seag	senag
Agriculture	62	26	1,492	0
Flowers	6	1	0	4
Coffee	102	13	0	72
Tea	54	7	0	38
Fish	12	2	0	87
Mining	0	1	0	18
Other food	23	5	0	61
Beverages tobacco	37	26	0	140
Textile	5	1	0	18
Petrochemical	48	4	0	0
Other manufactures	37	16	0	124
Electricity	105	17	0	0
Water and sanitation	45	814	0	0
Construction	97	223	0	199
Public administration	50	897	0	0
Primary education, private	25	265	0	0
Secondary and tertiary education, private	43	726	0	0
Primary education, public	115	293	0	0
Secondary and tertiary education, public	10	164	0	0

Health, private	53	96	0	0
Health, public	9	75	0	0
Other infrastructure	0	5	0	0
Other services	329	292	0	2,787
TOTAL	1,267	3,964	1,492	3,550

Source: Authors' calculations

A2.1.1.3 Introducing the oil sector

The initial SAM does not take petroleum into account as crude oil is not currently produced in Uganda and there is also no refining capacity in the country. We need to introduce oil production and refined oil sector in the SAM as well as their corresponding products. We follow Wiebelt et al. (2011) to proceed.

As they did, we apply the input structure from the Nigerian SAM for 2006.

TABLE 11: INPUT STRUCTURES FOR CRUDE OIL AND REFINING SECTORS IN NIGERIA (2006)

Activities	Crude %	Refined %
Wood, wood products, furniture	0.05	1.91
Transportation and other equipment	2.03	6.08
Other manufactured products	1.77	5.04
Crude petroleum and natural gas	0.00	44.13
Refined oil	0.99	4.51
Other mining	0.00	7.02
Electricity and water	0.00	4.63
Road transport	2.22	2.72
Other transportation	0.39	0.00
Wholesale and retail trade	0.00	1.04
Telecommunications, Post and broadcasting	0.00	0.76
Financial institutions, insurance and business services (not health or education)	0.32	0.76
Labor	0.25	0.25
Capital	91.98	21.13
Taxes on activity	-	-
Total	100.00	100.00

Source: Nwafor et al. (2010)

Using the 2009 SAM nomenclature we have the following.

TABLE 12: INPUT STRUCTURES FOR CRUDE OIL AND REFINING SECTORS USING UGANDAN NOMENCLATURE (IN %)

	Crude	Refined
Labor	0.25	0.25
Capital	91.98	21.13
Crude	0	44.13
Mining	0	7.02
Refined petroleum	0.99	4.51
Other manufactories	3.85	13.03
Electricity	0	4.63
Other services	2.92	5.29
TOTAL	**100**	**100**

Source: Authors' calculations using the Ugandan 2009 SAM

Following Wiebelt et al. (2010), we find the following figures.

TABLE 13: INPUT VALUES FOR CRUDE OIL AND REFINING SECTORS IN THE UGANDAN MODEL (UGX BILLIONS)

	Crude	Refined
Labor	0.032	0.044
Capital	11.879	3.722
Crude	0.0	12.9
Mining	0.0	0.2
Refined petroleum	0.1	0.1
Other manufactories	0.5	0.4
Electricity	0.0	0.1
Other services	0.4	0.1
TOTAL	**12.9**	**17.6**

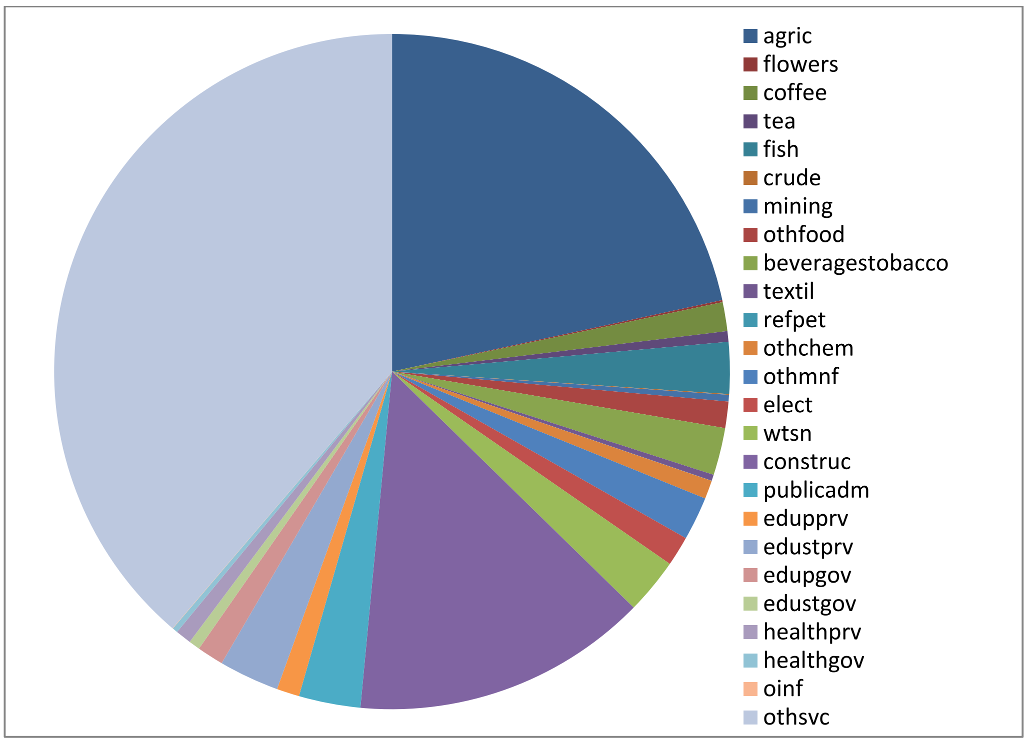
Source: Authors' calculations

A2.1.2 Structure of the SAM

A2.1.2.1 Contribution of sectors to GDP

The figure below represents the contribution of the different sectors to GDP. The main contributor is the services sector (here, the sector "other services" accounts for 39% of GDP), while the agricultural sector alone contributes 22% of total GDP. The construction sector represents 14%. Finally, industrial sectors have a very limited contribution. These findings are consistent with the official data presented in the report.

FIGURE 15: CONTRIBUTION OF THE SECTORS TO GDP (IN %)



Source: Computation from the SAM

A2.1.2.2 Distribution of value added between labor and capital

The table below shows the distribution of value added between the different factors of production. For instance, land accounts for 71% of the value added in the agricultural sector while self-employed workers account for 21%. The fish, mining, beverage and tobacco, chemicals and construction sectors are intensive in capital. Not surprisingly, the education and health sectors (both public and private) are intensive in skilled workers.

TABLE 14: DISTRIBUTION OF VALUE ADDED BETWEEN THE PRODUCTION FACTORS (IN %)

Activities	Unskilled	Skilled	Self employed	Capital	Oil capital	Land	Total
Agriculture	0.89	0.37	21.50	6.62	0.00	70.62	100.00
Flowers	17.91	2.23	12.69	21.77	0.00	45.40	100.00
Coffee	22.96	2.86	16.27	18.74	0.00	39.17	100.00
Tea	32.92	4.10	23.32	8.75	0.00	30.91	100.00
Fish	1.47	0.21	11.03	87.29	0.00	0.00	100.00
Crude	0.09	0.18	0.00	0.00	99.73	0.00	100.00
Mining	0.26	0.51	17.61	81.62	0.00	0.00	100.00
Other food	5.73	1.12	15.18	77.97	0.00	0.00	100.00
Beverages and tobacco	5.07	3.52	19.21	72.20	0.00	0.00	100.00
Textile	5.29	1.34	19.26	74.11	0.00	0.00	100.00
Refined petroleum	1.09	0.08	0.00	0.00	98.83	0.00	100.00
Other chemicals	16.95	1.29	0.00	81.76	0.00	0.00	100.00
Other manufactures	5.51	2.32	18.58	73.59	0.00	0.00	100.00
Electricity	22.96	3.70	0.00	73.34	0.00	0.00	100.00
Water and sanitation	5.24	94.76	0.00	0.00	0.00	0.00	100.00
Construction	2.14	4.90	4.37	88.59	0.00	0.00	100.00
Public administration	5.24	94.76	0.00	0.00	0.00	0.00	100.00
Primary education, private	7.26	75.89	0.00	16.85	0.00	0.00	100.00
Secondary and tertiary education, private	4.70	78.45	0.00	16.85	0.00	0.00	100.00
Primary education, public	28.15	71.85	0.00	0.00	0.00	0.00	100.00
Secondary and tertiary education, public	5.65	94.35	0.00	0.00	0.00	0.00	100.00
Health, private	21.85	39.29	0.00	38.86	0.00	0.00	100.00
Health, public	10.36	89.64	0.00	0.00	0.00	0.00	100.00
Other infrastructure	5.24	94.76	0.00	0.00	0.00	0.00	100.00
Other services	2.64	2.35	22.39	72.62	0.00	0.00	100.00

Source: Computation from the SAM

A2.1.2.3 Households

Households receive their income from three main sources: labor income, capital income and transfers. More than the half of their total income comes from land and capital income (60%), followed by labor income (self-employed and skilled).

TABLE 15: STRUCTURE OF HOUSEHOLD INCOME (IN %)

Labor income			Capital income		Land income	Domestic interest	Transfers from government	Transfers from the rest of the world
Unskilled	Skilled	Self employed	Capital	Oil capital				
3.56	11.14	14.16	45.85	0.00	14.44	0.92	3.51	6.42

Source: Computation from the SAM

Households spend most of their income on consumption (78%) and they save 14% of their income. As mentioned in the report, the direct tax rate is quite low.

TABLE 16: STRUCTURE OF SPENDING (IN %)

Consumption	Savings	Direct taxes	Transfers to government	Transfers to the rest of the world
78.26	14.04	3.95	0.31	3.44

A2.1.2.4 Government

Most of government income comes from the collection of import duties (almost 40%). As explained in the main report, the Ugandan government relies a lot on foreign transfers. The share of oil capital and capital income it receives is quite marginal in the base year.

TABLE 17: STRUCTURE OF GOVERNMENT INCOME (IN %)

Capital income	Oil capital income	Transfers from households	Indirect taxes	Import duties	Direct taxes	transfers from the rest of the world	Total
0.22	0.24	2.11	14.47	38.73	26.71	17.52	100.00

Source: Computations from the SAM

The government spends most of its income on consumption of public commodities (public administration. public education. public health). The government transfers 25% of its income to households. Note that government savings is negative and accounts for one-third of its total income.

TABLE 18: STRUCTURE OF GOVERNMENT SPENDING (IN %)

Transfers to households	24.94	**Savings**	-32.64
Payments of domestic interest	6.93	**Investment in public administration**	2.04
Transfers to the rest of the world	0.00	**Investment in primary education**	15.38
Payment of international interest	1.18	**Investment in secondary education**	2.44
Consumption of public administration	46.64	**Consumption of other infrastructure**	0.23
Consumption of public primary education	10.29	**Investment in health**	2.07
Consumption of public secondary and tertiary education	4.38	**Investment in other infrastructure**	15.28
Consumption of health	5.81	**Total**	100.00

Source: Computation from the SAM

A2.1.2.5 Relations with the rest of the world

The following table gives us some indications on the relations between Uganda and the rest of the world. The first column of the table shows the breakdown of production (XS), notably the share of total production dedicated to exports (EX). For instance, the entire production of the refined petroleum sector is exported. Flowers (77%), textiles (64%) and coffee (62%) export most of their production. These sectors might be more affected in the case of an external shock.

The second column shows the shares of each exported commodity (EX) in total exports (EXT). For instance, 34% of total exports are "other services", whereas beverage and tobacco accounts for 13% of total exports and coffee accounts for 11%.

The third column refers to the import penetration rate, i.e., how the Ugandan market (Q) relies on imports (IM). For instance, 55% of the "other manufactured" commodities are imported, 49% of other chemicals, and 33% of mining. As the manufacturing sector is quite small in Uganda, this is not a surprise that manufactured commodities are mainly imported. In agricultural commodities, we can see that they import 28% of their other cereals and 24% of flowers.

Finally, the last column gives the breakdown of total import (IMT) between imported commodities (IM). As mentioned in the document, most of Uganda's imports are manufactured commodities. This is what we find here as "other manufactured commodities" and "other chemicals", which sum up to more than the half of total imports.

TABLE 19: RELATIONS WITH THE REST OF THE WORLD (IN %)

Commodities	EX/XS	EX/EXT	IM/Q	IM/IMT
Coffee	62.11	11.25	2.04	0.08
Tea	35.42	2.77	0.07	0.00
Flowers	77.20	2.17	23.66	0.23
Maize	0.33	0.51	13.50	0.66
Rice	0.00	0.00	18.86	0.27
Other cereals	0.31	0.47	27.56	1.66
Cassava	0.00	0.00	0.00	0.00
Root	0.00	0.00	0.00	0.00
Pulses and oilseeds	0.79	1.22	0.83	0.11
Matoke	0.00	0.00	0.00	0.00
Other agriculture	2.14	3.30	0.06	0.02
Fish	29.56	6.39	0.34	0.03
Crude	0.00	0.00	0.00	0.00
Mining	10.57	0.33	32.97	0.82
Other food	7.21	6.96	8.23	4.50
Beverages tobacco	23.01	12.99	6.20	1.61
Textiles	64.43	7.12	32.42	3.83
Refined petroleum	100.00	0.28	0.00	0.00
Other chemicals	15.68	4.42	48.83	18.15
Other manufactories	7.57	4.42	55.38	37.65
Electricity	4.11	0.36	1.85	0.08
Water and sanitation	0.00	0.00	0.00	0.00
Construction	0.00	0.00	0.00	0.00
Public administration	2.09	0.69	19.04	4.13
Private primary education	0.00	0.00	0.00	0.00
Private secondary and tertiary education	0.00	0.00	0.00	0.00
Public primary education	0.00	0.00	0.00	0.00
Public secondary and tertiary education	0.00	0.00	0.00	0.00
Private health	0.00	0.00	0.00	0.00
Public health	0.00	0.00	0.00	0.00
Other infrastructure	2.09	0.00	19.04	0.02
Other services	11.72	34.35	16.19	26.16
Total	-	100.00	-	100.00

Source: Computation from the SAM

A2.1.2.6 Structure of demand

The table below shows the structure of demand between the main components: final consumption (household and public), intermediate consumption and investment (consumption for investment purposes and changes in inventories).

For instance, more than 80% of cassava, beverage and tobacco and matoke are dedicated to household consumption, and therefore rely a lot on household income. Other services for instance rely more on other sectors as most of the market is absorbed by intermediate consumption. Not surprisingly, construction relies on the investment component, and will therefore be sensitive in the case of a change in total investment.

TABLE 20: STRUCTURE OF DEMAND (IN %)

Commodities	Final consumption	Public consumption	Total intermediate consumption	Consumption for investment purposes (private)	Consumption for investment purposes (public)	Changes in inventories
Coffee	2.30	0.00	91.20	0.00	0.00	6.50
Tea	69.23	0.00	28.75	0.00	0.00	2.02
Flowers	66.07	0.00	33.93	0.00	0.00	0.00
Maize	12.07	0.00	87.86	0.00	0.00	0.07
Rice	39.43	0.00	60.50	0.00	0.00	0.07
Other cereals	29.52	0.00	70.42	0.00	0.00	0.06
Cassava	86.18	0.00	13.71	0.00	0.00	0.11
Root	72.65	0.00	27.24	0.00	0.00	0.10
Pulses and oilseeds	62.22	0.00	37.67	0.00	0.00	0.11
Matoke	89.58	0.00	10.32	0.00	0.00	0.10
Other agriculture	60.16	0.00	39.72	0.00	0.00	0.12
Fish	51.31	0.00	48.27	0.00	0.00	0.42
Crude	0.00	0.00	100.00	0.00	0.00	0.00
Mining	34.16	0.00	65.82	0.00	0.00	0.02
Other food	69.92	0.00	30.06	0.00	0.00	0.01
Beverages tobacco	86.32	0.00	13.49	0.00	0.00	0.19
Textiles	72.35	0.00	27.61	0.00	0.00	0.04
Refined petroleum	0.00	0.00	0.00	0.00	0.00	0.00
Other chemicals	49.04	0.00	50.93	0.00	0.00	0.02
Other manufactures	19.22	0.00	59.11	16.44	5.00	0.23
Electricity	19.87	0.00	80.35	0.00	0.00	-0.22
Water and sanitation	90.81	0.00	9.25	0.00	0.00	-0.06
Construction	5.72	0.00	6.90	66.96	20.35	0.07
Public administration	0.00	92.34	7.66	0.00	0.00	0.00
Private primary education	81.81	0.00	18.19	0.00	0.00	0.00
Private secondary and tertiary education	81.81	0.00	18.19	0.00	0.00	0.00
Public primary education	0.00	81.81	18.19	0.00	0.00	0.00
Public secondary and tertiary education	0.00	81.81	18.19	0.00	0.00	0.00
Private health	84.28	0.00	15.71	0.00	0.00	0.01
Public health	0.00	84.28	15.71	0.00	0.00	0.01
Other infrastructure	0.00	92.34	7.66	0.00	0.00	0.00
Other services	28.55	0.00	71.45	0.00	0.00	0.00

Source: Computation from the SAM

A2 Data outside the SAM

Some of the data we used do not come from the SAM. Indeed, the education variables such as the number of students in each cycle cannot be found in a SAM. The same applies for all the elasticities used in the model. Some are estimated and some are borrowed from previous studies. The section below summarizes the sources and data we used.

A2.2.1 Education data

In our model, we have 2 education cycles: the primary (primary) that lasts 7 years, and our second cycle comprises both secondary and tertiary cycles (secter). This second cycle lasts 10 years. This is a main change from the cycles used in MAMS.

The total number of students registered in each cycle (NSTO) is borrowed from MAMS, while the number of new students (NST_NO) comes from the Uganda Education Statistical Abstract (2009), page 29 for the primary cycle and page 31 for the secter cycle. The number of old students (NST_OO) is computed by taking out from total students the new students.

For the primary cycle, all the student behavior shares are borrowed from MAMS, except grd_csup that is borrowed from UNESCO.[10] For the second cycle, promotion (prom) and dropout (dropout) rates are a weighted average of the ones used in MAMS for secondary and tertiary education levels. The repetition rate (rep) is computed residually. Indeed, in each year a student can pass (prom), drop out (dropout) or repeat (rep). The sum of these three shares is therefore equal to one. For the behavior prom_grd, representing among those of pass, those who passed the last year of the cycle, the value taken is the one MAMS takes for secondary. The table below summarizes the data.

TABLE 21: SUMMARY OF EDUCATION DATA USED IN THE MODEL

	primary	Secondary and tertiary
NSTO	8,298	1,401
NST_NO	1,699	293
NST_OO	6,599	1,108
Entry	0.723	
Prom	0.802	0.794
Dropout	0.109	0.135
Rep	0.089	0.071
prom_grd	0.053	0.053
prom_ctn	0.750	0.741
grd_csup	0.580	
grd_fin	0.420	
Number of years (ny)	7	10

The education elasticities used in the intermediate function are borrowed from Matovu et al. (2010).

A2.2 Elasticities and other data used in the model

Most of the data and elasticities we use are borrowed from the MAMS model. Indeed, we borrowed their elasticity values for trade (in the CES and CET functions), the LES elasticities in the household consumption function and the elasticity of substitution between production factors in the nested production function.

Finally, in the model, we also refer to the total population, the population of children aged 6, the stocks of domestic and foreign debts. All these data are borrowed from MAMS.

[10] http://stats.uis.unesco.org/unesco/TableViewer/document.aspx?ReportId=121&IF_Language=en&BR_Country=8000

Annex 3: Estimation of the microeconomic component

As microeconomic behaviours are estimated from 2009/2010 cross-sectional data, the parameters are kept constant over time.

A3.1 Education module

The main objective of this module is to determine how many new skilled individuals there are in each year (i.e. those who graduate in the last year of primary school – P7). These people are added to the pool of skilled people in the previous year. To identify these individuals along the whole simulation period, we need to trace the evolution of schooling records for each person and, in particular, whether the person is at school – and eventually in which grade – or dropped out. The individual education status is estimated year by year. It is then necessary that all education behaviours are estimated as they are used to determine the individual skills level as well as the time when a person enters the labor market.

The education behaviours to be estimated are:

1. Entry into primary school (for children aged 6 to 7);
2. Graduation from each class of primary school (for children aged 6 to 16 and grades P1 to P7);
3. Dropout of each class of primary school (for children aged 6 to 16 and grades P1 to P7);
4. Graduation from the last year of primary school (P7-certificate), which determines whether a person becomes "skilled";
5. Graduation from the last year of primary school (P7-certificate) and continuation of the studies;
6. Graduation from each class of secondary school (for children aged 13 to 25 and grades S1 and higher);
7. Dropout of each class of secondary school (for children aged 13 to 25 and grades S1 and higher).

The choice of each education behavior is modeled within a discrete (binary) utility-maximizing framework. The different education behaviors described above are defined as binary variables taking a value of 1 if the person is observed as satisfying a specific behavior. The utility associated to each possible behavior is a function of a set of individual and household characteristics. Among these explanatory variables, the age of the child and the real household income (proxied by the real per adult equivalent household consumption) are updated yearly throughout the entire simulation period. The function to be estimated is (the "zero" category has an arbitrary utility equal to zero):

$\Pr\left(Y=1\middle|X\right)=CDF\left(X'\beta\right)$ where CDF is the *cumulative distribution function* of the standard normal distribution.

Alternatively, we can see the probit model as a latent variable model:

$$Y^*=\alpha_m+\sum_{j=1}^{J}\beta_{mj}X_{ij}+u_{ij} \quad \text{with } u_{ij}\text{~N(0,1)}$$

The residual term (u_{ij}) of the probit model is estimated by following Gourieroux et al. (1987) as follows:

$$u_{ij}=\frac{(y-PDF(y_{xb}))CDF(y_{xb})}{(PDF(y_{xb})(1-PDF(y_{xb}))}$$

where $PDF(y_{xb})$ is the standard normal probability density function of the linear prediction of the dependent variable *y*.

We then derive the probabilities associated to Y^* by using the standard normal distribution. It is to be noted here that, while the coefficients of each education behaviour are constant over time (as they are estimated on the observed data, in 2009), the probabilities associated to each behaviour change as the age and the household income of each child evolve over time.

Also note that children are aged yearly. As an example, for children aged 0 in 2009 (the year of the survey), in 2015 they will belong to the pool of children eligible to enter primary school, and so on. To clarify, although the risk of dying for children under 5 is high, we did not account explicitly for mortality. As discussed above, the population evolves according to the projected population growth rate.

As the household survey does not provide information on dropping out, we estimated the coefficients of being at school. These parameters are used to draw the probabilities of being at school; individuals attending in the current year and showing the lowest probability (and according to the CGE results) are those selected for dropping out of school in the following year.

Finally, in each year the pool of skilled and unskilled people is updated. Children who got the P7 certificate will migrate to the pool of skilled people; however, they only enter the labor market after the end of their studies. At the same time, children dropping out of school before the completion of primary school will enter the labor market as unskilled labor. It is noteworthy that, at the end of the schooling career, for each individual we are able to assign a precise (although simulated) schooling degree, and not only whether or not he or she is skilled. Within the same pool of skills, a higher education degree is associated to a larger productivity (in the revenues module) as well as to a larger probability of getting a job (in the employment module).

Because of lack of data or inconsistencies with the macro data, we calibrated the relevant education figures for the base year according to the ratios that were used in the SAM. Specifically, we talk about the entry rate in primary school, the graduation rate in primary and secondary/tertiary school, the dropout rate in primary and secondary/tertiary school and the rate of people completing P7 and leaving school. For the simulation scenarios, we used the new ratios as simulated by the CGE model.

A3.2 Income Generation Model: Employment and revenues

This module ultimately aims to estimating the variations in household welfare due to changes in employment status and revenues from all working activities. Consistently with the SAM and the CGE model's hypotheses, we need to:

1. Identify:
    - the occupational choices available to household members
    - the categories of workers based on their skills
    - the economic sectors;
2. Establish the degree of rigidities to the labor market (e.g. degree of mobility of workers across economic sectors and categories of workers);
3. Identify the best suited function for the occupational choice and revenues, and estimate them;
4. Predict the change in individual employment status as well as the corresponding revenue, and estimate the total household revenue.

A3.2.1 Occupational status[11]

The occupational choices available to household members are: (1) wage worker; (2) self-employed; (3) farmer; (4) not working (which also includes unemployed and apprentices). In order to keep the modelling more easily manageable and due to the incompleteness of the information on second occupations, we only look at the first occupation. We did not then create mixed categories (e.g. wage worker and self-employer), and the definition of each choice is thus exclusive. Note that we decided to distinguish between wage workers and the self-employed because we assumed that the Ugandan labor market is imperfectly competitive. If this is not the case, we should find that the (actual or shadow) wage rates for these types of occupation are not different.

[11] This section takes inspiration from Robilliard et al. (2008).

As anticipated in the education module, we have two categories of workers (based on their individual education skills): (1) skilled (if they completed at least primary education – P7); (2) unskilled (if their education level being lower than completed primary education). Workers can be employed in one of the 25 economic sectors (4 agricultural and 21 non-agricultural) identified in the SAM and the micro data.

The hypotheses on labor mobility adopted in this model consistently with the CGE model are:

a) Students: each former student (skilled or unskilled) leaving the school and entering the labor market can decide to work either as a farmer, as self-employed in the non-agricultural sector or as a wage worker. However, his/her choice is subject to individual and household characteristics and to an imperfect substitutability between the labor categories;

b) Workers: in each period, each worker can potentially reassess his/her utility of being in one of the three categories and eventually become a wage worker, farmer or non-agricultural self-employed. However, his/her choice is finally determined by individual and household characteristics. In addition, every year, 1% of working people aged over 60 exit the labor force. These individuals are chosen randomly as we have no information on retirement behaviour from the micro data.

Given that we have no good data on the number of hours worked, the labor supply by a household member is defined as discrete choice, identifying one of the four alternatives presented above. As is commonly done with multiple discrete choices, the individual labor supply is estimated with a standard multinomial logit model,[12] where each choice is then modeled within a discrete utility-maximizing framework. The utility associated to each possible category is a function of a set of individual and household characteristics. The model we used to estimate the individual labor supply is a reduced-form model in the sense that the remuneration rate (in each of the three working alternatives) does not enter the estimation of the labor supply. The general function to be estimated is (the fourth category – inactive – has an arbitrary utility equal to zero):

$$\ln \frac{P(Y_i = m)}{P(Y_i = 4)} = \alpha_m + \sum_{j=1}^{J} \beta_{mj} X_{ij} + u_{ij} = Z_{mi}$$

where Z_{mi} represents the actual individual utility function associated to each occupational choice *m*. Among the explanatory variables *X*, we inserted the individual's age and his/her highest educational degree. While the multinomial parameters are estimated in the base year (on the observed variables), the individual residual terms u_{ij} are drawn after the age and education variables are updated in each year. These error terms were generated by following the methodology described in Bourguignon, Fournier and Gourgand (2001), where it is shown that the distribution of residuals of a multinomial logit model is independent random and has a double exponential form.

We can then estimate the individual probabilities of being in one of the four categories in each simulation period *t* as follow:

a) For other than reference categories: $P(Y_i = m) = \dfrac{\exp(Z_{mi})}{1 + \sum_{m=1}^{m=3} \exp(Z_{mi})}$

b) For the reference category: $P(Y_i = 4) = \dfrac{1}{1 + \sum_{m=1}^{m=3} \exp(Z_{mi})}$

[12] We are aware that with such approach we do not control for the potential selection in the estimation of revenues (from wage and profits) associated to each occupational alternative (this issue may be solved by using e.g. the method developed in Bourguignon, Fournier and Gourgand, 2007). However, for profits we only have information at the household level and we preferred not to decompose it into individual values (for more details, see below in the text).

After the probabilities associated to each occupational status are estimated, we can proceed with assigning the new individual employment status. Differently from Robilliard et al. (2008), this is done by a "job queuing" approach. According to the CGE results concerning the employment status, the absolute numbers moving in or out the three working categories is estimated. The individuals changing from one alternative to another are selected according to their probability of being in the concerned choice. As an example, assume that the CGE predicts an increase from 20 to 23% of the ratio associated to "skilled wage workers"; we then rank all working-age skilled individuals according to their probabilities of being in that sector and we select the absolute number:

- corresponding to this change among individuals not previously working in the wage sector (but as farmers, non-agricultural self-employed or not employed) **and**
- showing the highest probability of being in that sector

up to when the predicted share of the workers in this category satisfies the macro result.

As remarked above, the CGE results need to be plugged into the microsimulation analysis in a consistent manner: i.e., the share of each working category in the CGE model and the microsimulation model must be the same in each simulated period.

Finally, it is important to update the total number of skilled and non-skilled workers per household by each occupational choice. This is particularly important for the prediction of the change in profits from self-employment activities.

A3.2.2 Revenues from working activities

a) Individual wage

The wage equation follows the Mincer model and is estimated by a two-step procedure (Heckman model). We first estimate the "selection equation" (i.e. being in the wage sector) through a probit model as:

$$z_i^* = \gamma w_i + u_i$$

$$z_i = \begin{cases} 1 & if\ z_i^* > 0 \\ 0 & if\ z_i^* \leq 0 \end{cases}$$

We then estimate the "wage" equation as: $y_i = \begin{cases} \beta x_i + \varepsilon_i & if\ z_i^* > 0 \\ . & if\ z_i^* \leq 0 \end{cases}$

As is well-known, this procedure is suggested because if u_i and ε_i are correlated then β is biased and inconsistent ($E(\varepsilon_i) \neq 0$). In simpler terms, in such a case the unobservable variable in the selection equation (being a wage worker) also affects the wages.

In addition, for simulation purposes, ε_i, which can be identified as individual unobserved fixed effects (or, heterogeneity of individual earnings), is easily estimated only for individuals employed in the wage sector at the base (observed) year. For individuals who did not report information on wages (i.e. non-wage workers), this residual term is estimated by drawing randomly from a normal distribution with the relevant (e.g. skilled or unskilled) observed variance. Note that, after the simulations, only the deterministic component of the model is recomputed (by using the parameters' regression estimated in the base year).

Finally, we can integrate the variations in the wage rates as predicted by the CGE. Note that changes in average wages with respect to the baseline figures in the micro-simulation must be equal to changes in wages obtained in the macro model for each type of worker category.

b) Household profit (farmers and non-agricultural self-employed)

The basic model to be estimated for household profit is:

$$\ln \Pi_{h,t} = \alpha + \beta_1 \ln X_{h,t} + \beta_2 \ln N_{h,t}^{sk} + \beta_3 \ln N_{h,t}^{unsk} + u_h$$

where $\ln N_{h,t}^{sk}$ and $\ln N_{h,t}^{unsk}$ are the number of skilled and unskilled family workers in period *t* respectively and $X_{h,t}$ identifies some usual household characteristics. Then, similarly to wages, we need to recover the error term u_h both for those households who reported a positive profit value in the base year and those with missing values.

As for wages, the changes in the profits from farming and non-agricultural self-employment activities as simulated by the CGE are fed into the microsimulation model. Again, the changes in income from self-employment activities in the micro-simulation must be equal to changes in income per worker in non-agricultural and farming sectors resulting from the macro model.

We can finally estimate the total household revenue at time *t* as:

$$Y_{h,t} = \sum_{i=1}^{N} w_t^{sk} I(n_{i,t}^{w,sk}) + \sum_{i=1}^{N} w_t^{unsk} I(n_{i,t}^{w,unsk}) + \sum_{j=f,na} \left(P_{c,t}^{O,j} Q_{h,t}^{O,j} (N_{h,t}^{sk,unsk}) - P_{c,t}^{I,j} Q_{h,t}^{I,j} \right) + y_{h,t}^{ex}$$

Note that $y_{h,t}^{ex}$ identifies eventual exogenous private (e.g. remittances) or public (e.g. government program of cash transfer) transfers to the household. The new vectors or changes predicted by the CGE for $w_t^{sk,unsk,na,a}, L_t^{sk;w,f,na}, L_t^{unsk;w,f,na}, \Pi_t^{f,na}$ are integrated into the microsimulation as described above.

We can then easily calculate absolute change of revenues between *t-1* and *t* as:

$$\Delta Y_{h,t} = Y_{h,t} - Y_{h,t-1}$$

Finally, we added this change to the total household consumption (the proxy for household welfare) variable of the preceding year, and divide it by the household size (or per an adult equivalent scale). Note that we implicitly made the hypothesis that the marginal savings rate is zero (one more/less UGX is added/subtract to household expenditures).

A3.3 Household consumption and prices

This module serves to estimate the predicted change in real household consumption. We are then able to estimate the variation in child poverty and inequality for each simulation period. The change in real consumption comes from the variation in household incomes (as derived in the previous modules) and consumer prices.

Per capita consumption in constant prices is our variable of interest to estimate changes in poverty and inequality across the different simulation scenarios.

The first step was to associate each commodity distinguished in the household survey with one of the 28 categories of goods distinguished in the macro model. These categories are determined by mapping the categories in the underlying micro and macro data and then aggregating by nature of commodity.

Definition of household consumption

Consumption values in the household survey have been converted into the monthly expression of the poverty line. Total consumption was obtained by aggregating purchases, self-consumption and gift values over all household consumption categories to calculate total household consumption. In this definition, we excluded the purchase of durables and the value of their services, except for the real or imputed value of rent for housing which are included. Finally, the user fees and charges as well as local service taxes were included in the definition of household consumption.

Equivalent income

To take into account the heterogeneity of the effect of price changes across households, it is important to calculate a household-specific price index. To do so, we relied on King's (1983) approach to define the concept of *equivalent income*. For a given budget constraint the equivalent income is defined as that income level that, at the reference price system $\boldsymbol{p^r}$, yields the same utility level as that utility level reached under $(\boldsymbol{p_c^t}, \boldsymbol{x_{h,c}^t})$

$$v\left(p_c^t, x_{h,c}^t\right) = v\left(p^r, e_{h,c}^t\right)$$

where *v(.)* is the indirect utility function, and $e_{h,c}^t(.)$ is the *equivalent income* function specific to the household *h*. By inverting the indirect utility function, we can obtain the equivalent income as an expenditure function:

$$e_{h,c}^t = e\left(p^r, p_c^t, x_{h,c}^t\right)$$

Let assume that $\boldsymbol{p^r} = \boldsymbol{p^0}$, where $\boldsymbol{p^0}$ represents the vector of prices faced by households living in Kampala region at the base year (i.e. before policy reforms). By following King (1983), the change in household welfare (equivalent gain) after the reform (t=1) is given by:

$$EG_{\mathrm{h},c} = e(\mathbf{p}^0, \mathbf{p}_c^1, x_{\mathrm{h},c}^1) - e(\mathbf{p}^0, \mathbf{p}_c^0, x_{\mathrm{h},c}^0)$$

If $EG_{\mathrm{h},c}$ <0, then a transfer to household *h* equal to $EG_{\mathrm{h},c}$ would allow a compensation of the lost due to the policy.

Equivalent income based on a Stone-Geary utility function

Ideally, using richer and various cross-sectional survey data, a complete demand system should be estimated to derive the equivalent income functions. As an alternative approach we will assume *k*-commodity Stone-Geary preferences with the indirect utility function:

$$v(p,x) = \frac{x - \sum_{k=1}^{K} p_k \gamma_k}{\prod_{k=1}^{K} p_k^{\beta_k}} \quad \text{with } \sum_{k=1}^{K} \beta_k = 1$$

where γ_k is the subsistence requirement for the commodity *k* and β_k is the proportion of the residual income (i.e., $x_{t,h} - \sum_{k=1}^{K} p_k^t \gamma_k$) allocated to the consumption of *k* once the committed expenditure $p_k \gamma_k$ is bought.

We can then finally derive the equivalent income as:

$$e_{h,c}^t\left(p^r, p_c^t, x_{h,c}^t\right) = \sum_{k=1}^{K} p_k^r \gamma_k + \frac{x_{t,h} - \sum_{k=1}^{K} p_k^t \gamma_k}{\prod_{k=1}^{K} \left(\frac{p_k^t}{p_k^r}\right)^{\beta_{k,h}}}$$

Poverty and distributive analysis[13]

For the purpose of poverty and distributive analysis, we used the standard poverty gap indices and the Gini inequality index. We also run some stochastic dominance analysis to assess the robustness of our results throughout the simulation period.

The FGT poverty indices are defined as:

$$P_\alpha^t(z) = \frac{1}{\mathbf{N}} \sum_{h=1}^{H} \rho_{h,c} n_{h,c} \left(\frac{z - e_{h,c}^t(\mathbf{p}^r, \mathbf{p}_c^t, y_{h,c}^t)}{z}\right)_+^\alpha$$

where z is the monthly poverty line in the reference cluster (Kampala) in the base year (32106.24 UGS); $f_+ = \max(0, f)$; **N** is the number of households in the survey (and corresponds to the sum of the sampling

[13] Poverty and distributive estimates, as well as significance tests and dominance curves were carried out by using the DASP program (Araar and Duclos, 2007).

weights); $N_{h,c}$ is the size of household *h*; $\rho_{h,c,t}$ is the sampling weight of *h* in time *t* (remember that the sampling weight evolves according to the population growth, as explained above); and α is a parameter that captures "aversion to poverty".

The variation in the FGT index between the base year (*t=0*) and the simulated period *t* can be written as:

$$\Delta P_{\alpha}^{t}(z)=\frac{1}{\mathbf{N}}\left(\sum_{h=1}^{H}\rho_{h,c}n_{h,c}\left(\frac{z-e_{h,c}^{t}(\mathbf{p}^{r},\mathbf{p}_{c}^{t},y_{h,c}^{t})}{z}\right)_{+}^{\alpha}-\sum_{h=1}^{H}\rho_{h,c}n_{h,c}\left(\frac{z-e_{h,c}^{0}(\mathbf{p}^{r},\mathbf{p}_{c}^{0},y_{h,c}^{0})}{z}\right)_{+}^{\alpha}\right)$$

According to the stochastic dominance literature, if

$$\Delta P^{s}(z)=P^{t=1,\dots,T}(z;s)-P^{t=0}(z;s)<0$$

for any choice of poverty index within a class of ethical order *s=*α *+1* and for any poverty line $[0,z^{+}]$, then we can unambiguously affirm that poverty in scenario *t* is decreasing (the distribution under this scenario is said to stochastically dominate the distribution in the base year). If ΔP^{s} changes sign, then the poverty results should be interpreted with some caution.

To assess the distributive effects of the different policy simulations, we use the well-known Gini Index. Starting from the class of single-parameter Gini indices:

$$I\left(\rho,p^{r},p^{t},y^{t}\right)=\int_{0}^{1}\left(s-L\left(s\right)\right)\kappa\left(s;\rho\right)dp$$

for *ρ=2*, we obtain the standard Gini index, with *ρ* being an ethical parameter; *L(s)* being the cumulative percentage of total income held by the cumulative proportion *s* of the population (ranked according to increasing consumption values *y*); *κ(s, ρ)* being the percentile-dependent weights to aggregate the distances *s-L(s)*.

The variation in the Gini index between the base year (*t=0*) and the simulation *t* can be written as:

$$\Delta I_{Gini}^{t}=I_{Gini}^{t}\left(p^{r},p^{t},y^{t}\right)-I_{Gini}^{0}\left(p^{r},p^{0},y^{0}\right)$$

A3.4 Final methodological remarks

As discussed, the estimations of schooling, employment and incomes include some random terms. This implies that the household income for the counterfactual scenarios is random. We then proceeded by replicating each simulation a sufficiently large number of times (100 times). Then, we took the median values of these 100 replicates for each relevant estimator (namely, per adult equivalent income, and poverty and inequality indices) in each simulated year, and estimated their corresponding confidence intervals.