Poverty and income distribution in a CGE-household sequential model

Luc Savard[•]

April 2003

Preliminary draft

Abstract

This paper highlights the idea of combining CGE modeling with a micro-household model (micro-simulation) to generate a convergent solution, thus providing the basis to perform counterfactual analysis of trade and fiscal policies and their impact on poverty. In recent years, a number of papers have presented different approaches using CGE models to analyze poverty. Among them, the standard CGE models, which generates changes in the income of representative households in order to allow poverty analysis, albeit with no intra-group changes in the distribution; CGE models with high levels of household desegregation (3200) and the micro-simulation approach to modeling (with no feedback effect to the CGE model). In this paper, we provide an alternative to these methods that allows for richer micro-household modeling then the first two approaches while keeping the properties of standard CGE (feedback effect of household behavior) which is usually simplified in micro-simulation context. We also introduce segmented labor markets with waiting unemployment inspired by Magnac (1991), which provides a basis for important changes in household income (i.e. when a worker leaves unemployment or becomes unemployed). Global and decomposable poverty analysis and income distribution indicators are computed at base year and after a 50% reduction in trade.

Key words: Computable general equilibrium models, Estimation, Personal Income and Wealth Distribution, Measurement and Analysis of Poverty

JEL Classification: I32, D31, C13, C68

Introduction

[•] International Development Research Centre, (IDRC-Dakar, Senegal); lsavard@idrc.org.sn

Introduction

We have witnessed a flourishing literature in recent years around the nexus of macro-modeling and poverty analysis. Most of the recent impetus to this literature has been tied to the PRSP process that implicitly requires policy makers to present a framework for linkages between macroeconomic reforms and poverty. There seems to be a relatively wide consensus around key criteria to consider in this type of analysis. They are: the importance of prices and factor remuneration, the macroeconomic balances/coherence, and integrating household behaviours in terms of expenditure and labour market. In this context, we can see that the main challenge is to reconcile the microeconomic behaviours and the macroeconomic aggregates. The two fields that deal with these issues and allow for linkages are CGE modeling and consumers microeconomics (consumption and labour market). The recent methodological developments in the area have drawn upon both fields with different ways to apply them.

CGE and income distribution has a relatively long history. The first attempts using them in this context, brings us back to the pioneering work by Dervis, de Melo and Robinson (1982) and Gunning (1983). These papers were followed by a second important wave in the early 90's with the OECD sponsored papers such as Thorbecke (1991), Bourguignon et al. (1991), de Janvry et al. (1991)[1]. The last impetus to this literature came near the end of the 90's with contribution by Cogneau (1999), Decaluwé et al. (1999a) Decaluwé et al. (1999b), Cogneau and Robillard (2000), Agenor et al. (2001), Cockburn (2001), Bourguignon, Robillard and Robinson (2002) and Boccanfuso et al. (2003) among others. Each of these authors adapted standard CGE modeling in order to allow for income distribution or poverty analysis. We will classify the work in three main categories. The first one would be the CGE models with representative agents which perform poverty analysis with variation of the average income of the representative household, (CGE-RH) or simply income distribution by comparing RH variation of income between groups. The second is the

[1] In this literature we do not make reference to authors who exclusively looked at income distribution between groups of representative households. We refer to authors that attempted to look at the poverty indices or income distribution beyond the inter group comparison of RH.

multi-households CGE analysis (CGE-MH)[2], and finally the micro-simulation approach which uses a CGE model to generate prices that links into a micro-econometric household micro-simulation model (CGE-MS).

The CGE –RH approach is the traditional method, and has been widely used in the literature at least for income distribution issues. In this approach, poverty analysis is performed by using the variation of income of the RH generated by the CGE model (output of CGE model) with household survey data to perform ex ante poverty comparison. Dervis et al (1982) have applied this approach, as well as de Janvry et al. (1991), Chia et al. (1994), Decaluwé et al. (1999a), Colatei and Round (2000) and Agenor et al (2001). The main drawback to this approach is that it either supposes there is no intra-group income distribution change, or that this intra-group distribution change is linked to a theoretical statistical relationship between average (μ) and variance (σ^2) of the distribution of the lognormal distribution. There is no economic behaviour behind this change in intra-group distribution. We can easily see that the average behaviour of a specific group is biased towards the richest in the group. As they are the ones endowed with most of the factors, their behaviour will be dominant in the group[3]. The main advantage of this approach is that it is easier to use then other approaches, as it does not require specific modeling effort outside what is done in standard CGE modeling exercise. The modeller can simply use a standard CGE model and apply the outputs to perform poverty analysis.

The second approached, which we refer to, is the CGE-IMH modeling. This approach consists of multiplying the number of representative households compared to the

[2] Some make reference to this approach as the micro-simulation CGE approach, but we prefer to distinguish it since micro-simulation has been widely used in a different context and could lead to confusion. Micro-econometric household modeling used for policy simulations such as what is proposed in Mitton, Sutherland and Weeks (2000) is a good illustration of this approach as well as Bourguignon, F., F. Ferreira, and N. Lustig (1998), Bourguignon Fournier and Gurgand (1999) and Atalas and Bourguignon (2002). The main criterion for differentiating between the approaches is that the approach relays mainly on a micro-econometric household model. One of the approaches discussed later will describe the efforts made to combine this approach with macro modeling.

[3] Standard CGE modeling uses household groupings that will take into account the total income and expenditure of each groups and the behavioural parameters which are generally calibrated at base year. These parameters will in great part reflect the aggregate behaviour and not necessarily the average behaviour (This could easily be done but it is generally not done in this fashion). Moreover, when doing poverty analysis we are most interested by behaviour around the poverty line, nothing really demonstrates that the average of aggregated behaviour will be a representative of the households around the poverty line.

CGE-RH approach. With major gains in computing efficiency over the last few years, larger models become easier to solve. It is therefore quite simple to add as many households in the CGE model as what is found in income and expenditure household surveys. This approach was applied by Decaluwé et al. (1999) on fictitious data, Cockburn (2001) on Nepal and Boccanfuso et al. (2003) in Senegal. The main advantages of this approach compared to the previous approach are that it allows for intra-group distribution of changes as well as leaving the modeller free from pre-selecting household grouping or aggregation. The last issue on household aggregation has raised a lot of controversy as many have been using income deciles to group the households and other socio, demographic, or geographic criteria[4]. This approach avoids this constraint as the modeller can perform any decomposition of poverty and income distribution analysis since all, or a large sample of the household survey is directly used in the model. The main disadvantages of this approach are the limits it imposes in terms of microeconomic household behaviours. As a matter of fact, the size of the model can quickly become a constraint and data reconciliation can be relatively difficult. On the first point, CGE modeling imposes that behavioural function respects certain conditions on behavioural functions. For example, modeling that introduces switching regimes are not easily modeled with standard CGE modeling software as the equation system of the model cannot change as the iteration process moves along. Micro-econometric modeling provides much more flexibility in terms of the modeling structure used. It is easy to see that an increase of one production branch in a CGE-IMH approach using 5000 households will increase the number of model equations by over 5000. If non-linear equations are used in such a model, the resolution difficulties are amplified. For the last constraint, the data reconciliation process will lead to changes in structure of either the income or expenditure of the household behaviour. This comes from the fact that both accounts need to be balanced out as well as levelled to the national accounts' data found in the SAM[5]. You will often find some under or over reporting for items in the Household survey.

[4] For more discussion on this debate, see Decaluwé, Patry, Savard and Thorbecke (1999), views have been exchanged between De Maio, Stewart and van der Hoeven (1999) who have strongly criticized the work done by Sahn et al. (1997). The approach proposed below and in the multi-household approach eliminates this debate altogether.

[5] Scaling data presents problems that have been partly resolved by approaches such as RAS methods or the entropy method proposed by Robilliard and Robinson (2000) but these methods will still introduce some level changes in the structure to balance out accounts.

The third approach draws on micro-simulation literature first developed by Orcutt in the 1960's. According to Bonnet and Mahieu (2001), micro-simulation is required to analyse income distribution (dispersion) opposed CGE since RH is a good indicator of changes in averages but not in dispersion, while mostly using micro-econometrics modeling of household behaviours and using price vector generated by a CGE model or even exogenous price vector changes. An illustration of this approach can be seen in Bourguignon, Robillard and Robinson (2002). The main advantage of this approach is that it provides richness in household behaviour while remaining extremely flexible in terms of specific behaviours that can be modeled. The main drawbacks to the approach are the coherence between the macro and micro models, which is not always guaranteed, and the fact that the feedback effects of household behaviours are not taken into account in the CGE or macro model. In fact, it is possible to take into account part of the feedback effects as the modeller can compute aggregate elasticities from the household module to incorporate into the aggregate CGE behaviours, but complete feedback and coherence is not explicitly imposed.

In this paper, we experiment with another method that attempts to use the advantages of the last two approaches discussed earlier. We propose to examine coherence between the household model and the CGE model, introducing a bi-directional link and therefore obtaining a converging solution between the two models. The approach has three main advantages over the CGE-IMH approach. First, there is no obligation of scaling the household data to national accounts and no need to balance income and expenditure. Consequently, it allows the modeller to use the exact income and expenditure structure found in the household income and expenditure surveys. The second advantage is that there is not limit to the level of desegregation in terms of production sectors and # of households to be included in the model, as this is likely to be a temporary constraint since computing power increases rapidly for the CGE-IMH approach[6]. Finally, and most importantly, the degree of freedom in choices of functional forms used to reflect micro-economic household behaviour is much higher in this approach. As mentioned earlier regime-switching models can easily be applied

[6] Some experiments done in Boccanfuso et al. (2003) have currently revealed difficulty in resolving a CGE model of 3272 household and 15 sectors with functional forms having a fair amount of non linearity with the GAMS software. Chosing more linear functional forms and slightly reducing the number of production sectors (10 branches) have shown to facilitate resolution of the model.

as we will demonstrate in the application section. With respect to the CGE-MS approach, the main advantage is its efficiency to validate the coherence between the CGE and household models. Linking the CGE model of the HH model imposes a constraint of coherence between the two models and the converging solution produces a numerical validation of the coherence. Although some of the behavioural functions might be difficult to introduce directly in the CGE model, this problem can be solved by using functions that mimic the aggregate behaviours of the HH model and parameters of the aggregate CGE model which are obtained with numerical simulation of the HH model. As the forms used in the CGE might be different then the ones used in the HH model the econometric estimations might not be useful. Aggregate elasticities are easily obtained and re-imported in the CGE model. It is important to note that nothing guarantees a converging solution to be found; therefore it must be validated and numerically checked for the introduction of each new hypothesis[7].

Aggregation question

This is a very important question that could have been addressed earlier, but, given its significance, we preferred to set this discussion in a separate section. The aggregation issue is at the centre of this debate since it is what allows us to go from the micro-behaviours to the macro-model and vice versa. The modeller launching into such an exercise should always reflect on what the final contribution of including a large number of households in the modeling exercise should be. Why not then simply use the CGE model into a HH model as was done by Sadoulet et al. (1992) or then again solely apply the approach proposed by Bourguignon, Robillard and Robinson (2002). The answer to this question is linked to the aggregation question and its coherence. If the behaviour of RH in the CGE-RH model is a perfect aggregate of the behaviour in the HH model, there is no value added to linking the two models as the feedback effects of the household behaviour will be fully taken into account in the CGE model and the results of the HH model will provide all information necessary to do poverty, welfare and income distribution analysis.

[7] In parallel experiments on this line of work, we have found situations where the convergence was difficult; namely when using the “Almost Ideal Demand System”.

To address this issue, we need to look at both components of household behaviour in CGE modeling, namely the income and the expenditure behaviours. For the income side, in CGE modeling we generally have fixed factor endowments paid at their respective prices, fixed transfers from other agents of the model and dividends proportional to the total dividend payments. In the traditional CGE models, this approach to income modeling perfectly aggregates. We can look at the two important elements separately to show why it perfectly aggregates. First we have the capital or labour income that is represented by $kdh_h r$ and we can see that:

$$KDH.r = \sum_h kdh_h r \quad \text{where } KDH = \sum_h kdh_h$$

KDH is the aggregate household capital endowment, *kdh* is the specific household endowment and *r* is the rental rate of capital. The same applies for most of the elements of the household income as they are generally modelled the same way. One element that is computed differently is the dividends *(Div)*. In the models, it is assumed that there is an amount of total dividends which is distributed proportionally between the households that are endowed with shares of companies. Therefore, we have the following:

$$Div_h = tdv_h.TDIV \quad \text{where} \sum_h tdv_h = 1$$

where *tdv* is calibrated at base year by isolating from the dividend equation. Given these relations we see that $\sum_h Div_h = TDIV$ always holds since:

$$\frac{\partial TDIV}{\partial TDIV} = \sum_h \frac{\partial Div_h}{\partial TDIV}$$

Consequently on the income side we have perfect aggregation. This is an illustration of a typical CGE modeling exercise. However, as we will see in more details below, when we relax the assumption of fixed labour endowment, the perfect aggregation will not necessarily hold. Our model of the labour market allows for workers to move from one labour market to the other, and in and out of unemployment. This creates a constraint to aggregation as individual workers need to be taken into account and, as a result, we don't have the conditions for perfect aggregation.

On the expenditure side, the situation is somewhat different. For the expenditure function we can draw from Deaton and Muelbaeur 1980 to show that we get perfect aggregation if we can write the demand equation such that $\overline{q_i} = g_i(\bar{x}, p)$ for one g_i and for all i. Moreover, $g_i(\bar{x}, p)$ must be coherent with the utility function. This shows that if we transfer income from the richest household to the poorest it will have no impact on the total expenditure. In other words, this come to having all the same Engal curves, and these must be parallel for each household. When using C-D or LES for demand systems, they can allow for perfect aggregation when consistent parameters are used between households[8]. As for other elements of the household expenditure, we are confronted with a situation where perfect aggregation is not achieved. These specific elements are income tax, savings and transfers. In each of these three cases, we have the same type of relation that precludes perfect aggregation:

$$Ith_h = ty_h Yh_h$$

$$\frac{\partial Tith}{\partial Tyhh} \neq \sum_h \frac{\partial Ith_h}{\partial Yh_h} \text{ since} \sum_h ty_h \neq 1$$

where Ith_h is the income tax paid by household h, ty_h is the income tax rate and Yh_h is the total income of household h, *Tith* is the total income tax by all households and *Tyhh* the aggregate household income. We have the same type of relations with the savings and transfers as these rates are calculated on the specific household savings and transfers at the base years and these will never sum to one in either cases. We can see that whenever the share is calculated on the household component (expenditure element) this will not offer conditions for perfect aggregation. This case may be encountered when the share is calculated over the total value of the element itself as we saw for the dividends. The three elements contribute to the fact that the aggregate household does not provide perfect aggregation for the feedback effects. The relative importance of these elements in the total expenditure of household will determine the degree of differentiation between the micro results and the macro results.

[8] The calibration is done on the scaling parameter to maintain the perfect aggregation conditions. In another version of this approach we have used the AIDS to model household consumption but in this paper we do not present these results as problems arise to use it with the same labour market assumptions.

It should be noted that theoretically the LES demand system aggregates perfectly when the γ (non-discretionary consumption) and the β (budget share of discretionary expenditure) are the same for all households. However, if income elasticities and Frisch parameters are to calibrate the γ and β for each representative household, we don't have the conditions to respect perfect aggregation[9].

The sequential (CGE-HH) model

In the paper we combine the use of two types of models. The first one is relatively similar to the standard CGE model presented in chapter 9 of Decaluwé et al (2001). The household model introduces the consumption behaviours through a linear expenditure system (LES), the income structure of the household and finally the features of the labour market that provides the theoretical and empirical basis for the modeling of the labour market of the CGE model.

The household model (HH model).

As was stated previously, the household model comprises of a representation of the income structure and expenditure behaviour of the household. The household consumption is modeled by an LES demand system with all households having the same set of parameters (income elasticities of each good and the Frisch parameter)[10]. As for the savings and income tax behaviours, we assumed them to be fixed shares of income of each household. These hypotheses are very important as we saw in the previous section as they contribute to the non-aggregation of results. They will make a significant contribution to the differential results in the two models in the first run of the policy simulations. All transfers received and given to and from other agents are exogenous.

[9] We also could have chosen to use the same gamma and beta parameters for the household and that way, the Frisch parameter and income elasticity could have been calibrated. In this case however, since these parameters don't appear explicitly in the model, this calibration is not necessary.
[10] In this version of the paper we indirectly drew the LES parameters from Pollak and Wales (1969), given the fact that the aggregation level in our model does not correspond to the classification of this study. Agricultural goods all have the same parameters.

On the income side, we consider the capital endowment as being fixed to the level found in the FIES. In the household survey, we have information on the sector of activity of the head of household and the amount of non-wage income. This allows for a mapping of the branch of origin for each household capital income. From the household survey we classified the workers into qualified, unqualified work and unemployed, according to the category of work specified in the survey[11]. In terms of labour market behaviour, we assumed that it functioned as a rationed segmented labour market first proposed by Roy (1951) and further developed by Magnac (1991) and used in a micro-simulation context by Cogneau (2001). The sub-model will take into account the choice of workers to work in the qualified sector, the informal non-qualified sector or to be unemployed. We retain the non-competitive model proposed by Magnac (1991). The segmentation is obtained with a fixed wage and a cost of entry into the qualified sector that discourages the workers with potential wages below the qualified wage plus the cost of entry to participate in the labour market segment. . The key decision element in the model is the potential wage since this is what the workers use to make their labour choices. The product of a set of observable and non-observable characteristics determines the potential wage of workers:

$$\ln w^* = \ln \pi_i + \ln \tau_i \quad \text{where} \ln \tau = H\gamma + u$$

we have w^* as the potential wage, π as the qualification of the worker for the sector and H , as his home productivity and taste shifters and u as the non-observable fixed effect. We can synthesize the model with the following structure:

$$\begin{array}{ll} \text{choses sector 1 if :} & w^1 > w^2 - c, and..w^1 > w^* - c \\ \text{choses sector 2 if :} & w^2 > w^1, and..w^2 > w^* \\ \text{choses to be unemployed if :} & w^* > w^1, and..w^* > w^2 \end{array}$$

where w^1 is the qualified wage, w^2 the unqualified wage, w^* the potential wage and c the implicit cost of entering in the qualified sector. This model is estimated with a two steps method: the Tobit method followed by OLS estimation. This allows us to

[11] The information on the type of work performed by the head of household is very precise. For then 200 types of work categories are found. It is therefore relatively easy to classify the workers as qualified or unqualified from this information.

estimate parameters that will then be used to compute the potential wage[12]. Results from this estimation are provided in the annexe 3 and they are used to construct a ranking of workers for each of the two sectors (labour markets). We construct a queue of workers that offer their labour in the qualified labour market. At base year, we will have workers in the unqualified sector as well as unemployed. It is also important to build this queue around the frontier of w^1 as changes in the aggregate labour demand generated by the CGE model can be positive or negative. Therefore, it is important to capture marginal changes in both directions. The least qualified worker (according to their characteristics) will be at the bottom on the qualified workers queue and will be the first unemployed. A similar ranking is done for the informal labour market. We queue unqualified sector workers above the market wage w^2 and the unemployed with potential wages just bellow w^2. Once this exercise is done, we have a labour supply for both labour markets. Changes in the aggregate labour demand in the CGE model will determine the variation of frontier between the participants of the market segment and the non-participants (but seeking a job in the given market). We will therefore have a switching system were a worker can find himself on one market at base year and on the other after simulation. The changes in regime will appear with the reception of wages in the sector of activity or no wage in the case of unemployment. This will clearly generate very important income changes in concerned household (either positively or negatively). This situation is not possible in a standard CGE model and this type of effect can be very important for poverty analysis and income distribution as a household loosing 100% or 80% of its income (in case of a job loss) will not react the same way as a household that see its income reduced by 3% (types of results we usually get in a standard CGE model).

The CGE model

The CGE model used draws from chapter 9 of Decaluwé et al. (2001) which is characterized by the small open economy price taking hypothesis with import demand modeled with the Armington (1969) hypothesis. The main changes introduced in the

[12] The method used for estimation differs from Magnac (1991) and Cogneau (2001) as they supposed dependence of choice for qualified and unqualified sector as we supposed independence of choices. Matlab was used for the estimation of the model and a random sample of 13000 potential workers was taken from the total sample of 39520. Using the whole sample posed computational problems. For more information on this labour modeling approach, see from Magnac (1991) and Cogneau (2001).

model are the demand system which is represented by a LES function and the presence of a rationed dual segmented labour market with unemployment. We won't present the details of the model as it uses standard features of a CGE model and the reader can refer to Decaluwé et al. (2001) for more information. We will emphasize the presentation on the labour market, as this is what distinguishes it from other models[13]. The choice of the hypothesis for the CGE model was based on the objective of replicating the micro household behaviour. In some aspects, we reflect specific behaviours explicitly in the CGE model and in other cases it is necessary to introduce functions that will mimic characteristics of the household model. We will only describe the labour market change as other aspects are straightforward.

The first element to modify in the model is the decomposition of labour into two types of labour: the qualified and unqualified. We suppose that the production branches will use a combination of both types of workers and the optimal demand for each types of labour will be determined by a CES function. We also introduce unemployment in the model, with the qualified labour market having a rigid nominal wage and the unqualified labour market with a flexible nominal wage. As we saw in the HH model, there is a queue of workers willing to work in the qualified sector. In the CGE model, changes in labour demand will be satisfied by workers coming from either the unqualified or from the unemployed pool of workers. Inversely, if the qualified labour demand decreases, the workers will be pushed towards either the unqualified market or unemployment. It is important to note that the changes in the labour demand of the formal sector are driven by the changes in the real wages of each production sector. We noted that the nominal wage was fixed but not the real wage (w^1/P_i) where P_i is the producer price of good *i*. Moreover, external policy simulation can be performed on the fixed nominal wage.

In terms of modeling, we present the sequential logic used to model this behaviour (even if the model is solved simultaneously). First, following the policy simulation we will observe a change in aggregate labour demand. This change in qualified labour demand is computed with the difference in the post simulation labour demand compared to the base year figure:

---

[13] Note that a similar type of dual segmented labour market with unemployment was modeled in Fortin, Marceau and Savard (1997) and Savard and Adjovi (1998)

$$Lsqc = \sum_i Ldq_i - \sum_i Ldqo_i$$

where *Lsqc* is the change in labour demand in the formal sector, *Ldqo* and *Ldq* are respectively the sectorial labour demand at base year and after simulation. *Lsqc* is then decomposed into the proportion of workers coming from unemployment:

$$Uq = \delta.Lsqc$$

where *Uq* is the new qualified sector workers drawn from unemployment and δ is the share of new qualified workers coming from unemployment[14]. The remainder of new workers for the qualified sector are drawn from the unqualified sector

$$Lnqt = Lsqc - Uq$$

where *Lnqt* is the new qualified sector workers coming from the informal sector.

In the unqualified sector, the nominal wage varies to clear out the market and producer prices vary to balance goods market. The real wage change will induce a labour demand change and the nominal wage change a change in labour supply. As we mentioned in the HH model, when the nominal wage of the informal sector $w^2 < w^*$ then the reservation wage, the workers will prefer to become unemployed or do productive house work that will provide greater utility. We mimic this behaviour of the supply of labour out of (into) unemployment with the following relationship:

$$Unq = Uto\left[1 - \left(wo^2 / w^2\right)^{\xi}\right]$$

where *Unq* is the unemployed offering the labour in the informal sector, *Uto*, the total unemployed at base year, wo^2, the qualified sector wage at base year and finally, ξ is the elasticity of supply[15].

The total labour supply of the informal sector is determine by the following relation:

$$Lsnq = Lsnqo + Unq - Lnqt$$

[14] It is important to note that for calibration of this share, we perform numerical simulation to compute the share generated by the HH model labour supply. The share parameter of the CGE model is then drawn from this labour supply model.
[15] We use the same procedure to calibrate this parameter as the delta for the formal sector, and we calculate the elasticity from the HH model by simulating a 1% increase in the sector 2 wage.

where *Lsnq* is the total labour supply for the unqualified sector, *Lsnqo* is the total labour supply of the sector at base year, and the two other variables were defined earlier. Finally the unemployment rate is a straightforward ratio of unemployed over total labour force:

$$u = \frac{Ut}{Lsnq + Lsq + Ut}$$

It is important to highlight the macro-closure of the model to understand the results presented below. First, we fix the current account balance *(CAB)* and let the nominal exchange rate equilibrate this constraint. The total investment is fixed and government savings serve to clear this equation. We also use the models result (goods price vector) to compute an endogenous poverty line. In order to construct the poverty line, we identify the basic needs of households and associate specific volume for the goods basket. The price vector multiplies this goods vector pre and post simulation to compute the endogenous poverty line[16].

Sequencing the CGE and HH models (linking).

The main difficulty in this type of exercise is related to aggregation and coherence between the two models. As we stated in the introduction, the value added of this approach comes from the fact that feedback effects provided by the household model do not correspond to the aggregate behaviours of the representative households used in the CGE model. It is interesting to take these feedback effects of the HH model back in the CGE to insure coherence between the two models.

In the household model, our main objective is to obtain an aggregate goods consumption vector produced by the household model and to introduce the feedback effect into the CGE model on an aggregate level. The procedure is relatively simple as we integrate all households of the FIES of the Philippines in the household model and introduce price vector from the CGE into the HH model. This allows us to obtain a consumption matrix of 20 goods by 39520 households and aggregate over all the households, which produces a single vector for consumption as an output of the HH

[16] For more information of this approach to compute an endogenous poverty line see Decaluwé et al. (1999a).

model. The aggregate consumption vector obtained from the HH model is then imported into the CGE model. When doing this, we absolutely need to change the hypothesis of the model to allow it to be fully determined. Since we now have the consumption vector as exogenous, we will remove the equations determining consumption in the first run of the CGE model. Given this change, we need to insure the balance of the household budget constraint. A variable of this budget constraint needs to be endogenized in the following equation:

$$Thc = Ydh - Sh - Tgh$$

where *Thc* is the total household consumption. This variable is directly determined by the price vector of goods and the consumption levels obtained from the HH model. The household disposable income *(Ydh)* and household savings *(Sh)* are explicitly determined by a fixed proportion of the household's income. The transfers between the government and the household (*Tgh)* are exogenous. Two options are available to balance out the aggregate household budget constraint. First, *Tgh* could be endogenized or the savings rates could become endogenous. *Sg* is determined by $Sh = \varphi Yh$ and as this relation needs to be respected. Endogenizing the marginal propensity to save (savings rate) φ will allow respecting the savings relation and balance out the equation for *Thc*. The rest of the model's hypotheses are left unchanged[17]. As will be seen in the simulation, results of variation of this adjustment variable has shown to be relatively small[18]. Mis en forme

Running the full model involves the following procedure. We first compute the standard CGE simulation and sequentially run the household model. The solution of the HH model (consumption vector) is transformed into a data file that is used in the looping version of the combined model. In the second run (or looping version of the CGE model), as we stated, we need to change the hypothesis of the CGE model as the household consumption vector is now determined by the HH model. We remove the equation and transform the consumption vector into an exogenous vector. In the

[17] We experimented on both, and the results were not strongly affected by the choice of either of the two variables. But as the *Tgh* at base year was null it is difficult to interpret the variation from a 0 point. For the savings rate, it is easier to evaluate if the variation is marginal or not.
[18] In all the experiments performed, the variation was always less then 10% This is in the case of an initial savings rate of 11,34% with an 8.07% increase in the savings rate which brings the savings rate to 12,26% This is less then a 1% point in increase.

looping version, we run up to 12 loops automatically between the two models. In both scenarios presented, convergence at 5 decimals is obtained around the 6th loop. We should note that convergence is verified on the household consumption vector[19].

A sequential CGE-HH model application.

An application of this approach was done on the Philippines data. The models were constructed using the 1997 Family Income and Expenditure Survey (FIES) The Labour Force Survey for 1997 to 1998 and the 1990 SAM. The FIES and LFS were used extensively in the HH model and to estimate the labour supply, and the FIES and SAM were used in the CGE model. The main data manipulation needed was the conversion of the FIES nomenclature into the national accounts nomenclature found in the SAM. This was relatively easy and straightforward as the level of aggregation was quite high. The other data operation consisted in modifying household income and expenditure vectors of the SAM to have a perfect correspondence with the aggregate structures computed from the FIES data. In this process, we created disequilibrium in the SAM that required standard SAM balancing procedure[20]. As was stated earlier, it was not necessary to have a perfect balance between the income and expenditure accounts for each household. This spares for the need to introduce balancing hypothesis, which often lead to denaturing the household's income or expenditure structures, as we do not need to import nominal levels from the FIES into the SAM, but only its structures.

Policy simulations

We performed two types of policy simulation to illustrate the mechanics of the approach as well as the types of results that can be produced. First we simulate a 50% reduction in import tariffs across the board and second we increase the qualified sector wage by 20%. We display succinct macro-economic results by concentrating

[19] We tested a number of other policy simulation and the speed of convergence seems to be quite similar from one to the other. We maintained a higher number of loops to get convergence at 7 decimals for all goods.
[20] We did not use an automated procedure to balance out the SAM as these methods can sometimes modify structures with considering economic behaviour. We maintained all household accounts fixed, and balanced the SAM in the relatively large accounts in order to minimize the change in structure and not the changes in errors (as do automated procedures).

on factor payments as these are the key variables in terms of poverty and income distribution analysis. In Table 1, we present macro results and in Table 2 we show a few results by production branches. Finally, we present poverty analysis results as well as income distribution measures.

Simulation 1: Reduction across the board of import tariffs by 50%.

Let us first observe a few macro effects and then some sector-based effects, which help in the understanding of the macro changes. The first order effect of this policy is to reduce the price of imports and therefore increase the domestic demand for them. Given the fixed current account balance (*CAB*) we observe a pressure upwards on the nominal exchange rate (0,57%) to reduce imports and increase exports to balance out the *CAB*. The government income *(Yg)* is strongly reduced (-14,42%) given the importance of import tariffs as a source of income for government, moreover, as we fixed the total investment, government savings must balance out the saving investment constraint and therefore the policy generates an important reduction in public expenditure. This policy puts pressure on the labour market as civil servants are laid off due to the reduction in government spending. This effect is transmitted through unemployment (*Ui*), which rises by 2,15% and produces a negative effect on the informal wage, which drops by -2,54. In this first scenario, we observe a strong decrease in the poverty threshold (-2,84) resulting in market price decrease of goods composing the basic needs basket of the poverty threshold. This price decrease was the result of the decrease in prices of imports provoking a reduction in market price of aggregate goods (which include imported goods). This drop in import price is a direct result of the reduction in import duties.

In terms of capital payment, we note that owners of the *mining*, *logging-timber* and *livestock* capital are the beneficiaries from the policies whereas owners of the *finance*, *electricity-gas-water* and *other agriculture* capital are the main losers of this policy. The value added of production branches increases the most in the *construction*, *mining and finance* and the only branches to see a reduction in their outputs are *electricity-gas and water.*

Table 1: Macro results of CGE model after convergence

Variables	Base	Simulation 1 50% decrease in import tariffs	Simulation 2 20% increase in w-q
Yh	86,48	-0,79	-0,93
Yg	20,37	-14,42	-1,22
G	16,82	-1,81	0,71
Ye	26,17	0,97	-1,57
Sg	-1,16	-0,10	0,32
Sm	9,65	-0,03	0,06
Ui	0,17	2,15	7,30
w^1	1,00	0,00	20,00
w^2	0,50	-2,54	-9,08
e	1,00	0,57	0,08
mps	11,34	6,04	8,07
GDP	104,51	-1,00	-1,58
Poverty threshold	6080,00	-2,84	-2,04

Simulation 2: An increase of 20% in the qualified sector fixed wage.

In this situation we noticed, as expected, an important drop of the unqualified sector wage as the qualified labour demand decreases strongly with the policy increase of the nominal wage. Many workers will chose to supply their labour in the unqualified sector market, producing a drop of 9.08% in the nominal unqualified wage *(w^2)*. Others will prefer to become unemployed, which will lead to an increase of 7,30% in the unemployment rate *(U_i)*. The increase in unemployment comes from the latter source but also from informal sector workers no longer willing to work at the reduced nominal wage level. The effect on the government side is a lot less drastic with a reduction of income of 1,22% and an increase of 0,32% of government saving. In this policy simulation, there is also a pressure for a decrease in prices, which generates a reduction in the poverty threshold of 2.04%.

Table 2: Sectorial results of the CGE-HH model after convergence

Variables	branches	Base	Simulation 1 - 50% on import tariffs	Simulation 2 20% increase in w-q
Va	Paley & corn	5,20	0,62	-0,28
Va	Fruit & vegetable	4,21	0,76	0,39
Va	Coconut	1,79	1,05	-0,51
Va	Livestock	4,47	1,12	-0,07
Va	Fishing	4,00	0,91	0,36
Va	Other agric.	1,85	0,66	1,87
Va	Logging and timber	0,86	1,42	-0,11
Va	Mining	1,60	3,00	-1,05
Va	Manufacturing	13,11	1,46	-2,53
Va	Rice manufacturing	2,02	0,86	-0,47
Va	Meat industry	2,08	1,33	-0,70
Va	Food manufacturing	3,70	0,52	0,86
Va	Elec. Gas Water	2,34	-0,70	-2,05
Va	Construction	6,85	2,61	1,00
Va	Commerce	15,15	1,26	-1,56
Va	Trans. & comm.	5,21	0,93	-0,75
Va	Finance	3,58	-1,15	-2,88
Va	Real estate	7,31	0,77	-3,37
Va	Services	6,96	0,97	-0,58
r	Paley & corn	1,00	1,82	-10,06
r	Fruit & vegetable	1,00	2,39	-5,46
r	Coconut	1,00	0,12	-9,49
r	Livestock	1,00	2,80	-6,61
r	Fishing	1,00	2,38	-6,55
r	Other agric.	1,00	-0,88	-4,10
r	Logging and timber	1,00	3,82	-9,00
r	Mining	1,00	5,03	-3,13
r	Manufacturing	1,00	1,69	-0,06
r	Rice manufacturing	1,00	0,91	-6,53
r	Meat industry	1,00	1,97	-7,18
r	Food manufacturing	1,00	-0,46	-2,40
r	Elec. Gas Water	1,00	-3,13	4,23
r	Construction	1,00	1,93	-4,34
r	Commerce	1,00	1,49	1,89
r	Trans. & comm.	1,00	-0,26	-7,55
r	Finance	1,00	-3,92	1,67
r	Real estate	1,00	1,84	9,94
r	Services	1,00	0,03	-0,57

The capital payments are also pushed downwards with the biggest decrease in the *paley & corn*, *coconut* and *logging-timbe*r sectors. We observe an increase in four branches, namely real-estate, electricity, gas and water, commerce and finance. The output or value added increases the most in *other agriculture*, *construction* and *fruits-*

vegetables branches and the decrease is the strongest in *real-estate*, *finance* and *manufacturing* sectors.

Poverty and income distribution analysis

The main objective of this section is to illustrate the type of poverty and income distribution analysis that can be performed with the output of the convergent solution of the HH model. The indicators presented are far from being exhaustive as it is possible to apply all types of measure and methodology given the fact that the model produces a post simulation income vector for all households (39520) found in the survey. We only apply the Foster, Greer and Thorbecke (1984) (FGT_α) decomposable indices as well as the GINI index. We present results for two types of household groupings. This is done to demonstrate that the approach avoids the difficult choice of household classification raised by Di Maio et al. (1999). This is possible as the classification is not a part of either the CGE model or HH model. The analyst, after computation of models results, is free to choose the decomposition for poverty analysis. The only limit to household classification/aggregation is bound by information found in the household survey itself.

Poverty Analysis

We note that this policy has a significant positive impact on poverty reduction, which is strongly linked to the change in the poverty threshold that decreases by 2,84%. By combining income effect and threshold effect[21] we get a decrease in poverty for all educational groups. If we isolate and look exclusively at the income effect we get an increase in FGT_0 in all groups, except group 0[22]. We have a similar situation when looking at poverty by regional desegregation as the threshold effect pushes all indices

[21] Income effect is the change in the head count ration computed by maintaining the poverty threshold fixed. We simply use the changes in income of each household. The threshold effect is the contribution of the change in the endogenous poverty threshold calculated by the model and reflects the changes in the cost of basic needs basket as the income effects represent the change in income of households.

[22] Description of coding for education level of head of household and regional classification is provided in annexe 4.

to decrease with the exception of group 2. However, when we isolate income effect we have a decrease in only three of the regional groups (9, 12 15)[23].

Table 3: FGT poverty indices of P_0 for two types of household aggregation

	Code	Base	Sim1	Variation %	sim2	Variation %
Country		31,093	30,010	-3,483	32,071	3,144
Level of education of head of household	0	53,515	50,701	-5,258	54,716	2,243
	1	48,879	46,851	-4,148	51,517	5,397
	2	39,243	38,341	-2,297	40,865	4,133
	3	33,953	32,713	-3,652	35,608	4,875
	4	21,433	20,770	-3,094	22,556	5,239
	5	12,091	11,522	-4,706	12,153	0,519
	6	2,718	2,604	-4,205	2,386	-12,226
Regions	1	34,093	32,034	-6,039	34,882	2,313
	2	30,198	30,201	0,009	32,690	8,250
	3	14,938	14,505	-2,894	15,884	6,332
	4	24,456	23,950	-2,072	24,864	1,668
	5	46,432	44,744	-3,635	48,750	4,993
	6	35,047	32,432	-7,461	35,587	1,541
	7	30,060	28,869	-3,963	32,611	8,487
	8	38,271	37,046	-3,201	39,357	2,837
	9	32,616	31,823	-2,434	32,938	0,985
	10	41,784	40,820	-2,305	41,825	0,098
	11	34,272	33,518	-2,200	37,022	8,025
	12	45,390	44,403	-2,175	45,462	0,159
	13	6,223	6,026	-3,168	6,237	0,221
	14	38,011	39,297	3,384	38,092	0,212
	15	58,198	55,933	-3,893	58,009	-0,325
	16	49,020	47,509	-3,081	51,721	5,511

Simulation 2 produces somewhat different results. In this case we see the headcount ratio decrease for the most educated and a slight increase for group 5 who are also relatively highly educated. What is interesting with these results is that the poverty threshold softens the effect on all groups except the most educated who see the positive poverty reduction income effect amplified. In the case of regional

[23] We provide results of isolated income effect on poverty in annexe 3. Maintaining the poverty threshold exogenous does this.

decomposition we observe a reduction of the headcount ratio only in region 15. We also note that the regions 2, 7 and 11 all see the poverty levels increase by more then 8%. When we isolate the threshold effect, we get a negative impact on all regions.

In annexe we present results for FGT_1 and FGT_2 but we won't describe the results in detail. We will simply highlight the fact that these indicators generally follow the trend of the headcount ratio but the magnitude of the effects is often modified according to the decomposition and simulations performed.

Income distribution

We applied GINI index for the whole population and also for education attainment of head of household decomposition. We can see that the first simulation increases inequality for the whole population as well as for all groups. For the second simulation, we have a stronger increase in inequality for all groups with the exception of group 6 (most educated) who see their GINI index or inequality decrease slightly following the policy simulation.

Table 3: Income distribution measure: GINI index on education level

Education category	Base	Sim1	Sim2
Total	52,77	52,91	53,28
0	55,62	55,63	56,17
1	53,41	53,56	53,95
2	53,14	53,35	53,74
3	52,49	52,67	53,18
4	49,80	49,93	50,42
5	51,65	51,74	51,94
6	53,40	53,48	53,16

Conclusion

In this paper, we demonstrate why it is important to take into account the feedback effects of household behaviours generated by a HH model back into a CGE model as we have a number of elements preventing perfect aggregation of micro-economic behaviours. We also discussed some of the advantages tied to working in a separate context for household modelling instead of using the CGE-IMH approach. We illustrated the mechanics of the sequential CGE-HH modelling approach by constructing a relatively standard CGE and by incorporating labour market behaviours modelled in a household model. We also constructed a household model with income and expenditure structures of the household survey and integrated labour market behaviour inspired by the modelling proposed by Magnac (1991). We then proceeded to explain the links between these two models to insure global coherence and to obtain a converging solution, which was consequently obtained after less then 7 loops between the two models.

We think that this approach provides richer information then the standard CGE-RH approach, more flexibility (larger number of households and use of more flexible functional forms) then the CGE-IMH approach, and more global coherence then the unidirectional CGE-MS approach. One of the drawbacks is that the approach is not as tractable as the first two approaches. The other difficulty is the creativity needed to find appropriate functional forms that will mimic micro-economic behaviours of the HH model. However, the numerical method to generate the necessary parameters provides an interesting alternative to selecting ad hoc parameters as is frequently done in CGE modelling. We also show that removing representative household in the model allows taking into account intra-group distributional issues and that poverty and income distribution can be performed freely on any groupings available from the household surveys.

Bibliography

Adelman, I. and S. Robinson (1979), «*Income Distribution Policy: A Computable General Equilibrium Model of South Korea*», in Adelman, I, The selected essays of Irma Adelman. Volume 1. Dynamics and income distribution. Economists of the Twentieth Century Series. Aldershot, U.K., pp. 256-89.

Agénor, P. R., A. Izquierdo and H. Fofack (2001), « *IMMPA: A Quantitative Macroeconomic Framework for the Analysis of Poverty Reduction Strategies* », World Bank.

Armington, P.S. (1969), « *A Theory of Demand for Products Distinguished by Place of Production* », IMF Staff Paper n° 16, pp. 159-176.

Atalas, V. and F. Bourguignon (2001), "The evolution of the distribution of income during Indonesian fast growth: 1980-1996". Mimeo. Princeton University.

Bonnet, C, and R. Mahieu (2000), «Public pensions in a dynamic microanalytic framework : the case of France », in Mitton, L., H. Sutherland and M. Weeks**,** «Microsimulation Modelling for Policy Analysis: Challenges and Innovations, Cambridge University Press, Cambridge.

Boccanfuso, D., F. Cissé, A. Diagne and L. Savard (2003), « Un modèle CGE-Multi-Ménages Intégrés Appliqué à l'Économie Sénégalaise » miméo, CREA, Dakar.

Bourguignon, F., F. Ferreira, and N. Lustig (1998), « The microeconomics of income distribution dynamics…

Bourguignon F., M. Fournier, and M. Gurgand (2001), "Fast Development with a Stable Income Distribution: Taiwan, 1979-1994." *Review of Income and Wealth*, 47(2), 139-163.

Bourguignon, F., J. de Melo, and A. Suwa, (1991), « *Modelling the effects of adjustment programs on income distribution* », World Development, Vol. 19. no 11. pp. 1527-1544.

Bourguignon, F., A.-S Robillard and S. Robinson (2002) Representative versus real households in the macro-economic modeling of inequality, mimeo, World Bank.

Chia, N. -C., S. Wahba and J. Whalley (1994), « *Poverty-Reduction Targeting Programs: a General Equilibrium Approach* », Journal of African Economies, 3(2), pp. 309-338.

Cockburn, J. (2001), « *Trade liberalization and Poverty in Nepal: A Computable General Equilibrium Micro-simulation Analysis* », Working paper 01-18. CREFA, Université Laval.

Cogneau D. and A.-S Robillard. (2000), « *Income Distribution, Poverty and Growth in Madagascar: Micro simulations in a General Equilibrium Framework* », IFPRI TMD Discussion Paper No.61.

Cogneau D. (2001) «Formation du revenu, segmentation et discrimination sur le marché du travail d'une ville en développement : Antananarivo fin de siècle » Document de travail DT/2001/18 Dial, Paris.

Colatei, D, and J. I, Round, (2001) « *Poverty and Policy: Some experiments with a SAM-Based CGE Model for Ghana*» Mimeo, Warwick University.

Decaluwé, B., A. Patry, L. Savard and E. Thorbecke (1999a), « *Poverty Analysis Within a General Equilibrium Framework* » Working Paper 99-09, African Economic Research Consortium.

Decaluwé, B., J.C. Dumont and L. Savard (1999b), « *How to Measure Poverty and Inequality in General Equilibrium Framework* », Laval University, CREFA Working Paper #9920.

Decaluwé, B., A. Martens and L. Savard (2001), *La politique Économiques du Développement*, Université Francophone-Presse de l'Université de Montréal, Montréal. pp. 1-509.

de Janvry, A., E. Sadoulet and A. Fargeix (1991), « *Adjustment and Equity in Ecuador* » OECD Development Center, Paris.

de Janvry, A. and E. Sadoulet (1995), « *Quantitative Development Policy Analysis* », The Johns Hopkins University Press, Baltimore and London.

De Maio, L., F. Stewart and S. van der Hoeven (1999) *« Computable General Equilibrium Models, Adjustment and the Poor in Africa»*, World Development, 27(3) 453-470.

Dervis, K, J. de Melo and S. Robinson (1982), « *General Equilibrium Models for Development Policy* », Cambridge University Press, London, pp. 1-526.

Duclos J.Y., A. Arrar and C. Fortin (1999), « *DAD 4.02: Distributional analysis/Analyse distributive* », MIMAP Project, International Development Research centre, Government of Canada.

Fortin, B., N. Marceau and L. Savard (1997), "*Taxation, wage controls and the informal sector"*, Journal of Public Economics, 66, pp. 293-312.

Foster, J., J. Greer and E. Thorbecke (1984), « *A Class of Decomposable Poverty Measures* », Econometrica, 52(3), pp. 761-766.

Gunning, W.J. (1983), « *Income Distribution and Growth: A Simulation Model for Kenya* », in D.G. Greene (principal author), Kenya: Growth and Structural Change, 2 vols., Washington, DC: World Bank, pp. 487-621.

Harrison, G.W., T. Rutherford, D. Tarr, A. Gurgel, (2002), *«Regional, Multilateral and Unilateral Trade Policies of MERCOSUR for Growth and Poverty Reduction in Brazil»* mimeo.

Lofgren, H., O. Chulu, O. Sichinga, F. Simtowe, H. Tchale, R. Tseka, and P. Wobst (2001) *«External Shocks And Domestic Poverty Alleviation: Simulations With A CGE Model Of Malawi».* TMD Discussion Paper No. 71 IFPRI.

Magnac, T. (1991) « *Segmented of Competitive Labour Markets* » Econometrica, Vol 59, no 1, pp 165-187.

Mitton, L., H. Sutherland and M. Weeks (2000*),* *«Microsimulation Modelling for Policy Analysis: Challenges and Innovations, »* Cambridge University Press, Cambridge.

Morrisson, C. (1991), « *Adjustment incomes and Poverty in Morocco* ». World Development, Vol. 19. no 11. pp.

Orcutt, G., M. Greenberg, J., Korbel, and A. Rivlin (1961) *«Microanalysis of Socioeconomic Systems: A Simulation Study»* New York: Harper and Row.

Pollak, R.A, and Wales, T.J. (1969) *«Estimation of Linear Expenditure System»* Econometrica 37(4) pp. 611-628.

Roy, A.D, (1951) « *Some Thoughts on the Distribution of Earnings* » Oxford Economic Papers, Vol 3, no 2 pp 135-146.

Robilliard AS. and Robinson S., (1999), «*Reconciling Household Surveys and National Accounts Data Using a Cross Entropy Estimation Method* », IFPRI-TMD Discussion Paper, #50.

Sadoulet, E., A. de Janvry, M. Fafchamps and Raki (1992), «Structural Adjustment and the Peasantry in Morocco: A Computable Household Model» European Review of Agricultural Economics, 19(4): 427-453.

Sahn, D., P. Dorosh and S. Younger (1996) «Exchange Rate, Fiscal and Agricultural Policies in Africa: Does Adjustment Hurt the Poor? » World Development 26(4),

Sahn, D., P. Dorosh and S. Younger (1999) A reply to de Maio, Steward and van der Hoeven, World Development. 27(3) pp 471-475.

Savard, L. and E. Adjovi, (1998) «Externalités de la santé et de l'éducation et bien-être : Un MEGC appliqué au Bénin », L'Actualité Économique, Vol 74, #3 septembre, pp. 523-560.

Thorbecke, E. (1991), « *Adjustment growth and income distribution in Indonesia. and Equity in Indonesia* », World Development, Vol. 19. no 11. pp. 1595-1614.

Annexe 1 : Calculation of FGT_1 and FGT_2

		FGT P1 Index (depth of poverty)					FGT P2 Index (severity of poverty)				
		Base	Sim1	Variation %	sim2	Variation %	Base	Sim1	Variation %	sim2	Variation %
Country		9,83	9,46	-3,80	10,55	7,33	0,97	0,90	-7,15	0,94	-3,17
Education level of head of household	0	18,24	17,14	-6,03	19,58	7,33	3,33	3,10	-6,81	3,61	8,29
	1	16,76	16,00	-4,52	18,13	8,15	2,81	2,62	-6,72	3,10	10,46
	2	12,32	12,02	-2,47	13,31	8,03	1,52	1,41	-7,30	1,68	10,27
	3	10,31	10,01	-2,93	11,30	9,65	1,06	0,98	-7,27	1,18	11,77
	4	5,99	5,76	-3,88	6,66	11,25	0,36	0,33	-7,32	0,42	17,96
	5	2,93	2,75	-6,10	3,13	6,79	0,09	0,08	-7,84	0,10	14,02
	6	0,69	0,67	-3,31	0,61	-11,22	0,01	0,01	-7,05	0,01	-8,52
Regions	1	10,60	10,04	-5,32	11,40	7,50	1,12	1,03	-7,74	1,24	10,54
	2	8,28	7,79	-5,86	9,06	9,45	0,69	0,62	-10,56	0,79	15,05
	3	3,56	3,49	-2,02	3,91	9,73	0,13	0,12	-7,71	0,15	14,32
	4	7,24	6,96	-3,91	7,75	7,05	0,52	0,49	-6,46	0,57	10,12
	5	14,92	14,23	-4,61	15,96	6,96	2,23	2,07	-7,13	2,45	9,70
	6	10,68	10,11	-5,35	11,52	7,90	1,14	1,06	-7,08	1,26	10,36
	7	9,83	9,49	-3,43	10,66	8,44	0,97	0,90	-7,62	1,08	10,90
	8	12,39	12,05	-2,77	13,03	5,17	1,54	1,44	-6,41	1,65	6,93
	9	10,35	9,73	-5,96	11,04	6,64	1,07	1,00	-7,00	1,17	9,07
	10	4,02	3,98	-0,95	4,43	10,27	1,96	1,76	-10,09	2,38	21,53
	11	11,20	10,99	-1,84	12,32	9,96	1,25	1,15	-8,24	1,44	14,90
	12	17,05	16,21	-4,90	17,88	4,85	2,91	2,72	-6,45	3,10	6,38
	13	1,19	1,16	-2,15	1,27	6,88	0,01	0,01	-6,98	0,01	13,15
	14	14,23	13,92	-2,17	14,19	-0,31	2,02	1,79	-11,41	1,98	-2,20
	15	17,27	16,77	-2,92	17,65	2,19	2,98	2,50	-15,98	3,40	13,93
	16	18,04	17,07	-5,35	19,20	6,44	3,25	3,01	-7,50	3,50	7,83

Annexe 2: FGT_0 headcount index with poverty threshold exogenous.

	Code	Base	Sim1	Variation %	sim2	Variation %
Country		31,093	31,597	1,621	33,530	7,836
Level of education of head of household	0	53,515	53,497	-0,034	57,599	7,631
	1	48,879	49,323	0,909	54,377	11,249
	2	39,243	40,234	2,526	42,479	8,247
	3	33,953	34,588	1,872	36,900	8,681
	4	21,433	21,740	1,429	23,504	9,663
	5	12,091	12,153	0,511	12,832	6,128
	6	2,718	2,788	2,579	2,482	-8,680
Regions	1	34,093	34,638	1,599	37,160	8,996
	2	30,198	31,553	4,486	34,643	14,719
	3	14,938	15,614	4,525	16,546	10,770
	4	24,456	24,785	1,345	25,911	5,947
	5	46,432	46,749	0,683	50,232	8,185
	6	35,047	35,059	0,035	37,261	6,319
	7	30,060	30,364	1,012	34,445	14,586
	8	38,271	39,189	2,398	41,320	7,967
	9	32,616	32,625	0,027	34,501	5,779
	10	41,784	42,289	1,209	45,429	8,724
	11	34,272	35,806	4,477	38,282	11,701
	12	45,390	45,230	-0,353	47,039	3,632
	13	6,223	6,348	2,017	6,466	3,905
	14	38,011	39,297	3,384	40,827	7,408
	15	58,198	55,933	-3,893	63,648	9,364
	16	49,020	50,125	2,255	54,096	10,356

Annexe 3: Labour supply model estimation results

Probit				
Regressor	**Coefficient**	**Std. Error**	**t-stat**	**Prob>|t|**
constant	0.65757	0.19033	3.45488	0.00028
education	0.13534	0.00715	18.92428	0.00000
age	-0.04234	0.00910	-4.65417	0.00000
age2	0.00046	0.00010	4.44442	0.00000
size	0.06550	0.01048	6.24838	0.00000
sex	-0.05031	0.04109	-1.22433	0.11042
# workers	0.05341	0.00480	11.11954	0.00000
kids14	-0.04725	0.01218	-3.87871	0.00005

Heckman 2-Step Estimates of Selection Model Qualified				
Regressor	**coefficient**	**Std. Error**	**t-stat**	**prob>|t|**
constant	-90942.02861	18460.78990	-4.92623	0.00000
education	-6203.03829	1274.41965	-4.86734	0.00000
age	2398.37814	615.28815	3.89798	0.00005
age2	-25.84866	6.95627	-3.71588	0.00010
size	-3580.10333	847.90660	-4.22229	0.00001
sex	1596.73760	2239.53398	0.71298	0.23796
# workers	-2563.88083	528.70468	-4.84936	0.00000
kids14	2486.98244	815.45236	3.04982	0.00116

Heckman 2-Step Estimates of Selection Model Unqualified				
Regressor	**coefficient**	**Std. Error**	**t-stat**	**prob>|t|**
constant	-11574.40030	3206.09260	-3.61013	0.00015
education	-492.70108	249.23766	-1.97683	0.02405
age	238.22807	99.51362	2.39392	0.00835
age2	-2.47404	1.14271	-2.16505	0.01521
size	-171.63863	73.42372	-2.33765	0.00972
sex	475.31215	310.07945	1.53287	0.06267
# workers	-342.87460	113.30689	-3.02607	0.00124
kids14	-9333.21088	2331.48932	-4.00311	0.00003

Annex 4: Regional code definition

Region Code	Region Identification	Region Name
1	Region I	Ilocos Region
2	Region II	Cagayan Valley
3	Region III	Central Luzon Region
4	Region IV	Souther Luzon Region
5	Region V	Bicol Region
6	Region VI	Western Visayas Region
7	Region VII	Central Visayas Region
8	Region VIII	Eastern Visayas Region
9	Region IX	Western Mindanao Region
10	Region X	Northern Mindanao Region
11	Region XI	Southern Mindanao Region
12	Region XII	Central Mindanao Region
13	NCR	National Capital Region
14	CAR	Cordillera Administrative Region
15	ARMM	Autonomous Region of Muslim Mindanao
16	Caranga Region	Caranga Region

Annexe 5: Educational code definition

Education Code	Level of education
1	Elementary undergraduate
2	Elementary graduate
3	1st to 3rd Year High school
4	High School Graduate
5	College Undergraduate
6	At least College graduate
0	Not reported or no grade

Annexe 6: table of comparative advantages of the four approaches discussed

	Simplicity in application	Intra-group variation	Richness in behaviour	Macro coherence	# of house-holds used	Structural richness
CGE-RH	***	*	*	***	*	***
CGE-IMH	**	**	*	***	**	**
CGE-MS	*	***	***	*	***	***
CGE-HHS	**	***	**	**	***	***

*** High

** Medium

* Low