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IMPACTS OF THE GLOBAL CRISIS AND POLICY RESPONSES ON CHILD WELL-BEING: A MACRO-MICRO SIMULATION FRAMEWORK

Sami Bibi, John Cockburn,
Ismaël Fofana and Luca Tiberti

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Correspondence should be addressed to:

UNICEF Innocenti Research Centre
Piazza SS. Annunziata, 12
50122 Florence, Italy
Tel: (+39) 055 20 330
Fax: (+39) 055 2033 220
florence@unicef.org
www.unicef-irc.org

A UNICEF Research Project on the Impact of the Global Economic Crisis on Children in Western and Central Africa

This study is the result of a research promoted by the Regional Office of UNICEF for West and Central Africa, in collaboration with the UNICEF Innocenti Research Centre and the UNICEF Division of Policy and Practice and aimed at the assessment of the potential effects of the global economic crisis on children in Burkina Faso, Cameroon and Ghana and the proposal of concrete policy responses for consideration by policy makers.

A regional and three country teams of researchers were formed. The regional team, coordinated by the African office of the Poverty and Economic Policy (PEP) research network, based at the Consortium pour la recherche économique et sociale (CRES, Dakar), was composed of researchers from Africa (GREAT, Mali; University of Yaoundé, Cameroon), from the Université Laval in Canada and the UNICEF Innocenti Research Centre. The regional team developed the basic methodology, provided training and closely supervised the three country studies, and prepared a regional report and policy brief synthesizing the results for the three countries. The country teams led the country analyses, interacted with the local policy committees and wrote their respective country reports.

This research was initiated in June 2009. At the end of that month the regional team provided the methodology and held in Accra an intensive training workshop for the local teams. A visit to each country followed in August. In the following months the regional and country teams carried out the analyses and presented the preliminary results of the study in November and December at the WCARO Social Policy Network Meeting in Dakar, the ODI-UNICEF conference on "The global economic crisis – Including children in the policy response" in London and the AERC conference on "Rethinking African Economic Policy in Light of the Global Economic and Financial Crisis" in Nairobi. In the following two months the regional and country studies were finalized, including also some additional policy responses specific to each country.

The main outcomes of this project are:

Cockburn, J., I. Fofana and L. Tiberti (2010), "Simulating the Impact of the Global Economic Crisis and Policy Responses on Children in West and Central Africa', *Innocenti Working Paper* No. 2010-01, UNICEF Regional Office for West and Central Africa, Dakar, and UNICEF Innocenti Research Centre, Florence.

Bibi, S., J. Cockburn, I. Fofana and L. Tiberti (2010), "Impacts of the Global Crisis and Policy Responses on Child Well-Being: A Macro-Micro Simulation Framework", *Innocenti Working Paper* No. 2010-06, UNICEF Regional Office for West and Central Africa, Dakar, and UNICEF Innocenti Research Centre, Florence.

Balma, L., J. Cockburn, I. Fofana, S. Kaboré and L. Tiberti (2010), "Simulation des effets de la crise économique et des politiques de réponse sur les enfants en Afrique de l'Ouest et du Centre: Le cas du Burkina Faso", *Innocenti Working Paper* No. 2010-03, UNICEF Regional Office for West and Central Africa, Dakar, and UNICEF Innocenti Research Centre, Florence.

Bibi, S., J. Cockburn, C.A. Emini, I. Fofana, P. Ningaye and L. Tiberti (2010) "Incidences de la crise économique mondiale de 2008/09 et des options de politiques de réponse sur la pauvreté des enfants au Cameroun", *Innocenti Working Paper* No. 2010-04, UNICEF Regional Office for West and Central Africa, Dakar, and UNICEF Innocenti Research Centre, Florence.

Antwi-Asare, T., J. Cockburn, E. F. A. Cooke, I. Fofana, L. Tiberti and D. K. Twerefou (2010) "Simulating the impact of the global economic crisis and policy responses on children in Ghana", *Innocenti Working Paper* No. 2010-05, UNICEF Regional Office for West and Central Africa, Dakar, and UNICEF Innocenti Research Centre, Florence.

Bibi, S., J. Cockburn, M. Coulibaly and L. Tiberti (2009) "The Impact of the Increase in Food Prices on Child Poverty and the Policy Response in Mali" *Innocenti Working Paper* No. 2009-02, UNICEF Regional Office for West and Central Africa, Dakar, and UNICEF Innocenti Research Centre, Florence

Impacts of the Global Crisis and Policy Responses on Child Well-Being: A Macro-Micro Simulation Framework

Sami Bibi[a], John Cockburn[a], Ismaël Fofana[a], Luca Tiberti[b]

[a] Laval University, CIRPEE and the Poverty and Economic Policy (PEP) Research Network

[b] UNICEF Innocenti Research Centre, Florence

Corresponding author: John Cockburn, email: jcoc@ecn.ulaval.ca

Summary: This paper outlines the methodology of a UNICEF research project on the impact of the global economic crisis on children in Western and Central Africa, which can also be applied to study the effects of other socio-economic shocks on households and, particularly on children in developing countries. To understand the nature and the extent of the effects of a crisis in developing countries requires a rigorous analysis of the transmission mechanisms at both the macro and micro levels. This paper provides a tool to attempt to predict *ex ante* the impacts of the crisis, and possible policy responses, on households and their children. As timely data monitoring child well-being are not readily available to guide the rapid implementation of policies to protect children, predictive model was developed that anticipates the impacts of the crisis on various essential dimensions of child well-being. Specifically, this paper proposes and discusses a combined macro-micro model following a top-down approach.

Keywords: macro-micro models, CGE, micro-econometrics, socio-economic crisis, child poverty, hunger, education, child labour, health

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INTRODUCTION

The global economic crisis, started in the summer of 2007 with the *subprime* crisis in the United States and spread to the rest of the world in 2008 and 2009, is acknowledged as the worst crisis after the Second World War. The impact of this crisis is expected to differ among developing countries depending on their initial condition and their links to the global economy through commodity trade, international aid, foreign investment and international remittances. In particular, the crisis will have varying impacts on product and factor markets, government finances, international trade and households. As a result, the distributive impacts of the crisis on households and individuals are also likely to vary substantially depending on their location, sources of income, consumption patterns and adaptation strategies. A combination of macro- and micro- analysis is thus needed to fully capture the effects of the global crisis on developing countries and to help in formulating policies to mitigate its negative effects on households and children. The use of modeling is also due to the fact that timely data monitoring child well-being are not readily available and wide time span before household survey data are collected occur, especially in developing countries.

Macro-economic analysis assesses the impact of macro shocks and policies on variables such as wage rates, employment, food and non-food prices, etc. Given the magnitude of the shocks engendered by the global crisis, a computable general equilibrium (CGE) framework is required to incorporate the structural aspects of the economy and capture the numerous and complex direct and indirect interactions between factor markets, good markets, households, government, private firms and the foreign partners. However, CGE models cannot distinguish the impacts on individual households and their members, as is required to evaluate the impacts on the monetary poverty, hunger, schooling, labor and access to health services of children.

The micro-economic approach models individual and household behavior using data from household surveys. The effects of the global economic crisis on households and individuals can be captured in terms of changes in employment opportunities and earnings, commodity prices, private and public income transfers, and the provision of public services. The extent to which such effects impact on household and individual welfare depends primarily on their income sources and consumption patterns. To make an appropriate micro-economic analysis, we need to take account of the ability of households and individuals to substitute among consumer goods, according to their relative prices, and to adjust their sources of income.

A combination of the two methodologies is essential to capture the impacts of the global crisis on households and children and to design adequate policy responses. The macro-economic approach uses a country-specific CGE model to account for the structural aspects of the economy and the variety of interrelations among sectors and institutions and their links with the global economy. The CGE framework is then linked to a micro-econometric behavioral model in a “top-down” fashion to assess the various impacts of the crisis on households and children.

1. MACRO-ANALYSIS: MODELING THE MACRO CHANNELS OF THE GLOBAL ECONOMIC CRISIS

The macroeconomic assessment of the global economic crisis on developing economies uses a CGE approach. A CGE model is a multi-market model of an economy based on real world data. The technique uses a system of mathematical equations that represent a market economy incorporating its various institutional and structural characteristics. CGE models are primarily based on neoclassical theory of general equilibrium, first formulated by Leon Walras in 1877 and later formalized by Arrow and Debreu (1954) and McKenzie (1954, 1959 and 1981). Improvements in data collection and advances in computer technology and software have enhanced their applications to applied policy analysis.

Most equations are derived from rigorous microeconomic foundations specifying how agents adjust the quantities supplied and demanded in each market in response to price changes. Standard CGE models capture impacts on production, consumption, factor markets and prices in an economy in which agents adopt profit and welfare maximizing behavior. Market prices adjust in order to reconcile endogenous supply and demand decisions, thus determining levels of production, employment and consumption. There are also a few macroeconomic equations ensuring that the behaviors of economic agents are consistent with macroeconomic constraints. Thus, the model is adapted to capture a number of structural features of the studied economies, such as the initial production structure, market segmentation, trade patterns and price rigidities. The resulting model is then used as a "laboratory" to conduct simulations of the effects of shocks and policies in order to explore their respective impacts.

CGE models are used when the external shocks or policy measures studied are expected to have general equilibrium effects, i.e. significant indirect effects that partial equilibrium analysis fails to capture. In the case of large shocks or major policy reforms, such as those stemming from the global economic crisis, these indirect effects can magnify or counteract the direct effects with potentially major implications for the final results. CGE models have been widely used in both developed and developing countries for economic and social policy analysis[1]. The principal advantage of using a CGE model in policy analysis is that it takes into account the numerous and complex interactions throughout the economy. Shocks and policies directly affecting one part of the economy may have substantial indirect effects on the other parts of the economy that are automatically taken into account using general equilibrium analysis.[2]

The main behavioral assumptions embedded in a standard CGE model are as follows:

- Household behavior is rational, which implies that in the presence of complete markets there is a separation between their production and consumption decisions.
- Perfect competition prevails in the sense that producers and consumers take as given the relative prices that simultaneously clear all markets.

[1] Devarajan and Robinson (2005) review the use of CGE models in the policy debate.

[2] As mentioned by van der Mensbrugghe (1998), "the strength of this class of economic models is consistency with generally accepted microeconomic theory, significant structural detail, and the nature of general equilibrium, i.e. changes in any one area of economic activity may have measurable impacts in other areas".

- A representative producer in each industry maximizes profit under a given constant returns to scale technology and independent prices.
- Representative households make consumption decisions in order to maximize their well-being under budget constraints and given market prices.
- Money illusion is absent, that is utility and profit maximization are based on real values; consequently, quantities are homogeneous of degree zero in all prices.

The global financial and economic crisis is expected to affect developing economies differently according to the various channels of impact: trade, remittances, investment, and aid flows. We now briefly discuss how each of these channels is captured in the CGE model developed for this study. The basic structure of the CGE model is presented in Annex 3.

1.1. Trade

International trade is governed by the degree of substitution between imported and domestic goods on the consumption side, and between domestic and export markets on the production side. The relative prices of foreign goods are assumed to be fixed in the international market according to the small country hypothesis. At the country level however, these prices are affected by the exchange rate and government interventions (taxes, subsidies and tariffs). All these determine, in turn, import and export flows.

Following the Armington assumption, locally produced (D) and imported (M) commodities are assumed to be imperfect substitutes in domestic consumption (Q). The demand for imported relative to locally produced goods is derived from cost minimization subject to the Armington elasticity (ε), import and domestic good prices (p^m and p^d), where β and α are the scale and share parameters.

$$Q = \beta \times \left[\alpha \times M^{-\left(\frac{1-\varepsilon_i}{\varepsilon_i}\right)} + 1-\alpha \;\times D^{-\left(\frac{1-\varepsilon}{\varepsilon}\right)} \right]^{-\left(\frac{\varepsilon}{1-\varepsilon}\right)} \qquad (1)$$

$$\frac{M}{D} = \left[\left(\frac{\alpha}{1-\alpha} \right) \times \left(\frac{p^d}{p^m} \right) \right]^{\varepsilon} \qquad (2)$$

The model also captures the allocation of locally-produced commodities (V) between the export (X^s) and local (D) markets according to a constant elasticity of transformation (CET). Export supply is derived from profit maximization subject to the CET function parameters, i.e. the elasticity of transformation (ω), and the prices for domestic and export sales (p^d and p^x), where δ and γ are the scale and share parameters.

$$V = \delta \times \left[\gamma \times X^{s^{-\left(\frac{1-\tau}{\tau}\right)}} + 1-\gamma \;\times D^{-\left(\frac{1-\tau}{\tau}\right)} \right]^{-\left(\frac{\tau}{1-\tau}\right)} \qquad (3)$$

$$\frac{X^s}{D} = \left[\left(\frac{\gamma}{1-\gamma} \right) \times \left(\frac{p^d}{p^x} \right) \right]^{\tau} \qquad (4)$$

Export supply balances exogenous export demand ($\overline{X^d}$) through adjustments in the export f.o.b. prices (p^{fob}).

$$X^s = \overline{X^d} \tag{5}$$

Export prices are equal to the border world prices for exports (p^{fob}), converted into domestic prices by the exchange rate (e) and adjusted by the tax on exports (t^x). Import prices (p^m) are equal to fixed world prices (p^{wm}) converted into domestic prices by the exchange rate and adjusted for import taxes (t^m).

$$p^x = \quad p^{fob} \times e \Big/ 1 + t^x \tag{6}$$

$$p^m = \overline{p^{wm}} \times e \times \; 1 + t^m \tag{7}$$

The global crisis is expected to lead to a reduction in global trade and, consequently, affect the national economy through a decline in demand for its major exports. As a consequence, the equilibrium f.o.b. prices of exported commodities fall. Import prices are also likely to fall. The trade shock is simulated via a reduction in export demand ($\overline{X^d}$) and in the international import prices (p^{wm}), which are inputted exogenously into the CGE framework.

1.2. Remittances

Household earnings (YH) are generated from the payment of its productive factors, i.e. labor (wL) and capital (rK) income. They also receive transfers from other households ($\overline{\mathrm{T}}^{\mathrm{prv}}$) and Government ($\overline{\mathrm{T}}^{\mathrm{gov}}$), as well as remittances from abroad $\overline{\mathrm{T}}^{\mathrm{row}}$. The global crisis is expected to reduce remittances from family members living and working abroad, which will result in decreasing household disposal income – gross income (YH) net of income taxes and private out-transfers at rates (t^{c}) and ($\mathrm{t}^{\mathrm{prv}}$) – and consequently, in a reduction in final consumption (CH) and savings (SH).

$$YH = wL + rK + \overline{T}^{prv} + \overline{T}^{gov} + \overline{T}^{row} \tag{8}$$

$$YH / \; 1 + t^c \;\cdot\; 1 + t^{prv} \;\; = \; CH + SH \tag{9}$$

1.3. Foreign aid

Government is passive in the sense that it does not optimize any objective function. Its role is limited to that of regulating economic activity and redistributing wealth. Its income (YG) comes from import (M) and export (X^s) taxes, net taxes on products (Q), production (V) taxes, direct taxes on households (YH) and firms (YF), interest and dividends (rK), and net foreign aid ($\overline{T}^{row}$). Its expenses consist of transfers to domestic and foreign (debt payment) institutions ($\overline{T}^{gov}$) and current expenditures on public services ($\overline{CG}$). Government balance adjusts through its deficit/surplus (SG). The global crisis is expected to reduce aid flows and thus reduce public surplus on increase public deficit.

$$YG = \; t^m \cdot p^{wm} \cdot e \cdot M \; + \; t^x \cdot p^{fob} \cdot e \cdot X^s \; + \; t^q \cdot p^q \cdot Q \;\; + \; t^v \cdot p^v \cdot V \;\; + \; t_h \cdot YH \; + \; t_f \cdot YF \; + rK + T^{row} \tag{10}$$

$$SG = YG - p^{G} \cdot \overline{CG} - \overline{T^{prv}} \tag{11}$$

1.4. Foreign capital inflows

The current account and the capital[3] account are the two main components of the balance of payments, along with variations in reserves. The capital account records net foreign direct investments (FDI) and other capital (K^{row}) transactions with the global economy. With fixed international reserves, the current account balance CAB is constrained by the capital account balance:

$$CAB = \overline{FDI} + \overline{K}^{row} \tag{12}$$

Thus a current account deficit corresponds to a capital account surplus, which represents foreign savings made available for local investment. Thus, a reduction in foreign savings deteriorates the investment capacities in developing countries.

The global crisis reduces foreign direct investment and other capital inflows from abroad and, thus, the investment capacity in developing countries. In a context of tight international borrowing, the foreign exchange market re-equilibrates via adjustments in the exchange rate or domestic prices. Countries that have accumulated substantial foreign reserves could be in a position to adjust to a reduction in foreign capital inflows by drawing down reserves.[4]

2. MACRO-MICRO LINKS: MODELING OF THE LINKING VARIABLES IN THE MACRO MODEL

In order to assess the distributional and child welfare impacts of these shocks and eventual policy responses, we must first transmit changes in commodity and factor prices, as well as employment levels, from the CGE model to the micro level. Existing Macro-Micro models differ primarily in the type of effects examined and the mechanism of linking these two components. As mentioned by Essama-Nssah et al. (2007), one can identify the following three types of effects to track the distributional impact of macroeconomic shocks and policies: *the price effects*, or change in prices of factor endowments and purchased goods; *the reallocation effects*, i.e. change in the use of domestic resources; and *the endowment effects*, or change in the availability of resources.

Ravallion and Lokshin (2004) use the envelope theorem to track the distributional welfare impacts of price changes imputed to agricultural trade reform in Morocco. The authors evaluated the first-order approximation to the welfare impact in the neighborhood of the household's optimum by the weighted sum of proportionate changes in prices, the weights being the initial quantities (envelope property)[5]. As a short term effect, the analysis does not account for either the reallocation or the endowment effects.

[3] The term capital should be taken in a broader sense as physical and financial assets.
[4] Tighter global liquidity, increased risk aversion, and withdrawal of funds from the domestic banking system by foreign banks also impact the national economy.
[5] For more details refer to Ravallion and Lokshin (2004).

Many studies have accounted for both price and reallocation effects (Robillard, Bourguignon, and Robinson 2008). The micro-econometric specification developed in these studies accounts for three types of behavior: an allocation of individuals across occupations using a multinomial logit model; a model of earnings; and a household income generation rule. Macro changes in the labor market are replicated in the micro model by a random selection procedure (Ganuza et al. 2002).

Models that endogenize endowments (various labor and capital categories) through human capital development, fertility, migration, and saving behavior, as well as household formation, on the basis of econometric estimation are still underexploited, particularly in developing countries. According to Bourguignon et al. (2002), it is not easy to develop multi-layered macro-micro models in a truly dynamic framework.[6]

Besides differences in the effects captured, three distinct procedures can be identified for linking the macro- and the micro- components of the model. As its name suggests, the integrated approach involves integrating the micro model directly into the macro (CGE) model. The CGE model thus includes all the actual households from a household survey, eliminating the assumption of representative agents (Cockburn 2006). This method is appropriate for analyzing the price effects and the first-order approximation of welfare impacts attributed to macroeconomic shock. However, it is generally necessary to adopt relatively simple micro behavior due to technical constraints on model size and complexity. In particular, it is difficult to capture discrete micro-econometric behavior, such as changes in employment status.

This limitation is overcome in the "top-down" (Robillard, Bourguignon, and Robinson 2008) or the "bottom-up" (Cogneau and Robillard 2000) layered approaches, in which the macro- and micro components are solved sequentially. In the "top-down" approach the macro-model is solved first and its results, notably in terms of price variations, are fed into the micro-model. The layered approach has the advantage of allowing sophisticated micro-econometric behavior. Its disadvantage lies in the lack of feedback from the micro to the macro-component and thus potentially important inconsistencies between the two models.

The "top-down/bottom-up" approach (Savard 2005; Essama-Nssah et al 2007) corrects for the lack of feedback from the micro-component. The macro- and micro- models are run in a loop, feeding results from one to the other, until the two produce consistent results. The "top-down/bottom-up" method is a promising avenue for macro-micro modeling, although the complexity of the procedure does not always ensure satisfactory convergence.

We use the sequential "top-down" approach following Robillard, Bourguignon and Robinson (2008). Our analysis captures the price and reallocations effects of the global financial and economic crisis.[7] The macro- and micro- models are run sequentially over three years. While

[6] Discussion on methodology endogenizing labor supply and saving behavior is discussed in Bourguignon et al. (2001).
[7] We do not integrate the endowment effects given the short perspective (three years) of the analysis.

it is suitable to first simulate most of the impact of the global crisis at the macro level (i.e. trade and trade prices, savings/investments, and some government policy responses), the change in remittances from family members living and working abroad and other government policy responses, such as the change in public transfers, can be performed both at the macro- and the micro- levels.

The links between the macro and the micro analysis concern changes in wage rates, commodity prices, and the levels of employment for various categories of workers. These are obtained from simulations using the macro model and then serve as inputs to the micro analysis. The extent to which such effects impact household and individual welfare depends primarily on their connection to the market, their factor endowments and consumption patterns, and the ability to adjust to the shock through the income and prices elasticities of consumption, changes in labor supply and savings behavior. While these impacts will be the focus of the micro analysis, it is important that the macro analysis generate results in a manner that is compatible with the ensuing micro analysis.

2.1. Commodity prices

The micro analysis distinguishes roughly 15 food groups and a single non-food group as explained in the micro methodology further on. It is therefore essential that the price variations transmitted from the macro model be organized into these same categories. These groups thus dictate the minimal sectoral decomposition in the CGE model. It is, of course, possible for the CGE model to be disaggregated further, in which case price variations from several sectors would be aggregated before being passed on to the micro analysis. Extreme care must be taken to ensure that the definition and contents of the commodity groups (sectors) in the CGE analysis correspond exactly to their counterparts in the micro analysis.

2.2. Labor market segmentation

Changes in labor income – both wage rates and employment status – constitute an important channel of transmission of the crisis to individuals and their households, especially the poor. A rigorous specification of the labor market structure and functioning is crucial in assessing the distributional effects of the global crisis in developing countries. Different segmentations of the labor markets can be distinguished according to criteria such as geographical location, education/skill, and formality. By distinguishing these different categories of workers in the CGE model, differences in impacts of the global crisis on their respective wage rates and employment levels are distinguished and passed on to the micro analysis.

We limit our labor market segmentation to rural/urban, skilled/unskilled (urban only) and formal/informal, and thus obtain six separate labor categories: rural formal, rural informal, urban formal skilled, urban formal unskilled, urban informal skilled and urban informal unskilled. Wage rates are generated for each of these categories. Labor market participation within each of the categories is exogenously adjusted by a uniform labor force growth rate.[8]

[8] Alternatively, one can have an endogenous labor market participation specification. In terms of employment levels, the CGE model will first determine labor market participation within each of the categories. Individuals will respond to the change in their (and their household's) economic conditions through an elastic labor supply.

2.3. Mobility between labor markets

We assume that there is no geographic mobility of labor, nor is there any movement between skilled and unskilled workers (as a result of education/training), as we are only interested in the short-term (3-year) impacts of the crisis. However, movement between the formal and informal sectors is allowed, assuming that those who lose formal sector jobs will move to the informal sector. This movement is modeled in the following way.

First, individuals seek formal work, which is rationed on the demand side. The excess supply of labor, i.e. total labor supply (LS) net of formal employment (LD^{for}), is fully employed on an informal basis ($LD^{\inf}$). The formal wage rate is exogenous in real terms whereas the informal wage rate is assumed to be competitive, determined by supply and demand.

$$LS - LD^{for} = LD^{\inf} \quad (13)$$

The sectoral demand for formal and informal work is generated from profit maximization. The various categories of labor are imperfect substitutes in the production technology, according to the elasticities of substitution. The derivative demands for formal and informal workers depend on the relative wages and the elasticities of substitution, between capital and aggregate labor, on the one hand, and among various categories of formal and informal labor, on the other hand.

2.4. Non-labor income

At the macro level, the gross operating surplus by sector of production is distributed to institutional units (household categories, firms, and the rest of the World) according to their shares in the ownership of capital. This share is updated each period according to previous period savings. At the micro level, gross incomes – production outcome valued at producer prices – net of inputs and imputed self-employment costs determine the gross operating

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Thus, household labor supply will be endogenously determined in each period. A neoclassical theory of labor supply can be adopted, which analyzes the time allocation of individuals on the basis of a tradeoff between labor and leisure. It considers that individuals have limited time, which is allocated between work and leisure. The wage rate that an individual could earn is a key element in this decision, as well as the level of his/her personal or household (full) income.

A unitary model of labor supply is applied, considering the household as a single decision centre. Household members are identified by labor categories considered above. The utility function takes the form $U(C,\ell)$, where c is the consumption of various market goods and services, and ℓ the leisure time of household members. Maximization of the above utility is subject to the following constraints:

Budget: $p \times C = R + w \times LS$

Time: $T = LS + \ell$

The two constraints are combined into the full income constraint: $p \times C + w \times \ell = R + w \times T$

The derivative demands for goods and services and supply of labor are given by:

$$C = f\left(p, w, R\right)$$

$$LS = T - \ell = T - f\left(p, w, R\right)$$

The maximum time available for work and leisure is adjusted by the labor force growth at rate χ :

$$T_{t+1} = T_t \cdot \left(1 + \chi\right)$$

surplus or the return to own-used capital. Households receive public and private transfer incomes from domestic and foreign institutions. Transfers are fixed in real terms; they are indexed to the economy-wide average price at the macro level, thus remain fixed at the micro level.

3. MICRO-ANALYSIS: MODELING OF THE LINKING VARIABLES IN THE MICRO MODEL

3.1. Commodity prices

As discussed above, commodity prices changes are estimated at the sectoral level in the CGE model. These sectors are defined to correspond to the categories of commodities distinguished in the micro analysis. Thus the link here is direct.

3.2. Wage prediction

The analysis of the change in occupational status and the prediction of actual or potential wages are made for the working age population: people aged between 15 and 65 years old who participate or not in the labor market. Those who participate in the labor market may work in the formal wage sector or in the informal (wage) sector. People receiving income from a self-employment activity are treated separately (see below). We thus capture the peculiarities of the labor market in Sub-Saharan African countries.

Here we focus first on transmitting the changes in wage rates for formal and informal workers (distinguished by urban/rural status and, with the urban area, by skilled/unskilled status) from the macro model to the individual workers in the micro model (household survey). We will then turn our attention to modeling changes in formal/informal employment

Wage regressions for the formal and informal sectors are defined as follows:

$$\begin{aligned} \ln w_i^F &= \alpha + \beta_i X_i + \varepsilon_i \\ \ln w_i^{INF} &= \lambda + \vartheta_i X_i + \upsilon_i \end{aligned} \quad (14)$$

where $\ln w_i^F$ and $\ln w_i^{INF}$ are the logarithm of the wage received by individual i working in the formal (*F*) and informal (*INF*) sectors, respectively. The vector X_i includes the following variables: individual characteristics (gender, years of education and its square value, experience in work activities – expressed as the age of the individual i minus the years of education minus 6 – and its square value); household demographic and geographical (region) characteristics.

As the macro model provides wage variations for six categories of workers (rural formal, rural informal, urban formal skilled, urban formal unskilled, urban informal skilled and urban informal unskilled), these wage regressions are made separately for urban and rural areas and, among the urban workers, separately for skilled and unskilled workers.

These equations are estimated following the standard Heckman selection model. In other words, since wages in a specific labor sector are observed only if a person works in that sector, a selectivity problem arises. This problem may also be strengthened if the error term of the wage regression is correlated with the error term of the model predicting the probability that an individual works in a specific sector. With selectivity problems, the usual least squares estimators of the constant term and of explanatory variables are biased and inconsistent. The Heckman procedure makes it possible to estimate consistent estimators and, specifically, it estimates the wage equation in a sector under the condition that the person actually works for that specific sector. Here we propose to jointly estimate the two sets of equations (wage equation and probability – or selection – equations) by maximum likelihood techniques for each of the labor categories. The probability equation depends on the civil status, the age, the gender, region of residence and educational level and the number of children.

After the estimation of the joint model by each sector, we predict the wage and the probability of being employed in one of the six sectors identified above on the entire relevant sample of working age people (participating or not in the labor market) aged between 15 and 65 years old. As we assume that there is no rural-urban or skilled-unskilled mobility, wage regressions and the probability model regressions for each labor sector are run separately on the corresponding subgroup of the working age population: formal and informal urban skilled sector regressions are run on the sample of skilled urban working age people; formal and informal urban unskilled sector regressions are run on the sample of unskilled urban working age people; finally, formal and informal rural sector regressions are run on the sample of rural working age people. The predicted probability of being in the formal or informal sector for each of the three main sector categories – urban skilled, urban unskilled and rural – will be used later for the reconciliation between the macro and micro part of the model.

3.3. Movement between the formal and informal labor markets

The macro model provides us with variations in formal and informal employment. Self-employment is assumed to be fixed, as discussed below. Variations in formal and informal employment reflect both changes in the overall labor market participation rates, as well as mobility between the formal and informal labor markets. In order to transmit these variations to the micro analysis, we must determine which individuals are affected. We propose here to follow the so called “job-queuing” approach. In particular:

- Rank the working age people according to their predicted probability of being in the formal wage sector and in the informal wage sector.
- Use these predicted probabilities to select the individuals that change employment status in the micro data so as to reproduce the CGE results and their predicted probabilities. An example may be useful to better understand the approach. Say that before the economic shock 20% of the total working age population is employed in the formal wage sector, 70% in the informal wage sector and 10% is working age but not participating in the labor force. As a consequence of the shock, the labor demand in the formal wage sector decreases by 5% (from 20% to 19%, i.e. one percentage point) and that in the informal wage sector increases by 10% (from 70% to 77%, i.e. seven percentage points). The 5% of the people employed in the formal wage sector showing the lowest probability of being in that sector will be moved into the informal labor market, thus reducing employment in this sector to 19% of the total working age population. The 7 percentage points increase in employment in the informal labor market will be absorbed from a pool including those

moving out of the formal wage sector after the crisis and those aged 15 to 65 years but not initially participating in the labor market. Those who move into the informal wage sector after the crisis will be those showing the highest probability of being in the informal wage sector in this pool.

Some weaknesses with this approach should be noted. First, behavioral parameters are assumed to be unaffected by the various scenarios. Second, the pathway of labor transition is imposed "a priori" according to an arbitrary, but reasonable, ranking of individual preferences: formal wage sector, informal wage sector, not working. Some barriers to labor mobility are imposed: no geographical mobility (urban/rural) nor mobility between different skill categories (skilled/unskilled). However, this is fairly reasonable in the short term.

3.4. Income from self-employment and capital (business from the agriculture and non-agriculture sectors)

Income from self-employment activities (π_h), both in the agriculture (food and non-food) and non-agriculture sectors, for household *h* is defined as:

$$\pi_h = \sum_{k=1}^{K} Y_k p_{Y,k} - I_k p_{I,k} \qquad (15)$$

where Y_k is the quantity production of good *k*, $p_{Y,k}$ is the producer price of good *k*, I_k is the quantity of inputs purchased for the production of good *k* and $p_{I,k}$ is the price of inputs for the production of good *k*. Note that self-consumption is included in this income component. The only difference with the other components included under this source of income is that self-consumption is calculated by using consumer prices and their changes, rather than producer prices.

Starting from values observed in the base year, the change in π_h is determined by applying to each component the relevant change provided by the macro level (both for volumes and prices), that is, changes in the volume of production (ΔY_k), producer price ($\Delta p_{Y,k}$), volume of inputs (ΔI_k) and input price ($\Delta p_{I,k}$).

We assume that the number of people working in this sector does not change over the period covered by our analysis for several reasons: (1) the short-run horizon of the analysis, (2) structural rigidities in the capital market preventing expansion of activities; and (3) low marginal productivity of additional workers in self-employment.

3.5. Transfers and dividends

Define transfers received by households (Tr_h) as:

$$Tr_h = Tr_{h,pu} + Tr_{h,\Pr Ex} + Tr_{h,\Pr In} + Div_h \qquad (16)$$

where $Tr_{h,PrEx}$ are public transfers, $Tr_{h,PrEx}$ are international remittances, $Tr_{h,PrIn}$ are internal private transfers and Div_h are dividends. Rates of change for all of these components are obtained directly from the macro analysis.

3.6. Household aggregate income

Changes in total household income (ΔY_h) relative to the base year for each scenario can thus be written as:

$$\Delta Y_h = \sum_{i \in h} \Delta w_i^F \Delta F_i + \sum_{i \in h} \Delta w_i^{INF} \Delta INF_i + \Delta \pi_h + \Delta Tr_h \qquad (17)$$

where Δ is for the difference in the value or status in each associated variable relative to the base year.

4. MICRO-ANALYSIS: MODELING THE CONSUMPTION IMPACTS OF THE GLOBAL CRISIS

We need to capture how individuals adjust their consumption levels and compositions to changes in commodity prices and household income in order to estimate impacts on monetary poverty and caloric intake. We first calculate base-year consumptions for each of the commodity categories. We then turn our attention to convert the value of the aggregate consumption and that of each commodity categories in real terms, by proposing three different approaches, namely (1) an approach using a behavioral demand system, (2) one using household specific preferences but with fixed budget shares, and (3) one using a consumer price index for any household living in a given cluster. These approaches will allow us taking into consideration spatial and temporal price differences and, in our particular case, the impacts of the global crisis.

4.1. Calculation of base year total consumption per adult equivalent

The first step is to associate every commodity distinguished in the household survey with one of the 16 categories of good (15 food categories and 1 non-food category) distinguished in the micro model. These categories are determined by mapping the categories in the underlying micro and macro data and then aggregating by nature of commodity (e.g. meat, milk products, etc.). Consumption values in the household survey must be converted to an annual basis where required. Total consumption is obtained by aggregating purchases, self-consumption and gift values over all household consumption categories to calculate total household consumption. See annex 1 for details on the procedure followed to aggregate consumption.

Individual consumptions per adult equivalent are calculated by dividing total household consumption by the total number of adult equivalents in the household (assuming a unitary model). For this purpose, we use the "caloric requirements" approach to determine equivalence scales. For example, if we use the WHO data in Table 1 below, the equivalence scale for a household with 1 adult male member aged 35, 1 adult female member aged 27, 1 young male member aged 13 and 1 young female member aged 2 is 3.17 (=0.96+0.77+0.92+0.52).

Table 1: Equivalence scale based on daily caloric intakes by gender and age (in percentage of an adult male 18-30 years old)

Young children		
<1	0.32	
1-2	0.44	
2-3	0.52	
3-5	0.60	
Older children	**Boys**	**Girls**
5-7	0.71	0.67
7-10	0.81	0.69
10-12	0.85	0.75
12-14	0.92	0.81
14-16	1.02	0.83
16-18	1.10	0.83
Adult	**Men**	**Women**
18-30	1.00	0.77
30-60	0.96	0.79
>60	0.81	0.71

Source: FAO/WHO/UNU (1985)
Notes: The caloric requirements for an adult male aged 18-30 used to estimate the food poverty line is normally 2450 kcal a day.

4.2. Calculation of adjustment in consumption under each scenario.

In order to evaluate the impacts of the global crisis on monetary poverty and hunger (caloric intake), it is essential that we be able to calculate adjustments in household consumption patterns in the face of changes in prices and income. For this purpose, there are at least three different approaches (for further details see Annex 2):

a) Demand system, integrating price and substitution effects

The first step in this approach is to express all individual adult equivalent consumption values in terms of shares of total consumption. Second, unit values – consumption values divided by consumption quantities, as reported in the household survey – must be calculated for each food category. When, within the same category, the same good is expressed in different units of measure, the median unit value relative to the most frequent unit of measure is used. In addition, for categories including more than one good, the price for the most consumed good within that category should be used.

The demand system is the *Almost Ideal Demand System* (AIDS) proposed by Deaton and Muellbauer (1980). It involves the estimation of the following model:

$$w_{j,c,h} = a_j + \sum_{k=1}^{K} b_{j,k} \ln p_{k,c} + c_j \ln \frac{x_{c,h}}{z_c} + e_j D_{c,h} \tag{18}$$

with

$$b_{j,k} = b_{k,j}; \sum_{j=1}^{J} a_j = 1; \sum_{j=1}^{J} b_{j,k} = \sum_{j=1}^{J} c_j = \sum_{j=1}^{J} e_j = 0 \tag{19}$$

where $w_{j,c,h}$ is the budget share devoted by the household h living in cluster c to the commodity j, $p_{k,c}$ is the price of that commodity in the cluster c (the median price of j in c),

$x_{c,h}$ is the per-adult equivalent household's total expenditure (as constructed in point d.i), z_c is the poverty line in c, $D_{c,h}$ is a vector of socio-demographic characteristics of households, and $\mu_{j,c,h}$ is the residual term.

Equation (18) can be re-written as

$$w_{j,c,h} = a_j + \sum_{k=1}^{K} b_{j,k} \ln p_{k,c} + c_j \ln y_{c,h} + e_j D_{c,h} \tag{20}$$

with $y_{c,h} = \dfrac{x_{c,h}}{z_c}$ (21)

where $y_{c,h}$ (real household total expenditure normalized by the local poverty line) is deemed to be endogenous.

The AIDS model identified by equation (20), in which budget shares are linear in b_{jk} and c_j, is estimated by following Deaton (1997) and relying on the spatial variability of prices in the country to estimate the parameters of price (b_{jk}), income (c_j) and of the socio-demographic characteristics (e_j). The triple ordinary least squares model is used for this purpose. The model is run separately for urban and rural areas in order to take into account their structural differences.

After the estimation of the parameters in equation (20), we can calculate the consumption in real terms as

$$\ln e_{c,h} = b(\mathbf{p}_r)\left[\frac{\ln x_{c,h} - \ln z(\mathbf{p}_c)}{b(\mathbf{p}_c)}\right] + \ln z(\mathbf{p}_r) \tag{22}$$

where $e_{c,h}$ is the real consumption or the *equivalent* consumption in King's (1983) terminology and $z(\mathbf{p})$ and $b(\mathbf{p})$ are defined as (see Deaton and Muellbauer 1980):

$$\ln z(p_c) = a_{0c} + \sum_{k=1}^{K} a_k \ln p_{c,k} + \frac{1}{2}\sum_{j=1}^{J}\sum_{k=1}^{K} b_{j,k} \ln p_{c,j} \ln p_{c,k} \tag{23}$$

$$b(p) = c_0 \prod_j p_j^{c_j} \tag{24}$$

In turn, the own and cross price elasticities as well as the income elasticity are calculated as follows:

- the own price elasticity ($\varepsilon_{j,j}$) for good j is obtained as

$$\varepsilon_{j,j} = \left(\frac{b_{j,j}}{\overline{w_j}}\right) - 1 \tag{25}$$

with $\overline{w_j}$ identifying the mean value of good j's share.

- the cross price elasticity of the demand of good j with respect to a change in good k's price ($\varepsilon_{j,k}$) is given by:

$$\varepsilon_{j,k} = \frac{b_{j,k}}{\overline{w_j}} \tag{26}$$

- finally, the income elasticity (η_j) is calculated through the following formula:

$$\eta_j = \frac{\mu_j}{\overline{\overline{w_j}}} + 1 \tag{27}$$

where $\mu_j = c_j$

This approach is advantageous in that it makes it possible to take account of substitution effects between consumer goods. It also is more flexible in taking account adjustments in household consumption patterns to variations in household income.

b) Cobb-Douglas approach: household specific price effects with fixed budget share

If the AIDS model does not work with the existing data (i.e. some of the own price elasticities are positive or there is insufficient price data), one alternative is to adopt the Cobb-Douglas utility function. This approach is based on the strong hypothesis that any price increase results in a proportional fall in the quantity consumed (unitary price elasticity). The equivalent consumption (i.e. the consumption in real terms) per adult equivalent would thus be:

$$e_{t,h} = \frac{x_{c,h}}{\Gamma^0_{t,c,h}} \tag{28}$$

with

$$\Gamma^0_{t,c,h} = \prod_{k=1}^{K} \left(\frac{p_{t,c,k}}{p_{0,C,k}} \right)^{w_{h,c,k}} \tag{29}$$

where $\Gamma^0_{t,c,h}$ is the household-specific consumer price deflator, $p_{0,C,k}$ is the reference unit price, which corresponds to the price of good k at time 0 (the reference period) chosen in a given cluster C (the reference cluster), $p_{t,c,k}$ is the unit price at time t for good k for cluster c, $w_{h,k}$ is the budget share for good k by household h.

c) Consumer price index: assumption of uniformity of price effects on households with fixed budget shares

If it is not possible to calculate household-specific consumer-price deflators for lack of data, a last alternative is to assume the uniformity of the price changes over the households, regardless of their consumption pattern and socio-demographic characteristics. To see how this can be done, let $\pi^0_{t,c}$ be either the official consumer price index (CPI) in cluster c, given the average spatial (among clusters) and temporal (between baseline 0 and time t) price differences, or the aggregate CPI computed from the household survey using the following formula:

$$\pi^0_{t,c} = \sum_{k=1}^{K} \overline{w}_{0,c,k} \frac{p_{t,c,k}}{p_{0,C,k}} \tag{30}$$

where $\overline{w}_{0,c,k}$ $p_{0,C,k}$ is the average budget share observed in cluster c at time 0, $p_{0,C,k}$ is the unit price of good k observed in the reference cluster C at time 0, $p_{0,c,k}$ is the unit price of good k observed in cluster c at time t. Note that, by definition, $\pi^0_{0,C} = 1$. The purchasing power of each household at any given period and cluster could then be approximated by

$$e_{t,h} = \frac{x_{c,h}}{\pi^0_{t,c}} \qquad (31)$$

5. CHILD POVERTY AND WELFARE ANALYSIS

The income and consumption effects calculated above are used to predict the impact of the global crisis and policy responses on children in terms of their monetary poverty, hunger (caloric poverty), schooling, work and access to health services.

Most poverty and inequality analysis is based at the household level. However, given our preoccupation with the impacts of the global crisis on children, we conduct our analysis at the individual level. Note that we will not attempt to model intra-household allocation decisions and simply assume that consumption is shared equitably (according to caloric needs) among members of each household.

As a consequence, children are considered to suffer from monetary poverty if they belong to a monetarily poor household, i.e. a household for which per-adult equivalent consumption expenditure is less than the poverty line. We test the robustness of the results over a wide range of poverty lines and various poverty measures.

A demand system is estimated in order to assess changes in consumption patterns and, in combination with nutritional tables, the impacts on hunger (caloric poverty). When a full demand system cannot be successfully estimated, two alternative approaches, assuming fixed budget shares, are adopted. Caloric poverty is measured by the calorie adequacy ratio (CAR).[9]

Estimation of household decisions on child schooling and work activities take into account the impact of the global crisis and government policy responses on household income and the opportunity cost of education (market or implicit child wage), which are determined endogenously in each period. These decisions also depend on individual, household and community characteristics, which are assumed to be unaffected by the crisis.

The probability that an ill individual will consult a health service, and the choice of the type of service (modern, traditional, etc.), are also determined by individual, household, and community characteristics. Following the example of education, these decisions will also be affected by household incomes.

5.1. Monetary poverty

The standard FGT measures of monetary poverty (headcount index, poverty gap and squared poverty gap) are calculated for children in the base year and each of the three simulation

[9] The caloric poverty line is thus equal to one.

years for each scenario. Results are presented for different groupings: national, by region, urban vs. rural, by number of children in the household, by gender of the household head, etc.). These results capture changes in consumer prices and household income. Absolute changes in household income are fully transmitted to household consumption with the hypothesis that there is no change in savings. Three different approaches are proposed following the methodologies presented in section 4.2 above:

a) When the AIDS approach is used, total real consumption per adult equivalent, as calculated in equation 22, is normalized by dividing by the relevant cluster poverty line, as calculated in equation 23, and then multiplying by 100. Thus, the new poverty line is 100 for all individuals in all clusters. If we are interested in the food poverty rates, we need simply to use the food consumption in real terms and the absolute food poverty line. In order to calculate the poverty rates for each year in each simulation scenario, we need to re-estimate total real consumption using the new vector of prices and the change in total household income, as obtained from equation 22[10]. With the new total consumption value expressed in real terms, we can calculate poverty rates in the same way as for the base year[11].

b) When the Cobb-Douglas approach is used, total real consumption per-adult equivalent, as calculated in equation 28, is obtained by dividing total household consumption by the household's price deflator (Γ), as calculated in equation 29, and equivalence scale. This value is then normalized by the cluster-specific poverty line and then multiplying by 100. Thus, the new poverty line is, once again, 100 for all individuals. In order to calculate poverty rates for each year in each simulation scenario, we need to integrate the new vector of prices and the change in total household income. We thus need to:

- Divide total household consumption in the base year by the new value for the household-specific price deflator, as calculated in equation 29 with the new price vector in the numerator.
- Add the income change as obtained from equation 17.
- Divide by the household equivalence scale.
- Divide total per-adult equivalent consumption thus obtained by the poverty line of the reference cluster (region/area) and then multiply by 100. Thus, the new poverty line would be 100 for all individuals, as in the base year.

c) When the Consumer Price Index approach is used, poverty rates before and after the economic shock are estimated in the same way as for the Cobb-Douglas approach; the only difference is the use of the household's weighted price deflator, as calculated by equation 30 instead of equation 29.

[10] When equation 22 is re-calculated for each scenario, we need to use the relevant price system and include the estimated change in total household income.

[11] We need to recalculate the poverty line for each simulation scenario and each year according to the new price vectors, calculated from equation 23.

Poverty indices are then calculated by aggregating over individuals according to various criteria: national, region, urban/rural, number of children in the household, gender of the household head.

5.2. Hunger (caloric poverty)

In order to calculate the caloric poverty rate, we first need to calculate, for each food category, quantities consumed in the base year and each year of the various simulation scenarios:

1. Base-year food quantities are calculated by dividing base-year food consumption values by the relevant base-year cluster-median unit values (or independently collected market prices if unit values cannot be calculated).

2. Food quantities for each year of each simulation scenario are calculated using the same three approaches already discussed in the case of monetary poverty:

a) When the demand system is used (AIDS), we proceed as follows:

- Estimate the demand system (equation 20) and save the residuals (namely, observed minus predicted values of the dependent variable - $w_{j,c,h}$)

- Predict the new vector of budget shares after changes in prices (in each relevant good category identified in the AIDS) and household income ($x_{c,h} + \Delta Y_{c,h}$).

- Add the residuals to the predicted new vector of budget shares.

- Since the model will likely predict some negative shares after price and income changes (generally when the pre-crisis value of the good *i*'s budget share is "zero" and the residuals are thus negative), we propose to replace the negative values with a small share of the pre-crisis value (i.e. if $w'_{j,c,h}<0$ then $w'_{j,c,h}$ should be replaced by one-tenth of $w_{j,c,h}$). It follows that the new (final) budget shares should be re-weighted by the new (after the replacement of negative values) sum of all the budget shares (somewhat larger than 1): we thus ensure that the sum of the shares will be exactly equal to one.

b) If the Cobb-Douglas or consumer price index approach is used, for each year of each simulation, we simply divide values of food consumption in each category by the relevant median unit price.

3. With the vectors of food quantities consumed in the base year and in each year of each scenario, we are able to study the impacts on hunger (caloric poverty) as follows. The caloric poverty index is the individual calorie adequacy ratio (CAR), where we assume that all members of a given household have the same value (e.g. total household calories are distributed equitably within the household proportionally to each member's caloric requirements). The CAR is calculated as follows:

a) The quantities of each food category consumed by the household are equal to the corresponding consumption value divided by (median cluster) price:

$$Q_{h,i,c,t} = \frac{V_{h,i,c,t}}{p_{h,i,c,t}} \tag{32}$$

where:

$Q_{h,i,c,t}$ = quantity consumed of food category *i* by household *h* living in cluster *c* at time *t*
$V_{h,i,c,t}$ = value of food category *i* consumed by household *h* living in cluster *c* at time *t*
$p_{h,i,c,t}$ = median cluster price of food category *i* for household *h* living in cluster *c* at time *t*

b) Individual quantities consumed (per male adult) are calculated by dividing the quantities consumed by household *h* (see the previous point) by the household equivalence scale:

$$Q_{h,i,n,c,t} = \frac{Q_{h,i,c,t}}{ES_h} \tag{33}$$

where

$Q_{h,i,n,c,t}$ = the quantity of food category *i* consumed by member *n* of household *h* living in cluster *c*, expressed in terms of the equivalent quantity consumed by a reference male adult at time *t*
ES_h = equivalence scales for household *h*

c) Calorie intakes are calculated from nutritional tables for all food categories consumed as follows:

$$CI_{h,i,n,t} = Q_{h,i,n,c,t} * K_i \tag{34}$$
$$CI_{h,n,t} = \sum_i CI_{h,i,n,t} \tag{35}$$

where

$CI_{h,i,n,t}$ =Calorie intake from food category *i* by individual *n* from household *h* expressed in terms of the equivalent intake for the reference male adult at time *t*.
K_i = Caloric content of food category *i* expressed per unit of measure of $Q_{h,i,n}$ [12].

[12] For categories including more than one good where the goods are heterogeneous in caloric content, calculate a weighted calorie property based on the average national consumption shares of each goods) (i.e. for calorie

$CI_{h,n,t}$ = Total calorie intake of individual *n* from household *h* expressed in terms of the equivalent intake for the reference male adult at time *t*.

d) calculate the CAR

$$CAR_{h,n,t} = \frac{CI_{h,n,t}}{CR^*} \tag{36}$$

where

CR^* = Calorie requirements of the reference male adult (we suppose to be 2450 kcal a day multiplied by 365 days). The poverty line is thus simply 1 ($CI_{h,n,t} = CR^*$).

e) Estimate caloric poverty indices – headcount index, poverty gap and squared poverty gap – for the base year and for each year of each scenario for different subgroups: national, by region, by urban/rural area, by number of children in the household, by gender of the household head, etc.

f) Estimate the elasticity of calorie intake with respect to income (η_r) and to the price of good *j* ($\varepsilon_{p,j}$). Specifically:

$$\eta_r = \sum_i \eta_i \omega_i \tag{37}$$

$$\varepsilon_{p,j} = \sum_i \varepsilon_{i,p,j} \omega_i \tag{38}$$

where η_i et $\varepsilon_{i,p,j}$ are the elasticities of demand for good *i* with respect to income and the price of good *j* respectively and ω_i is the contribution of food *i* to total caloric intake.

5.3. Child schooling and work

In this section we propose to estimate how, given a number of other fixed explanatory variables, variations in total household real consumption per adult equivalent influences the probability that a child is in one of four situations: i) no work-no school; ii) no work- school; iii) work-no school; iv) work-school. To do so, we adopt the following four steps:

a) Use a bivariate probit regression to estimate the probability of a child attending school and working based on various individual, household and community characteristics, as well as household real consumption per adult equivalent.

b) Predict change in probabilities of children being in each of the four situations after substituting the new household real consumption per adult equivalent obtained for each year of each simulation scenario.

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properties specific for Sub-Saharan African countries, see http://www.fao.org/docrep/003/X6877E/X6877E00.htm#TOC)

c) We then calculate the average change between the predicted probabilities (of the four situations) for each year of each scenario and the predicted probabilities in the base year.

d) We then add this average change to the base-year shares of children in each situation in order to estimate the shares of children in these situations for each year of each scenario.

5.4. Access to health care

In this section we propose to see whether, given a number of other fixed explanatory variables, variations in total household real consumption per adult equivalent influences: a) the probability that a health service will be consulted when a child falls ill; b) the choice of health service consulted (i.e. use of lower quality health services in the face of income losses). To do so, we follow the steps below:

a) restrict the sample to only children reported to be ill (normally in the two or four weeks preceding the household survey)

b) run a logit model where the dependent variable is a binary variable taking the value 1 if the ill child consults a health service and 0 if not. Explanatory variables include various individual, household and community characteristics, which we assume to be unchanged in all scenarios, and total household real consumption per adult equivalent.

c) run, among ill children who consult a health service, a multinomial logit regression where the dependent variable depends on the type of service consulted: 1 if a hospital, 2 if a community clinic, etc. (ranked by presumed decreasing quality up to a maximum of 4/5 types of services, aggregating where necessary). Again, the explanatory variables include various fixed individual, household and community characteristics, as well as total household real consumption per adult equivalent.

d) predict change in the probabilities of ill children consulting a health service (using the logit model from point 2 above) and, for those who consult, in the probabilities of consulting each type of service (using the multinomial logit regression from point 3 above) due to the predicted change in total household real consumption per adult equivalent.

e) We then calculate the average change between the predicted probabilities for each year of each scenario and the predicted probabilities in the base year.

f) We then add this average change to the base-year shares of ill children consulting each type of health service in order to estimate these shares for each year of each scenario.

6. DATA

The parameters in CGE models are calibrated such that the model exactly reproduce the base year values given by the underlying Social Accounting Matrix (SAM). A SAM is a representation of all transactions between economic agents in a condensed matrix form with an important property that the sum of the row elements (receipts) is equal to the sum of the corresponding column elements (payments). It is a consistent quantitative macroeconomic data framework representing an economy during a given period of time, in general, one year. The SAM is therefore consistent in the sense that it describes a general equilibrium of an economy.

The micro model uses information on households and individuals gathered from a nationally representative household survey. These surveys integrate socio-demographic and economic information on household and individuals, including children. In particular we make use of survey data on the value, quantities (and thus unit prices) of food products consumed by households, on the value of non food expenditures, on school participation and labor-related activities, and on the use of health services.

7. FORMULATING POLICY RESPONSES TO THE ECONOMIC CRISIS IN WCA

The study simulates the impact of the global economic crisis on developing countries through four main channels of transmission: trade, remittances, foreign investment and foreign aid.

7.1. Crisis scenario

In our core crisis scenario, we assume that government expenditures per capita are kept constant and that the increase in the government deficit induced by the contraction of national economy and the reduction of aid flows are compensated through domestic borrowing. Note that this exacerbates the effects of the global crisis by lowering the availability of private savings for domestic investment.

7.2. Pro-cyclical fiscal policy response

When government faces a budget deficit constraint, a reduction in government current and investment spending and/or an increase in taxes are required to balance its budget (pro-cyclical fiscal policy response). This would increase the short-term impacts of the crisis on the national economy. Spending cuts would target government transfers or public services such as health and education. The impact of tax increases would depend on their nature, income taxes being, for example, generally progressive, whereas sales taxes are often regressive. In this scenario, per capita public expenditures are assumed to be fixed (i.e. increasing at the population growth rate) given the short term perspective of the analysis, while indirect and direct taxes are increased to maintain the budget deficit constant.

7.3. A counter-cyclical policy (stimulus plan)

In this study we analyze two counter-cyclical policy responses:

- **Food subsidy**

This subsidy is captured in the CGE model as a uniform consumer subsidy introduced on all food products. The model is solved and the values of the linking variables – in particular the reduced prices for food goods – are passed on to the micro model.

- **Targeted cash/in-kind transfers to poor children**

Cash transfers are provided to children who are identified as poor through a proxy-means test approach. The literature refers to many different approaches useful for the Government to identify and target poor people and try to counteract the negative effects of the crisis (see Bibi et al. 2009, for a wider discussion). In our analysis we made use of regression models to predict the household real consumption per adult equivalent and thus the poverty status of each child. These models were constructed and regress separately for rural and urban areas. Explanatory variables were selected in order to minimize the two possible targeting errors: leakage and undercoverage. Care was taken to use a restricted number of easily observable and non-modifiable socio-demographic characteristics as the explanatory variables:

- Geographical (region, binary distance to usable road/market)
- Demographic (number of household members aged 15 and over, number of household members aged 14 and under)
- Characteristics of dwelling (owner or not, floor in cement or not, hard walls or not, with electricity or not, number of rooms per household members)
- Assets (with automobile or not, with a motorcycle or not)

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ANNEX 1: Methodological notes on the calculation of the total household consumption aggregate

Total base year household consumption includes:

- **Food expenditure**: The individual/household amounts recorded are summed across the period of reference for each food item and then converted to an annual basis (i.e. for expenditures reported on a monthly basis, multiply by 12; if applicable, also multiple by the proportion of the year in which the household consumed each food item). This category of expenditure includes the actual or imputed expenditure for food items purchased in the market, received as gift or as in-kind income, or self produced and consumed outside the home. These annual estimates are then summed across all food items to get the estimate of the household's total annual expenditure on food. It is preferable to use the unit values reported by the household (or calculated from reported values and quantities) rather than the market price in a specific cluster; this takes into account differences in the quality of food consumed.

- **Housing expenditure**: this includes the cost (actual or imputed) of the housing service used by the household. Specifically, this component includes actual expenditure on rent by households (both payments in cash and in kind), which are estimated by annualizing the values provided by respondents. This cost must be imputed for owner-occupied dwellings, for those whose dwelling is provided by a relative or other private individual on a rent-free or subsidized basis, and those claiming neither to rent nor ownership of their dwelling. If not already available, the imputation is based on the prediction of the hedonic rental equation, taking the regression results for renters of the following formula: the annualized rental value of a dwelling (previously cleaned of any outliers) is a function of the location and the characteristics and amenities of the dwelling. The location variables correspond to urban/rural and regional variables. Dwelling characteristics and amenities include items such as the type of light and water sources, type of toilets, and whether the floor is in concrete or tiled, as well as the size of the dwelling (all these variables – except for the size of the house – are dichotomous, e.g. a variable takes the value 1 if the dwelling has piped water or 0 if not). Note that the imputation as described above should be preceded by a careful look at the number of households paying the rents: if this is number is relatively low, estimates may result not stable and thus potentially inaccurate.

- **Expenditure for other services**: this includes (actual or imputed – for those benefiting from a subsidy) expenditure on water, electricity and garbage disposal, whose amounts should be annualized.

- **Expenditure on education**: various expenditures on education – school and registration fees; contributions to parents'/teachers' associations; uniforms and sports clothes; books and school supplies; transport to and from school; food, board and lodging at school; other educational expenditure – are recorded for each individual. Expenditure on education is therefore estimated by reporting each component on an annual basis and then by aggregating the different items of expenditure referred to above and summing over individuals in the household.

- **Expenditure on health related services**: various expenditures on health are recorded for each individual. Expenditure on health is therefore estimated by reporting each component on an annual basis and then by aggregating the different items of expenditure referred to above and summing over individuals in the household.

- **Other daily non-food or less frequent expenditure**: this includes expenditure for transport and communication, for leisure, for religious or civil celebrations, clothes, and all the other expenditure not already covered before. However we do not include expenditure for durables, purely work-related expenditures (i.e. transport to work or work clothing), taxes, purchase of assets and repayment of loans. These expenditures are converted to an annual basis, as discussed for the previous items.

- **Final notes**:
  - Since we do not take into account the month in which the interview took place and, thus, when a particular item was purchased, the estimate of each household's annual expenditure is likely to be over-estimated for those households that purchased food and non-food items during the survey period, but that do not purchase them in all months of the year. However, this over-estimation for some households will be counterbalanced by a corresponding under-estimation for those households that do consume the item in some months although they did not consume any during the survey period. Although the overall variation between households will be exaggerated, the estimate of total and mean household expenditure should be unbiased, since the survey work was spread throughout the year
  - Possible outliers are not, in principle, corrected, nor are missing values. They are simply dropped.

The final total household consumption aggregate should then be adjusted by cost of living differences (spatial and temporal) and by the household composition (equivalence scales), as discussed in the main document.

ANNEX 2: Methodology for the estimation of potential effect of price changes on household welfare and poverty: King's (1983) approach

To capture the effects of price changes on the distribution of real income, the easiest approach is to assume the uniformity of the price changes over households, regardless of their consumption pattern, region of residence, and socio-demographic characteristics. For this, let $Q_{r,k}$ be the aggregate consumption of the commodity k in the reference situation r, $p_{r,k}$ be the price of the commodity k in the reference situation r, $p_{s,k}$ be the price of the commodity k following the simulation s, π^r_s be the consumer price index (CPI) which indicates the average price change following the move from the reference situation r to the simulation s

$$\pi_s^r = \frac{\sum_{k=1}^{K} p_{s,k} Q_{r,k}}{\sum_{k=1}^{K} p_{r,k} Q_{r,k}} \tag{39}$$

By definition, $\pi^r_r = 1$ and π^r_s may be lower or greater than 1 according to whether the CGE model predicts a fall or a rise in consumer prices on average. The expected purchasing power of each household in any given situation could then be approximated by

$$e_{s,c,h} = \frac{x_{s,c,h}}{\pi_s^r} \tag{40}$$

Clearly however, this is not the best approach due to the diversity in the household consumption patterns. In reality, the impact of price changes should vary across households. It is well known, for instance, that the poor devote a larger budget share to food than the non-poor. This means that a rise in food prices hurts the poor more than the non-poor. It is thus important to calculate consumer price indices that are specific to each household.

To achieve this goal, we rely on the King's (1983) approach to define the concept of *equivalent consumption*. For a given budget constraint ($\mathbf{p}_{s,c}$, $x_{s,c,h}$), the equivalent consumption is defined as that income level which, at the reference price system $\mathbf{p}_r$, yields the same utility level as that utility level reached under ($\mathbf{p}_{s,c}$, $x_{s,c,h}$), i.e.

$$v(\mathbf{p}_r, e_h(\mathbf{p}_r, \mathbf{p}_{s,c}, x_{s,c,h})) = v(\mathbf{p}_{s,c}, x_{s,c,h}) \tag{41}$$

where $\mathbf{p}_r$ is the reference price (which may correspond to the initial price observed at a given cluster c of reference), $\mathbf{p}_{s,c}$ is the price system obtained following the simulation s, and $x_{s,c,h}$ is the per equivalent adult consumption predicted under the simulation s (if s = 0, we have the consumption level observed in the initial situation), v(.) is the indirect utility function, and e_h(.) is the *equivalent consumption* function that is specific to the household h. Since $\mathbf{p}_r$ is fixed across all households, e_h(.) is an exact monetary metric of the indirect utility $v(\mathbf{p}_{s,c}, x_{s,c,h})$ because e_h(.) is an increasing monotonic transformation of v(.). Thus, inverting the indirect utility function, the *equivalent consumption*, $e_h(\mathbf{p}_r, \mathbf{p}_{s,c}, x_{s,c,h})$, is obtained as

$$\begin{aligned} e_{0,h} &= e_h(\mathbf{p}_r, \mathbf{p}_{0,c}, x_{0,c,h}) \\ e_{s,h} &= e_h(\mathbf{p}_r, \mathbf{p}_{s,c}, x_{s,c,h}) \end{aligned} \tag{42}$$

where $e_{0,h}$ and $e_{s,h}$ stand henceforth for the equivalent consumption pre- and post-environment-change, respectively. Enduring the world crisis is then equivalent to taking from each household an amount of income equal to their $\Delta e = e_{s,h} - e_{0,h}$. Putting it differently, Δe is that sum of money which the household h would be willing to sacrifice in its initial position to avoid the potential negative effects of the international economic decline.

Ideally, a complete demand system should be estimated to derive the equivalent consumption functions. If the demand system chosen corresponds to the AIDS defined either by equation (18) or (20), the equivalent consumption functions will be given by equation (22). However, if the Cobb-Douglas preferences are chosen to characterize the households' consumption behavior, then applying the above methodology (described by equations (41) and (42)) yields the following equivalent consumption functions:

$$e_h(\mathbf{p}_r, \mathbf{p}_{s,c}, x_{s,c,h}) = \frac{x_{s,c,h}}{\pi^r_{s,c,h}} \quad \text{where} \quad \pi^r_{s,h} = \prod_{k=1}^{K} \left(\frac{p_{s,c,k}}{p_{r,k}} \right)^{w_{k,c,h}} \tag{43}$$

One of the most striking features of the Cobb-Douglas preferences is the fact that the inference of the household's specific consumer price index $\pi^r_{s,h}$ is straightforward as $w_{k,c,h}$ simply corresponds to the budget share devoted by h to the commodity k and as this budget share is deemed to be unchanged from a simulation to another.

To measure the poverty effects of the world crisis, we use the popular Foster-Greer-Thorbecke (1984) (FGT) family of poverty indices. Let z be a real poverty line, that is, a line measured in terms of the reference prices $\mathbf{p}_r$. The FGT family is then defined as

$$P_\alpha(z) = \frac{1}{\mathbf{N}} \sum_{h=1}^{H} \rho_{c,h} n_{c,h} \left(\frac{z - e_h(\mathbf{p}_r, \mathbf{p}_{s,c}, x_{s,c,h})}{z} \right)_+^\alpha \quad \forall s = 0,1... \tag{44}$$

where $f_+ = \max(0, f)$, $\mathbf{N}$ the number of the households in the survey, n_h is the size of the household h, ρ_h is the sampling weight of h, and α is a parameter that captures the "aversion to poverty" or the distribution sensitivity of the poverty index: a larger α gives a greater weight to a loss of income to the poorest than to the not-so-poor. The FGT indices are averages of powers α of normalized poverty gaps: $\frac{z - e_h(.)}{z}$. As it is well known, $P_0(z)$ measures the incidence of poverty (headcount ratio), $P_1(z)$ measures the depth of poverty (poverty gap), and $P_2(z)$ is often described as the severity of poverty (squared poverty gap). For $\alpha > 1$, $P_\alpha(z)$ is sensitive to the distribution of living standards among the poor, and when α becomes very large, approaches a Rawlsian measure.

The potential effects of the global crisis on poverty could then be computed as

$$\Delta P_\alpha(z) = \frac{1}{\mathbf{N}} \left(\sum_{h=1}^{H} \rho_{c,h} n_{c,h} \left(\frac{z - e_h(\mathbf{p}_r, \mathbf{p}_{s,c}, x_{s,c,h})}{z} \right)_+^\alpha - \sum_{h=1}^{H} \rho_{c,h} n_{c,h} \left(\frac{z - e_h(\mathbf{p}_r, \mathbf{p}_{0,c}, x_{0,c,h})}{z} \right)_+^\alpha \right) \tag{45}$$

The magnitude of the poverty change calculated by $\Delta P_\alpha(z)$ is likely to vary with the choice of the poverty line (z) and aversion parameter (α), as may the policy recommendations that follow. The application of well-known results from the stochastic dominance literature shows, however, that if $\Delta P_\alpha(z) \geq 0$ for a reasonable range of poverty lines $[z^-, z^+]$ and for any choice of poverty measure within a class of ethical order $\alpha + 1$, then we can robustly conclude that poverty increases.

For $\alpha = 0$ (first-order poverty dominance), the test simply involves calculating differences between the incidence of poverty before and after the simulation. If $\Delta P_0(z)$ is non-negative for any choice of poverty line within $[z^-, z^+]$, then the simulation can unambiguously be declared as poverty increasing. If $\Delta P_0(z)$ switches sign for some poverty threshold within $[z^-, z^+]$, then the conclusions are ambiguous. For some choices of poverty lines, poverty will be found to rise, while for others, poverty will be shown to fall.

Two avenues can be followed to tackle this issue. The first is to reduce the reasonable range of poverty lines based on judgment. The second avenue is to assess the poverty effects of the simulation over a higher-order class of poverty indices in exactly the same manner. It can be shown that robustness at any given order guarantees robustness for all higher orders, but not vice versa. It is thus possible to find robustness for a higher order dominance, even if this is not the case for lower orders.

ANNEX 3: Structure of the CGE model

The model takes the form of five blocks of interdependent equations, namely, (i) supply, (ii) demand, (iii) equilibrium and macroeconomic constraints, (iv) income distribution, and (v) dynamic of the economy.

i. ***Supply***

Goods sold on the domestic market are a combination of local products and imports. The local production technology is represented by a constant return to scale function. It takes the form of nested functions with several levels. First, sectoral production combines value added and total material inputs according to a fixed proportionality relationship (also known as the Leontief input-output function). Second, an imperfect substitution relationship (Constant Elasticity of Substitution or CES) combines aggregate labor and capital in sectoral value added. Third, various types of labor are imperfect substitutes in aggregate labor, according to a unitary substitution relationship or Cobb-Douglas (CD) function.

A proportion of domestic supply is provided by the international market: the imports of goods and services. The latter are consider as imperfect substitutes to local products. This specification is known as the Armington assumption. Composite products are a combination of local and imported products according to a constant elasticity of substitution (CES). The total supply of non-imported products is provided by local production.

ii. ***Demand***

Local production of exportable goods is sold on domestic and foreign markets (exports) according to a constant transformation elasticity (CET) function. Local production of non traded goods and services is entirely sold on the domestic market.

Product demand for intermediate consumption for each good is a fixed proportion of the total material input consumption by economic sectors. Demand for investment purposes is a fixed value share of total investment. Inventory changes are assumed to be exogenous.

Final (consumer) demand is derived from household preferences, which are represented by a "Stone-Geary” function. Maximization of the latter subject to a budget constraint results in a linear expenditure system (LES) with a fixed component related to the non discretionary consumption and a variable component or supernumerary. The latter is allocated to commodities by constant distributive shares. Public consumption is an exogenous variable which is assumed to be related to the Government fiscal policy.

iii. Equilibrium and macroeconomic constraints

Besides the choice of behavioral functional forms and parameter values, CGE models differ also in the choice of macroeconomic closure rules. The latter describes the functioning of products, factors and external markets in the setting of basic prices, the Government budget balancing and its fiscal policy, and the savings-investment closure rule. Thus, these macroeconomic constraints are imposed onto economic agents.

Import prices are exogenous, i.e. the small country assumption with infinite supply elasticity. Import prices are converted into local prices using the exchange rate, adjusted for the tax on imported products. The international f.o.b. prices for exports are determined by supply and demand; that is, exporters face a finite export demand elasticity. Exports prices are transformed into local prices by the exchange rate adjusted by export taxes when applicable.

Product markets are perfectly competitive. The equilibrium price or basic price for a product is the price that ensures aggregate equality between supply and demand. Consumer prices for non-import competing products are equal to the market clearance prices adjusted by consumption tax rates. Consumer prices for import-competing products are equal to average weighted prices of locally-produced and imported products also adjusted by consumption tax rates. Producer prices for non-exported products are equal to their local prices, while producer prices for exportable products are equal to the weighted average of their local and foreign prices. The value added price index is obtained by output valued at producer prices, net of production taxes and inputs costs, divided by the volume of value added.

The labor market includes three segments according to the categorization of workers identified by the study: rural, urban skilled and urban unskilled. Each segment is also divided into formal and informal sub-segments. Imperfect competition prevails and the segments are fully segregated, i.e. absence of movement among segments. The inelastic (exogenous) supply of labor is fully employed either formally or informally in each segment of the labor market. Within each segment of the labor market, there is perfect mobility of labor between firms, with supply and demand determining the equilibrium wage rate. Wages paid in the public sector are assumed to be fixed in real terms, indexed to the consumer price index. Further discussion on the structure and functioning of the labor market are provided in the next section.

In each period, capital is sector-specific. Returns to capital are thus determined as a residual after deducting the cost of labor from value added.

Exporters face an inelastic export demand. The latter is affected by international market conditions in a period of global crisis, drawing down export prices and volumes.

The current account balance consists of two components: the trade balance and the balance of income transfers. The specification of the current account balance is discussed in detail in the next section.

Investment is equal to the sum of domestic and foreign savings net of the exogenous changes in stocks. Total investment is driven by total savings.

Provision of public services and public transfers are fixed per capita, i.e. exogenously set within a period and increasing by the population growth rate between periods. Therefore, the quantity of factors (labor and capital) and intermediate inputs required in public services are also exogenous within each period. However, public expenses remain endogenous through factor and input prices. The government budget is balanced through changes in its primary savings, i.e. gross income net of current expenses.

The economy-wide basic producer price index is chosen as the “numeraire” or reference price. Variations in other prices are interpreted in real terms in relation to this numeraire.

iv. Income distribution

Fixed total labor (by segment) and capital endowments are assumed in each period. Therefore, changes in factor incomes are solely due to changes in factor prices. Remittances from domestic and foreign institutions are fixed in real terms, i.e. indexed to the consumer price index.

Household income is a sum of its labor and capital earnings. Capital earnings for each household category are a fixed share of the economy-wide capital earnings. Household receives different types of labor income when its members are engaged in various labor market segments. This work is paid either directly, when they are wage or salary workers, or indirectly, when they are self-employed workers. In the first case, the member receives a real wage. Self-employed workers receive a shadow wage equal to their potential earnings in the labor market, which is equal to the time worked multiplied by the segment wage rate.

Transfers between agents take the form of taxes and social security payments, dividends, interests and rents, and gifts and donations. Transfer payments, excluding taxes and social security payments that are fixed proportions of the gross income, are also fixed in real terms. Household disposal income is used for consumption and saving.

Capital earnings are partially allocated to firms according to their ownership share in the total capital endowment. In addition to capital income, firms receive transfers from other economic agents, i.e. interest and subsidies. They pay taxes and interest on their debt, and they distribute dividends. Direct taxes are levied on their profits. Other transfers are exogenous in real terms. They save (thus, invest) the balance of their budget, i.e. incomes net of expenses.

The government's role is passive in the model. In other words, it does not optimize a behavioral function. Its role is limited to the provision of public services and redistribution of wealth. It is financed through tax receipts on households and corporations and on economic activities. Government also receives dividends from public companies and grants from abroad.

Government revenues are partially transferred to other economic agents as debt payments, subsidies to enterprises, and income transferred to households, provision of public services and investment. Public services are entirely produced and consumed by Government. They are valued at production cost including wages paid to public servants, capital cost and material input costs.

v. Dynamics

In most comparative static CGE models, private savings are investment driven. That is, investment is assumed fixed at it base year level and savings are forced to adjust through various mechanisms. In a comparative static context, this means that the macroeconomic shocks or policies are not passed on to the future. In order to capture the effect of the global crisis on savings and investment and, thus economic growth, one must go beyond the static analysis and integrate consequences over multiple periods in a dynamic setting.

In this standard framework, total non public domestic investment is equal to total domestic private savings; that is, the model is savings driven. Non public sectoral capital stocks are updated with a capital accumulation equation involving the rate of depreciation and investment by sector of destination and foreign direct investment flows. This equation describes the law of motion for the sectoral capital stock. It assumes that stocks are measured at the beginning of the period and that the flows are measured at the end of the period.

New investments are allocated between the different sectors through an investment demand function that is similar to Bourguignon et al. (1989), and Jung and Thorbecke (2003). The capital accumulation rate[13] is increasing with respect to the ratio of the rate of return to capital and its user cost. The elasticity of the rate of investment with respect to the ratio of return to capital and its user cost is assumed to be equal to 2.

The user cost is equal to the investment price multiplied by the sum of the depreciation rate and the interest rate. The sum of investments by sector of destination is equal to private investment, which is, in turn, determined by total savings.

The workforce is adjusted in each period for the growth rate of the labor force, which is assumed equal to the population growth rate. The minimal (non discretionary) consumption level of each household is also adjusted by the growth rate of the population.

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[13] The ratio of investment to capital stock.