METHODOLOGY TO ANALYZE EX ANTE MACROECONOMIC POLICIES: LINKAGES BETWEEN CGE, ALMOST IDEAL DEMAND SYSTEM AND LABOR PARTICIPATION MODELS

Laura Atuesta

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Methodology to analyze ex ante macroeconomic policies: Linkages between CGE, Almost Ideal Demand System and labor participation models

Laura Atuesta[a]
[a] *Department of Agricultural and Consumer Economics,*
University of Illinois at Urbana-Champaign, Urbana, IL, 61801

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SUMMARY

This paper describes a methodology to analyze the impacts of macroeconomic shocks at the household level. Because the impact affects all the agents in the economy, the shock is analyzed using a CGE model. However, when the interest centers on poverty or welfare impacts at the household level, microeconometric models are needed in order to account for microeconomic behavior of households. The CGE model interacts with two microeconomic models: a labor participation model to measures migration decisions of households, and an Almost Ideal Demand System (AIDS) to estimate household demand and calculate welfare measures of different household groups. The interaction between the CGE model and the labor participation model considers feedback loops from top to bottom and behavioral responses from households at the microeconomic level. On the other hand, the interaction between the CGE and the AIDS could be described in two steps: the AIDS estimates the budget shares used in the CGE, and the changes in income and prices from the CGE are used in the AIDS to calculate the welfare measures of different household deciles.

Keywords: CGE models, microsimulations, labor participation models, AIDS, censored data.

1. INTRODUCTION

Policy makers have increased their interest in the distributional effects of macro policy shocks. Since the 1970s, the World Bank has established the reduction of world poverty as a goal for development, and several authors have stated the importance of including distributional effects as goals for economic growth and development (Ravallion, 2001; Barro, 2000). However, when analyzing the effects of macroeconomic policies on the economy, the aggregate or national accounts ignore the effect that policies may have on individual household groups. Recently, the literature has been more concerned to find a way to evaluate the distributional effects of a macroeconomic shock by linking national and aggregate accounts with household level data.

The uses of general equilibrium frameworks to evaluate the impacts of macro policies have several explanations: the first one is related to the nature of the policy analyzed (Bourguignon et al., 2008). When the policy has a macroeconomic nature, a general equilibrium is needed, but the effect is different for every household group. The second one is related to the methodology used to evaluate a policy impact. When doing *ex post* impact evaluation analysis, control and treatment groups are defined using different econometric techniques, and the output of the treatment is compared to the output of the control group. However, if an *ex ante* analysis is needed for a macro policy, defining control and treatment groups is not an easy task, because all the households are affected by the policy, and secondly, because none of the households has received the treatment yet.

In this paper, a methodology to analyze the impacts of an *ex ante* macroeconomic shock is described by linking a general equilibrium model with microeconomic models that account for the different responses of households to the macro shock. Two microeconomic models are used to simulate the households' behavior: the first one is a segmented labor participation model using a Heckman two-step methodology (Magnac, 1991); the second one is an Almost Ideal Demand System (AIDS), first developed by Deaton and Muellbauer (1980). The labor participation model includes behavioral responses in the sense that the household responds to

second and third-round effects of changes in the macro model. The AIDS uses as an accounting approach without second-round effects, but it is later used also to calculate welfare measures at the household level, taking into consideration the changes in income and prices of the CGE model. An application of this methodology using Colombian data for 2006 shows that the microeconomic labor model and the CGE model converge after three iterations, and the results can be easily used to calculate economic welfare measures at the household level.

The paper is divided as follows. The first section below presents a description of the labor participation model. Then, section 3 describes the AIDS model used to estimate household demands. Section 4 describes the social accounting matrix (SAM) and the CGE model used to estimate the macro shocks to the economy using Colombian data for 2006. The linkages between the two microeconomic models and the CGE model are described in section 5. Finally, section 6 provides some concluding remarks.

2. THE LABOR PARTICIPATION MODEL

When analyzing the effects that a macroeconomic shock has on households' welfare, the labor market is one of the conduits through the different household types are affected. Households are assumed to be working in one of the labor markets in the economy, and in some cases, when the wages of these markets are affected, households decide to migrate to other labor markets because the expected gains there are greater than their actual earnings. Migration in this case is understood as a movement from one segmented market to another (formal vs. informal), or from one region to other one (rural vs. urban). Migration between labor markets is modeled using a labor participation framework following Magnac (1991), Savard (2003) and Cogneau and Robilliard (2006) on segmented labor markets.

In this specific case, changes in wages are assumed to be exogenous to the labor participation model because they are estimated in the CGE model. Then, the labor participation model uses these wage changes to calculate changes in labor supply and migration flows across

different labor markets. The urban areas are disaggregated into three components: unemployed and two labor markets: informal labor and formal labor. The rural areas only have rural labor, but it is assumed that the rural unemployment rate is 10%.[1]

The model uses the Integrated Household Survey of Income and Expenses (GEIH) of 2007 for Colombia. The Survey was conducted in both rural and urban areas collecting information about the demographic, income, expenses and labor characteristics of 64,119 different households. Most of the information is available at the household level and disaggregated information is also available for the household head. The labor participation model uses labor and demographic characteristics of the household heads, assuming that the labor choices of other household members are the same.

Table 1 shows a summary of the statistics of the labor market at the initial equilibrium, with 45.80% of the total households in the rural sector and 54.19% in the urban sectors. From the urban households, 28.74% are unemployed, 30.95% belong to the informal sector, and 40.37% to the formal sector. Rural workers have the lowest level of education, and most of the unemployed are women. Highest wages are earned by the formal workers followed by the rural workers and the informal workers. Notice that the informal wages are lower than the rural wages suggesting an incentive to migrate from the urban informal market to the rural areas.[2]

In order to determine the direction of the migration flows, the Heckman two-step method with a bivariate Probit in the first step is used to estimate the probability of a worker being employed in each of the labor markets. The first Probit estimation determines whether the worker is employed in rural or in urban areas. The second one, determines in which of the urban labor markets or rural labor market (rural vs. unemployment), the worker is employed. Because these probabilities are dependent on each other, a bivariate Probit considers the

[1]Households consider this unemployment level by calculating their potential rural wage as the 90% of the monetary wages.

[2]This situation could be explained by the noneconomic factors that affect the migration decision of households such as the existence of an armed conflict in the countryside.

correlation of the error terms of the two equations. The model can be specified as follows:

$$Y_{1i}^{*} = X_{1i}\beta_1 + \mu_{1i} \qquad Y_{2i}^{*} = X_{2i}\beta_2 + \mu_{2i}, \tag{1}$$

where,

$$\mu_{1i} = \eta_i + \epsilon_{1i} \qquad \mu_{2i} = \eta_i + \epsilon_{2i}, \tag{2}$$

and X_1 and X_2 are characteristics of the households such as household head gender, age, education, marital status, other income of the household, number of persons and number of occupied persons.

In the specific case of the urban formal workers, $Pr(Y_{1i} = 1)$ is the probability of being employed in the urban areas, and $Pr(Y_{2i} = 1)$ is the probability of being employed in the urban formal labor market rather than in the informal market, or being unemployed. Similar analyses are conducted for the informal workers, urban unemployed and rural workers. The results of the bivariate Probit models are shown in table 2. A higher socioeconomic status, as well as higher level of education, and having other sources of income different than wages, increases the probability of a worker being employed in urban areas, in any of the urban labor markets. Larger families are more likely to be found in rural areas, but with greater chances of being unemployed. When more members of the family are working, the probability of the household being located in urban areas is greater. Finally, older household heads are less likely to be employed in the rural areas or in the formal markets, increasing the probability of unemployment and informal employment in the cities.

Once the bivariate Probits are estimated, Mills ratios for each of the labor markets are calculated as the ratio between the probability density function and the cumulative density function. The Mills ratios are then used in the second stage of the Heckman method as independent variables to calculate the potential wages that each of the workers would earn in each of the markets. Other socioeconomic characteristics of the households are also included

in the regression such as the age of the household head and its square, a dummy equal to one if the household head is a male, education status and its square, marital status, and a dummy variable for department.[3] The results of the linear regressions for estimating the potential wages are shown in table 3.

The potential wages for each of the workers in each of the markets are calculated as the fitted values of wages in the OLS regressions. Changes in wages are applied to each of these potential wages to determine whether or not the worker has an incentive to migrate to other labor markets. Following Cogneau and Robilliard (2006) and Savard (2003), the location of each of the labor markets for worker i is given by the following scheme:

1. The worker i chooses the rural sector if $w_i^R > w_i^E$.
2. The worker i chooses being unemployed if $w_i^0 > w_i^R$, $w_i^0 > w_i^I$, and $w_i^0 > w_i^F - cost_f$.
3. The worker i chooses the informal sector if $w_i^I > w_i^R$, $w_i^I > w_i^0$, and $w_i^I > w_i^F - cost_f$.
4. The worker i chooses the formal sector if $w_i^F - cost_f > w_i^R$, $w_i^F - cost_f > w_i^0$, and $w_i^F - cost_f > w_i^I$,

where w_i^R is the rural potential wage of worker i; w_i^0 is the urban reservation wage of worker i; w_i^I is the informal potential wage of worker i; and $w_i^F - cost_f$ is the formal potential wage of worker i minus a cost of entry to the formal market, which is also estimated econometrically. The definition of the expected wage (w_i^E) which enters into the migration decision of rural workers, follows Harris and Todaro (1970): it is equal to the product between urban wages (both informal and formal wages) and the probability of getting a job in the urban sector (in the informal and formal markets). Unemployment in both urban and rural areas is considered in the migration decision.[4]

[3] Colombia is divided in 32 departments. The capital city, Bogota, has its own geographical division named district capital.

[4] Following official statistics and estimates done by the author, an unemployment rate of 10% is considered in both areas.

Once each of the workers has chosen in which labor market to work, the labor supply is calculated as the sum of the workers in each market, taking into consideration the expansion factors of the survey. The labor supply is then used as an input in the CGE model to calculate a second round of macro changes. The mechanism by which the two models are interconnected is described in section 5, and it is shown in figure 1.

3. THE ALMOST IDEAL DEMAND SYSTEM (AIDS)

The second microeconomic model used to feed the CGE model is the AIDS. The AIDS allows to model households behavior of the CGE model taking into consideration the microeconomic theory. The AIDS was developed by Deaton and Muellbauer (1980) as an alternative approach to the linear and the translog models in the literature. The main difference with the linear models is that the AIDS does not assume straight Engel curves for different households considering the different income levels between groups. Additionally, it is more flexible than the other models, allowing for the estimation of many free parameters as there are independent economic parameters such as the cross-price and income elasticities of demand.

Additionally, two modifications are considered when estimating the AIDS. The first one is the inclusion of an equivalence scale of sociodemographic characteristics that affect the estimation of the expenditure function following the methodology proposed by Ray (1983). The second one is the estimation of the shares using censored data following the two-stage estimation proposed by Shonkwiler and Yen (1999). A similar approach, used by Atuesta and Paredes (2011), calculates the AIDS model for Colombia with censored data to estimate a spatial cost of living index for the country.[5]

According to the AIDS, the preferences of a rational consumer are represented by the

[5]In that paper, only the food consumption is considered, and the estimation is done only for urban areas.

following expenditure function:

$$c(p,u) = (1-u)\log(a(p)) + u\log(b(p)), \tag{3}$$

where

$$\log(a(p)) = \alpha_0 + \sum_{i=m}^{m} \alpha_i \log p_i + \frac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{m} \gamma_{ij} \log p_i \log p_j, \tag{4}$$

and

$$\log(b(p)) = \log(a(p)) + \beta_0 \prod_i p_i^{\beta_i}. \tag{5}$$

Both, namely $\log(b(a))$ and $\log(b(p))$, are homogeneous of degree one in prices satisfying the theoretical restrictions of the expenditure function. Because the consumption shares are the derivatives of the expenditure function with respect to prices (Shepard's lemma), the estimable shares are defined as:

$$s_i = \alpha_i + \sum_{j=1}^{m} \gamma_{ij} \log p_j + \beta_i(\log w - (\alpha_0 + \log a)), \tag{6}$$

where α, β and γ are parameters of the model; s_i is the budget share of good i; p_i is the price of good i; and w is total expenditure.

The first modification of this estimable share is proposed by Ray (1983) who included a general equivalence scale to control for demographic characteristics of each of the households. This equivalence scale enters into the equation twice: the first way is through a basic element which is constant across price distributions and utility $\overline{m}_0$, while the second one is through an element that varies across utility φ. the function φ is defined such that the theoretical restrictions of the expenditure function remain unaffected. For the AIDS, the best way of

defining φ is the following:

$$\varphi(z,p,u) = \exp\left(u\prod_j p_j^{\beta_j}\left\{\prod_j p_j^{\theta_{1j}z_1+\theta_{2j}z_2}-1\right\}\right). \tag{7}$$

The second modification uses censored data in the estimation of the shares, needed to correct for the bias generated by the households that reported zero consumption. Perales and Chavas (2000) analyzes the causes of zero consumption in the case of Colombian households. After studying the distribution of the zero expenditures by income class and within income groups, the authors conclude that the zero shares are explained because some goods are too expensive for some of the households to consume. The bias produced by these corner solutions is reduced by including censored data in the estimation following the methodologies of Heien and Wessels (1990) (H-W hereafter) or Shonkwiler and Yen (1999) (S-Y hereafter).

In this paper the two-stage method proposed by S-Y is used.[6] The first step uses a binary variable equal to one if the household consumed the good and zero otherwise, and regresses it as a function of demographic and socioeconomic characteristics. Probit models are estimated for each of the consumption goods and the cumulative (Φ) and the density (ϕ) probability functions are estimated. In the second step, the estimation of the shares includes the cumulative probability function as a scalar multiplying the non-linear part of the equation, while the density function enters as an extra linear variable in the estimation.

The modified estimable shares, for the nine different consumption categories, with the demographic equivalent scale and censored data has the following functional form:

$$\begin{aligned} s_i = \quad & \Phi[\alpha_i + \textstyle\sum_{j=1}^{m}\gamma_{ij}\log p_j + (\beta_i + \theta i1 z_1 + \theta_{i2}z_2 + \theta i3 z_3)(\log w \\ & -(9+\log(1+\rho_1 z_1+\rho_2 z_2+\rho_3 z_3)+\log a))] + \delta\phi, \end{aligned} \tag{8}$$

[6] S-Y use Monte Carlo simulations to compare the bias reduction of their method with the bias reduction using the methodology proposed by H-W. The results suggest that H-W estimator is inconsistent and performs poorly.

where $\log a = \alpha_0 + \sum_{i=m}^{m} \alpha_i \log p_i + \frac{1}{2} \sum_{i=1}^{m} \sum_{j=1}^{m} \gamma_{ij} \log p_i \log p_j$.

α, β, γ, θ and ρ are parameters of the model; s_i is the budget share of good i; p_i is the price of good i; and w is total expenditure. z_1, z_2 and z_3 are number of persons in the household, education of the household head, and location (rural or urban) of the household respectively; and δ is an extra parameter of the model with no restrictions. In order to maintain the additivity restriction of the shares, the system estimates $n-1$ equations, where n is the number of shares, and the last share is recovered as a residual of the $n-1$ shares.

The β parameters provide information about the characteristics of the goods with respect to income level. If $\beta_i > 0$, an increase in the expenditure would increase the budget share of i, then, the good i is a luxury. On the contrary, if $\beta_i < 0$, the good i is a necessity. The parameters γ measure the changes in the budget shares following a change in the relative prices.

The AIDS model satisfies restrictions of adding-up, homogeneity and symmetry: it adds up to total expenditure (the sum of the budget shares is equal to the total expenditure), it is homogeneous of degree zero in prices and total expenditure, and the total expenditure satisfies the Slutsky symmetry.[7] These theoretical restrictions above are imposed through the linearity of the parameters in the following way:

$$\sum_{i=1}^{n} \alpha_i = 1, \qquad \sum_{i=1}^{n} \gamma_{ij} = 0, \qquad \sum_{i=1}^{n} \beta_i = 0, \qquad \sum_{j=1}^{3} \theta_{ij} = 0, \tag{9}$$

$$\sum_{j} \gamma_{ij} = 0, \tag{10}$$

$$\gamma_{ij} = \gamma_{ji}. \tag{11}$$

[7]The Slutsky symmetry means that $\frac{\partial h_i(p,u)}{\partial p_j} = \frac{\partial^2 e(p,u)}{\partial p_j \partial p_i} = \frac{\partial h_j(p,u)}{\partial p_i}$; where $h_i(.)$ and $h_j(.)$ are the Hicksian demands of goods i and j respectively; p are prices and u is the level of utility.

As in the labor participation model, the GEIH of 2007 for Colombia is used. Unitary prices are only reported for the "food" category. However, the DANE provides price indexes for 79 goods and services for low-, middle- and high-income households. Once the goods and services of the Survey are aggregated into these 79 categories, prices are assigned according to the level of income of the households (low, middle and high). In order to have an AIDS model compatible with the CGE model, the nine categories included in the SAM should be the same as the ones used for the estimation of the AIDS. Following Urzua (2010), the weighting factors for each of the nine goods are calculated for each household:

$$a_{jh} = \frac{w_{jh}}{W_{ih}}, \tag{12}$$

where w_{jh} is the expenditure of household h in the individual good j that belongs to group i (where $j = 1...1{,}055{,}945$), and W_{ih} is the total expenditure of household h in group i (where $j = 1...9$). Using these weights and the unit prices assigned for each of the individual goods, the composite price of group i is calculated as:

$$P_i = p_1^{a_1} p_2^{a_2} \dots p_n^{a_n}. \tag{13}$$

This is the price of group i used in the estimation of the AIDS. The composite expenditure of group i is the sum of the expenditures of each of the goods j which belong to group i. The budget shares are easily estimated by dividing the expenditure of each of the groups over the total expenditure of the household. The AIDS is estimated using a non-linear seemingly unrelated regression (nlsur) where the shares are the dependent variables, and the prices, total expenditures, socio-demographic characteristics and the density functions (ϕ) are the independent variables.

The results of the Probit models estimated in the first stage are shown in table 4. Households with lower socioeconomic status and a greater number of household members have greater probability of consuming food, clothing, housing, health, tobacco and alcohol and

other services; while households with a greater socioeconomic status and lower number of household members have a greater probability of consuming education, transportation and cultural services. The consumption share of food increases when the household head is a female, while the consumption share of the other eight groups increase when the household head is a male. Older household heads have a lower probability of consuming clothing, tobacco and alcohol, and transportation services. The level of education increases the consumption shares of all the consumption groups, and urban households are more likely to have greater consumption shares of housing, education and transportation than rural households.

The coefficients of the estimable shares are shown in table 6. Most of the coefficients are significant at the 95% level, excepting some of the θ parameters of the equivalent component for demographics. The parameters of the AIDS are used to estimate budget shares for all households, and the median share of each income group are then used as parameters for the CGE model. The AIDS model is also used for estimating the welfare measures of each income group, once the changes in income and prices have been calculated in the CGE model.

Two measures of welfare are used in the analysis. The first one is the compensated variation (CV) that measures how much money the consumer has to receive in order to offset the losses of the price increase. The second one is the equivalent variation (EV) that measures how much money the consumer has to give away in order to have a loss equal to the price increase. Both measures answer the same problem: how much extra income is needed in order to offset the price changes. Then, *negative* EV and CV mean that the consumer receives a *gain* in economic welfare, and positive measures mean a loss in economic welfare. The CV and EV are defined as:

$$CV(p^0, p^1, w) = e(p^0, u^0) - e(p^1, u^0) = w - e(p^1, u^0), \tag{14}$$

$$EV(p^0, p^1, w) = e(p^0, u^1) - e(p^1, u^1) = e(p^0, u^1) - w, \tag{15}$$

where $e(p^i, u^j)$ is the expenditure function estimated with prices i and utility j. The expenditure function is calculated using two different price indexes: $log(a)$ which is defined before in equation 8, and $b(p)$ which is defined as:

$$b(p) = \prod_{i=1}^{n} pi^{\beta_i}. \tag{16}$$

4. THE CGE MODEL

4.1 Construction of the Social Accounting Matrix (SAM)

The main source of data for the CGE model comes from the SAM. The SAM is built following Corredor and Pardo (2008) using Colombian data from 2006. The National Department of Statistics, DANE, provides the tables required for the construction of an aggregated SAM: the utilization matrix (UM), the supply matrix (SM) and the general economic equilibrium matrix (GEE). The UM shows the final and intermediate demand for each of the products in the economy. The final demand is disaggregated into domestic consumption and exports. The SM shows the components of the total supply for each product at producers' prices. The final supply consists of imports, domestic production, taxes, import taxes, and commercial and transportation margins. Finally, the GEE shows the economic activities of the institutions. The DANE disaggregates the demand into five institutions: households, financial firms, non-financial firms, government and non-profit organizations.

The production side is disaggregated into ten legal sectors and one illegal sector: illegal drugs, food, housing, clothing, health, education, culture, transportation (infrastructure), addictions (alcohol and tobacco), other services and security. All products, excepting the security and health services, are both imported and exported. The main exports come from the transportation and the food sectors (46% and 16% respectively). The exports of illegal

drugs represent only the 3.37% of the total exports. The highest level of imports is observed in the housing sector followed by the transportation sector (44.35% and 17.93% of the total imports respectively).

Additionally, the DANE provides a "satellite" account for the illegal drug activities which is used to model the illegal drug market. According to the definition provided by the System of National Accounts of 1993 (SNA93), "satellite accounts are linked with the central framework of national accounts and through them to the main body of the integrated economic statistics. (...) Because they preserve close connections with the central accounts, they facilitate analyses of specific fields in the context of macroeconomic accounts and analyses" (SNA, 1993).

The Quality of Life Survey for 2003 and the GEIH of 2007, both conducted by the DANE, are used to disaggregate the factors of production and the demand side of the SAM. Corredor and Pardo (2008) also provide tables explaining how this disaggregation is accomplished. Households are divided into income deciles and labor is disaggregated into three different labor forces, rural labor, urban informal labor, and urban formal labor, and unemployment. However, an additional household disaggregation by location is needed in order to analyze the effects of legalization in rural and urban areas. To accomplish this task, the 2005 Census, also conducted by the DANE, is used to divide households into rural and urban areas. Finally, a disaggregation of households by location and by deciles is obtained yielding in total 20 representative households (ten rural and ten urban).

After the disaggregation, the original SAM is rebalanced using the RAS method first developed by Stone and Brown (1962). Table 6 shows a simplified version of the 2006 SAM used as a benchmark economy for the development of the CGE model. Households are the owners of the factors of production and receive money from them. However, the illegal activity only uses a factor of production called the *illegal factor* which is not paid to the households but to the rest of the world. This account is called *income leakage* and basically represents the opportunity cost of the prohibition (money the households are not receiving because of the illegality of the drugs). The SAM is built in a way that the urban households only provide

urban labor and the rural households only provide rural labor.

4.2 The benchmark economy

The CGE model is drawn following one of the standard frameworks developed by the IFPRI (Lofgren et al., 2002) with additional modifications in order to suit the Colombian economic situation. Colombia is treated as a small-open economy where the international prices are given and are only affected by an exchange rate that is assumed to be flexible (fixed foreign savings). Producers and consumers maximize their profits and utility respectively. Producers use Cobb-Douglas production functions that are estimated endogenously by the model. Consumption is estimated endogenously but using the budget shares previously estimated in the AIDS as exogenous parameters.

Constant elasticity of substitution functional forms are used to measure the imperfect substitution between imports and domestic output sold domestically (the Armington function), and between exports and domestic output sold domestically (also known as the output transformation function). The elasticity of substitution between imports and domestic goods, and the elasticity of substitution between exports and domestic sales are set exogenously.

Capital is fully employed and not mobile, following the assumption that specific capital is needed for each of the economic activities. The "illegal factor" is also fully employed and immobile because it cannot be used for any other economic activity. In both cases, the wages and the factor demands are fixed. Labor supplies in rural areas and in the three different urban labor markets are set exogenously and are estimated using the labor participation model. The households receive money from the factors of production, transfers from the government and transfers from the rest of the world. The government receives income from taxes, tariffs, capital and transfers from the rest of the world; and spends it on consumption (of manufacturing, services, security and health), transfers to households, and savings (or investment depending on the sign of the account). The government is the only institution

that spends money on security because security is considered a public good provided by the state.

The model includes three closures. The first one is that investment is saving-driven, meaning that investment is defined in terms of savings in order to satisfy the savings-investment quality, $SAV - INV = 0$. The second one is the closure of the factors of production: capital and illegal drugs are fully employed and not mobile, and the labor supplies are fully mobile in order to allow migration between different labor markets. Finally, the foreign savings are fixed and the model uses a flexible exchange rate to adjust prices and clear the current account.

5. LINKAGES BETWEEN THE MICROECONOMIC MODELS AND THE CGE

When analyzing the impact of macroeconomic shocks, macroeconomic models should be combined with micro models in order to simulate the effect of the shock in many different dimensions, and consequently, to the specific individual households. This section explains the interaction between the two microeconomic models described above and the CGE model. The shock is imposed to the CGE model affecting all the agents in the economy. Then, changes predicted by the CGE model are then applied to the microeconomic models to simulate the microeconomic behavior of each of the household groups.

When all households are affected by the same policy, it is necessary to analyze not only the micro counterfactual (impacts within the same group), but also the macro counterfactuals (impacts between different groups) (Bourguignon et al., 2008). The literature describes several methods to introduce micro analysis in macroeconomic models. The simplest one is to introduce heterogeneous representative households in the CGE models. Instead of assuming that all households behave in the same way (one representative household at the national level), the assumption here is that all households *within* a specific group behave in the same way. This approach is useful when the policy implemented does not affect the intra-distribution of income within each of the household groups. Extensions of this approach have tried to

increase the level of household's behavior heterogeneity by including as many representative households in the CGE as the number of households in the economy (see Lofgren et al., 2003; and Dervis et al., 1982).

The macro models with representative households have been criticized because it is not possible to model microeconomic behavior within groups with just one observation (one representative household per group). Then, all households must have the same budget shares because the demand is not estimated econometrically (Bourguignon et al., 2008). To introduce household level data in macro models, three approaches have been suggested by the literature: the top-down accounting modeling, the top-down simulation modeling, and the feedback loops from top to bottom. The top-down accounting modeling uses results from the CGE model as a shock to the household level micro model to estimate policy implications at the microeconomic level. The households in this case do not change the behavior of consumption or labor participation with the new information. The changes from the CGE model only affect the outcome of the micro model without considering behavioral effects. The criticism of this approach is that it is only consistent when the markets are competitive or when the changes at the macro level only affect in a marginal way the budget of individuals (Bourguignon et al., 2008).

The top-down simulation modeling considers the behavioral responses of individual from a macro shock. When changes in prices, income and wages are calculated at the macro level, these changes enter into the decision-making of the households changing their consumption and labor participation patterns. With non-competitive markets or rationed markets, considering these second-round effects is needed in order to have a simulation consistent to household economic behavior.

Finally, Savard (2003) suggests a third method that includes feedback loops from top to bottom until convergence is achieved. He explains that, in order to have coherence between the CGE model and the household models, it is necessary to obtain a converging solution between the two models. When these results are compared with those that use only a top-

down approach, Bourguignon and Savard (2008) show that a bias is generated by ignoring the feedback effects from the micro to the macro models, particularly when analyzing labor markets.

In this specific case, feedback loops from top to bottom are considered between the CGE and the labor participation models using behavioral responses at the micro level. A diagram explaining how this interaction works is shown in figure 1. When the shock is implemented in the CGE model, changes in prices, wages and household income are calculated. Workers receive information about the new wages and migrate according to their individual preferences, following the labor participation scheme proposed in section 2. Once workers move from one labor market to the other, the total number of workers in each labor market is re-estimated in order to calculate the new labor supplies. These new labor supplies are then compared to the initial supply levels and the percentage changes are used to "feed" the CGE model.

The CGE model receives this new information about the labor supplies as a shock to change again prices, income and wages. A new level of wages is calculated and used again in the labor participation model to calculate changes in labor supplies. These iterations between the CGE model and the labor participation model continue until the models achieve convergence. According to Savard (2003), by including these iterations between the micro and the macro model, the bias of using different data sources in each of the model is minimized and the simulations produce more accurate results.

The iteration between the CGE model and the AIDS is simpler. The AIDS is used to estimate the consumption shares of each of the household groups, and these shares are included as parameters in the CGE model. The shock is imposed in the CGE model and the iteration between the CGE model and the labor participation model begins. Once these two models find convergence, the changes in prices and income of the CGE model are used in the AIDS to calculate the welfare measures for each of the household groups. These measures are calculated based on a median representative household, but they can also be calculated for different percentiles of the intra-group income distribution.

Both, the labor participation model and the AIDS use the feedback loops with the CGE model as shown in figure 2. However, only the labor participation model assumes microsimulations in which the individual behavior is fed from the macro shock, and at the same time, it estimates the changes in labor supply that are going to be used for the reestimation of the macro shock itself. The relationship between the AIDS model and the CGE model is straightforward: the shares are used *ex ante* to the macro shock, and the AIDS parameters are used *ex post* for the estimation of welfare measures once the utility and the expenditure functions, evaluated at the new prices and income, have been recovered.

6. CONCLUSIONS

In this paper, a methodology that links macro models to microeconomic models is explained. This methodology is useful for simulating the effects at the household level of imposing a macroeconomic shock to the economy. Because the shock would affect all the agents of the economy, a general equilibrium framework is needed. Once the changes at the macro level have been calculated, the microeconomic models are used to estimate the impact of the shock at the household level. In this specific example, two microeconomic models are used in order to understand migration decisions following labor participation of individuals, and consumption patterns.

Assuming imperfect labor markets with unemployment, using only top-down accounting models does not provide a result consistent with microeconomic behavior. For this reason, it is necessary to link the labor participation model and the CGE model using simulation techniques and feedback loops from top to bottom. The simulation techniques take into consideration the behavioral responses of households to the shock. In other words, the shock would change not only the outcome of the household decision, but the household taking-decision process itself. In the case of the AIDS model, this simulation is not needed because the changes only affect marginally the household budgets. Then, once the budget shares are

estimated in a first round and included in the CGE model, the macro shocks are calculated and the results are used for the calculation of welfare measures.

By using data for Colombia, and an application that simulates the effect of legalization of drugs in the Colombian economy, this methodology is used in Atuesta (2011) to calculate the changes in economic welfare of households. The CGE and the labor participation models converge after three iterations, and the AIDS is then used for calculating welfare measures. After estimating six scenarios with different assumptions about the prices, future of the armed conflict predictions, and government reinvestment, the author concludes that the economic welfare gains of legalizing drugs are too small if the social cost of war and drug addiction is not considered.

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Table 1: Summary of statistics of demographic characteristics of households by labor sector

	Labor sectors			
	Rural	Unemployed	Informal	Formal
Ln wage	14.78	0	14.08	14.95
	(1.64)	(0)	(3.23)	(3.12)
Male (%)	0.71	0.45	0.68	0.75
	(0.45)	(0.50)	(0.47)	(0.44)
Age HH head	48.13	57.63	45.73	41.21
	(15.70)	(17.12)	(12.62)	(41.21)
Education	2.65	3.25	3.47	4.52
1-6 (low-max)	(1.81)	(1.82)	(1.72)	(1.54)
Number of kids	3.76	3.59	3.75	3.47
(<3 years old)	(1.96)	(2.04)	(1.86)	(1.61)
Husband (%)	0.64	0.43	0.63	0.69
or wife	(0.48)	(0.49)	(0.48)	(0.46)
Working persons	1.40	0.91	1.77	1.67
in HH	(0.94)	(1.04)	(0.93)	(0.82)

Figure 1: Interaction between the labor participation model and the CGE model: Estimation of wages and labor supplies

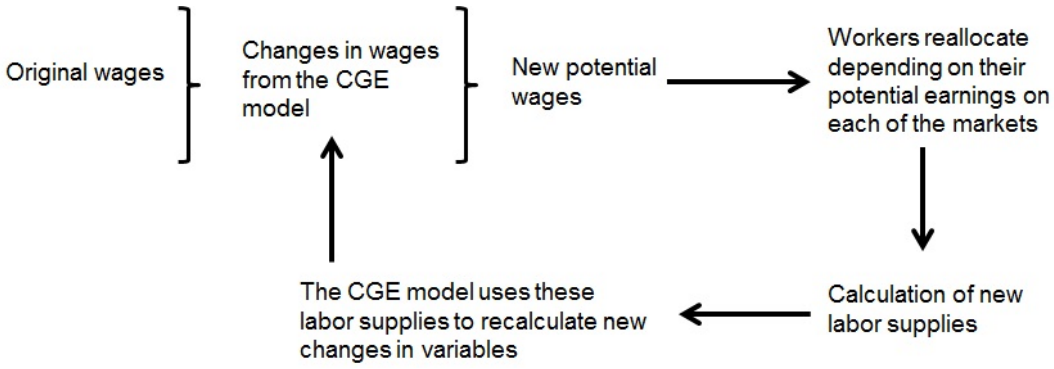

Table 2: Bivariate Probit models for the different labor markets.

First Probit	**Prob. Rural**		**Prob. Urban**		**Prob. Urban**		**Prob. Urban**	
	coefficient	**S.E.**	**coefficient**	**S.E.**	**coefficient**	**S.E.**	**coefficient**	**S.E.**
socioec. status	-0.31	0.0004	0.28	0.0004	0.30	0.0004	0.30	0.0004
No. persons in HH	0.01	0.0003	-0.01	0.0003	-0.02	0.0003	-0.02	0.0003
No. occupied	-0.04	0.0005	0.08	0.0005	0.10	0.0005	0.10	0.0005
male	0.19	0.0009	-0.20	0.0009	-0.16	0.0009	-0.17	0.0009
education	-0.16	0.0003	0.16	0.0003	0.16	0.0003	0.17	0.0003
marital status	-0.10	0.0016	0.03	0.0016	0.09	0.0016	0.07	0.0016
other income	-0.36	0.0011	0.39	0.0011	0.38	0.0011	0.39	0.0012
age HH head	0.00	0.0000	0.00	0.0000	0.00	0.0000	0.00	0.0000
constant	1.15	0.0025	-1.02	0.0026	-1.09	0.0025	-1.02	0.0025
Second Probit	**Prob. Employed**		**Prob. Unemployed**		**Prob. Informal**		**Prob. Formal**	
	coefficient	**S.E.**	**coefficient**	**S.E.**	**coefficient**	**S.E.**	**coefficient**	**S.E.**
socioec. status	-0.26	0.0004	0.17	0.0005	0.06	0.0005	0.18	0.0005
No. persons in HH	-0.02	0.0003	0.09	0.0003	-0.06	0.0003	-0.05	0.0003
No. occupied	0.10	0.0005	-0.36	0.0006	0.25	0.0005	0.23	0.0005
male	0.60	0.0010	-0.58	0.0010	0.10	0.0010	0.26	0.0010
education	-0.13	0.0003	0.08	0.0003	0.02	0.0003	0.18	0.0003
marital status	-0.06	0.0017	0.10	0.0017	0.00	0.0019	0.12	0.0019
other income	-0.54	0.0013	0.57	0.0011	-0.11	0.0014	-0.12	0.0014
age HH head	-0.01	0.0000	0.02	0.0000	0.00	0.0000	-0.02	0.0000
constant	0.71	0.0026	-2.41	0.0030	-1.22	0.0029	-1.27	0.0029
N	10974961.00							
rho	0.9956	0.0000	0.9950	0.0001	0.9731	0.00035	0.9867	0.0004
Log likelihood	-8736257.00		-9171928.80		-9860755.70		-9838944.10	

All the estimations are weighted by the expansion factors to be representative of the population.

Table 3: OLS estimates for the prediction of wages for each worker in each of the labor markets.

	log (rural wage)		**log (reservation wage)**		**log Informal wage)**		**log (formal wage)**	
	coefficient	**S.E.**	**coefficient**	**S.E.**	**coefficient**	**S.E.**	**coefficient**	**S.E.**
age HH head	0.0461	0.0002	0.0183	0.0005	0.0114	0.0010	0.1059	0.0012
age^2	-0.0004	0.0000	-0.0002	0.0000	-0.0002	0.0000	-0.0012	0.0000
male	0.3606	0.0015	0.2433	0.0034	0.3684	0.0047	0.1915	0.0038
education	-0.0756	0.0012	-0.3125	0.0036	-0.2016	0.0066	-0.3915	0.0049
$education^2$	0.0396	0.0002	0.0266	0.0005	0.0347	0.0008	0.0452	0.0006
marital status	0.6854	0.0026	0.8367	0.0029	1.0370	0.0093	0.1973	0.0065
Mills ratio	0.3929	0.0061	-1.4831	0.0084	-1.0332	0.0140	-1.6799	0.0122
constant	12.5161	0.0062	15.6193	0.0180	15.1608	0.0319	15.1714	0.0281
R2	0.1534		0.1269		0.1057		0.0879	
N	4,833,540		2,127,235		1,652,804		2,361,382	

Robust standard errors. Regressions are weighted by the expansion factors. All regressions include dummy variables for department.

Table 4: Probit estimation for household consumption: first stage of S-Y estimator.

	group 1	group 2	group 3	group 4	group 5	group 6	group 7	group 8	group 9
socioec. Status	-0.1614	-0.0863	-0.0040	-0.0012	0.0130	0.0733	0.0069	-0.0374	-0.1408
No. persons	0.0245	0.0282	0.0217	0.0033	0.3149	-0.0048	-0.0176	-0.0056	0.0363
No. persons working	-0.0055	-0.0079	0.1200	0.0556	-0.1266	0.1619	0.2458	0.1615	-0.0282
male	-0.0459	0.1872	0.1067	-0.0313	0.0961	0.2163	0.0669	0.3042	0.1597
skill	-0.0436	0.0381	0.0582	0.0324	-0.0457	0.0903	0.0885	0.0173	-0.0114
age partner	-0.0021	-0.0019	-0.0064	0.0016	-0.0156	-0.0050	0.0020	0.0043	-0.0018
age HH head	0.0056	0.0094	-0.0058	0.0015	0.0032	0.0009	-0.0016	-0.0045	0.0042
wage	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
education	0.0244	0.0727	0.0822	0.0565	0.1020	0.0952	0.1084	0.0492	0.0732
rural vs. urban	-0.2122	0.0971	-0.0243	-0.0620	0.0923	-0.0318	0.1109	-0.0434	0.1175
constant	1.3947	1.1752	0.1795	-0.1000	-0.7316	-1.1083	-0.3018	-1.2466	1.4080
Pseudo R2	0.0263	0.0144	0.0334	0.0089	0.1097	0.0468	0.0593	0.0307	0.0154

All the estimations are weighted by the expansion factors to be representative of the population.

All coefficients are significant at 0.005 level.

The groups are the following: 1: food; 2: housing; 3: clothing; 4: health;

5: education; 6:culture; 7:transportation; 8: tobacco and alcohol; 9: other services.

Table 5: Coefficients of the AIDS model with censored data and equivalent component.

	Coeff.		Coeff.		Coeff.		Coeff.		Coeff.
α_1	0.287***	γ_{11}	-0.233***	θ_{11}	0.014***	δ_1	-0.217***	ρ_1	-0.841***
α_2	0.137***	γ_{12}	0.053***	θ_{21}	0.013***	δ_2	0.497***	ρ_2	0.896***
α_3	-0.063***	γ_{13}	0.134***	θ_{31}	-0.009***	δ_3	0.142***	ρ_3	-0.071***
α_4	0.018***	γ_{14}	0.026***	θ_{41}	-0.000	δ_4	0.052***		
α_5	0.097***	γ_{15}	0.085***	θ_{51}	0.006***	δ_5	0.048***		
α_6	0.058***	γ_{16}	0.035***	θ_{61}	-0.001***	δ_6	0.059***		
α_7	0.285***	γ_{17}	0.067***	θ_{71}	-0.036***	δ_7	0.184***		
α_8	-0.085***	γ_{18}	0.072***	θ_{81}	0.018***	δ_8	0.183***		
β_1	-0.080***	γ_{22}	-0.162***	θ_{12}	-0.002***				
β_2	0.026***	γ_{23}	0.048***	θ_{22}	0.000***				
β_3	0.023***	γ_{24}	0.002***	θ_{32}	0.000**				
β_4	0.001***	γ_{25}	0.017***	θ_{42}	0.000				
β_5	0.026***	γ_{26}	-0.026***	θ_{52}	0.000***				
β_6	-0.003***	γ_{27}	0.098***	θ_{62}	0.001***				
β_7	0.058***	γ_{28}	-0.005***	θ_{72}	-0.001***				
β_8	-0.072***	γ_{33}	-0.227***	θ_{82}	0.005***				
		γ_{34}	-0.007***	θ_{13}	0.005***				
		γ_{35}	0.027***	θ_{23}	-0.001***				
		γ_{36}	-0.024***	θ_{33}	-0.006***				
		γ_{37}	0.079***	θ_{43}	-0.001***				
		γ_{38}	0.074***	θ_{53}	-0.002***				
		γ_{44}	-0.061***	θ_{63}	0.003***				
		γ_{45}	0.022***	θ_{73}	-0.001***				
		γ_{46}	-0.005***	θ_{83}	0.003***				
		γ_{47}	0.010***						
		γ_{48}	0.004***						
		γ_{55}	-0.030***						
		γ_{56}	-0.075***						
		γ_{57}	0.033***						
		γ_{58}	0.015***						
		γ_{66}	0.096***						
		γ_{67}	0.053***						
		γ_{68}	-0.027***						
		γ_{77}	-0.358***						
		γ_{78}	0.163***						
		γ_{88}	-0.235***						

1) *, ** and *** represent the level of significance to 10%, 5% and 1%, respectively.

Table 6: Colombian 2006 Social Accounting Matrix with illegal drugs

		1...11	12...22	23...27	28...49	50	51	52...54	55	Total
Activities	1. Illegal 2. Food 3. Housing 4. Clothing 5. Health 6. Education 7. Culture 8. Transp. 9. Alcohol 10. Other ss 11. Security		Product.				Invest.			
Goods	12 - 22	Int.Cons.			Consumpt.	Consumpt.			Exports	
Factors of Production	23. Rural labor 24. Informal labor 25. Formal labor 26. Capital 27. Illegal factor	Value Added		Income from factors of produc.						
Institutions	28. Non-financial firms 29. Financial firms 30. Rural HH decile 1 31. ... 38. 39. Rural HH decile 10 40. Urban HH decile 1 41. ... 48. 49. Urban HH decile 10				Transfers	Transfers			Transfers	
	50. Government 51. Savings-Investment 52. Income tax 53. Sales tax 54. Tariffs 55. ROW		Taxes Tariffs Imports	Inc.leakage	Savings taxes	Savings		Revenue	Transfers Ext.savings	
TOTAL										

Figure 2: Model structure: interaction between micro models and CGE model