Poverty and Income Distribution in a CGE-Household Micro-Simulation Model: Top-Down/Bottom Up Approach[1]

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October 2003

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 disaggregation (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 a richer micro-household modeling than 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

[1] I would like to thank F. Bourguignon, D. Boccanfuso, J. Davies and R. Medhora for very helpful advice and comments and participants at the WIDER conference in Helsinki who provided valuable comments. The usual disclaimer applies.

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JEL Classification: I32, D31, C13, C68

Introduction

In recent years, we have witnessed a flourishing literature around the nexus of macro-modeling and poverty analysis. 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) et Morrisson (1991)[2]. The last impetus to this literature came near the end of the 90's with contribution by Decaluwé et al. (1999a) Decaluwé et al. (1999b), Cogneau and Robilliard (2000), Agenor et al. (2001), Cockburn (2001), Bourguignon, Robilliard 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 model 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

[2] 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.

integrated multi-households CGE analysis (CGE-IMH)[3]; and finally, the sequential micro-simulation approach, which uses a CGE model to generate prices that links into a micro-econometric household micro-simulation model (CGE-SMS).

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 (2001) 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[4]. 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 approach, is what we refer to as the CGE-IMH modeling. This approach consists of multiplying the number of representative households compared to the

[3] 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 (2001) 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.

[4] Standard CGE modeling uses household groupings that will take into account the total income and expenditure of each group and the behavioural most parameters are calibrated from observed base year data. 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. Decaluwé and al. (1999b) were the first to explore this approach; in which they used fictitious data. Cockburn (2001) on Nepal, Cororaton (2003) for the Philippines and Boccanfuso et al. (2003) in Senegal applied this approach to real country data. The main advantages of this approach, compared to the previous approach, are that they allow for intra-group income distributional 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[5]. 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

[5] For more discussion on this debate, see Decaluwé, Patry, Savard and Thorbecke (1999a), views have been exchanged between De Maio, Stewart and van der Hoeven (1999) who have strongly criticized the work done by Sahn et al. (1996) who replied in Sahn et al. (1999). The approach proposed below and in the multi-household approach eliminates this debate altogether.

accounts' data found in the Social Accounting Matrix (SAM)[6]. You will often find some under or over reporting for items in the Household survey.

The third approach draws on micro-simulation literature, first developed by Orcutt et al. (1961). According to Bonnet and Mahieu (2000), 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, Robilliard 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. We will refer to this approach as the CGE-MS

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 disaggregation in terms of production sectors and number of households to be included in the model. This is likely to be a temporary constraint since computing power increases rapidly for the

[6] Scaling data presents problems that have been partly resolved by approaches such as RAS methods or the entropy method proposed by Robilliard and Robinson (1999) but these methods will still introduce some level changes in the structure to balance out accounts.

CGE-IMH approach, but it is presently a real constraint[7]. 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.

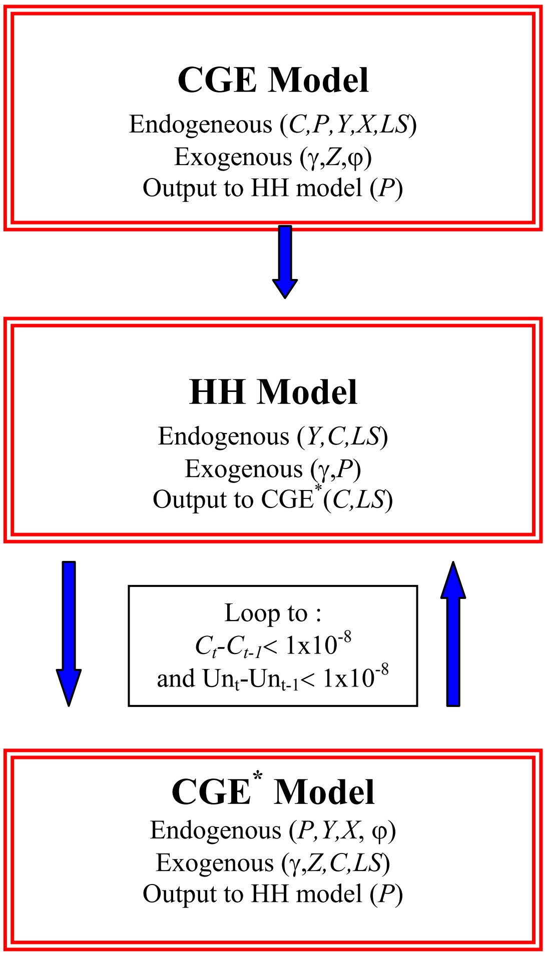
Let us detail what we mean with this argument. In a CGE, there are some behavioural functional forms that do work since they do not respect inherent constraints to CGE models, such as regime switching behaviours. A regime-switching behaviour implies that a variable can have specific characteristics in presence of a certain conditions and another set of characteristics in presences of another set of condition. A good example of this is waiting unemployment, where a worker chose to work in a sector if his reservation wage is below the effective wage, and chooses to be unemployed, if it is higher then the prevailing wage rate. Modeling such behaviour involves setting conditions on equation resolution, and this is not possible to apply in most software's with pre-programmed algorithm as the set of equations of the model need to be fixed. If one is interested by macro-economic results of such a model, this would not pose a problem as one aggregates the income obtained by households into one aggregate household. But if one wishes to attribute exactly who receives, informal sector wages, formal sector wages, and unemployment benefits (or no income), a regime switching mechanism is not possible with standard software such as GAMS. To resolve such a model, an alternative algorithm needs to be used and this is what we will attempt to do in the rest of the paper.

The basic idea of the approach is to use the CGE model to generate a price vector (including wage rates) and a household micro-simulation (HHMS) model, to calculate the household behaviours (consumption and labour supply). These vectors are then fed into the CGE model in which they are now exogenous variables and the iteration process continues until the results, between two iteration processes for all variables, are equal to zero. In this context it is important to have the two models and data base

[7]This constraint is not independent of functional forms used in the model. Using Cobb-Douglas functional forms for consumption and production will allow the modeller to use a larger number of households in the IMH approach (Cororaton 2003 has used 24797 households with C-D functional forms). But the introduction of non-linear functional form will quickly pose numerical resolution problems. 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. Choosing more linear functional forms and slightly reducing the number of production sectors (10 branches) have shown to facilitate resolution of the model.

as coherent as possible. In cases where a specific micro behaviour cannot be introduce directly in the model, a functional form that mimic the aggregate behaviour can be used for first approximation to accelerate the convergence. An example of this, with a labour supply function, will be shown in section dealing with the HHMS 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[8].

C : Household consumption
P : Price vector (goods and factors)
Y : Household income
X : Other endogenous variables
LS : Labour supply
γ : Parameters of the model
Z : Exogenous variables of the model
φ : Marginal propensity to save



[8] 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".

The 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, Robilliard 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.

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 dividend *(Div)*. In the models, it is assumed that there is an amount of total dividends, which is distributed proportionally between the households, which are endowed with shares of firms. 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[9] since:

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

Consequently, on the income side we have perfect aggregation. This illustration is valid for most typical CGE modeling exercise. However, as we will see in more detail below, when we relax the assumption of fixed labour supply, the perfect aggregation on the income side 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 $\overline{q_i} = g_i(\overline{x}, p)$ for one g_i and for all *i* were *i*=1…n goods consumed. Moreover, $g_i(\overline{x}, p)$, 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 Engel curves, and these must be parallel for each household. The C-D utility function generates a demand system that respects the above conditions and aggregate perfectly. The other commonly used demand system is the Linear Expenditure System (LES) which do not perfectly aggregate when calibrated such as proposed by Dervis et al. (1982). Selecting identical γ and β parameter will not allow the modeller to balance out the household budget constraint. As for other elements of the household expenditure, we are faced with a situation

[9] If the tdv_h are calibrated such that $\sum_h tdv_h = 1$.

where perfect aggregation is not necessarily achieved. Three specific elements are generally concerned; income tax, savings and transfers. In each of these three cases, we have the same type of relation that makes perfect aggregation unlikely occurrence:

$$Ith_h = ty_h Yh_h \text{ and } Tith = Ty.Tyhh$$

$$\frac{\partial Tith}{\partial Tyhh} = \sum_h \frac{\partial Ith_h}{\partial Yh_h} \Leftrightarrow \sum_h ty_h = Ty$$

where Ith_h is the income tax paid by household h, ty_h is the income tax rate for household h and Yh_h is the total income of household h; $Tith$ is the aggregate income tax paid by all households, Ty the aggregate income tax rate, and $Tyhh$ the aggregate household income. There is nothing but luck that will lead the modeller to obtain this condition. 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 year, and these are unlikely to sum to the aggregate calculated rate. We can see that, whenever a rate (income tax and savings) is calculated on the specific household income versus a share that calculated on the aggregate income (see the dividend case), it is unlikely to respect perfect aggregation conditions. These three elements contribute to the fact that the aggregate household of the CGE model does not provide the identical feedback effect that would be obtained with disaggregated household 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.

It should be noted that 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.

$$cc_i = \gamma_i + \beta_i \left(\frac{Ydh - \sum_j P_j \gamma_j}{P_i} \right)$$

where c_i is the consumption of good i, γ_i the non-discretionary expenditure, β_i marginal share of expenditure of good i, Ydh disposable income and P_i price of good i.

However, as we mentioned in previously this is not an option in the CGE context. Therefore we adopt the calibration method proposed by Dervis et al (1982). This consists of selecting income elasticities and Frisch parameters outside the model and calibrating the γ_i and β_i parameter that will be household specific and will balance out its respective budget constraint[10].

The Top-Down/Bottom-Up (TD-BU) CGE-Household Micro-Simulation Model

In the paper, we combine the use of two types of models. The first one is relatively similar to the standard CGE model, such as presented in chapter 9 of Decaluwé et al (2001). The household micro-simulation model introduces the consumption behaviour through a linear expenditure system (LES), the equation that determines the income of the household, and finally, features of the labour market such as endogenous labour supply based on a theoretical labour market model that will be presented in the following section. We proceed to present the two sub-components of the CGE-TD-BU approach.

The Household Micro-Simulation model (HHMSl).

As was stated previously, the household micro-simulation 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. We use the calibration method proposed by Dervis et al. (1982), but with all households having the same income elasticity of each good, and the Frisch parameter[11]. As for the

[10] The following relation $\beta_i = \omega_i \varepsilon_i$ between the marginal budget shares, ω_i the average budget shares and ε_i the income elasticity allow us to calibrate the marginal budget share. The following equation $\gamma_i = \frac{Ydh}{P_i}\left(\omega_i + \frac{\beta_i}{\phi}\right)$ where γ_i is the non discretionary income and ϕ the Fricsh parameter which is a ratio of the total expenditure and the discretionary income $\phi = -\frac{Ydh}{Ydh - \sum_j P_j \gamma_j}$

[11]We could have chosen to use differentiated Frisch parameters according to the income level of households, but it would only have increased the degree of heterogeneity in the household model. 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.

savings rate, it is calibrated as a fixed share of the household disposable income[12], and income tax rates are calibrated from the total income of the households. The savings and tax rates are household specific. These hypotheses are very important, as we saw in the previous section, since they contribute move away of perfect aggregation when going from the household level to the CGE model (with representative agent). These standard hypotheses will make a significant contribution to the differential results that we obtain from the two models in the first iteration of the policy simulations. All transfers received and given are exogenous.

On the income side, we consider the capital endowment as being fixed to the level observed in the Family Income and Expenditure Survey (FIES-1997). In the household survey, we have information on the head of household sector of activity, and the amount of non-wage income. This allows for a mapping of the sector of origin for each household capital income. From the FIES, we classified the workers into qualified, unqualified work and unemployed, according to the category of work specified in the survey[13].

In terms of labour market behaviour, we assumed that the labour market is segmented as was first proposed by Roy (1951), and further developed by Magnac (1991). As in Magnac, we introduce a formal labour market that is rationed with queued unemployment and an informal labour market, with waiting unemployment based on reservation wages of workers and unemployed. The approach is similar to what Cogneau (2001) did in his CGE-MS model. The type of modeling allows us to have two segmented labour markets, and two types of unemployment (rationed and waiting) with movement in and out of both labour markets and unemployment. We adopt the non-competitive version of the models proposed by Magnac (1991). The segmentation is obtained with a fixed wage and a cost of entry into the formal sector, which discourages the workers, with potential wages below adjusted with the cost of entry, to participate in the labour market segment to supply their labour on the market.

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[12] In fact it is the disposable income minus the non-discretionary income, which is used to calibrate the savings $Yddh = Yh - Ty - \sum_j P_j \gamma_j$ where *Yh* is the household income, *Ty* the income tax and last expression is the non-discretionary income.

[13] The information on the type of work performed by the head of household is very precise where 200 types of work categories are found. Given the rich set of information, it is relatively easy to classify the workers as qualified or unqualified work.

In the formal sector, we make a relatively strong assumption that firms have perfect information and they will hire out the most qualified workers (workers with the highest potential wage). When they choose workers to layoff, they will layoff the least qualified workers. From the workers side, they will offer their labour on the formal market if their reservation wage minus the cost of entry is higher then the prevailing wage on the labour market.

As for the informal sector the wage it is flexible and will adjust according to the prevailing supply and demand of labour. The reservation wage level of each worker determines their choice to supply their labour on this market and we aggregate the individual choices to determine the aggregate labour supply in the HHMS model. A worker will decide to offer is labour if his reservation wage is below the prevailing informal sector wage. The product of a set of observable and non-observable characteristics determines the potential wage of workers and the reservation wages of workers *i*:

$$\ln w_i^{j^*} = \ln \pi^j + \ln \tau_i^j \text{ where } \ln \tau_i^j = H_i \gamma^j + u_i^j$$

we have $w_i^{j^*}$ as the potential wage of worker *i* in sector *j*, π is the price of the qualification in sector *j* and τ_i^j is the level of qualification attained by worker *i*, and H_i, his level of human capital and u_i^j the non observable individual fixed effect. The non-observed reservation wage is determined by the following equation:

$$\ln \overline{w}_i^0 = (H_i Z_i)\overline{\gamma}^0 + u_i^0$$

where Z_i are household characteristics. As we mentioned earlier there is a cost of entering into the formal labour market; we modeled this cost with the following equations:

$$\ln c_i = (H_i Z_i)\overline{\gamma}^c + e_i$$

We can synthesize the model we described above with the following structure:

$$\begin{array}{ll} \text{choses sector 1 (formal sector) if :} & w^1 - c > w^2, and..w^1 - c > \overline{w}_i^0 \\ \text{choses sector 2 (informal sector) if :} & w^2 > w^1 - c, and..w^2 > \overline{w}_i^0 \\ \text{choses to be unemployed if :} & \overline{w}_i^0 > w^1 - c, and..\overline{w}_i^0 > w^2 \end{array}$$

where w^1 is the formal sector wage, w^2 the informal sector wage, $\overline{w_i}^0$ the reservation wage and c the cost of entry in the formal sector. This model is estimated with a Heckman two steps method: the Probit in the first stage, followed by OLS estimation[14]. Results from this estimation are provided in the annexe 3 and they are used to classify workers, first, according to the above labour supply model, and second, with the potential wage for the selection process in the formal sector market.

At base year, we will observe formal sector workers, informal sector workers as well as unemployed. It is important to build the queues around the frontiers of w^1 and w^2 as changes in real wages generated by the CGE model can be positive or negative. This will allow to capture marginal changes in both directions for both wages (or labour market).

The queue of workers for the formal sector are taken from the workers supplying their work on that sector (according to the model described above) and from this group we rank the workers according to their potential wages w_i^{1*}, and construct a queue from the observed workers and unemployed. Above, we will find the formal sector workers with the lowest potential wages, and bellow the border, the informal sector workers and unemployed with the highest potential wage. From this, when the real wage decreases, firms will hire out the most qualified workers just bellow the border first, and then, go down the queue; if the real wage increases, they will layoff the least qualified formal sector workers just above the border.

It is important to add that we can make external shocks on the nominal wage[15] for policy simulation purpose. Therefore, we needed to add a condition that, for a worker to offer his labour on the formal market, the new formal wage must be above his

[14] 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).

[15] In the discussion on labour supply we talk about the nominal wage, where in fact we should be talking about the real wage, which is the decision parameter for the worker. However, in our modeling exercise, the price index is fixed and therefore the important element is the nominal wage. This is not the case for the producer as the real wage he faces takes into account his sector specific market price and not the general price index.

reservation wage. The two conditions of the above model for the worker must, therefore, be satisfied for him to be included in the queue.

On the informal sector, we classify the informal sector workers with the highest reservation wages and place them just above the border (wage). They will be the first to become unemployed if the real wage decreases in the informal sector. Bellow the border (wage), we rank the unemployed with the lowest reservation wage, and they will be the first to supply their labour on that market when the real informal wage increases.

Once this ranking exercise is completed, we have ranking of workers to be selected by firms, to be hired or laid off (formal sector), and who respect the conditions of the model described above; and we have a labour supply model for the informal sector, based on the reservation wages of workers and unemployed. Changes in the aggregate labour demand, in the formal sector in the CGE model, will determine the variation of frontier between the participants of that market segment and the non-participants (but seeking a job in the given market), since the nominal wage is fixed. In the informal sector, we have an endogenous labour demand that will be directly influenced by the endogenous wage. We will, therefore, have a regime switching system were a worker can find himself on one market at base year, and on the other, or unemployed, after simulation.

The changes in regime will materialize themselves when obtaining the specific wage of his sector of activity, or no wage, in the case of unemployment. This will clearly generate very important income changes in the affected households (either positively or negatively). This situation is not possible in a standard CGE model and this type of effect can generate very changes in poverty and income distribution, as a household loosing 100% or 80% of its income (in case of a job loss) will not have the same impact on indices, as we generally have in a traditional CGE were changes in income are rarely more then + or – 10%. Therefore, the HHMS model will have, as input, a price vector (including factor payments), and, as an output, the informal sector labour supply (or its mirror effect the unemployment rate).

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 model are the household consumption 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[16]. For the CGE modeling, as is shown in figure 1, we have two version of the model. The first model has both consumption and informal sector labour supply as endogenous; and in the second version, these two variables become exogenous. The reason behind this is that we use the first run of the CGE to provide a first order approximation of what the HHMS model results; which will facilitate convergence between the two models. Therefore, in the first run we try to reproduce the behaviour we modeled in the HHMS model.

For some components, we reflect the specific behaviours of the HHMS model in the CGE model, and in other cases, it is necessary to introduce functions that will mimic characteristics of the HHMS model. We will only describe the labour market structure, as other aspects are straightforward.

The first element we modify, in the model, is the segmentation of the labour market into two segments: the formal (who are mainly qualified) and informal (who are mainly unqualified). We suppose that the production branches will use a combination of both types of workers, and the optimal labour demand for each types of labour will be determined by a cost minimizing behaviour under the constraint of a CES function.

We also introduce unemployment in the model, with the qualified labour market having a rigid nominal wage and therefore generating rationed unemployment, and some waiting unemployment based on the HHMS model where the reservation wage

[16] 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)

of workers will determine the choice to work or to be unemployed. The nominal wage in the informal sector is flexible and will adjust to balance the supply and demand of labour. In the first run of the CGE model, we will try to mimic the behaviour explained in the HHMS section for the informal sector supply; to approximate this behaviour, we use the following equation that determines the new level of unemployed and indirectly the labour supply (as we simply subtract one from the other):

$$Ut = Uto\left(wo^2 \Big/ w^2 \right)^{\xi}$$

where the *Ut* is the unemployed after simulation, *Uto* the unemployed at base year, *wo2* the informal sector wage at base year, *w2* the informal sector wage after simulation, and ξ the elasticity of supply. We can see that, if the wage decreases after simulation, more potential workers will have the reservation wage above the prevailing wage, and therefore, we will observe a reduction in labour supply or an increase in unemployment. The elasticity used in the CGE model is drawn for from the estimation of the labour supply model around the queue constructed in the HHMS model.

In the formal sector as we explained there is a fixed nominal wage and the change in labour demand will be generated by the change is the real wage (w^1/P_i); where P_i is the producer price of good i, is what is important for the producers decision-making process. The new prevailing real wage in each sector will then determine the aggregate labour demand. This will generate either an increase or a decrease in total labour demand. We need to add an equation that will replicate what happens in the household model in terms of origin (when we have hiring) or destination (when we have layoffs) of the workers. Do they come from the informal sector or do they come from unemployment. In fact, the ranking of workers and reservation wage comparison of the HHMS model has this information. Given this situation, we used the following equation to reflect this behaviour in the model.

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 given the change in real wage. This change in qualified labour demand is computed with the difference in the post simulation labour demand compared to the base year figure:

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

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[17]. The remainder of new workers for the qualified sector are drawn from the unqualified sector

$$Lnqt = (1-\delta)Lsqc$$

where *Lnqt* is the new qualified sector workers coming from the informal sector. The δ parameter is drawn from the HHMS model ranking at base year, and is recalculated at every iteration to take into account the actual position of the border between formal sector workers and non-formal sector workers, given the origin of the workers concerned.

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

$$Lsnq = Lsnqo + (Uto - Ut) - Lnqt$$

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

$$u = \frac{(Ut - Uq)}{Lsnqo + Lsqo + Uto}$$

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

[17] 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.

exchange rate clear out 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[18].

Sequencing the CGE and HH Micro-Simulation 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; given non perfect aggregation characteristics described previously. 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 calculate two variables (or vectors) that will back into the CGE model, in which they will be exogenous variables. The first one is the aggregate goods consumption vector; the second is the informal sector labour supply (this will be calculated via two sources; laid off workers of the formal sector and labour supply of the informal sector) produced by the household model, and to introduce the feedback effect into the CGE model on an aggregate level. The procedure is relatively simple for the household consumption, as the HHMS model generates a consumption matrix of 20 goods by 39520 households, and we simply aggregate the individual consumption over all 39520 households, which produces a single vector for consumption as an output of the HH 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

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

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. The price vector of goods and the consumption levels obtained from the HH model directly determines this consumption variable. The household disposable income *(Ydh)*, and household savings *(Sh)*, are a fixed proportion of the household's income in the first run of the CGE. 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*.

On the labour market side, we simply calculate the new value for *Ut*, and calculate the value to attribute to the δ parameter. The two variables help us calculate a new labour supply in the informal sector. The equation determining *Ut* in the first runs of the CGE model is removed in the subsequent runs of the model, and is entirely determined by the HHMS model.

The rest of the CGE model's hypotheses are left unchanged[19]. As will be seen in the simulation, results of variation of this adjustment variable have shown to be relatively small[20].

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 and labour supply variables (*Ut* and δ) are transformed into a data file that is used in the looping version of the combined model.

[19] 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.

[20] 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.

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, and *Ut* are now determined by the HH model. We remove the two equations and transform the consumption vector and *Ut* into an exogenous vector and variable. In the looping version, we run up to 12 loops automatically between the two models. In both scenarios presented, convergence at 6th decimal is obtained around the 8^{th} loop. We should note that convergence is verified on the household consumption vector[21] as well as on *Ut* variable.

An application of the "top-down/bottom-up" CGE-HHMS model

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 Social Accounting Matrix (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 disequilibria in the SAM that required standard SAM balancing procedure[22]. As was stated earlier, it was not necessary to have a perfect balance between the income and expenditure accounts for each household, as we transmit the effect via a percentage variation from the income to the expenditure. This spares for the need to introduce balancing hypothesis, which often lead to denaturing the household's income or expenditure structures. Since we import the aggregate structure of income and expenditure from the FIES or the HHMS model into the SAM and the CGE model, and not nominal level, this constraint (of balancing household

[21] 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.

[22] We did not use an automated procedure to balance out the SAM as these methods can sometimes modify structures without 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).

income and expenditure) no longer needs to be respected, as it is the case in the CGM-IMH approach.

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 30% 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 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 30%.

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 (0,35%) to reduce imports and increase exports to balance out the *CAB*. The government income *(Yg)* is strongly reduced (-8,42%) 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 3,34% and produces a negative effect on the informal wage, which drops by –1,12%. In this first scenario, we observe a strong decrease in the poverty threshold (-1,31) 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 *mining* and *construction*, and the only two branches to see a reduction in their outputs are *electricity-gas and water* and *finance* sectors.

Table 1: Macro results of CGE model after convergence

Variables	Base	Simulation 1 30% decrease in import tariffs	Simulation 2 10% increase in w-q
Yh	86,48	-0,61	-0,63
Yg	20,37	-8,49	-0,66
Ye	26,17	0,43	-0,84
Sg	-1,16	-8,42	-1,92
Sm	9,65	-1,90	0,88
Ui	0,17	3,34	5,80
w^1	1,00	0,00	10,00
w^2	0,50	-1,12	-4,55
e	1,00	0,35	0,07
mps	11,34	-3,39	2,42
GDP	104,51	-0.74	-1,00
Poverty threshold	1185,00	-1,31	-1,86

Simulation 2: An increase of 10% in the qualified sector fixed wage.

In this scenario we observed, 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 4,55% in the nominal unqualified wage (w^2). It is important to note that there is also a demand effect on labour as producers will shift their demand from qualified to unqualified, as (w^1/ w^2) increased. As for laid off formal sector workers, given their reservation wage some will prefer to become unemployed on the basis of their reservation wage with respect to the prevailing wage (w^2). This will, in part, contribute to an increase of 5,80% in the unemployment rate (U_i). The other portion of the increase in unemployment comes from informal sector workers (at base year) no longer willing to work at the reduced nominal wage *(w^2)* level. The effect on the government side is a lot less drastic, with a reduction of income of 0,66% and a reduction of 1,92% 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 1.86%.

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	14800	0,23	-0,18
Va	Fruit & vegetable	13000	0,34	0,18
Va	Coconut	14100	0,48	-0,29
Va	Livestock	18700	0,55	-0,02
Va	Fishing	14600	0,40	0,15
Va	Other agric.	14800	0,20	0,89
Va	Logging and timber	3800	0,71	-0,07
Va	Mining	12000	1,57	-0,56
Va	Manufacturing	96500	0,70	-1,31
Va	Rice manufacturing	10400	0,36	-0,28
Va	Meat industry	12200	0,65	-0,32
Va	Food manufacturing	20700	0,19	0,40
Va	Elec. Gas Water	8200	-0,54	-1,22
Va	Construction	79400	1,39	0,46
Va	Commerce	103500	0,59	-0,81
Va	Trans. & comm.	44900	0,41	-0,42
Va	Finance	17400	-0,79	-1,67
Va	Real estate	30400	0,33	-1,83
Va	Services	65300	0,43	-0,45
r	Paley & corn	1,00	0,53	-5,31
r	Fruit & vegetable	1,00	1,14	-2,72
r	Coconut	1,00	0,09	-4,86
r	Livestock	1,00	1,51	-3,20
r	Fishing	1,00	1,10	-3,32
r	Other agric.	1,00	-0,61	-2,05
r	Logging and timber	1,00	2,06	-4,56
r	Mining	1,00	2,79	-1,56
r	Manufacturing	1,00	0,86	0,06
r	Rice manufacturing	1,00	0,36	-3,39
r	Meat industry	1,00	1,10	-3,44
r	Food manufacturing	1,00	-0,33	-1,19
r	Elec. Gas Water	1,00	-2,19	1,69
r	Construction	1,00	1,24	-2,18
r	Commerce	1,00	0,75	0,97
r	Trans. & comm.	1,00	-0,11	-3,84
r	Finance	1,00	-2,49	0,44
r	Real estate	1,00	0,82	4,99
r	Services	1,00	0,03	-0,37

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*, *finance* and *manufacturing*. The output, or value added, increases the most in *other agriculture*, *construction* and *food manufacturing* 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 HHMS model. The indicators presented are far from being exhaustive as it is possible to apply all types of measures and methodologies 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 decomposition household groupings. This is done to demonstrate that the approach avoids the difficult choice of household classification raised by Di Maio et al. (1999) in the CGE-RH approach. This is possible as there is no classification in either the CGE or HHMS models. The analyst, after computation of models results, is free to choose the decomposition for poverty and income distribution analysis. The only constraint to household decomposition is bound by information found in the household survey itself.

Poverty Analysis

We note that the first policy simulation has a significant positive impact on poverty reduction at the national level (-1,77%). This decrease is strongly linked to the change in the poverty threshold that decreases by 1,31%. By combining income effect and threshold effect[23], we get a decrease in poverty for all educational groups except for the most educated group, who see their poverty increase by 4,83%. If we isolate and

[23] 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.

look exclusively at the income effect, we get an increase in FGT_0 in all groups, except for the non reported group (#0)[24]. We have a similar situation when looking at poverty by regional decomposition, as the threshold effect pushes all indices to decrease, with the exception of Manila region households (group 13) with an increase of 0,26%. However, when we isolate income effect, we have an increase in all regions, although the increase is very small in region 9 and 15 with 0,10% and 0,11% respectively.

Table 3: FGT poverty indices of P_0 Decomposition by two household groups With endogenous poverty line

	Code	Base	Sim1	Variation %	sim2	Variation %
Country		31,093	30,543	-1,77	32,144	3,38
Level of education of head of household	0	53,515	52,234	-2,39	53,501	-0,03
	1	48,879	48,103	-1,59	49,400	1,07
	2	39,243	38,543	-1,78	39,672	1,09
	3	33,953	33,325	-1,85	34,626	1,98
	4	21,433	20,940	-2,30	22,197	3,56
	5	12,091	11,904	-1,54	12,503	3,41
	6	2,718	2,850	4,83	3,032	11,53
Regions	1	34,093	33,232	-2,53	34,829	2,16
	2	30,198	29,726	-1,56	30,371	0,57
	3	14,938	14,622	-2,11	15,462	3,51
	4	24,456	23,896	-2,29	24,872	1,70
	5	46,432	45,797	-1,37	47,297	1,86
	6	35,047	34,411	-1,81	35,952	2,58
	7	30,060	29,493	-1,89	30,417	1,19
	8	38,271	37,653	-1,61	38,787	1,35
	9	32,616	32,054	-1,73	32,837	0,68
	10	41,784	40,859	-2,21	42,244	1,10
	11	34,272	33,756	-1,51	34,547	0,80
	12	45,390	45,076	-0,69	45,953	1,24
	13	6,223	6,239	0,26	7,385	18,68
	14	38,011	37,201	-2,13	37,969	-0,11
	15	58,198	56,350	-3,18	57,125	-1,84
	16	49,020	48,692	-0,67	49,175	0,32

Simulation 2 produces different results, and one that merits to be highlighted, as it would not be possible to obtain such a result in CGE-RH and CGE-IMH approaches. In these models, an increase in the formal sector wage would inevitably benefit the

[24] Results of income effect are found in Annexe 2. Description of coding for education level of head of household and regional classification is provided in annexe 4.

most educated and hurt the less educated. However, with our labour market assumptions (of endogenous labour supply, unemployment) we obtain somewhat counter-intuitive results. We have that poverty levels increase the most for educated, and less for the lower educated groups. These results from the fact that the increase in the formal sector wage benefit mainly the non poor, and therefore does not have much effect on poverty indices. However the important effect of this policy is the strong lay off of workers in the formal sector given higher wages. The other effect is the strong reduction of the informal sector wage (-4,55%). We need to look at who are the ones concerned by this. Laid off workers of the formal sector will go in the informal sector and get lower paying wages; this produces a drop of over 50% in their income, as most of the workers in the formal sector are educated, they will be strongly affected. Moreover, of this group, the ones that are most educated will have a higher reservation wage (on average and *ceteris paribus*), and therefore, many will choose to be unemployed. The workers will get an even stronger negative impact on their income. The third mechanism in the model that explain these results are the informal sector workers who see their wage drop by 4,55%, and therefore, the ones with the highest reservation wage in that group, who are also the most educated, decide to become unemployed. Therefore, these three combined effects will play a stronger effect than the marginal changes on the formal sector and informal wages.

In the case of regional decomposition, we observe a reduction of the headcount ratio only in region 14 and 15, and a strong increase in poverty in the capital region (13). We also note that the regions 1, 3 and 6, all see the poverty levels increase by more then 2%. When we isolate the threshold effect, we get a negative impact on all regions except in Autonomous Region of Muslim Mindanao (-0,06%).

In annexe, we present results for FGT_1 and FGT_2, but we won't describe the results in this paper. 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. We note that we get different signs, in a few instances such as for the college undergraduate who have a reduction in headcount for simulation 1, but an increase in depth and severity of poverty.

Income distribution

We applied GINI index for the whole population, calculated inter-group and intra-group indices and this for decomposition at the educational and regional levels. We can see that the first simulation increases inequality for all groupings but the Bicol Region and Cordillera Administrative Region, who experience a drop in inequality. The intra-group inequality increases more than the inter-group for both educational and regional decomposition.

For the second simulation, the inequality effects are much stronger with a 1,48% increase at the national level. It is interesting to note that in this case, we have the inter-group effect stronger for educational decomposition, and intra-group effect stronger in the case of the regional decomposition. Given our explanation of the poverty effect on the educated group in the previous section, it is not surprising to see this group has a strong increase in the index. The explanation can be found in the fact that the richest of the group keep their jobs and get a higher wage, and some of the poorest of the group loose their formal sector job, and get a informal sector wage or become unemployed. When considering regional decomposition, we note that the effects are quit similar for all regions with Cordillera Administrative Region, and the Autonomous Region of Muslim Mindanao having the lowest inequality effects in the Bicol Region, the Western Visayas and the Region National Capital Region having the strongest inequality effects.

Table 3: Income distribution measure: GINI decomposition by Educational and Regional groupings

	Code	Base	Sim1	Variation %	sim2	Variation %
Country		0,5182	0,5188	0,12	0,5265	1,48
GiniDecomposition by Educational Groups						
Inter-Group		0,4537	0,4541	0,09	0,4617	1,67
Intra-Group		0,0646	0,0647	0,15	0,0648	0,15
Level of education of head of household	0	0,3987	0,3991	0,10	0,3992	0,03
	1	0,4073	0,4073	0,00	0,4092	0,47
	2	0,4111	0,4112	0,02	0,4134	0,54
	3	0,4158	0,4167	0,22	0,4191	0,58
	4	0,4133	0,4152	0,46	0,4185	0,79
	5	0,4551	0,4554	0,07	0,4582	0,61
	6	0,4920	0,4935	0,30	0,4999	1,30
Gini Decomposition by Regional Groups						
Inter-Group		0,4712	0,4717	0,11	0,4785	1,44
Intra-Group		0,0470	0,0471	0,21	0,0480	1,91
Regions	1	0,4590	0,4595	0,11	0,4648	1,15
	2	0,4271	0,4275	0,09	0,4333	1,36
	3	0,3854	0,3868	0,36	0,3925	1,47
	4	0,4462	0,4467	0,11	0,4537	1,57
	5	0,4684	0,4681	-0,06	0,4767	1,84
	6	0,4533	0,4543	0,22	0,4624	1,78
	7	0,5035	0,5040	0,10	0,5110	1,39
	8	0,4649	0,4650	0,02	0,4724	1,59
	9	0,4829	0,4831	0,04	0,4892	1,26
	10	0,5236	0,5241	0,10	0,5324	1,58
	11	0,4696	0,4703	0,15	0,4757	1,15
	12	0,4621	0,4625	0,09	0,4698	1,58
	13	0,5085	0,5093	0,16	0,5192	1,94
	14	0,5042	0,5038	-0,08	0,5088	0,99
	15	0,3766	0,3767	0,03	0,3802	0,93
	16	0,4638	0,4641	0,06	0,4708	1,44

Conclusion

In this paper, we demonstrate why it is important to take into account the feedback effects of household behaviours generated by a HHHS model back into a CGE model, as we have a number of elements preventing perfect aggregation of micro-economic behaviours, and, therefore, representative household in the CGE cannot reflect behaviours of the HHMS model. We also discussed some of the advantages tied to working in a separate context for household micro-simulation modelling instead of using the CGE-IMH approach. We illustrated the mechanics of the top-down/bottom-up approach of CGE and HHMS modelling by constructing a relatively standard CGE, and by incorporating some of the labour market behaviours modelled in the HHMS model. We also constructed a HHMS model with income and expenditure structures of the household survey, and integrated labour market supply 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 10 loops between the two models.

We think that this approach provides richer information than the standard CGE-RH approach, more flexibility (larger number of households and use of more flexible functional forms) than the CGE-IMH approach, and more global coherence than the unidirectional CGE-MS approach. We also demonstrate that more richness in the household behaviour can generate results that are difficult if not impossible to obtain from the CGE-RH and CGE-IMH approaches.

One of the drawbacks is that the approach is not as tractable as the first two approaches. We also show that the approach is extremely flexible in terms of application of poverty and income distribution measures, and in terms of the types and level of decomposition that can be made ex-post to the modelling exercise, which is not the case with the most commonly used CGE-RH approach, and that was rightly criticized by Di Maio et al (1999).

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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		12,97	12,68	-2,22	13,29	2,51	6,09	5,93	-2,63	6,30	6,24
Education level of head of household	0	23,48	22,82	-2,81	23,58	0,43	11,50	11,10	-3,48	11,59	4,41
	1	21,74	21,16	-2,67	22,04	1,38	10,77	10,41	-3,34	10,98	5,48
	2	16,09	15,67	-2,63	16,43	2,14	7,47	7,23	-3,21	7,69	6,36
	3	12,83	12,58	-1,91	13,22	3,04	5,67	5,56	-1,94	5,91	6,29
	4	7,02	6,97	-0,67	7,44	6,01	2,99	2,99	0,00	3,25	8,70
	5	3,37	3,42	1,65	3,68	9,14	1,30	1,35	3,85	1,50	11,11
	6	0,77	0,81	5,90	0,96	25,46	0,29	0,33	13,79	0,44	33,33
Regions	1	12,04	11,72	-2,66	12,45	3,41	5,21	5,03	-3,45	5,46	8,55
	2	13,75	13,35	-2,91	14,06	2,25	5,84	5,62	-3,77	6,02	7,12
	3	4,14	4,09	-1,21	4,49	8,45	1,54	1,55	0,65	1,75	12,90
	4	7,14	6,92	-3,08	7,39	3,50	2,95	2,86	-3,05	3,12	9,09
	5	21,58	21,14	-2,04	22,19	2,83	10,20	9,94	-2,55	10,61	6,74
	6	15,87	15,59	-1,76	16,54	4,22	7,12	6,98	-1,97	7,56	8,31
	7	20,39	19,94	-2,21	20,80	2,01	10,37	10,09	-2,70	10,66	5,65
	8	23,72	23,17	-2,32	23,99	1,14	11,95	11,60	-2,93	12,12	4,48
	9	20,05	19,59	-2,29	20,44	1,95	10,23	9,94	-2,83	10,49	5,53
	10	19,44	19,06	-1,95	19,86	2,16	9,59	9,38	-2,19	9,94	5,97
	11	16,14	15,81	-2,04	16,42	1,73	7,64	7,44	-2,62	7,80	4,84
	12	21,69	21,27	-1,94	22,03	1,57	11,16	10,87	-2,60	11,37	4,60
	13	0,51	0,53	3,92	0,66	29,41	0,15	0,18	20,00	0,23	27,78
	14	14,13	13,82	-2,19	14,09	-0,28	6,68	6,55	-1,95	6,71	2,44
	15	19,70	18,96	-3,76	19,21	-2,49	7,93	7,53	-5,04	7,68	1,99
	16	23,87	23,32	-2,30	24,15	1,17	12,25	11,87	-3,10	12,44	4,80

Annexe 2: FGT_0 headcount index with poverty threshold exogenous.

	Code	Base	Sim1	Variation %	sim2	Variation %
Country		31,093	31,332	0,767	32,011	2,953
Level of education of head of household	0	53,515	53,467	-0,091	53,786	0,505
	1	48,879	49,081	0,414	49,957	2,207
	2	39,243	39,440	0,502	40,256	2,582
	3	33,953	34,222	0,793	35,180	3,614
	4	21,433	21,833	1,867	22,549	5,204
	5	12,091	12,481	3,225	12,914	6,813
	6	2,718	2,926	7,636	3,100	14,059
Regions	1	34,093	34,292	0,583	35,616	4,466
	2	30,198	30,378	0,596	30,848	2,152
	3	14,938	15,243	2,047	15,856	6,145
	4	24,456	24,646	0,774	25,462	4,110
	5	46,432	46,795	0,783	47,778	2,898
	6	35,047	35,502	1,298	36,306	3,594
	7	30,060	30,210	0,499	30,644	1,943
	8	38,271	38,500	0,598	39,149	2,293
	9	32,616	32,648	0,098	33,372	2,317
	10	41,784	42,048	0,633	42,662	2,103
	11	34,272	34,419	0,430	34,918	1,887
	12	45,390	45,703	0,689	46,265	1,928
	13	6,223	6,644	6,766	7,647	22,884
	14	38,011	38,242	0,609	38,627	1,621
	15	58,198	58,262	0,110	58,163	-0,061
	16	49,020	49,160	0,287	49,849	1,691

Annexe 3: Labour supply model estimation results

Probit				
Regressor	Coefficient	Std. Error	t-stat	Prob>|t|
constant	1.61683	0.46963	3.44281	0.00029
education	0.14937	0.00932	16.02265	0.00000
age	-0.10990	0.02984	-3.68280	0.00012
age2	0.00121	0.00030	3.99504	0.00003
experience	0.02414	0.00976	2.47298	0.00671
size of family	0.06281	0.00779	8.06703	0.00000

Heckman 2-Step Estimates of Selection Model Qualified				
Regressor	coefficient	Std. Error	t-stat	prob>|t|
constant	4.15523	0.55819	7.44413	0.00000
education	0.22921	0.03320	6.90336	0.00000
age	0.06746	0.02143	3.14754	0.00084
age2	-0.00064	0.00025	-2.59636	0.00476
size of family	-0.26829	0.08243	-3.25484	0.00058
Lambda	-0.90843	0.25598	-3.54883	0.00020

Heckman 2-Step Estimates of Selection Model Unqualified				
Regressor	coefficient	Std. Error	t-stat	prob>|t|
constant	3.25639	0.48463	6.71934	0.00000
education	0.12500	0.03129	3.99533	0.00003
age	0.05280	0.01901	2.77727	0.00275
age2	-0.00055	-0.00055	-2.52059	0.00588
lambda	-1.65604	0.25121	-6.59213	0.00000

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