HAL
open science

Households heterogeneity in a global CGE model: an illustration with the MIRAGE-HH (MIRAGE-HouseHolds) model

Antoine Bouet, Carmen Estrades, David Laborde

To cite this version:

Antoine Bouet, Carmen Estrades, David Laborde. Households heterogeneity in a global CGE model: an illustration with the MIRAGE-HH (MIRAGE-HouseHolds) model. 2013. hal-00780103v2

HAL Id: hal-00780103

https://hal.science/hal-00780103v2

Preprint submitted on 28 Jan 2013

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

larefi Working Paper
Laboratoire d'Analyse et de Recherche en Économie et Finance Internationales

Households heterogeneity in a global CGE model: an illustration with the MIRAGE-HH (MIRAGE-HouseHolds) model

Antoine Bouet, Carmen Estrades and David Laborde

LAREFI Working Paper N°2013-01

Janvier 2013

http://lare-efi.u-bordeaux4.fr

LAREFI
Université Montesquieu-Bordeaux IV
Bâtiment Recherche Economie – 1er étage
Avenue Léon Duguit – 33 608 Pessac

LAREFI – LABORATOIRE D'ANALYSE ET DE RECHERCHE EN ECONOMIE ET FINANCES INTERNATIONALES

AUTHORS

Antoine Bouet, LAREFI, Université Montesquieu Bordeaux IV and IFPRI Washington DC

Carmen Estrades, International Food Policy Research Institute (IFPRI)

David Laborde, International Food Policy Research Institute (IFPRI)

NOTICES

LAREFI Working Papers contain preliminary material and research results. They have been peer reviewed. They are circulated in order to stimulate discussion and critical comment; any opinions expressed are only those of the author(s).

Copyright LAREFI. All rights reserved. Sections of this material may be reproduced for personal and not-for-profit use without the express written permission of but with acknowledgment to LAREFI. To reproduce the material contained herein for profit or commercial use requires express written permission. To obtain permission, contact LAREFI at cyril.mesmer@u-bordeaux4.fr.

Sommaire

1. Introduction 7
2. Trade liberalization and poverty 9
2.1 Trade and poverty: what theory predicts 9
2.2 Trade and poverty: the empirical evidence 10
2.3 Trade and poverty: the methodological debate 12
2.4 Micro-macro synthesis 15
2.4.1. Static vs. dynamic microsimulation framework 18
2.4.2. Country level vs. global framework 18
3. Methodological improvements of this paper 20
3.1 Including households' heterogeneity in the MIRAGE model 20
3.1.1 The public agent 20
3.1.2 Households' behavior 24
3.1.3 Endogenous inter-household private transfers 28
3.2 The data 30
3.2.1 Microdata 31
3.2.2 Clustering analysis 33
3.2.3 Incorporation into the model 33
3.3 Poverty analysis 35
3.4 Advantages of the new methodological framework 36
4. An application of the new MIRAGE-HH model: impact full trade liberalization on household's welfare and poverty 37
4.1 Database, disaggregation of households and simulation scenario 38
4.2 Impact of full trade liberalization with the traditional model with a single household in each country 40
4.3 Impact of trade liberalization with MIRAGE-HH household disaggregation in five countries 42
4.4 Adjustement through a consumption tax vs. through an income tax 47
4.5 Price effect vs. income effect 52
4.6 A decomposition of the income effect 56
4.7 Impact on poverty and inequality 57
5. Conclusion 59
6. References 62

List of table

Table 1. Sectoral Disaggregation 38
Table 2. Geographical disaggregation 39
Table 3. Analysis of intra and inter household income variance. Per capita income. Theil index and Atkinson(1) index 39
Table 4. Household surveys used 40
Table 5. Impact on macroeconomic variables - Single household version of MIRAGE - 2025 - Scenario/Baseline, percent variation 42
Table 6: Impact on poverty and inequality 58

List of figure

Figure 1 The representative agent in the traditional version of MIRAGE..... 21
Figure 2 The representative and public agent in the new version of MIRAGE..... 22
Figure 3 The new version of MIRAGE with household heterogeneity 26
Figure 4: Framework to build a systematic and flexible treatment for a global model 31
Figure 5: Brazil - 2025 - Impact of full trade liberalization on households'welfare 43
Figure 6: Pakistan - 2025 - Impact of full trade liberalization on households'welfare 44
Figure 7: Tanzania - 2025 - Impact of full trade liberalization on households'welfare 45
..... 45
Figure 8: Uruguay - 2025 - Impact of full trade liberalization on households'welfare..... 45
Figure 9: Vietnam - 2025 - Impact of full trade liberalization on households' welfare 46
Figure 10: Brazil - 2025 - Impact of full trade liberalization on households' welfare 48
Figure 11: Pakistan - 2025 - Impact of full trade liberalization on households' welfare 48
Figure 12: Tanzania - 2025 - Impact of full trade liberalization on households' welfare 49
..... 49
Figure 13: Uruguay - 2025 - Impact of full trade liberalization on households' welfare..... 49
..... 49
Figure 14: Vietnam - 2025 - Impact of full trade liberalization on households' welfare 50
Figure 15: Brazil - 2025 - Decomposition of the total impact of full trade liberalization on households'welfare into a price effect and an income effects 54
Figure 16: Pakistan - 2025 - Decomposition of the total impact of full trade liberalization on households'welfare into a price effect and an income effects 54
Figure 17: Tanzania- 2025 - Decomposition of the total impact of full trade liberalization on households'welfare into a price effect and an income effects 55
Figure 18: Uruguay - 2025 - Decomposition of the total impact of full trade liberalization on households'welfare into a price effect and an income effects 55
Figure 19: Vietnam - 2025 - Decomposition of the total impact of full trade liberalization on households'welfare into a price effect and an income effects 56
Figure 20: Brazil - 2010/2025 - Dynamic impact of full trade liberalization on households' welfare..... 69
Figure 21: Pakistan - 2010/2025 - Dynamic impact of full trade liberalization on households' welfare..... 69
Figure 22: Tanzania - 2010/2025 - Dynamic impact of full trade liberalization on households'welfare 72
Figure 23: Uruguay - 2010/2025 - Dynamic impact of full trade liberalization on households'welfare 72
Figure 24: Vietnam - 2010/2025 - Dynamic impact of full trade liberalization on households'welfare 73
Figure 25: Brazil - 2025 - Decomposition of the variation of households' disposable income ... 73
Figure 26: Pakistan - 2025 - Decomposition of the variation of households' disposable income 74
Figure 27: Tanzania - 2025 - Decomposition of the variation of households' disposable income 74
Figure 28: Uruguay - 2025 - Decomposition of the variation of households' disposable income 75
..... 75
Figure 29: Vietnam - 2025 - Decomposition of the variation of households' disposable income 75

Abstract

The objective of this paper is to develop a version of the MIRAGE model with household heterogeneity and a public agent, to better analyze the impact of trade liberalization and other trade reforms on real income and welfare at the household level In a first step, the model disaggregates the representative household into up to 13-39 households in five developing countries (Brazil, Pakistan, Tanzania, Uruguay and Vietnam). The sources of income and consumption structure reflect disaggregated statistical information coming from households' surveys. The new model better captures the behavior of the public agent in terms of revenues collected and in terms of expenditures. Since domestic remittances may constitute an important determinant of income redistribution, the new version also endogenizes private inter-households transfers. This new version of MIRAGE takes into account the reaction of households to these shocks in an integrated and consistent framework. We study the impact of full trade liberalization on these households. This study concludes that: (i) while the impact of full trade liberalization may be small at the macroeconomic level, the effect on households' real income may be quite substantial at the household level with a great heterogeneity in terms of results; (ii) the major channel of heterogenity of the impact of trade liberalization on households' real income is productive factors' remuneration while the channel of consumption prices of commodities has limited impact; (iii) various domestic policies simultaneously implemented to trade liberalization like modification of public transfers to households or changes in income taxation may significantly change the picture and offer compensation for negative effects of this shock or amplify direct impact of full trade liberalization; (iv) the impact of trade reform on poverty and inequality is significant and diverse from one country to the other.

Keywords: CGE modeling, poverty, trade liberalization, households survey

JEL classification: F11, F17, O19.

1. Introduction

Poverty in developing countries can be directly impacted, either negatively or positively, by international shocks at the worldwide level, such as climate change, financial crises, volatility of world food prices, major trade agreements, domestic policies in rich countries (e.g. agricultural domestic support, biofuel mandates...). The channels of transmission of external shocks to poverty are manifold: changes in price of goods and factors, changes in public revenue and impact on transfers to the poor, short term risks, adjustment costs, etc. It is therefore important to develop a consistent and detailed modeling instrument that allows i) understanding these different channels of transmission, and ii) accounting for changes in poverty in developing countries when these shocks occur.

The objective of this paper is to develop a new version of the MIRAGE model of the world economy in an integrated framework in order to tackle this issue[1]. A new version of this model is developed and it is enriched with disaggregation of households in some developing countries. Herein we develop the model and we test it with households disaggregation in five developing countries: Brazil, Pakistan, Tanzania, Uruguay and Vietnam. For each country, the model disaggregates the representative household into up to 13-39 households, applying a clustering procedure. The sources of these households' income and consumption structure strictly reflect disaggregated statistical information coming from households' surveys. Moreover, the new model better captures the behavior of the public agent in terms of revenues collected and in terms of expenditures but it also endogenizes private inter-households transfers which may play an important role in case of trade reform.

This new version of MIRAGE allows studying the impact of various policy shocks and identifying which households are expected to win, which households are expected to lose and why,

[1] The MIRAGE model is a dynamic multi-sector multi-country Computable General Equilibrium Model. See Bchir et al., 2002 and Decreux and Valin, 2007.

while taking into account the reaction of households to these shocks. This version is dynamic and models the long term evolution of the various strata of households[2]. A systematic procedure is developed to reconcile disaggregated statistical information coming from households' surveys and the GTAP database. This allows a large flexibility in order to add countries to the scope of study. It represents a considerable improvement of the MIRAGE model.

To our knowledge, it is the first global CGE model with household disaggregation. This paper is the first step of a long term research project. In the long run, the model will include more countries with household disaggregation and a higher number of household categories in each country. We also intend to study dynamic relation that we think are important concerning the impact of trade reform on poverty and income distribution, in particular households' savings and households investment in education[3].

In this first step, we test the model by simulating full trade liberalization at the world level. As various studies have already evaluated the potential impact of full trade liberalization on poverty, this exercise will allow comparing these first results to results from past studies. In section 2 we present the methodological and analytical debate regarding trade and poverty. In section 3 we present the methodological framework developed for this paper: first improvements introduced to MIRAGE to model the public agent and to include disaggregation of households, second the way statistical information coming from households' survey has been treated and reconciled to the GTAP database on which the MIRAGE model is grounded, and third the micro-accounting procedure to extend the analysis at a micro-level. Section 4 presents the shock implemented, the data used for this exercise and the results obtained, using both the traditional version of MIRAGE with a unique representative agent by country and the new version with household disaggregation. While pointing out the heterogeneity of individual situations we also identify in Section 4 the main channels through which trade liberalization impacts individual situations. We also discuss various rules of indexation of public transfers and closure to the public accounts. Finally, Section 5 concludes.

[2] Until now we have neglected this aspect and ony included proportional changes in the evolution of strata. We will focus on this aspect in the near future.
[3] This will be done in the coming months

2. Trade liberalization and poverty

In the last decade, several efforts have been made to analyze the effects of trade liberalization and other trade policies on poverty in developing countries. Classical and neo-classical trade theory generally predicts welfare gains as a consequence of trade liberalization. However, theory has proved insufficient to explain the complex links between trade liberalization and poverty in developing countries, so it turns down to be an empirical question. In recent years, discussion has become empirical and methodological. This section presents the most recent contributions to this debate.

2.1 Trade and poverty: what theory predicts

In general, classical trade theory predicts an increase in welfare associated with trade liberalization[4]. Efficiency gains from trade openness are mostly static and a consequence of improved resource reallocation of the economy. In a two-country, two-good, two-factor model, Heckscher-Ohlin theory predicts an increase in exports and production in the sector which employs more intensively the abundant factor of production of the economy. Since developing countries tend to be more abundant in unskilled labor, trade would improve unskilled labor real remuneration (Stolper-Samuelson theorem) which will increase more than proportionally to the increase in the price of the produced good (magnification effect, first presented by Jones, 1965). More modern trade theory also predicts dynamic efficiency gains as a consequence of liberalization, due to economies of scale, diffusion of information, technology transfers, spillover effects, etc. However, these elegant and powerful theories fail in explaining the impact of trade liberalization when other things are taken into account, such as non-tradable goods, non-homogenous goods, specific factors or segmented labor markets (Winters 2002).

[4] Ricardo considers the case of a country in perfect competition moving from autarky to free trade. Base on more realistic assumptions, other authors (Bickerdike 1906 -large countries-, Viner 1950 -custom unionamongst others) have shown that trade liberalization may reduce welfare. This remains specific cases in generally positive view of the impact of free trade on an economy.

2.2 Trade and poverty: the empirical evidence

The shortcomings of trade theory to fully explain the links between trade and poverty have turned the debate into an empirical one. Several authors have developed conceptual frameworks that are fed with theory and empirics. Among them, Winters (2002) develops an analytical framework and identifies six main channels of transmission of external shocks to poverty[5]5:

- Price and availability of goods. Full trade liberalization should lead in each country to an increase of domestic prices of exportables goods and a reduction in prices of imported goods, as long as price transmission mechanisms work properly. The impact on each household's real income depends on households' consumption structure at a detailed level, and on the ability of the household of accomodate this structure given relative price changes. If trade reform allows households to have access to new goods and services, welfare can also be enhanced.

- Factor prices, income and employment. The impact on each household's real income will depend on households' source(s) of income, on how households' endowment in primary factors can be reallocated across different sectors of activity (intersectoral factor mobility), on the relative change in factor prices, on the impact on employment and the characteristics of the households hurt by unemployment.

- Government transfers. Full trade liberalization implies a loss of public revenues which can be compensated or not by an increase of different taxes (lump-sum taxes, income taxes, indirect taxes) and/or a decrease in public expenditures or public transfers to households and/or a reduction in the public budget surplus. Households are differently impacted depending on how they rely on public transfers and/or how the public agent reacts to this initial variation in public revenues.[6]

- Incentives for investment and innovation that affects long term growth. National investment can either augment or contract depending on the impact of trade liberalization on remuneration of capital, on private and public savings. Trade liberalization also affects land supply and may have a long term impact on the split of the population bewteen skilled vs. unskilled workers

[5] throughout this enumeration we will envisage the impact of full trade liberalization on developing countries' households, but another type of shock may be considered

through the remuneration of these factors. Trade liberalization may also affect labor supply and the time share between leisure and work.This process should also favor innovation. Increased accumulation of capital, land and skilled labor effects can boost economic growth which usually leads to poverty reduction.

- External shocks and in particular changes in terms of trade. Variations in terms of trade are related to openness of foreign and domestic markets. The former can either be positive (more demand for national exportable commodities thanks to the elimination of protection previously taxing these exports) or negative (less demand for national exportable commodities thanks to an erosion of initial preferences). Opening domestic markets usually leads to increased national demand for foreign products that translates in augmented import prices and deterioration of terms of trade.

- Short run risks and adjustements costs. The impact of trade liberalization on households' real income may be negative in the short term, but positive in the long term when considering the capacity of reallocation of productive factors to sectors in expansion. This reallocation takes time and implies adjustment costs in the short term. One of the most significant adjustment costs to the poor is the rise in transitional unemployment.

Nissanke and Thorbecke (2006) also present an analytical framework in which they establish the different channels through which trade liberalization affects poverty, and provide some empirical evidence about the way these channels work. They emphasize the intermediate role of inequality as a link between globalization and poverty. Factors such as differential cross-border mobility, technical progress and information flows (see Nissanke and Thorbecke 2006) might affect negatively inequality and thus not reduce poverty as a consequence of liberalization. They also warn that the most frequently mentioned channel of transmission of liberalization to poverty, the globalization-growth-inequality-poverty, is not automatic and conclude that the pattern and structure of growth obtained from liberalization will be a determinant of the ultimate impact of liberalization on poverty.

Bhagwati and Srinivasan (2002) focus on the impact of trade liberalization on poverty in poor countries. They group the effects in two: static effect and dynamic effects. Among the former, they include the effect predicted by Stolper-Samuelson theorem –poor countries present usually comparative advantages in sectors that employ more intensively unskilled labor- and they also

consider the positive effect of macroeconomic stabilization policies that usually are implemented together with trade liberalization on domestic prices. The dynamic argument is that openness brings about growth and thus reduces poverty.

Winters, McCulloch and McKay (2004) review the empirical evidence that supports the links between trade and poverty thanks to a meta-analysis. They provide a rigorous review of literature under the analytical framework presented by Winters (2002). Some of the links included in the framework seem to be more empirically supported than others. For example, the link between trade and growth is not very clear, but there is strong evidence supporting a positive effect of trade on productivity. Similarly, there seems to be a weak link between trade and employment and wages of poor workers, as well as low evidence supporting a fall in government spending on the poor. However, in these cases, as well as in others, there is evidence of exceptions. The authors conclude than in general the link between trade and poverty seems to be a positive one, which could be complemented with adjustment policies to boost the positive impacts or mitigate the negative impact on the poor. Finally, some knowledge gaps, such as the effect of trade on poverty dynamics at the household level, should be addressed.

2.3 Trade and poverty: the methodological debate

Given the different channels through which trade liberalization and other external shocks may affect poverty in specific countries, there is also a rich debate about the best methodological approach or approaches to captures these channels.

Hertel and Reimer (2005), in an extensive review about the effects of trade liberalization on poverty, broadly define four categories of studies according to the methodology applied : partial equilibrium or cost of living analysis; general equilibrium models; micro-macro synthesis ; and studies that analyze the long run effects of trade liberalization focusing on the impact on economic growth. The authors conclude that both macro and micro methodological approaches should be considered. Trade liberalization and trade shocks affect poverty through different channels, as Winters (2002) pointed, but some of the links have been more deeply analyzed in literature than others. One issue less explored has been the labor market. According to the authors, “labor market deserves the greatest attention by those studying trade and poverty”, because the main endowment of the poor is

their own labor. If poor households are more dependent on unskilled labor income, those trade shocks that affect unskilled labor remuneration will increase poverty. The authors consider that CGE models are the most suitable tools for analyzing these links, because they model explicitly the labor market. However, the majority of trade-poverty linkages are captured by studies that combine general equilibrium models with detailed household information, even when this approach is not "necessarily elegant in a theoretical sense". Bourguignon and Pereira da Silva (2003) and Bourguignon et al (2002) also consider that macro-micro syntheses are the most suitable methodological approach to analyze the impact of macroeconomic policy on poverty and income distribution. In both reviews, the authors present different approaches that combine macro model with micro approaches.

Kraev and Akolgo (2005) also compare four methods for evaluating the impact of macro reforms on poverty: fixed ratio, econometric, CGE and microsimulation models. They conclude that CGE models perform better than the rest of the methods in five criteria: i) representing specific policy levers used in the policy package; ii) providing flexibility in modeling production and employment structures; iii) representing interactions between macroeconomic variables and the production structure; iv) representing short- and medium-term dynamics rather than just long-term equilibria; and v) producing measures of confidence for the model's output. The main problem of econometric models is that they do not deal very efficiently with many simultaneous, nonlinear equations, and are not suited for representing a disaggregated production structure and the many causal channels that a macro policy package can work through.

Ravaillon (2005) also warns about the shortcomings of applying cross-country comparisons, to which he refers as "macro-lenses", in order to analyze the impact of trade on poverty. Cross-country comparisons raise concerns about data and econometric specifications, which include different control variables and assumption in the error terms. Besides, cross-country comparisons only provide results on averages, and fail to capture the way different household are impacted

differently from trade reform. Thus, the author suggests the use of CGE models, which in conjunction with microsimulations, better capture the heterogeneous household response to trade reform.

CGE are thus one of the most applied tools to evaluate the impact of trade liberalization on welfare, and ultimately, on poverty. CGE analysis are usually undertaken under a hypothesis of a unique or several representative agent(s): the average income and total income are endogenous while the moments of the distribution are exogenous. It is usually supposed that the real income of each category of households vary identically. This assumption has been criticized by Dervis, de Melo and Robinson (1982), Huppie and Ravallion (1991) and Ravallion and Chen (1997). Moreover, in the case of single country CGE models, the impact of multilateral trade reform cannot be tackled, in particular the complexity of international trade relations based on numerous trade agreements, either being multilateral, regional or non reciprocal. This complexity justifies the design of multi-country multi-sector CGE models.

Cloutier et al (2008) present a review of CGE modeling contribution to the debate about the impact of trade liberalization on poverty and welfare. The literature reviewed by the authors differs in the results, as the model structure of the underlying CGEs and the policy scenarios simulated are different as well. In terms of policy simulations, differences can arise concerning the nature of the trade liberalization itself (tariff elimination or reduction, simulation of quota reduction, to all sectors or limited to some sectors, etc.), the compensatory mechanisms to compensate tariff loss revenue (fixed government spending assumption, fixed revenue, etc.) and the model closure adopted (fixed savings, fixed investment, etc.). Bouët (2006), in a review of 16 studies that apply general equilibrium analysis to assess the impact of world full trade liberalization, also finds distinctive underlying assumptions in the models, as well as in the scenarios simulated. In spite of these differences, the impact of trade reform on world welfare is found to be positive. The main gains come from agriculture liberalization, although for some countries, such as food import countries, or countries that already have preferential access to some markets, the impact on welfare might be negative. All these models focus on the impact of liberalization on welfare, both at the worldwide level or at country level, but without accounting for changes in income distribution and poverty at the micro level. In the next subsection we present different strategies to overcome this shortcoming.

2.4 Micro-macro synthesis

The first and simplest approach in order to compute effects on poverty and income distribution using CGE models is to expand the number of representative households (RH), in order to account for different earning patterns. However, even though in this case results on income distribution are accounted between groups, the approach does not account for changes within groups, which can be even more important, as Agenor et al. (2003b) show. The higher the number of RH the more the problem is minimized, but as Piggot and Whalley (1985) show, even with a high number of households (they consider more than 100 households), there are still important intra-group heterogeneities that the technique does not account for.

In order to overcome this problem, some authors move from "representative" to "real" households in the CGE model, that is, the household survey is integrated into the CGE model, so that the model includes as many households as the household survey sample. This methodology was applied by Cockburn (2001) for Nepal (3,373 households), Cororaton (2003) for the Philippines and Boccanfuso et al. (2003) and Boccanfuso and Savard (2007) for Senegal (3,278 households) and for Mali (4,966 households). However, this methodology may present solving problems (due to the especially high number of equations and unknown variables) and data reconciliation issues (reconciliation of data coming from Social Accounting Matrix and data coming from household surveys). Therefore, other techniques have been more widely used to estimate the effects on poverty and income distribution. They can be roughly divided in two groups: representative household (RH) approach and the microsimulation approach (MS), although each one "covers a potentially wide range of alternatives with overlapping boundaries" (Lofgren et al, 2003).

The RH approach presented in Lofgren et al (2003) consists in feeding data on the CGE results for the RHs into a separate module that contains additional information about each RH. The authors propose two different alternatives to this approach: i) assuming a distribution function in order to compute income distribution within groups, or ii) feeding the CGE results on a household disaggregated data (which is in turn consistent with the SAM used to calibrate the CGE).

With respect to the first alternative, the most adequate distribution function has been discussed in several papers. The most commonly used is the lognormal frequency function (in Adelman and Robinson 1978, Dervis, de Melo and Robinson 1982 and others), while other authors suggest the Pareto distribution (de Janvry et al. 1991), or the more flexible Beta distribution function (Decaluwe and others 1999) . The parameters of the distribution functions are estimated with household survey data (and it is the only instance in which household survey data is used in this procedure).

The second alternative assumes that each RH is representative of all households in its group, and the survey can be fed with both data on income by RH and commodity prices in order to compute the changes in real income for all households of the survey, and to also adjust the value of the poverty line. The problem with the second approach is that it assumes that within-group distributions are unaffected by the shocks under consideration. It also disregards changes in employment at a macro level (individuals are assumed to stay in their initial activity). If the model is dynamic, this approach does not take into account other changes, as the change in population structure by age and rural/urban structure. A variant of this approach is what Agenor et al (2003a) call "reweighting method", a procedure that includes changes in employment structure (the authors suggest three dimensions: rural/urban, agriculture/formal/informal, skilled/unskilled –although it could be improved by adding new dimensions, such as age and gender). This procedure reweights the household survey sample, holding the underlying characteristics constant. Income distribution within groups changes with this approach to the extent that population and income shares of each group change over time (Agenor et al 2003a).

Alternative to the RH approach is the microsimulation approach, which also presents two alternatives: a top-down/bottom-up approach or a sequential (called 'top-down') approach. In the top-down/bottom-up approach, changes in consumption and labor supply obtained in microsimulations are in turn transmitted to the CGE model, which is run in turn and loops between the two models are run until a convergent solution is found (Savard, 2003 and 2004). Even though

this approach appears to be the one that provides a more coherent methodology between the macro model and the micro model, it has not been widely applied (it has been applied by Avitsland and Aasness (2004) and Ferreira Filho and Horridge, 2006), probably because it is more complex than the more standard sequential approach.

The top-down approach is applied in a sequential fashion, taking parameters from the CGE model and feeding them into the micro module, but without any further interaction between the macro and the micro level. This approach has been more widely applied, and it also has variants. Roughly, we can mention two techniques: a) estimation of income equation using econometrics; b) random assignation of changes in parameters to households in the survey.

a) The methodology described in Bourguignon et al (2001) and applied in several works (Chen and Ravaillon, 2003; Bourguignon et al., 2003; Bussolo and Lay, 2003; among many others) consists in modeling the income generation process of the households, estimating a series of equations using household survey data. The income generation model entails an earning model and an occupational choice equation. Household real income is specified as a non linear function of the observed characteristics of household members (age, education, etc.), some characteristics of the household, the distribution of its budget, and unobserved characteristics. This function depends on four sets of parameters. The parameters in the earning functions, for each labor market segment; the parameters of the self-employment income functions for the different sectors; the parameters in the utility of the alternative occupational choices, for the various demographic groups; and the vector of prices. These parameters are taken from the CGE model and are fed into the micro-simulation module.

b) A second microsimulation approach assumes that occupational shifts can be proxied by a random selection procedure within a segmented labor market structure. This procedure allows the imposition of counterfactual changes in key labor market parameters (participation rate, unemployment, employment composition by sector, wage structure, and so on) on a given distribution derived from household survey data, and the estimation of the impact of each change on

poverty and income distribution at the household level. That is to say, random numbers are used to determine which persons at working age change their labor force status; who will change occupational category; which employed persons obtain a different level of education; and how new mean labor incomes are assigned to individuals in the sample. Hence, the assumption is that, on average, the effect of the random changes correctly reflects the impact of the actual changes in the labor market. Because of the introduction of a process of random assignation, the microsimulations are repeated a large number of times in Monte Carlo fashion. This allows constructing 95 per cent confidence intervals for the indices of inequality and poverty, except in the case of the simulations of the effect of change in the structure and level of remuneration, which do not involve random numbers. This approach was developed by Ganuza, Paes de Barros and Vos (2002) and applied in Vos et al. (2006) and other studies.

Most of these techniques are applied to single country studies (in some cases even to regions within a country) and in a static framework, although more recently there has been efforts to expand the different frameworks to dynamic models and/or to global models.

2.4.1. Static vs. dynamic microsimulation framework

The way and difficulties of applying Bourguignon et al. (2001) approach in a dynamic setting are presented in Bussolo and Lay (2003). The wage equation changes in this context, because now wages have also a temporal determinant. The Ganuza-Paes de Barros-Vos (2002) approach in a dynamic setting was applied in Sanchez and Vos (2004 and 2005). In this context, the methodology makes some unrealistic assumptions, for example that the population structure (such as aging) remains unchanged during the whole simulation period.

2.4.2. Country level vs. global framework

Hertel et al. (2002) measure the effects of multiregion trade liberalization of markets in 14 countries. They link a global macro model (GTAP model) with a microsimulation model based on country-level household surveys (they only simulate effects on poverty for Indonesia). One first step

in this methodology is making both data sources compatible, in order to produce the same national per capita outcomes. Since richest households tend to underreport income (especially capital income, as shown in Atkinson et al 1995 and Mistiaen and Ravaillon 2003), the authors adjust non-agricultural profit-type income for the wealthiest families in the household survey in order to keep the ratio agricultural/non-agricultural income from GTAP database. However, the authors also adjust GTAP database in order to reflect the factor composition of income from the household survey. Their microsimulation model considers a way of estimating the poverty line different from Decaluwe et al 1999 (they define a poverty level of utility as opposed to identifying a basic bundle of goods within a LES consumption function for households).

At the global level, the most remarkable initiative is the one from theWorld Bank (Global Income Distribution Dynamics), which links the LINKAGE model with household surveys from 121 countries. The microsimulation approach is top-down, and follows Bourguignon et al. (2001) technique (modelization of income generation). In order to consider the dynamics of demographic changes, before being fed with results from the CGE model, the household surveys are re-weighted with exogenous demographic projections and with 'semi-exogenous' projections of skill levels. The approach was applied for analyzing the impact on poverty of eliminating agricultural distortions (Bussolo et al, 2010), of climate change (Bussolo et al, 2008) and of rising food prices (Dessus et al, 2008).

This review of literature allows us to specify the properties desired in an analytical instrument designed to study the impact of world shock on poverty. First, it has to be economically consistent in the sense it must capture interdependance and income effects and all economic mechanisms in a single integrated framework. Second, it has to tackle the economic mechanisms that lead to international transmission of major shocks. Finally, it has to provide a detailed representation of the characteristics of poverty in developing countries. In the next section we present our methodological contribution to this debate: an improved version of a global dynamic

general equilibrium model, MIRAGE, with household disaggregation and inclusion of public sector, combined with a micro-accounting technique.

3. Methodological improvements of this paper

In this section we present metodological improvements introduced to the MIRAGE model. The first subsection presents the changes introduced to the modeling structure, then we present the data treatment and finally we present the method applied to analyze poverty and income distribution.

3.1 Including households' heterogeneity in the MIRAGE model

The objective of this section is to present the theoretical improvements included in the MIRAGE model of the world economy in order to include households' heterogeneity. It requests to model specifically a public agent, then to improve the modelling of the private agent (representative household), and finally to include households' heterogeneity.

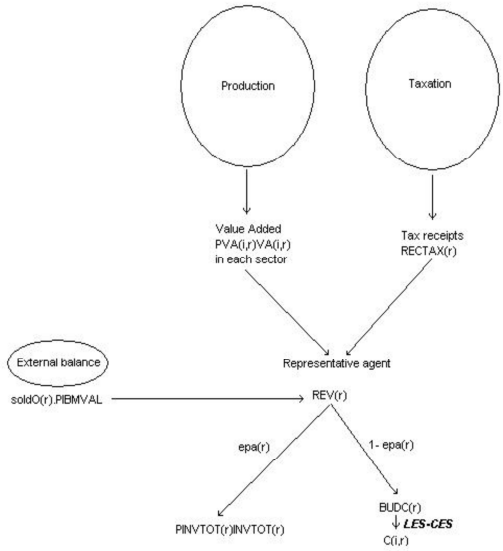
3.1.1 The public agent

Until now, the MIRAGE model was based on a representative agent who received income from production activities ($PV\ A(i;\ r)V\ A(i;\ r)$, where $V\ A(i;\ r)$ is value added in volume in sector i in country r and $PV\ A(i;\ r)$ is price of value added) and also tax receipts $RECTAX(r)$ (taxes on consumption, taxes on imports, taxes on production and taxes on exports). S/he spent a constant share of its income in savings ($epa(r)$; for country r) which financed investment while the rest of income was spent on final consumption ($BUDC(r)$). This representative agent had CES - LES preferences on all goods and these preferences defined her/his demand for each good ($C(i,r)$; demand for good i on country r). Therefore $C(i,r)$ represented both private and public final consumption. The budget closure implies that the economy can be in deficit or in surplus and thus can be financed by or finance the rest of the world but this deficit/surplus is constant as a share of

world GDP, which allowed for some limited flexibility: $sold0(r): P\ IBMV\ AL$ where $sold0(r)$ is the constant share of countryr's external balance in world Gross Domestic Product called $PIBMV\ AL$[6].

Figure 1 illustrates these assumptions.

Figure 1 The representative agent in the traditional version of MIRAGE



Source: Authors' elaboration

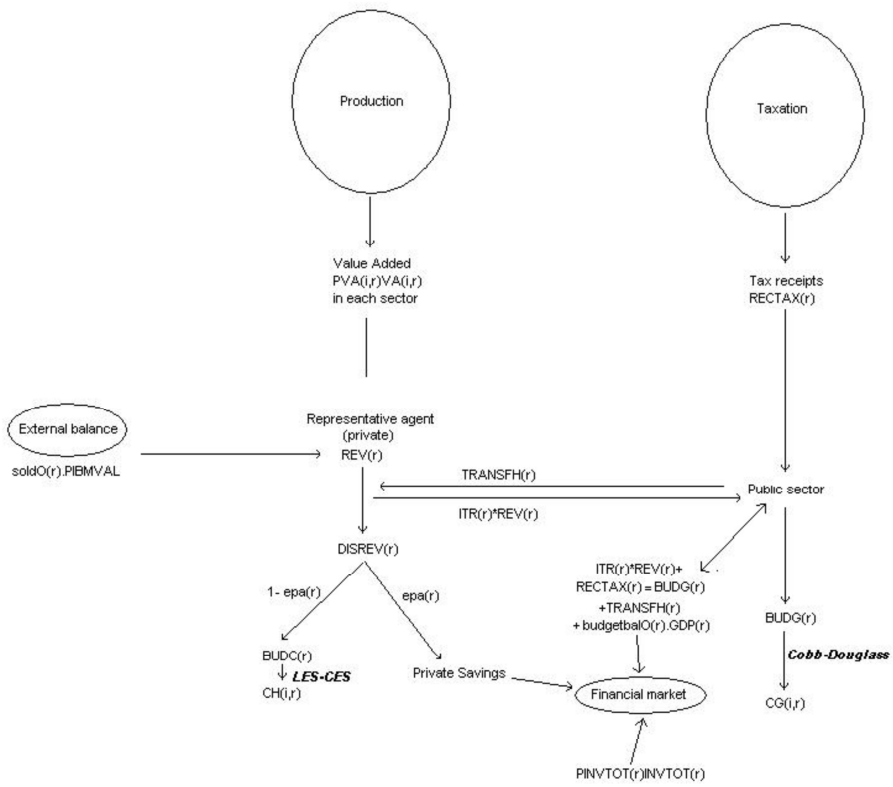
In the version of MIRAGE developed here, we first differentiate a public agent from a private agent. While the latter receives income from production activities, the former receives income from taxation ($RECTAX(r)$). The private agent has still CES - LES preferences on all goods but now these preferences define private final demand for each good ($CH(i,r)$; demand for good i on country r). Her/his disposable income is $DISREV\ (r)$ differs from revenue from productive factors since he pays income taxes at a rate $ITR(r)$ and receives public transfers ($TRANSFH(r)$). The public agent has

[6] This feature of MIRAGE may look uncommon but it only comes from the definition of the variable REV ($REV = BUDC\ +\ INV$). With the way the external balance is calibrated, $SOLD * PIBMVAL = SUM(PVA\ VA) + RECTAX - REV$, and with $epa = 1 - BUDC/REV$ it leads to: $BUDC + epa\ REV\ =\ REV$ and $epa\ REV\ =\ INV$. Another option would be to define REV as $REV = Sum\ PVA\ VA\ +\ RECTAX$ and to calibrate $SOLD * PIBMVAL\ =\ (REV - BUDC - INV)$. This implies: $BUDC\ +\ epa.REV\ =\ REV\ = BUDC + INV + PIBMVAL.SOLD$ and : $epa.REV - INV\ =\ PIBMVAL.SOLD$. This definition and calibration procedure will be adopted in the next version of MIRAGE.

Cobb-Douglas preferences, which implies that the share of public consumption of good i ($CG(i,r)$) in total public expenditures ($BUDG(r)$) is constant in value. Finally the consumption tax on public expenses is the same as for the private consumption ($taxcc(i,r)$). The public agent can spend more (public deficit) or less (public surplus) than tax receipts ($RECTAX(r) + ITR(r): REV(r)$) but this difference remains constant in proportion ($budgbal0(r)$) of country r's Gross Domestic Produc ($GDP(r)$)[8]. $C(i,r)$ represents total final consumption with $C(i;\ r) = CG(i;\ r) + CH(i;\ r)$.

Figure 2 illustrates these new assumptions.

Figure 2 The representative and public agent in the new version of MIRAGE



Source: Authors' elaboration

Therefore the following equations (with traditional MIRAGE annotations - see Decreux and Valin, 2007) hold in this new version of MIRAGE[7]The objective of :

$$PC(i,r)\times CG(i,r)=\alpha_g(i,r)\times BUDG(r) \tag{1}$$

$$C(i,r)=CH(i,r)+CG(i,r) \tag{2}$$

$$CH(i,r)-cmin(i,r)=a_C(i,r)\times AUX(r)\times\left[\frac{P(r)}{PC(i,r)}\right]^{\sigma_C} \tag{3}$$

$$P(r)\times AUX(r)=\sum_i PC(i,r)\times CH(i,r)-cmin(i,r) \tag{4}$$

$$BUDC(r)=\sum_i PC(i,r)\times CH(i,r) \tag{5}$$

$$RECTAX(r)=BUDG(r)+budgbalO(r)\times\sum_i\left[PVA(i,r)\times VA(i,r)\right] \tag{6}$$

$$REV(r)+BUDG(r)+soldO(r)PIBMVAL=RECTAX(r)+\sum_i\left[PVA(i,r)\times VA(i,r)\right] \tag{7}$$

Equation (1) describes the Cobb-Douglass allocation of public expenses with $\sum_i \alpha_g(i,r)=1$, $CG(i,r)$ being government consumption in sector i. Equation (2) computes total final consumption. Equation (3) describes the LES-CES allocation of private final consumption, where $cmin(i,r)$ is the minimal private consumption of good i in final demand of region r, $AUX(r)$ is the utility of the representative private agent in region r, $P(r)$ is the price of utility, $PC(i,r)$ is the price of good i in region r and $a_c(i,r)$ and σ_C are share and elasticity parameters. Equation (4) calculates the price associated to private utility ($P(r)$) and Equation (5) describes the private

[7] While the constant share in value of public consumption by sector may be considered as realistic, it is more problematic to consider that the government gets Cobb-Douglass preferences over public consumption by sector. The interpretation of this objective function is difficult. In particular there is no consideration for private well-being in this function. We will see later on that it is difficult to interpret real incomes's variation; for simplicity we focus on equivalent variation given by private consumption. This is not satisfactory but we will propose another solution in further research.

consumer's budget ($BUDC(r)$). Equation (6) is the budget closure of public agent, with $budgbalO(r)$ being the government's budget balance in proportion as domestic GDP, and $VA(i,r)$ and $PVA(i,r)$ being the value added and the price of value added respectively. Finally equation (7) describes the macroeconomic closure for country r, with $REV(r)$ being the regional revenue, $soldO(r)$ the current account balance in region r and $PIBMVAL$ world's GDP in value[8].

3.1.2 Households' behavior

We extend the above model by incorporating household disaggregation for some countries. Instead of having a single household by country, we define a subset $rh(r)$ of countries r where households are disaggregated into $nh(rh)$ categories. Let us call $CHh(hh,i,r)$ the final consumption of commodity i per household in category hh in country r, $cminhh(hh,i,r)$ the parameter measuring minimal consumption of commodity i per household in category hh in country r, $AUXh(hh,r)$ the utility of the representative household of category hh in country r, and $PUh(hh,r)$ the shadow price of utility of the representative household of category hh in country r. As the functional form of all households' utility function from different categories is still CES-LES, we have:

$$CHh(hh,i,r) - cminh(hh,i,r) = ah_C(hh,i,r) \times AUXh(hh,r) \times \left[\frac{PUh(hh,r)}{PC(i,r)} \right]^{\sigma_C(hh,r)} \tag{8}$$

$$PUh(hh,r) \times AUXh(hh,r) = \sum_i PC(i,r) \times CHh(hh,i,r) - cminh(hh,i,r) \tag{9}$$

$$BUDCh(hh,r) = \sum_i PC(i,r) \times CHh(hh,i,r) \tag{10}$$

[8] See previous footnote on the macroeconomic closure in MIRAGE

Elasticities of substitution in consumption $\sigma_C(hh,r)$ are now defined at the households' level. However we did not yet estimate these behavioral parameters at the household level. We apply for all households within a country the demand elasticities traditionally used in MIRAGE[9].

In a country rh with households disaggregation, total final demand for commodity i is now:

$$\sum_{hh} Pop_{hh}(hh,r) \times CHh(hh,i,r) + CG(i,r) = C(i,r) \tag{11}$$

with $Pop_{hh}(hh,r,t)$ the number of households in category hh. In country r household hh also receives transfers $TRANSFh(hh,r,t)$ from government. We implement different modes of indexation of these transfers. Either we hold them constant relatively to national revenue $REV(r)$ or in real terms or relatively to households' income. The first mode of indexation implies:

$$\frac{TRANSFh(hh,r,t)}{TRANSFhO(hh,r)} = \frac{REV(r,t)}{REVO(r)} \tag{12}$$

where $TRANSFhO(hh,r,t)$ is the initial government's tranfer to representative household of category hh. When the indexation of transfers is on prices we get:

$$\frac{TRANSFh(hh,r,t)}{TRANSFhO(hh,r)} = \frac{PI(r,t)}{PIO(r)} \tag{13}$$

where $PI(r,t)$ is a price index ($PIO(r)$ is initial price index in country r).

Finally, if transfers are a constant share of households' income we have:

$$\frac{TRANSFh(hh,r,t)}{TRANSFhO(hh,r)} = \frac{REVh(hh,r,t)}{REVhO(hh,r)} \tag{14}$$

In the same vein we authorize several modes of determination of public expenditures evolution. First public expenditures may be constant in proportion of national revenue:

$$\frac{BUDG(r,t)}{BUDGO(r)} = \frac{REV(r,t)}{REVO(r)} \tag{15}$$

where $BUDGO(r,t)$ is initial public expenditures. When public expenditures are constant in real terms we get:

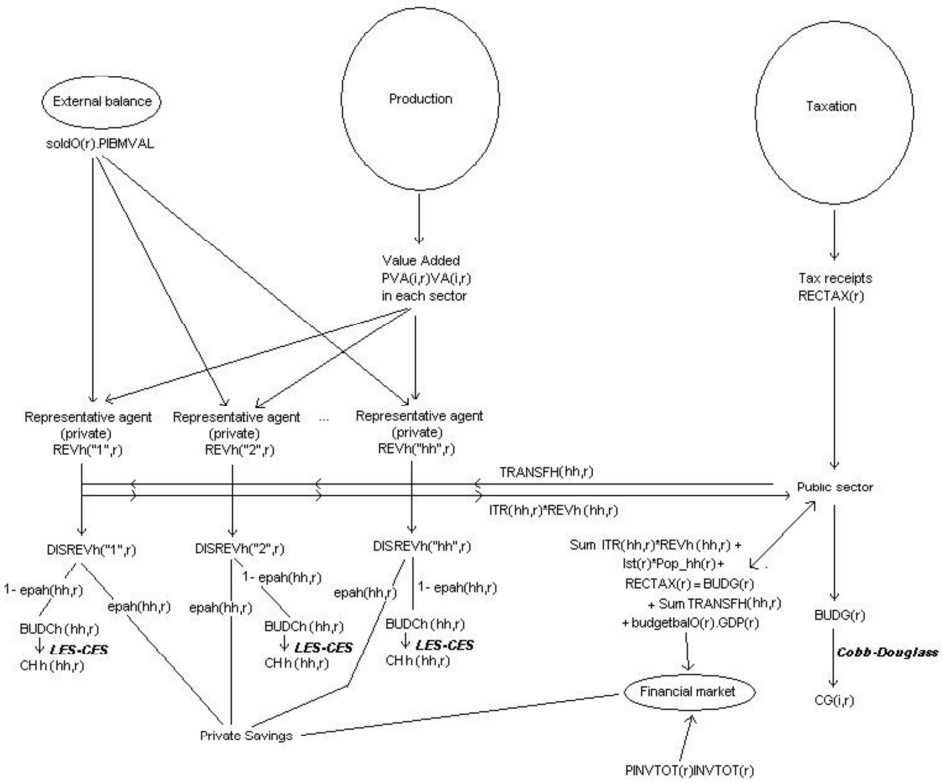
[9] We will proceed to a review of literature on this issue in further research

$$\frac{BUDG(r,t)}{BUDGO(r)} = \frac{PI(r,t)}{PIO(r)} \tag{16}$$

Finally, public expenditures can be defined as constant in nominal terms:

$$BUDG(r,t) = BUDGO(r) \tag{17}$$

Figure 3 The new version of MIRAGE with household heterogeneity



Source: Authors' elaboration

Of course changes in public expenditures may lead to changes in the level of provision of public goods. In that respect it is difficult to interpret this assumption: for example when public expenditures are constant in nominal terms this may imply a reduction in the provision of public good while the need for fiscal receipts decreases which may affect positively household's real income. This kind of results is difficult to interpret. Therefore throughout this paper we suppose that public expenditures are constant in percentage of national revenue. However we conduct sensitivity

analysis on the rule of indexation of public transfers and the tax (either consumption tax or income tax) used to compensate for the loss of custom receipts.

In a country with households disaggregation, the government's budget becomes:

$$\begin{aligned}&RECTAX(r,t)+\sum_{hh}ITRO(hh,r)\times Pop_{hh}(hh,r,t)\times REVh(hh,r,t)\\&=budgbal0(r,t)\times\sum_{i}PVA(i,r,t)\times VA(i,r,t)\\&+BUDG(r,t)+\sum_{hh}Pop_{hh}(hh,r,t)\times TRANSFh(hh,r,t)\end{aligned}\tag{18}$$

where $ITRO(hh,r)$ is the (constant) income tax applied on category hh's households.

In a country with disaggregation of households the disposable revenue of household hh is :

$$\begin{aligned}&DISREVh(hh,r,t)=(1-ITRO(hh,r))\times REVh(hh,r,t)\\&+TRANSFh(hh,r,t)+NT(hh,r,t)\end{aligned}\tag{19}$$

with $NT(hh,r,t)$ being the net transfers between households, explained in the next subsection.

Being $epah(hh,r)$ the saving rate of household hh, its final consumption budget is:

$$BUDCh(hh,r,t)=(1-epah(hh,r))\times DISREVh(hh,r,t)\tag{20}$$

In this version of MIRAGE without Foreign Direct Investment, the investment-savings equilibrium is now:

$$\begin{aligned}&\sum_{hh}[epah(hh,r)\times DISREVh(hh,r,t)\times Pop_{hh}(hh,r,t)]\\&+budgbal0(r,t)\times\sum_{i}PVA(i,r,t)\times VA(i,r,t)\\&=\sum_{i,s}PINVTOT(s,t)\times INV(i,r,s,t)\end{aligned}\tag{21}$$

with $INV(i,r,s,t)$ being the investment by country r in sector i of country s and $PINVTOT_{r,t}$ being a composite price of this investment. Figure 3 illustrates these new assumptions.

3.1.3 Endogenous inter-household private transfers

So far, we have only considered transfers from the public agent to the private agent. However, if we consider household disaggregation, we should also consider intra-households transfers as they may represent an important share of total income for some households, especially poor households. How are these remittances, or inter-households transfers, determined?

This is a controversial issue when considering the economic literature. Becker (1974) for example (see also Stark, 1984) develops a model based on *altruistic motive* and concludes that inter-household transfers are increasing with the gap of incomes of the donor and the recipient. In the case of altruistic transfers the relationship between the recipient's pre-transfer income and the transfer amount is always negative.

Cox (1987), but also Cox, Eser et Jimenez (1998) develop a *mutual exchange strategy* where transfer is the price of a service rendered by the receiver. The latter model is especially relevant in the case of intergenerational transfers (Laferrère and Wolff, 2006). In the case of altruistic transfers the relationship between the recipient's pre-transfer income and the transfer amount is always negative while a transfer under a *mutual exchange strategy* may admit a positive relationship.

Other common models rely on *strategic game* analysis (Stark and Wang, 2002), *insurance strategy*, *moral hazard* (Stark and Levhari, 1982; Rozenzweig and Stark, 1989) and *mixed motives* (Lucas and Stark, 1985; and Cox, Eser and Jimenez,1998). Amongst the models relying on *mixed motives*, *tempered altruism/enlightened self-interest* developed by Lucas and Stark (1985) involve both altruistic considerations and mutual exchange strategies.

We develop here a model of *pure altruism*. Following the formulation in Lucas and Stark (1985) without consideration for the number of persons in the recipient famlity [10], if we define u_m as the donor's utility, y_m her/his income, c_m her/his consumption and r the amount of the transfer, and we call u_h the utility of the recipient and c_h her/his consumption, then we have:

[10] This is without loss of generality since Lucas and Stark (1985) conclude on an un-restricted relationship between the level of remittance and this number.

$$u_m = u[c_m(y_m - r); u_h(c_h)] \tag{22}$$

The remittance augments the recipient's income and therefore her/his consumpion:

$$c_h = c[y_h + r] \tag{23}$$

Therefore we obtain:

$$r = r[y_m; y_h] \tag{24}$$

with $\frac{\partial r}{\partial y_m} > 0$ and $\frac{\partial r}{\partial y_h} < 0$. Therefore the private inter-households transfer is increasing with the donor's income and decreasing with the recipient's income. We adopt this theoretical microeconomic foundation first because of its simplicity and second since other theoretical frameworks like *mutual exchange strategy* or *tempered altruism/enlightened self-interest* require an intergenerational approach which looks difficult to implement herein.

We adopt the following functional form:

$$-NT(hh,r) = M(r).\frac{ARh(hh,r)}{\frac{\sum_{hh \in Re} ARh(hh,r)}{\sum_{hh \in Re} ARhO(hh,r)}}\left[1 + e^{\alpha(aNT(hh,r) - ARh(hh,r))}\right] \tag{25}$$

Equation 25 holds for $NT(hh,r) > 0$. As already explained NT(hh,r) is the private inter-household transfer and since in equation 25, $-NT(hh,r) < 0$, household hh is a donor. We call Re the set of recipient households. $M(r)$ is a positive parameter, characterizing inter-household transfers in country r. $aNT(hh,r)$ is a positive parameter reflectling household hh's idiosyncrasy. α is a parameter measuring the sensitivity of remittances to the donor's after-tax pre-remittance income $ARh(hh,r)$. We choose $\alpha = 0.05$ which implies that transfers are relatively rigid to the after-tax pre-remittance income of the donor. We will have to estimate econometrically this parameter in a next stage of this work.

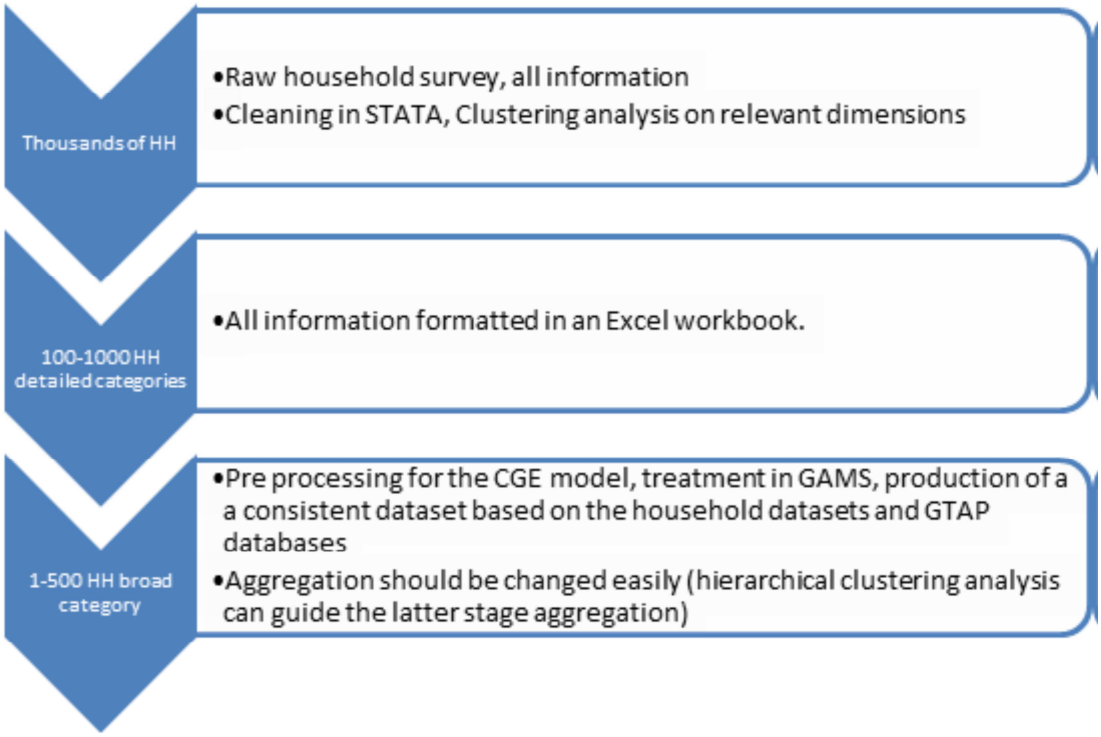
Therefore equation 25 implies that an inter-households private transfer varies positively with the donor's after-tax pre-remittance income $ARh(hh,r)$ and negatively with an increase of the

recipient's after-tax pre-remittance income as compared to the initial situation $\sum_{hh \in Re} ARh(hh,r) / \sum_{hh \in Re} ARhO(hh,r)$. Therefore we suppose that remittances decrease when the after-tax pre-remittance income of all households receiving transfers increases. It means that the donor adjusts remittances to the economic situation of all recipients. Of course this assumption may diminish the role of transfers in the transmission of shocks, but we cannot bilateralize transfers since we do not get data on bilateral remittances. Moreover the functional form described in equation 25 implies that the share of a transfer in the donor's after-tax pre-remittance income $-NT(hh,r)/ARh(hh,r)$ is a sigmoid function of the donor's after-tax pre-remittance income, other things being equal: therefore this share is a convex then a concave function of this income, with a maximum share $M(r)$ reflecting a societal characteristic existing for all households and $aNT(hh,r)$ the curvature of the function specific to household hh. We should note that we are only considering intra household transfers within one country, not between households located in different countries.

3.2 The data

This section is aimed at presenting how households were disaggregated in the new version of MIRAGE model. If the Social Accounting Matrix (SAM) is used to explore issues related to income distribution then the household account is to be broken down into a number of relatively homogeneous household groups reflecting the socioeconomic characteristics of the country or region under consideration (Decaluwe et al, 1999). Even if the goal of our approach is not to have households disaggregated for all the regions in the model, we need to develop a collection of national level datasets that provide us the opportunity to implement our model for a large set of countries. In addition, the process should grant enough flexibility to change the country coverage and the level of household disaggregation. Thus, we consider three different steps in the data processing generation, as displayed in Figure 4. The different stepts are detailed in the following subsections.

Figure 4: Framework to build a systematic and flexible treatment for a global model



3.2.1 Microdata

We start the analysis with a detailed household survey for each country for which we include household disaggregation in the model. We include household surveys as long as they contain detailed information on income by sources and consumption by type of good, and preferably contain also information about households characteristics, such as geographical location, size, main income source, education/gender/race/language of members, assets ownership, etc. Special attention is paid to taxes (income taxes may or may not be declared with incomes, depending on each country's tax system), and to the difference between purchased goods for consumption and good produced for self-consumption. In order to make the information included in the household survey consistent with the model structure, we map the income sources declared at the survey with income sources included in the model (skilled and unskilled labor –according to ILO classification - capital, land and natural resources/ public and private transfers). Then, a similar operation is done for the tax typology and the categories of goods included in the survey with GTAP sectors. For the latter, we allow n-to-n mapping. The information from the household surveys is also checked with information from other

sources: GDP, GDP per capita, structure of population (weight of each household type in total population), and poverty rates.

Most household surveys provide information on expenditures at consumer prices. Trade margins are included in the commodity prices. Since the GTAP database separates trade margins (a service) and underlying value of goods in the consumption structure, we need to collect sectoral information on trade margins in order to be able to recompute expenditures structure using the same nomenclature.

An important stage is to assess the overall level of discrepancies between the information from the household survey and the equivalent data from the GTAP database. It allows us to spot potential problems (mismatching in definition) and assess the magnitude of the fitting process to perform. Once the classification of households has been made, we compute the following shares: a) Share of each income source in total income of the household (differentiating among factor income and other income); b) Share of each household in income by source; c) Share of each household in consumption of each good; d) Savings rate for each household (savings/total income); e) Share of each household in income taxes. A first step is to compare some of these parameters to their equivalent from the National SAM extracted from the GTAP dataset. In addition to comparing information with GTAP database, we check consistency with GDP, GDP per capita, structure of population (weight of each household type in total population), and poverty rates from other sources (national accounts, etc.).

The information provided by the household surveys is fed into an excel file that works as a link between the household data and the model. In this file, specific for each country of analysis, we define the set of household groups, which includes information on the weight and size of each group. Other sets are also defined in this instance, such as a mapping between the consumption products included in the household survey and the products included in the model. Then, the file distinguishes between “resources” of the households and “uses” of the households. Among the former, we include all types of factor remuneration (as disaggregated as the information in the household survey

allows), and income from transfers (also with the highest possible level of detail). Then, in the "uses" of the household resources, we include expenditures in goods and services (in the product codes defined by each household survey), transfers to other agents, payment of taxes, and savings. Each household's resources and uses must balance. Finally, the file also includes information on trade margins by product, at the product level that the available information allows.

3.2.2 Clustering analysis

Once the microdata is obtained, cleaned and made compatible with the model structure, we apply a cluster methodology that allow us to group households that share similar characteristics in terms of consumption and income structure. The clustering procedure selected is a hierarchical analysis, which allows choosing different levels of aggregation of the clusters. There are different methods that can be applied when carrying out hierarchical analysis. We apply the weighted average linkage method, which is the method that reports higher optimum number of clusters and provides better distribution of households within the clusters. This operation is performed in STATA. In order to carry out the hierarchical analysis, we take into account three variables: income per capita of the household (in logarithm), consumption structure (share of each GTAP product in total consumption) and income structure (share of capital, labor, self-employed labor and transfers in total income of the household). Thus, we select 10 to 12 levels of cluster classifications, and we build a hierarchical map among the different cluster classifications, from less disperse (households classified in 10 clusters approximately) to more disperse (households classified in 500 clusters approx). This allows disaggregating households in more or less groups within the MIRAGE model, according to the needs. As a result of applying this procedure, the intra-household variance of income is minimized.[11]

3.2.3 Incorporation into the model

[11] See Table 3 for an example.

The last processing stage is to aggregate the data in the same sectoral nomenclature as the model (any subset of the GTAP nomenclature) and ensure that national Social Accounting Matrices (SAM) are consistent with the household datasets. The following paragraphs details this procedure. An important element to keep in mind is that we do not limit ourselves to fit the household surveys but we all for changing some aspects of the GTAP SAMs, in particular on some aspects of the database that are largely reprocessed during the building of the GTAP database (e.g. VA share in the agricultural sectors). The information preprocessed in the Excel workbook (clustered household dataset and mappings) is imported into a fitting procedure run in GAMS. This process implies making some assumptions and treating some inconsistencies of data between the information provided in the household survey and GTAP data.

We use sequentially different cross entropy procedures to fit different constraints. In a first step, we adjust the expenditure structure obtained from the household survey to fit GTAP macro figures. In spite of this, each household keeps its share in the overall expenditures of the economy. Second, we treat farm income and dwellings (virtual rental payments). In this step, data on value added from GTAP database may be modified. For the tax rate treatment, we take the factor specific tax rates from GTAP database. We map these rates with the taxes from the household survey (e.g. property tax), we compute the overall taxes based on income factor structure, and finally we rescale homogenously the model in order to maintain GTAP national tax level.

Specific attention is paid to the transfer matrix and savings rates of the households. In this sense, we apply a cross entropy method to ensure that domestically sum of transfers paid by households equals the sum of transfers received by households, and also to ensure that no household has negative savings rates (we set a minimum savings rate of 0.001 of disposable income). This constraint forces to replace negative savings rates from the household survey with intra household transfers.

3.3 Poverty analysis

To introduce poverty analysis within MIRAGE model, we apply a micro-accounting approach as described in Agenor et al (2003b, pp. 7), with some modifications. This approach assumes that each representative household (RH) in the model is representative of all households in its group, and the household survey can be fed with both data on income by RH and commodity prices in order to compute the changes in real income for all households of the survey, and to also adjust the value of the poverty line. This approach assumes that within-group distributions are unaffected by the shocks under consideration. This could be a problem, but the clustering procedure applied to create household groups guarantees very homogenous groups of households in terms of income distribution.

As we use a household survey to disaggregate households in the model in the first step, we can identify exactly each household in the survey with the correspondent household group in the model after computing changes in income and prices from the shocks. This is an advantage of our methodology: most macro-micro models work with a CGE model totally disassociated from the household survey. After computing the shock in the CGE model, we feed again the household survey with the results. We need two types of results. In the first place, changes in prices in order to update poverty lines. In this case, we take the changes in Consumer Price Index for poverty and Consumer Food Price Index for extreme poverty. In the second place, we modify income received by households by different sources. This approach shocks average income of households within a group differently, hence changing the income distribution within groups. Once income of households and poverty lines are updated with information from MIRAGE, we compute the well-known Foster Greer Thorbecke (FGT) poverty indicators: poverty headcount, poverty gap and squared poverty gap (poverty severity). For income distribution, we compute the Gini and Theil indicators. As we are creating a new income distribution at the microdata level, our approach allows us to also compute poverty indicators for different groups (according to location, sex of household head, and other relevant characteristics).

3.4 Advantages of the new methodological framework

The new assumptions constitute major improvements in the MIRAGE model.

First the distinction between private and public agent implies a much better modelling of final demand while the representation of public demand by a Cobb-Douglas is simple but realistic. It also allows taking into account how external shocks affects public revenues and transfers to households.

Second making a distinction between a high number of households allows to better understand the impact of the variation of factor prices on households' income and final demand. A modification in the distribution of income, under constant national income, may imply a variation in final demand but also of private savings as categories of households differ not only in terms of consumption structure but also in terms of saving rate. This is an important new economic mechanism that is now included in the model.

Third, the endogenizaton of inter-household private transfers allows us to take into account an important redistributive mechanism for households facing an economic shock.

Data treatment is also a major improvement, as we include an integrated bottom-up approach which takes data at the household level to incorporate to the model and we include checks that guarantees a consistent integration of the micro data and the SAMs. The method implemented to aggregate households from the household survey guarantees a low intra-household variance of income.

Finally, the micro-accounting procedure integrates results from the CGE model back to household survey module, in order to account for changes in poverty and income distribution indicators.

This methodology is applied to study the impact of full trade liberalization on households' real income, on poverty and inequality in five countries: results are described in the next section.

4. An application of the new MIRAGE-HH model: impact full trade liberalization on household's welfare and poverty

In order to make a first application of the MIRAGE-HH model described in the previous section, we analyze the impact of a full trade liberalization worldwide. First, we describe the database on which this simulation is based and the shock implemented. Then we simulate full trade liberalization using the traditonal version of the model with a single household in each country: in the presentation of the results we focus on the five countries for which we later implement households' disaggregation. In a third subsection we describe how full trade liberalization affects the economic situation of 13 representative households in Brazil, 25 in Pakistan, 35 in Tanzania, 39 in Uruguay and 33 in Vietnam with a special focus on 2025. This illustrates how the approach developed in this paper enriches the traditional method. In a fourth subsection, we modify the rules of fiscal compensation (taxes implemented to compensate the loss of public revenues) and those of indexation of public transfers and analyze how this affects the results at the households level. In subsections 4.5 and 4.6 we analyze the main channels of transmission of trade reform to households' welfare: consumption prices, remuneration of productive factors, public transfers and private transfers. Finally, in subsection 4.7 we present macroeconomic results in terms of poverty and inequality.

Table 1. **Sectoral Disaggregation**

	Abbrev.	Sector	GTAP correspondance
1	cmt	Cattle meat	cmt, omt
2	crp	Chemicals rubber plastic	crp
3	ff	Forestry and fishing	frs, fsh
4	lea	Leather products	lea
5	mil	Dairy	mil
6	mmet	Metals and minearls	nmm, i-s, nfm, fmp
7	oagr	Other Agricultural Products	pdr, wht, gro, v-f c-b, pfb, ocr, wol
8	oap	Other animal products	ctl, oap, rmk
9	ofd	Other food	vol, sgr, ofd, b-t
10	ome	Machinery and equipment	ome
11	omf	Other manufacture	mvh, otn, ele, omf
12	omn	Coal	coa, oil, gas, omn
13	osd	Oilseeds	osd
14	p-c	Petroleum and coal	p-c
15	pcr	Processed rice	pcr
16	serv	Services	ely, gdt, wtr, cns, trd, otp, wtp atp, cmn, ofi, isr, obs, ros, osg, dwe
17	tex	Textiles	tex
18	wap	Wearing apparel	wap
19	wpp	Wood and paper	lum, ppp

Source: authors' elaboration

4.1 Database, disaggregation of households and simulation scenario

We calibrate our model with the GTAP7 database, which is a consistent representation of the world economy in 2007, including information on 113 regions and 57 commodities[12]. We aggregate GTAP7 into a reduced database of 23 regions and 19 sectors, which are depicted on Tables 1 and 2.

Among the regions included in the model, we include five developing countries for which we apply household disaggregation as presented in the previous section: Uruguay, Brazil, Vietnam, Pakistan and Tanzania. The number of representative households varies in each country as a result of the clustering procedure, that provides different optimum number of clusters in each case. In any case, we are working with between 13-39 household groups in each country. Table 3 presents the intra and inter household income variance as a consequence of the clustering method. As we can

[12] Narayanan and Walmsley (2008)

see, the variance of income within groups is minimized, while the variance across groups is maximized. Specific information on the household surveys used in each case is presented in Table 4.

Table 2. **Geographical disaggregation**

	Code	Region	GTAP correspondance
1	ANDC	Andean countries	BOL, COL, ECU, PER
2	ANZCERTA	ANZCERTA	AUS, NZL
3	ARG	Argentina	ARG
4	BRA	Brazil	BRA
5	CHL	Chile	CHL
6	CHN	China	CHN
7	CIS	Community of Independent States	BLR, RUS, UKR, XEE, XER KAZ, KGZ, XSU, ARM, AZE, GEO
8	Dvp AS	Developed Asia	HKG, JPN, KOR, TWN
9	EFTAp	EFTA	CHE, NOR, XEF, HRV
10	EU27	European Union	AUT, BEL, CYP, CZE, DNK, EST, FIN, FRA, DEU GRC, HUN, IRL, ITA, LVA, LTU, LUX, MLT, NLD POL, PRT, SVK, SVN, ESP, SWE, GBR, BGR, ROU
11	MENA	MENA	IRN, TUR, XWS, EGY, MAR, TUN, XNF
12	MEX	Mexico	MEX
13	PAK	Pakistan	PAK
14	PRY	Paraguay	PRY
15	XAS	Rest of Asia	XEA, KHM, IDN, LAO, MYS, PHL SGP, THA, XSE, BGD, IND, LKA, XSA
16	XLAC	Rest of Latin America	XSM, CRI, GTM, NIC, PAN, XCA, XCB
17	ROW	Rest of the world	XOC, CAN, XNA, ALB
18	SSA	Subsaharan Africa	NGA, SEN, XWF, XCF, XAC, ETH, MDG, MWI, MUS MOZ, UGA, ZMB, ZWE, XEC, BWA, ZAF, ZSC
19	TZA	Tanzania	TZA
20	USA	United States	USA
21	URY	Uruguay	URY
22	VEN	Venezuela	VEN
23	VNM	Vietnam	VNM

Source: authors' elaboration

Table 3. **Analysis of intra and inter household income variance. Per capita income. Theil index and Atkinson(1) index**

	Intra-group variance (Theil index)	Inter-group variance (Theil index)	Intra-group variance (Atkinson(1))	Inter-group variance (Atkinson (1))
Brazil	0.110	0.552	0.102	0.382
Pakistan	0.108	1.085	0.108	0.483
Tanzania	0.068	0.889	0.080	0.462
Uruguay	0.001	0.311	0.001	0.311
Vietnam	0.077	0.256	0.079	0.205

Source: authors' elaboration

Table 4. **Household surveys used**

Country	Household survey	Year	Source
Brazil	Pesquisa da Orcamentos Familiares	2008-2009	Instituto Brasileiro de Geografia e Estatistica (IBGE)
Pakistan	Social and Living Standards Measurement Survey	2005-2006	Federal Bureau of Statistics
Tanzania	Household Budget Survey	2000-2001	National Bureau of Statistics
Uruguay	Encuesta Nacional de Gastos e Ingresos	2006	National Statistic Institute (INE)
Vietnam	Household Living Standards	2006	General Statistics Office (GSO)

Source: authors' elaboration

We use a (recursive) dynamic version of MIRAGE where economic growth is represented through the accumulation of primary factors (exogenously concerning labor, endogenously concerning land and capital) and adjustment of total factor productivity to capture technical progress.

As the model is calibrated in 2007 and as full trade liberalization is implemented starting on 2011, we develop a pre-experiment between 2007 and 2011 under which all trade agreements agreed in 2007 but not yet (fully) in exercise are implemented.[13]

We implement a removal of all import duties in all countries throughout the world linearly from 2011 to 2020. In order to capture full implementation of all effects we usually focus on year 2025, for which we compare the scenario (with full trade liberalization) with the baseline (without full trade liberalization).

4.2 Impact of full trade liberalization with the traditional model with a single household in each country

We first run the MIRAGE model with only one representative household in each region/country (but with disaggregation between public and private agent). Table 5 gives by how much the household's welfare is affected by full trade liberalization in 2025 in the five countries for

[13] Details may be requested from the authors.

which we later include household disaggregation. Welfare is calculated through the Hicksian approach of equivalent variation[14]. Table 5 also presents how real GDP, terms of trade and consumption prices are affected by the multilateral trade reform.

Uruguay gets a substantial macroeconomic benefit from the implementation of full trade liberalization: in particular exports of cattle meat (cmt), which represent more than 13 percent of total exports in the baseline in 2025, are increased by 186 percent in 2025 since in the baseline Uruguay faces an import duty on this commodity of 211 percent in EFTA countries, 83 percent in the European Union, 15 percent in the US and 13 percent in China. Uruguay's exports of dairy products, textile and of other agricultural products are also substantially increased. Consequently GDP is increased by 4.6 percent in real terms; since terms of trade are improved (Uruguay is a net exporter of agricultural commodities of which world prices increase) and domestic allocative efficiency is obtained through Uruguay's own liberalization, the representative household's welfare is augmented by 7.2 percent in 2025 as a consequence of the world trade reform.

Brazil follows the same pattern but while the 'Cattle meat' and 'Dairy products' sectors together represent 16.3 percent of Uruguay 's total exports in the baseline in 2025, they only represent 6.7 percent in the case of Brazil. Even if exports of other agricultural products (with sugar cane included) and of other food products (with sugar included) are substantially augmented, the impact on GDP in volume is positive but less pronounced than for Uruguay: 1.3 percent. With improved terms of trade, Brazil's welfare gains are still significant (2.4 percent).

In the case of Pakistan, Tanzania and Vietnam, in 2025, without trade reform, the average duty applied on imports is much higher than the average duty faced on exports: when weighted by bilateral trade, these averages are respectively 12.5 percent and 7.0 percent in the case of Pakistan, 8.5 percent and 4.7 percent in the case of Tanzania, 10.6 percent and 4.5 percent in the case of Vietnam. Consequently this trade reform implies a more pronounced openess of their own borders than an improved access to foreign markets. While terms of trade are consecutively deteriorated,

[14] See section 4.5 for more details.

domestic firms' intermediate prices are reduced and the representative household's consumption prices are decreased, implying efficiency gains. Welfare is augmented but real GDP increases less than for Uruguay and Brazil.

The impact on consumption price index illustrates well how full trade liberalization affects differently these five countries. In 2025, as a consequence of trade reform, the consumption price index is augmented by 6.2 percent in the case of Uruguay and 3.6 in the case of Brazil: economic activity is boosted in both countries and all domestic prices (consumer prices included) are augmented. On the contrary, it falls by 3.2 in the case of Pakistan, 3.1 percent for Tanzania and 2.7 percent for Vietnam.

Table 5. **Impact on macroeconomic variables - Single household version of MIRAGE - 2025 - Scenario/Baseline, percent variation**

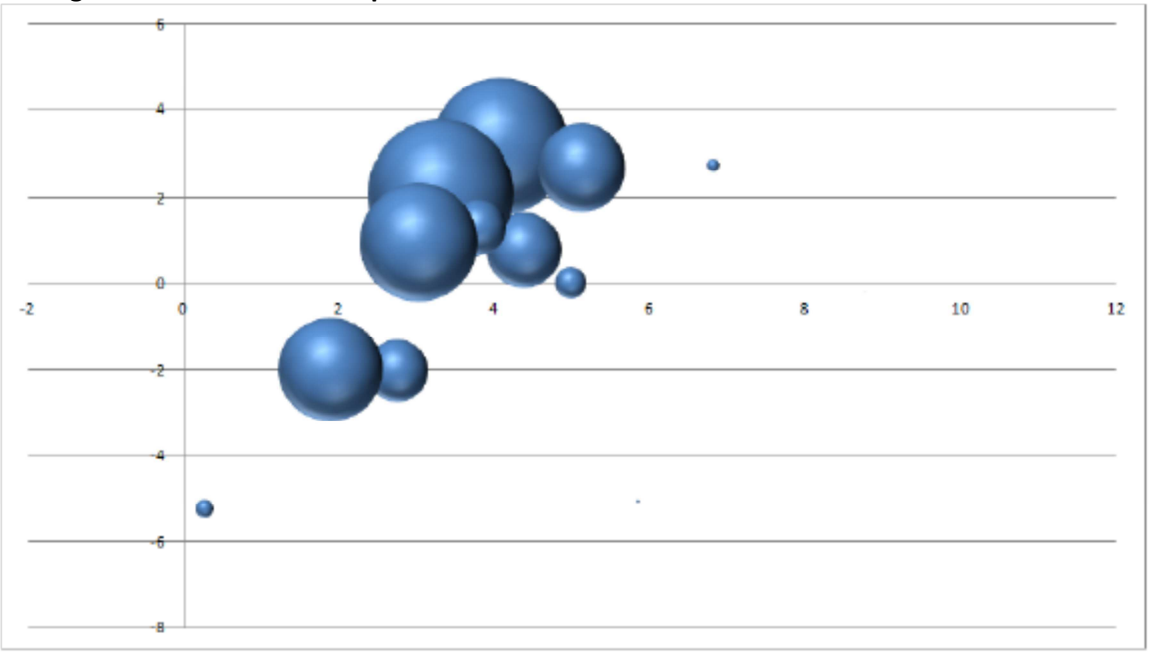
Country	Welfare	GDP in volume	Terms of Trade	Consumption Price Index
Brazil	2.4	1.3	4.7	3.6
Pakistan	1.8	3.3	-2.9	-3.2
Tanzania	0.8	1.5	-2.0	-3.1
Uruguay	7.2	4.6	9.5	6.2
Vietnam	1.1	4.8	-1.5	-2.7

Source: Authors' computation from MIRAGE results

4.3 Impact of trade liberalization with MIRAGE-HH household disaggregation in five countries

We turn now to the new version of MIRAGE presented in section 3 that includes household disaggregation for Brazil (13 representative households), Pakistan (25 households), Tanzania (35 households), Uruguay (39 households) and Vietnam (33 households). We implement the same scenario as in the previous subsection: removal of all import duties linearly from 2011 to 2020.

Figure 5: Brazil - 2025 - Impact of full trade liberalization on households'welfare



Source: Authors' elaboration from MIRAGE results

Note: Households' log of nominal income on x-axis in the baseline; real income variation (pct) on y axis. Bubbles are proportional to the size of the household's category.

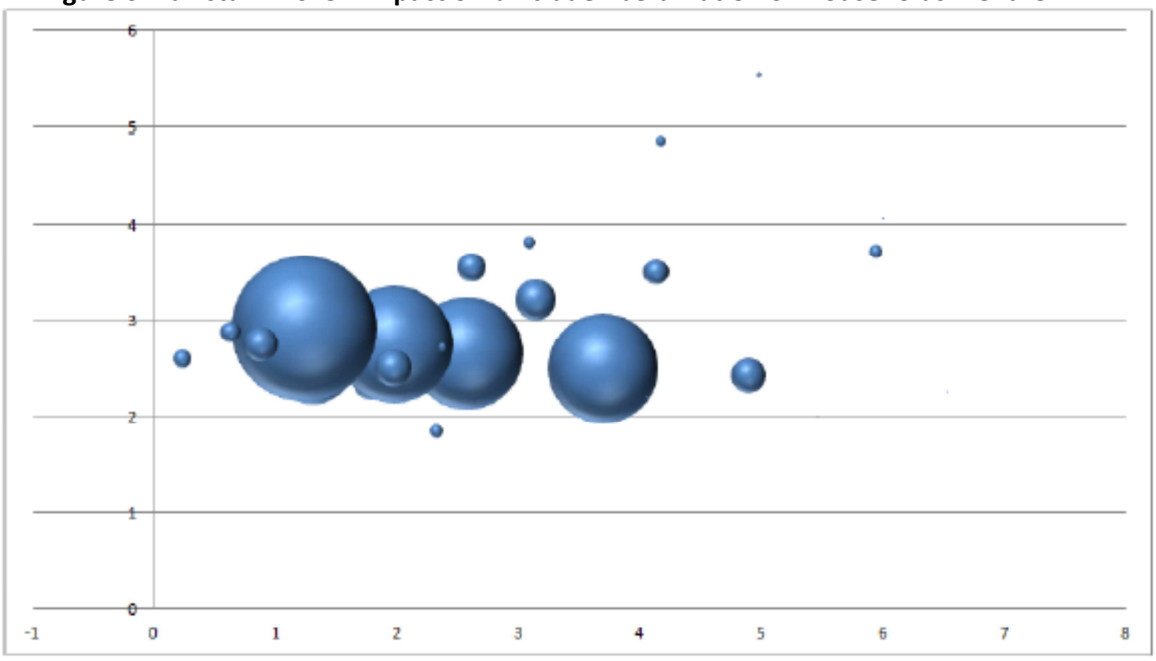
Figures 5 to 9 illustrate the impact of full trade liberalization on households' welfare in each of the countries. For each country we focus on 2025 and compare households' welfare in the scenario to households' welfare in the baseline (percentage variation, y-axis). On the x-axis each household is identified through the natural logarithm of (since variance of incomes is very high) the household's nominal disposable income. Bubbles are proportional to the size of an household's category.

In the case of Brazil (figure 5), while the traditional version of MIRAGE provided an increase of the representative agent's welfare by 2.4 percent in 2025 as a consequence of trade reform, the version with households' heterogeneity concludes on a range of household's welfare variation from -5.2 to 3.2 percent, with six households hurt by this reform and seven households gaining from liberalization. The size of households that are hurt by full trade liberalization is relatively small and households which benefit from this reform represent 81.6 percent of total number of households[15].

[15] It is noteworthy that at another period this proportion may differ; for example at the beginning of the liberalization process, the proportion of households positively affected by this reform is about 10 percent less.

Concerning Pakistan (figure 6), the modeling results provide a range of household's welfare variation from $+1.8$ percent to $+5.5$ percent in 2025 due to full trade liberalization (instead of a single figure of $+1.8$ percent) with welfare gains for all households.

Figure 6: Pakistan - 2025 - Impact of full trade liberalization on households'welfare



Source: Authors' elaboration from MIRAGE results

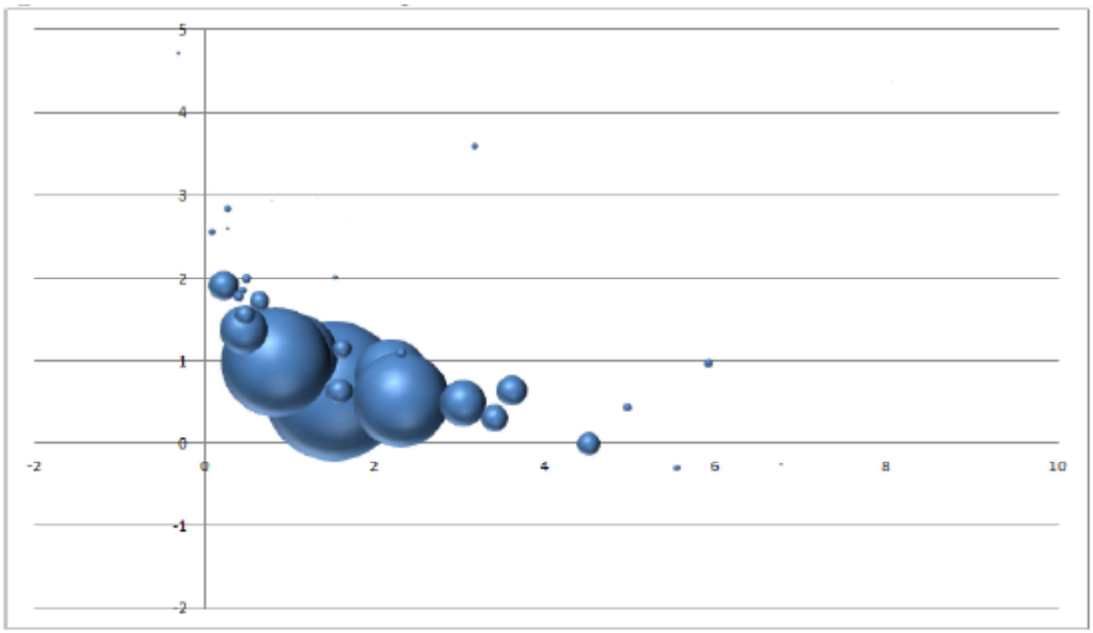
Note: Households' log of nominal income on x-axis in the baseline; real income variation (pct) on y axis. Bubbles are proportional to the size of the household's category.

In the case of Tanzania, the range of welfare variation in 2025 is from -0.3 percent to $+4.7$ percent (while the traditional model gave for Tanzania a welfare increase of 0.8 percent for the single representative agent) with 3 households hurt by full trade liberalization and 32 gaining from liberalization (that is to say 99 percent of total number of households. We should note, however, that gains for most households' are close to zero.[16]

These figures may look high; however we can consider that households who are only significantly benefitting from this reform are willing to politically support it, due to adjustments costs and/or uncertainty about the expected future benefits. If we consider only households of which the welfare gain is more than 1 percent as compared to the baseline in Brazil in 2025, they represent only 58 percent of total number of households.

[16] If we consider only households of which the welfare gain is more than 1 percent as compared to the baseline in Tanzania in 2025, they represent only 19 percent of total number of households.

Figure 7: Tanzania - 2025 - Impact of full trade liberalization on households'welfare

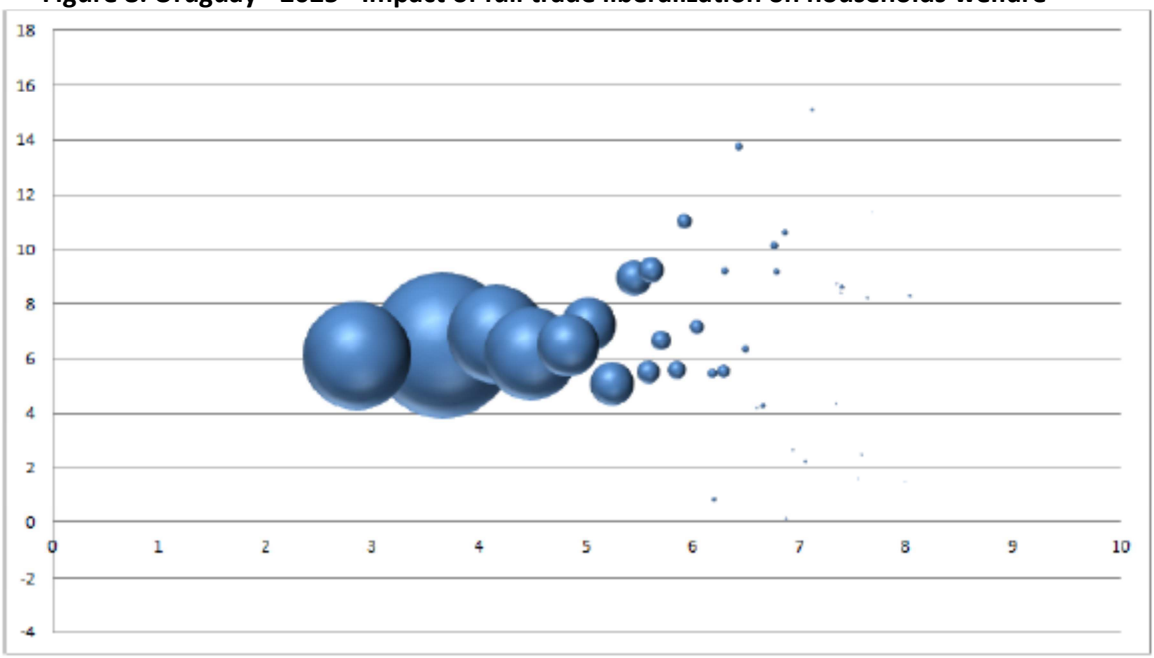


Source: Authors' elaboration from MIRAGE results

Note: Households' log of nominal income on x-axis in the baseline; real income variation (pct) on y axis. Bubbles are proportional to the size of the household's category.

In Uruguay, full trade liberalization leads to higher welfare for all households in 2025, from 0.1 percent to 15 percent. Welfare gains are higher for households with smaller size.

Figure 8: Uruguay - 2025 - Impact of full trade liberalization on households'welfare

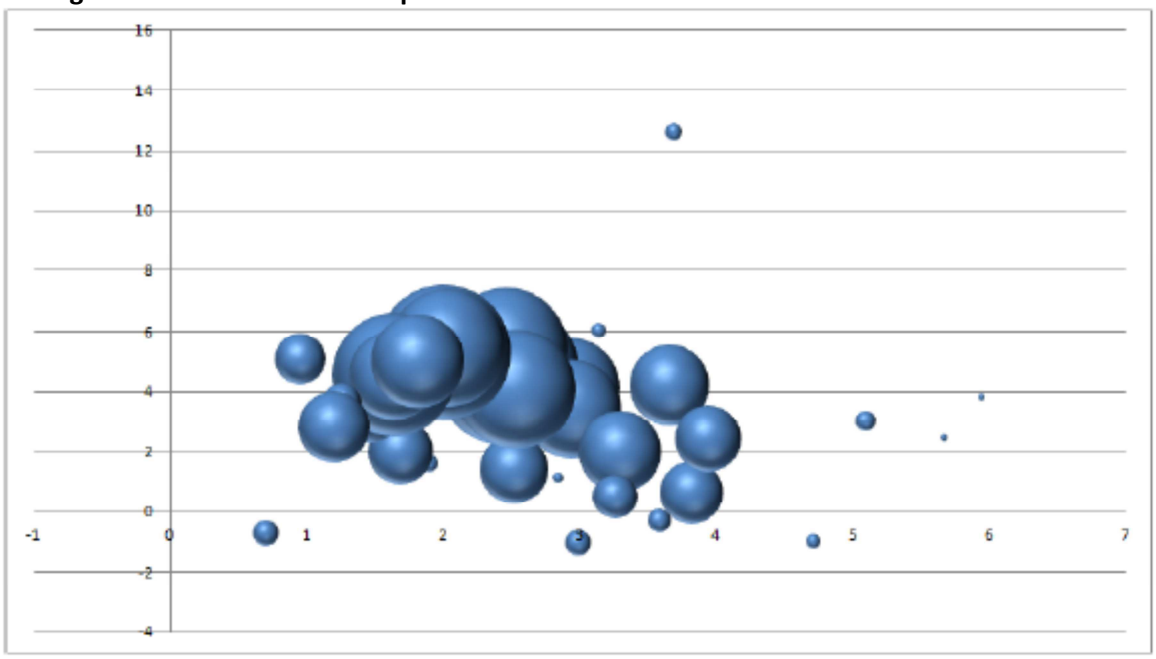


Source: Authors' elaboration from MIRAGE results

Note: Households' log of nominal income on x-axis in the baseline; real income variation (pct) on y axis. Bubbles are proportional to the size of the household's category.

In the case of Vietnam, the range of welfare variation in 2025 is from -1.1 percent to $+12.6$ percent (while the traditional model gave for Vietnam a welfare increase of 1.1 percent) with 4 households losing and 29 gaining from liberalization. These four households, hurt by trade reform, represent only 1 percent of the total number of households. For almost all households benefiting from trade liberalization welfare gains are greater than 1 percent in 2025.

Figure 9: Vietnam - 2025 - Impact of full trade liberalization on households' welfare



Source: Authors' elaboration from MIRAGE results

Note: Households' log of nominal income on x-axis in the baseline; real income variation (pct) on y axis. Bubbles are proportional to the size of the household's category.

We should keep in mind that we are applying a dynamic model such that we can describe the time pattern of the impact of this trade reform on households' welfare in order to assess if the impact at the year 2025 is specific or not. This allow us to analyze if there is an adjustment period as a consequence of trade reform that affects households' welfare. Figures 20 to 24 in the Annex show households' welfare gain/losses for 2011 and 2025, and also the highest and the lowest variation of welfare for each household in the period considered.

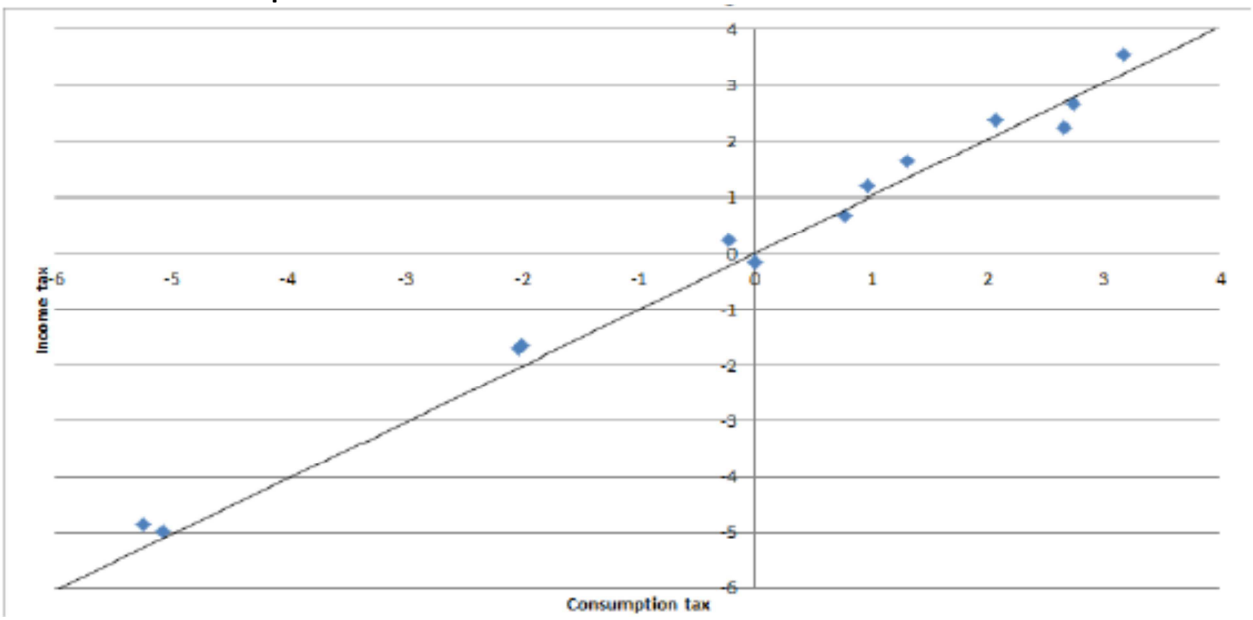
For most households in the five countries, gains from the trade reform are higher by the end of the period than at the beginning, and are the highest of the whole period. That means that welfare gains show an increasing trend along the period. For those household that lose welfare however, welfare losses are also usually higher at the end of the period considered. It is worth mentioning the case of Vietnam, where most households have a higher welfare increase at some point before 2025, which means that the adjustment process after the reform reduces welfare gains. In Pakistan, where all households gain welfare as a consequence of trade liberalization, we see that some households start losing welfare at the beginning of the liberalization process. Opposite examples can be found in Tanzania, Vietnam and Brazil, where some households experience welfare gains at some point during the liberalization process, but they end up losing welfare by 2025.

4.4 Adjustement through a consumption tax vs. through an income tax

The previous results are obtained under the assumption that governments implement increases in the consumption tax in order to compensate for the loss of public revenues coming from trade liberalization (removal of import duties). In this section we consider that fiscal compensation is implemented through increased income tax instead of increased consumption tax. In MIRAGE-HH income tax $ITR0(hh,r)$ is defined in percentage terms applied to households' income coming from productive factors and public transfers ($REVh(hh,r,t)+TRANSFh(hh,r,t)$). Thus, the tax rate is specific to each household and remains constant over time. As an alternative closure to keep fiscal revenue constant when custom revenue falls, we introduce a new component to income tax, not household specific: $ITR0(hh,r)+itr(r,t)$, being still applied on households' income coming from productive factors plus public transfers.

Figures 10 to 14 compare the impact of full trade liberalization on households' welfare in 2025 in the five countries when the loss of custom revenue is compensated by either a variation in income tax or a variation in consumption tax. For those households above the black line, welfare gains/losses are higher when income tax is raised.

Figure 10: Brazil - 2025 - Impact of full trade liberalization on households' welfare

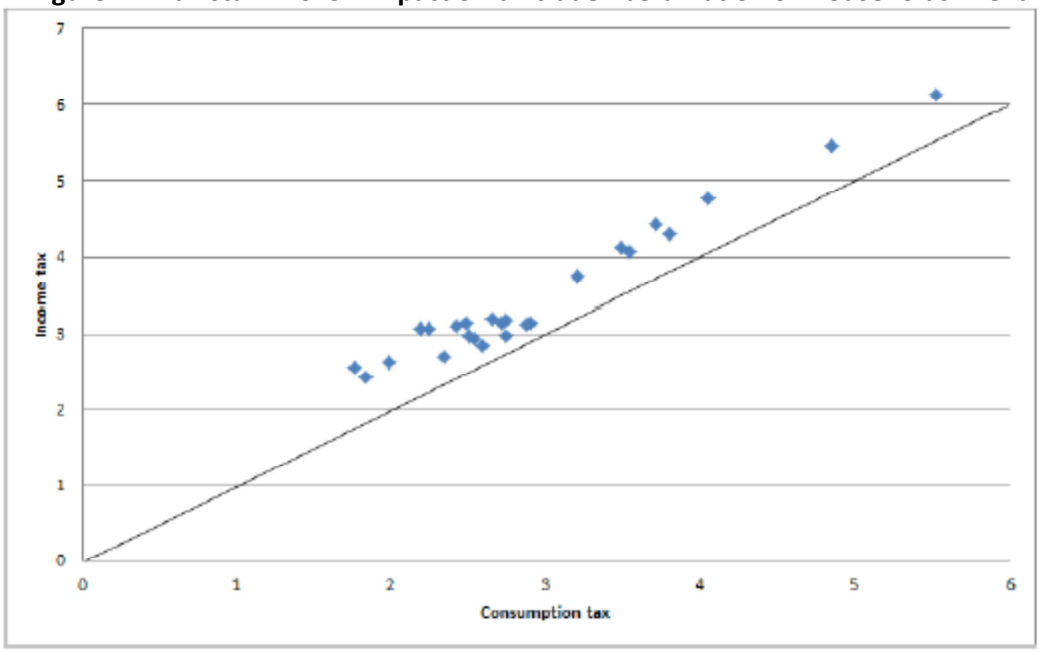


Source: Authors' computation

Source: Authors' elaboration from MIRAGE results

Note: Black line represents x=y

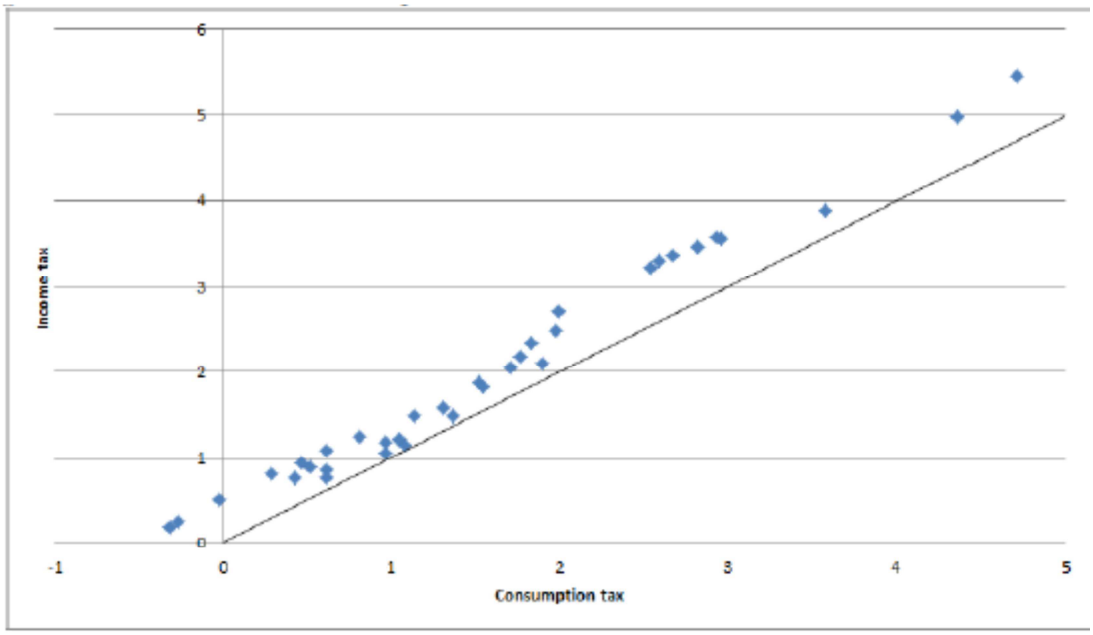
Figure 11: Pakistan - 2025 - Impact of full trade liberalization on households' welfare



Source: Authors' elaboration from MIRAGE results

Note: Black line represents x=y

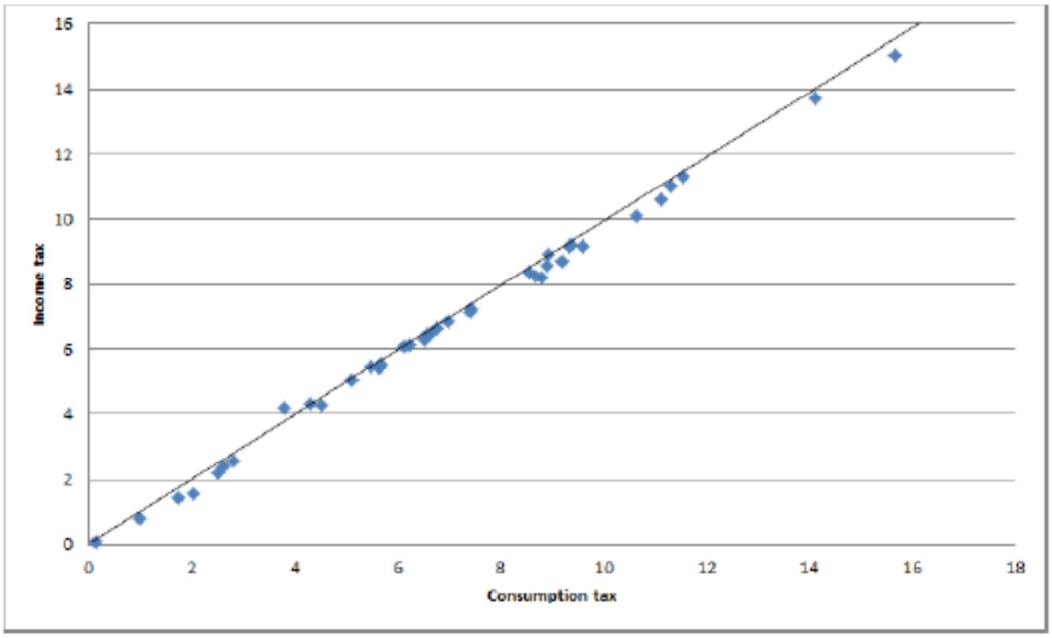
Figure 12: Tanzania - 2025 - Impact of full trade liberalization on households' welfare



Source: Authors' elaboration from MIRAGE results

Note: Black line represents x=y

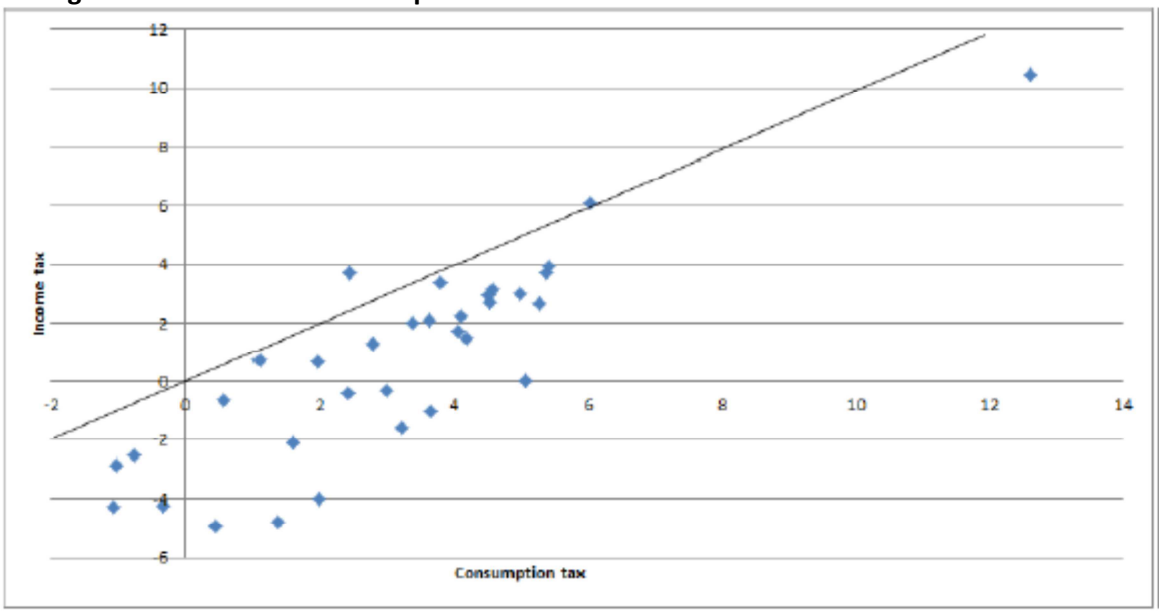
Figure 13: Uruguay - 2025 - Impact of full trade liberalization on households' welfare



Source: Authors' elaboration from MIRAGE results

Note: Black line represents x=y

Figure 14: Vietnam - 2025 - Impact of full trade liberalization on households' welfare



Source: Authors' elaboration from MIRAGE results

Note: Black line represents x=y

In Pakistan and Tanzania, the variation of welfare is, for all households, greater when the income tax makes the adjustment while in Uruguay and Vietnam, most households are better off in a situation where the consumption tax makes the adjustment tax. The case of Brazil is intermediate, with poor households in particular gaining more from trade reform when a variation of income tax compensates for the loss of custom duties. In most countries, except Vietnam, there is a high correlation among the impact on welfare using the two alternative closures; that is, we do not see big differences in the relative impact of the trade reform on households' welfare.

In fact it is difficult to conclude on a univocal comparison: in MIRAGE-HH the tax on final consumption ($taxcc(i,r)$) differs from the tax on intermediate consumption ($taxicc(i,j,r)$) and from the tax on consumption of capital goods ($taxkgc(i,r)$). When considering that consumption tax compensates for the loss of custom revenues, we add a supplementary (and uniform) consumption tax ($vat(r)$) to each of these three taxes. On the other hand, the rate of income taxation is household-specific. Consequently a comparison between both types of adjustment depends on several factors, amongst them the importance of import taxation in total public

revenues, the initial structure of consumption taxation and of income taxation. These three elements differ substantially from one country to the other.

In Vietnam for example custom revenue represents initially (in 2011 in the baseline) more than a quarter of total public revenues and income tax rates are low and similar for all households (between 0 and 1 percent). Therefore a substantial increase of income taxation on all households is required to compensate for the loss of custom revenues. In Brazil, also in 2011 in the baseline, import taxation represents only 2.2 percent of total public revenues and income tax rates differ substantially from one household to the other, varying from 0 to 26 percent. Thus, a relatively small variation of income tax rate (less than 1 percent) compensates for the loss of custom revenues.

We also conducted a sensitivity analysis on the rules of indexation of public transfers. In our central setting, public transfers are constant in percentage of each country's Gross Domestic Product. We consider two alternative rules, either they are constant in real terms of constnt in percentage of each household's pre-transfer and pre-income revenue.

Results are presented in Annex (see Tables 6 and 6). In 52 of cases (all households' categories in the five countries studied) changes in the rule of indexation of public transfers modify the impact on households' real income by more than 0.1 percent in absolute variation, in 40 percent of cases they are changed by more than 0.25 percent in absolute variation, in 24 percent of cases they are changed by more than 0.5 percent in absolute variation and in 8 percent of cases they are changed by more than 1 percent in absolute variation. For most households these rules of indexation do not have a significant impact on how trade liberalization affects their economic situation. For a few households for which public transfers represent a significant portion of income, a change of their indexation matters.

Let us focus now on the channels of transmission from trade reform to households' welfare.

4.5 Price effect vs. income effect

Trade reform modifies the consumption price of goods bought by each household and the factor remunerations that determine households' revenue. It is worth disentangling the *price effect* (variation of a household's welfare implied by the reform under constant revenue) and the *income effect* (variation of a household's welfare implied by the reform under constant consumption prices) from a trade reform.

Household's welfare variation is measured in terms of Hicksian equivalent variation. Remember that $AUXh_{hh,r}$ is the utility of household hh in country r, this utility depending on consumer prices $PC_{i,r}$ and disposable income $DISREVh_{hh,r}$ [17] (we omit the time variable t for convenience).

If initial situation (indexed by 0) is characterized by consumer prices PC_i^0 and disposable income $DISREVh^0$ (we omit indexes hh and r for convenience), final situation 1 is characterized by consumer prices PC_i^1 and disposable income $DISREVh^1$ and $e\left(PC_i^k; AUXh^k\right)$ is the expenditure function corresponding to consumer prices PC_i^k and utility $AUXh^k$ (minimal level of household's revenue required to reach utility $AUXh^k$ when consumer prices are PC_i^k), then the Hicksian equivalent variation (EV) characterizing the comparison between situations 0 and 1 is defined by:

$$EV = e\left(PC_i^0; AUXh^1\right) - e\left(PC_i^0; AUXh^0\right) \tag{26}$$

In order to evaluate the price effect and the income effect we calculate an intermediate situation where the household gets his initial income and attains utility $AUXh'$ (corresponding to maximal utility for this consumer when consumer prices are PC_i^1 and disposable income is $DISREVh^0$). Therefore the price effect is calculated as:

$$EV^P = e\left(PC_i^0; AUXh'\right) - e\left(PC_i^0; AUXh^0\right) \tag{27}$$

[17] Of course this is a shortcut since in general equilibrium all variables are determined simultaneously.

The income effect is:

$$EV^{I} = e\left(PC_i^0; AUXh^1\right) - e\left(PC_i^0; AUXh'\right) \tag{28}$$

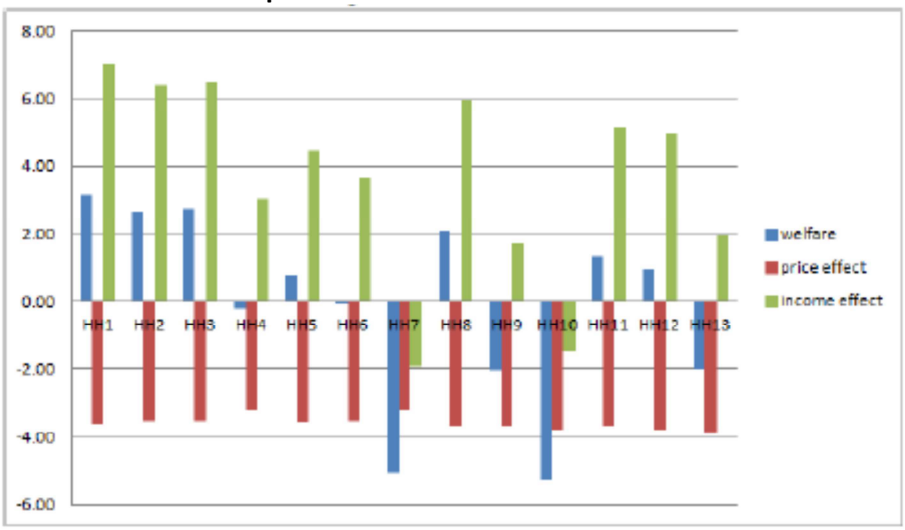
This methodology allows us to disentangle the price effect and the income effects from the trade reform. This is what is done on figures 15 for Brazil, 16 for Pakistan, 17 for Tanzania, 17 for Uruguay and 19 for Vietnam. The figures show the decomposition of the total impact of full trade liberalization in 2025 on each country households' welfare into a price effect and an income effect, with the blue bar showing total variation of welfare, red bar being the price effect and green bar being the income effect for each household.

It leads to at least two comments. First the situation is quite different between countries like Brazil and Uruguay where the price effect is negative for all households due to boosted economic activity and increased consumer prices, and countries like Pakistan, Tanzania and Vietnam where full trade liberalization leads to moderate expansion of economic activity with reduced consumer prices and therefore positive price effects for all households[18].

Second, on one side in each country the price effect is quite similar for all households, in particular for Brazil and Uruguay. Except in Vietnam, where we find substantial differences with price effects ranging from -2.3 percent ($HH26$) to 4.8 percent ($HH25$), on average, price effects are homogenous within each country. On the other side income effects are very different from one household to the other. This confirms that differences in the impact of full trade liberalization on households' welfare come mainly from different income effects, and to a lesser extent from price effects. The structure of sources of income is the most powerful channel of differentiated transmission of this shock while consumption structures are more homogenous amongst households inside one country.

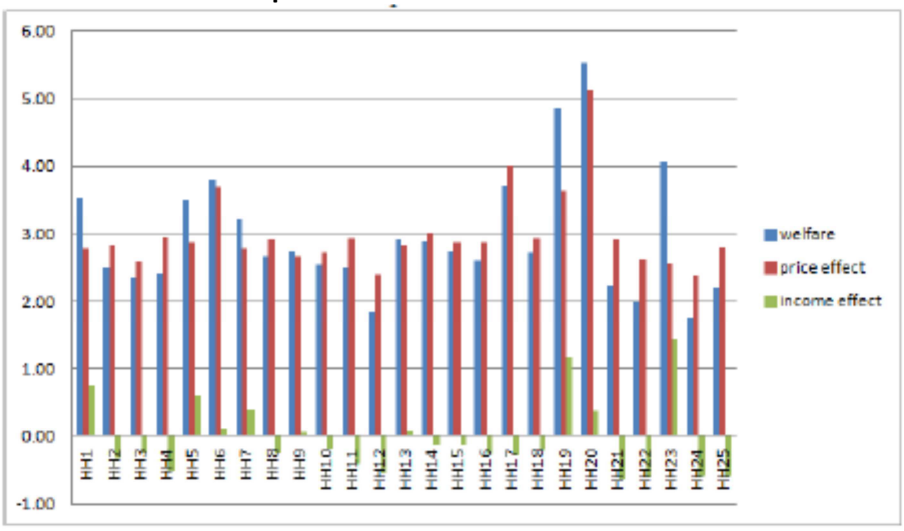
[18] With the exception of Vietnam since for nine households amongst thirty-three, the price effect is slightly negative - see below.

Figure 15: Brazil - 2025 - Decomposition of the total impact of full trade liberalization on households'welfare into a price effect and an income effects



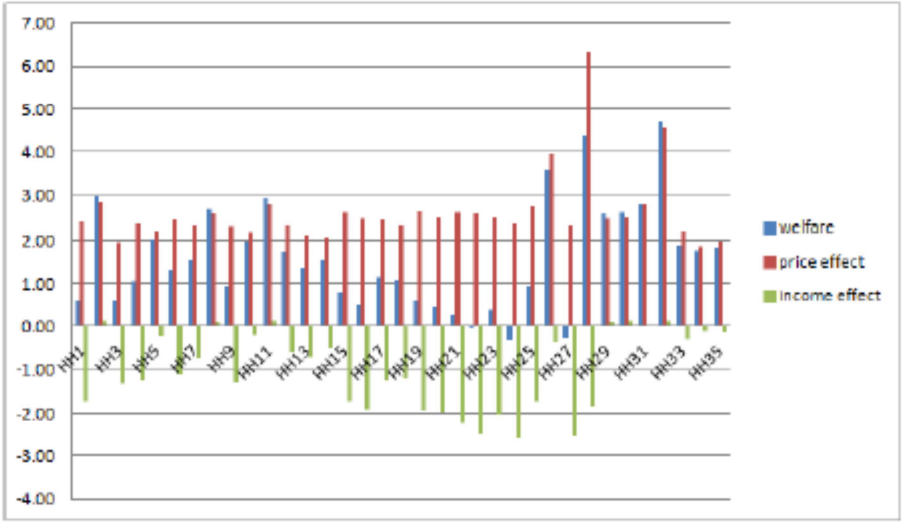
Source: Authors' elaboration from MIRAGE results

Figure 16: Pakistan - 2025 - Decomposition of the total impact of full trade liberalization on households'welfare into a price effect and an income effects



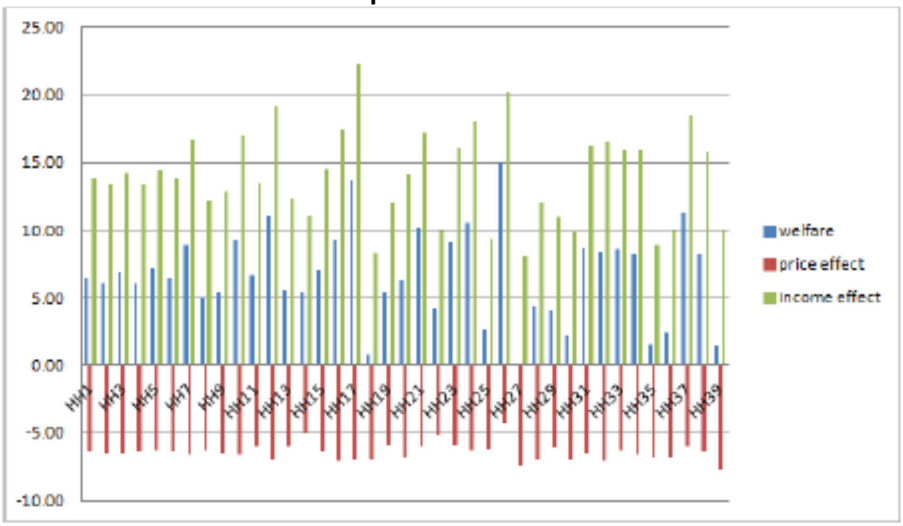
Source: Authors' elaboration from MIRAGE results

Figure 17: Tanzania- 2025 - Decomposition of the total impact of full trade liberalization on households'welfare into a price effect and an income effects



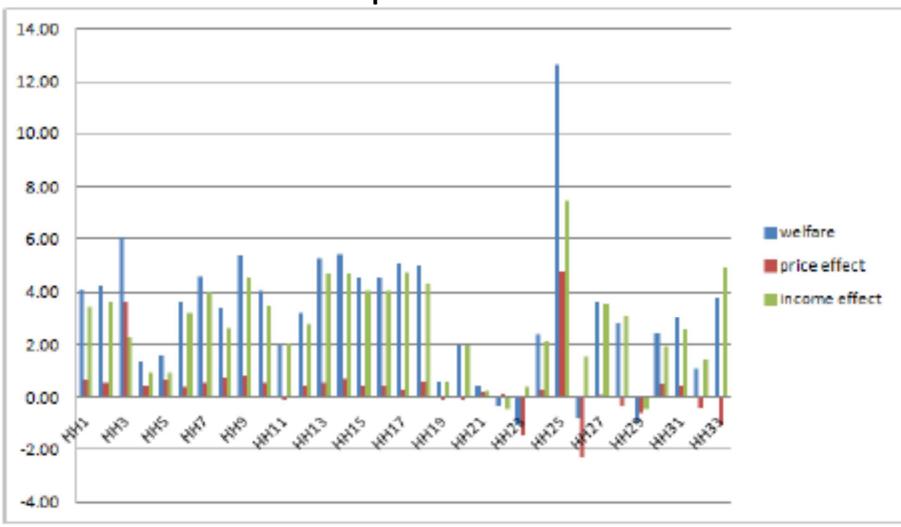
Source: Authors' elaboration from MIRAGE results

Figure 18: Uruguay - 2025 - Decomposition of the total impact of full trade liberalization on households'welfare into a price effect and an income effects



Source: Authors' elaboration from MIRAGE results

Figure 19: Vietnam - 2025 - Decomposition of the total impact of full trade liberalization on households'welfare into a price effect and an income effects



Source: Authors' elaboration from MIRAGE results

4.6 A decomposition of the income effect

In the previous subsection we showed that the heterogeneity of how a trade reform affects household's real income comes mainly from an income effect. Therefore it is important to understand what the sources of variation in households' disposable income are.

In Annex, figures 25 to 29 illustrate the decomposition of the variation of households' disposable income in 2025 as a consequence of trade reform. This decomposition is obtained by considering equation 19. With Δ being the variation operator we obtain:

$$\Delta DISREVh(hh,r,t) = \Delta REVh(hh,r,t) - ITRO(hh,r).\Delta REVh(hh,r,t) + \Delta TRANSFh(hh,r,t) + \Delta NT(hh,r,t) \quad (29)$$

Thus variation in a household's disposable income may come from a change in its income from productive factors ($\Delta REVh(hh,r,t)$ - pointed out by $VarRevh$ on figures 25 to 29 in Annex); from a change in income taxation, as the income tax is constant but income changes, ($-ITRO(hh,r).\Delta REVh(hh,r,t)$ - pointed out by $VarIR$ on figures 25 to 29 in Annex); from a change in public transfers ($\Delta TRANSFh(hh,r,t)$ - pointed out by $VarTransfh$ on figures 25 to 29 in

Annex); and from a change in private inter-households transfers ($\Delta NT(hh,r,t)$ - pointed out by Var Net Transfh on figures 25 to 29 in Annex).

In almost all households in all countries, most of the variation in households' disposable income is explained by variation in the revenue from productive factors. Let us note that for a few households like household $HH10$ in Brazil or $HH24$ and $HH25$ in Pakistan, changes in private inter-household transfers have also a substantial impact. For other households like $HH4$ and $HH23$ in Vietnam or $HH29$ in Uruguay, public transfers represent a substantial share of total variation in disposable income.

In spite of this, changes in private inter-household transfers are not higher than 3.3 percent (in absolute value) of an household's 2025 disposable income in the baseline situation (this is the case of $HH27$ in Uruguay). This comes from our assumption on small elasticity values of these transfers to the donor's after-tax revenue, as exposed in subsection 3.1.3. Changes in public transfers are not higher than 4.5 percent (in absolute value) of an household's 2025 disposable income in the baseline situation (the case of $HH29$ in Uruguay). These are uncommon figures: concerning both private and public transfers, their variation do not represent more than 0.5 percent (in absolute value) of an household's 2025 disposable income in the baseline situation in 75 percent of cases (households*countries). As already stated, the main changes in income for households in the five countries stem from changes in income from productive factors, which in turn determines the distinctive impact on households' welfare in those countries.

4.7 Impact on poverty and inequality

The analysis in the previous subsections was made taking into account results obtained through the application of the new version of MIRAGE with household disaggregation. In this subsection, we combine the results obtained in the CGE model with microdata in the micro-accounting procedure as depicted in section 3.3, in order to compute the impact on poverty and

income distribution indicators. Results are presented in Table 6, as percentage change of indicators value in each country in 2025 at the baseline and as a consequence of trade liberalization.

Table 6: Impact on poverty and inequality

		Poverty headcount	Gini index
Brazil	Base value	0.2239	0.5960
	Baseline (% change)	-37.7	1.9
	Trade liberalization (% change)	-0.8	-0.2
Pakistan	Base value	0.2192	0.6451
	Baseline (% change)	-77.3	1.6
	Trade liberalization (% change)	-6.8	-0.1
Tanzania	Base value	0.3810	0.5911
	Baseline (% change)	-48.0	1.8
	Trade liberalization (% change)	-1.6	-0.1
Uruguay	Base value	0.2052	0.4559
	Baseline (% change)	-39.4	2.2
	Trade liberalization (% change)	-11.5	-0.9
Vietnam	Base value	0.1845	0.4257
	Baseline (% change)	-88.3	3.4
	Trade liberalization (% change)	-15.9	-0.5

Source: Authors' computation from MIRAGE and microsimulation results

Let us first consider the evolution of poverty without trade liberalization, that is to say in the baseline. In all countries, as a result of economic growth up to 2025, poverty falls significantly. The most important reductions are found in Vietnam and Pakistan, due to the important economic growth in both economies. As a consequence of trade liberalization, poverty also falls in the five countries, but the magnitude of the fall is very different from one country to the other. The reduction is more important in Vietnam and Uruguay, where, as Figures 8 and 9 show, we find the highest increase in welfare for some households (the highest increase in welfare is 15% in Uruguay and 12.6% in Vietnam). Uruguay is the country for which trade liberalization has a more positive effect overall, however, as in Brazil, consumption prices are increased under this scenario, adjusting poverty lines and thus limiting the positive impact on poverty reduction. Tanzania, the country with the highest poverty rates at the benchmark, is the least benefited from trade reform. Under this

scenario, most households in this country experience welfare losses or welfare gains very close to zero.

Income inequality increases in the baseline as a consequence of economic growth for the five countries, but falls as a consequence of trade reform. However, only in Uruguay and Vietnam income inequality is reduced significantly.

This analysis is a good complement to the improvements to the CGE modelling presented before, as it shows exactly how the differentiated effects of trade reform on households are translated to improve income distribution and poverty indicators.

5. Conclusion

In this paper we have presented the design of a new version of MIRAGE, aimed at studying distributional impact of shocks on world markets in several developing countries and evaluate the consequences of these shocks on poverty and inequality. A review of the literature has shown the importance of designing a consistent theoretical framework, which is based on detailed data reflecting the diversity of situations at the households level. We chose an integrated framework where private households are disaggregated in five developing countries with data coming from households survey. An important part of this work has been to reconcile data coming from these surveys and GTAP data. Finally the methodology has been designed to be flexible enough such that it is possible to change households disaggregation, add more countries to the analysis and conduct sensitivity analysis to some of the assumptions adopted.

We have tested this new model called MIRAGE-HH by simulating a full trade liberalization implemented in ten years from 2011 to 2020, and evaluate the consequences on the world economy, with a specific focus on 13 representative households in Brazil, 25 in Pakistan, 35 in Tanzania, 39 in Uruguay and 33 in Vietnam. Results are particularly rich and show that:

1. Even when the impact of full trade liberalization is small at the macroeconomic level, the effect on households' real income may be quite substantial at the household level with a great

heterogeneity in terms of results. For example in Vietnam while the traditional version of MIRAGE (with a single household in all countries) evaluates the impact of full trade liberalization five years after end of implementation by a mere 1.1 percent augmentation of welfare (Hicksian equivalent variation), applying MIRAGE-HH we find a diversity of households' situation, from 1.1 percent losses of real income to 12.6 percent gains. Therefore this model shows clearly that trade liberalization is a source of in-depth redistribution of real income. It also illustrates why it creates simulatenously antagonism and support.

2. The major channel of heterogenity of the impact of trade liberalization on households' real income is the diversity of endowment in productive factors. Comparatively the diversity of consumption structures has a limited explanatory impact on differentiated impacts of a trade reform. Putting differently, households are more specialized in various sources of revenue than their structure of consumption differ.

3. Domestic policies implemented simultaneously to trade liberalization, like changes in public transfers to households or changes in income taxation, may significantly change the picture and offer compensation for negative effects of this shock or amplify direct impact of full trade liberalization. In this paper we have shown that the way the loss of custom revenues is compensated either by supplementary consumption tax or income tax change substantially the impact on households' real income. Changes in the rules of indexation of public transfers matter for a few categories of households, those for which these transfers are significant in proportion of personal revenue.

4. The impact of trade reform on poverty and inequality is significant and diverse from one country to the other. Poverty falls in all countries but the fall is more pronounced in Uruguay and Vietnam. Inequality also improves as a consequence of trade reform in the five countries, and again we find stronger results in Uruguay and Vietnam.

This paper is the first step of long term research project. We have to proceed to econometric estimations of behavorial parameters. We intend to include more countries with

disaggregation of households and more categories of households in each countries. We also intend to introduce some dynamic relations that we think are important concerning the impact of trade reform on poverty and income distribution, in particular households' savings and households investment in education. This corresponds to our belief that the relation between shocks on world markets and poverty is a complex and dynamic one and deserves a good metholodogical tool in order to be comprehensively understood.

6. References

1. Adelman, I. and Robinson, S. (1978) Income Distribution Policy in Developing Countries: A case Study of Korea, Stanford University Press> Stanford, Cal.

2. Agenor, P.R., Chen, D. and Grimm, M. (2003a) Linking Representative Household Models with Household Surveys for Poverty Analysis. A Comparison of Alternative Methodologies.

3. Agenor, P.R., Izquierdo, A., Fofack, H. (2003b) IMMPA: A Quantitative Macroeconomic Framework for the Analysis of Poverty Reduction Strategies.

4. Avitsland, T. and Aasness, J. (2004) Combining CGE and microsimulation models: Effects on equality of VAT reforms, Discussion Papers 392, Research Department of Statistics Norway.

5. Atkinson, A.B., Rainwater, L. and Smeeding, T.M. (1995) Income Distribution in OECD Countries. Paris: OECD.

6. Bchir, H., Decreux, Y., Guerin, J.-L., & Jean, S. (2002) MIRAGE, a Computable General Equilibrium Model for Trade Policy Analysis. Working Paper 02-17, CEPII.

7. Bickerdike, C.F. (1906) The Theory of Incipient Taxes. The Economic Journal , Vol. 16, No. 64, pp. 529-535.

8. Becker, G.S. (1974) A Theory of Social Interactions. Journal of Political Economy, Vol. 82, No. 6, pp. 1063-1093.

9. Bhagwati, J. and Srinivasan, T.N. (2002) Trade and Poverty in the Poor Countries. The American Economic Review, Vol. 92, No. 2, Papers and Proceedings of the One Hundred Fourteenth Annual Meeting of the American Economic Association, pp. 180-183

10. Boccanfuso D., Decaluwé, B. and Savard, L. (2007) Poverty, income distribution and CGE micro-simulation modeling: does the functional form of distribution matter?, *Journal of Economic Inequality*, 6(2), pp 149-184.

11. Boccanfuso, D. and Savard, L. (2007) Poverty and Inequality Impact Analysis Regarding Cotton Subsidies: A Mali-based CGE Micro-accounting Approach, Journal of African Economies 16, pp 629-659.

12. Bouët, A., Decreux, Y., Fontagnï¿½, L., Jean, S., and Laborde, D. (2008) Assessing Applied Protection across the World. *Review of International Economics* 16(5), pp 850-863.

13. Bouët A. (2006) *The Expected Benefits from Trade Liberalization - Opening the Black box of Global Trade Modeling*, Washington DC, IFPRI Food Policy Review 8.

14. Boumellassa H., Laborde D., and Mitaritonna, C. (2009) A consistent picture of the protection across the world in 2004: MAcMapHS6 version 2. *IFPRI Discussion paper* 00903, IFPRI, Washington DC.

15. Bourguignon F., Fournier, M. and Gurgand, M. (2001) Fast development with a stable income distribution: Taiwan, 1979-94, Review of Income and Wealth, 47(2), 139-163.

16. Bourguignon, F., Pereira da Silva, L.A. and Stern, N. (2002) Evaluating the poverty impact of economic policies: Some analytical challenges, Washington, D.C.: The World Bank (Mimeo).

17. Bourguignon, F. and Pereira da Silva, L.A. (eds.) (2003) The Impact of Economic Policies on Poverty and Income Distribution. Evaluation Techniques and Tools, Oxford University Press and World Bank: Washington D.C.

18. Bourguignon, F., Robillard, A.S. and Robinson, S. (2004) Representative versus Real Households in the Macroeconomic Modelling of Inequality. In T. J. Kehoe, T. N. Srinivasan, and J. Whalley, eds., Frontiers in Applied General Equilibrium Modelling. Cambridge: Cambridge University Press.

19. Bourguignon, F., Bussolo, M., Pereira da Silva, L.A., eds. (2008) The Impact of Macroeconomic Policies on Poverty and Income Distribution, Macro-Micro Evaluation Techniques and Tools. The World Bank: Washington, D.C.

20. Bussolo, M., and Lay, J. (2003) Globalisation and Poverty Changes: A Case Study on Colombia. Working Paper 226. OECD Development Centre, Paris.

21. Bussolo, M., De Hoyos, R., and Medvedev, D. (2008) Is the Developing World Catching Up? Global Convergence and National Rising Dispersion Policy Research Working Paper Series 4733, The World Bank.

22. Bussolo, M., De Hoyos, R., and Medvedev, D. (2010) Global Income Distribution and Poverty in the Absence of Agricultural Distortions, in K. Anderson, J. Cockburn, and W. A. Martin, ed. Agricultural Price Distortions, Inequality and Poverty Palgrave and The World Bank.

23. Chen, S., and Ravallion, M. (2003) Households Welfare Impacts of China's accession to the World Trade Organization. Working Paper 3040. World Bank, Washington, D.C.

24. Cloutier, M.H., Cockburn, J., Decaluwï¿½, B., Raihan, S., Khondker, B.H. (2008) Welfare, Poverty and Distribution Effects of Trade Liberalization: A Review of the CGE Literature, PEP.

25. Cockburn, J. (2001) Trade Liberalisation and Poverty in Nepal: A Computable General Equilibrium (CGE) Micro Simulation Analysis, Discussion Paper 01-18, Centre de Recherche en Economie et Finance Appliquï¿½e, Universitï¿½ Laval.

26. Cororaton, C. (2003) Analysis of trade, income inequality and poverty: using micro-simulation approach, the case of the Phillipines, Discussion Paper 2003-09, Philippine Institute for Development Studies.

27. Cockburn, J., (2001) Trade Liberalization and Poverty in Nepal: A Computable General Equilibrium Micro-Simulation Analysis, *Working Paper 01-18 CREFA*, University of Laval.

28. Cogneau, D., and Robillard, A.S. (2000). Income Distribution, Poverty and Growth in Madagascar: Micro-Simulations in a General Equilibrium Framework. *IFPRI TMD Discussion Paper*, 61, IFPRI, Washington DC.

29. Cox, D. (1987) Motives for Private Income Transfers. Journal of Political Economy , Vol. 95, No. 3, pp. 508-546

30. Cox, D., Eser, Z., Jimenez, E. (1998) Motives for private transfers over the life cycle: An analytical framework and evidence for Peru. Journal of Development Economics Vol. 55, pp 57–80 .

31. Decaluwï¿½ B., Patry A., Savard L., and Thorbecke, E. (1999). Poverty Analysis within a General Equilibrium Framework. *AERC Working Paper*, No. 99-09, African Economic Research Consortium.

32. Decreux Y. and Valin, H. (2007). MIRAGE Updated Version of the Model for Trade Policy Analysis: Focus on Agriculture and Dynamics, *CEPII Working Paper*, 15 October.

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

34. Dessus, S., Herrera, S. and de Hoyos, R.. (2008) The Impact of Food Inflation on Urban Poverty and Its Monetary Cost: Some Back-of-the-Envelope Calculations. Agricultural Economics Volume 39, Issue Supplement s1, pages 417–429.

35. Dollar D., and Kraay, A. (2004) Trade, Growth and Poverty. *The Economic Journal*, 114, 492:22-49.

36. Ferreira Filho, J.B.S., Horridge, M. (2006). Economic Integration, Poverty and Regional Inequality in Brazil, Rev. Bras. Econ. vol.60, n.4, pp. 363-387

37. Ganuza, E., Paes de Barros, R. and Vos, R. (2002) Labour Market Adjustment, Poverty and Inequality during Liberalisation. In: Vos, R., Taylor, L. and Paes de Barros, R., eds. Economic Liberalisation, Distribution and Poverty: Latin America in the 1990s, Cheltenham (UK) and Northampton (US): Edward Elgar Publishers, pp. 54-88.

38. Harrison, A. (2005) *Globalization and Poverty*. NBER.

39. Hertel, T., Preckel, P., Cranfield, J. and Ivanic, M. (2002) Poverty Impacts of Multilateral Trade Liberalization, Purdue University.

40. Hertel, T. and Reimer, J. (2005) Estimating the Poverty Impacts of Trade Liberalization, GTAP.

41. Huppie M., and Ravallion, M. (1991) The Sectoral Structure of Poverty During an Adjustment Period: Evidence for Indonesia in the Mid-1980's, *World Development*, 19(12).

42. de Janvry, A., Fafchamps, M. and Sadoulet, E. (1991) Peasant household behavior with missing markets: some paradoxes explained. Economic Journal, v.101:409, November, 1991, p.1400-1417.

43. Jones, R. W (1965) The Structure of Simple General Equilibrium Models. *Journal of Political Economy* 73: 557-572.

44. Kemal, D., de Melo, J. and Robinson, S. (1982) General Equilibrium Models for Development Policy, Cambridge University Press (Cambridge).

45. Kraev, E. and Akolgo, B. (2005) Assessing Modelling Approaches to the Distributional Effects of Macroeconomic Policy. Development Policy Review, 2005, 23 (3): 299-312.

46. Laferrère, A. and Wolff, F. C. (2006) Microeconomic Models of Family Transfers. In: Handbook on the Economics on Giving, Reciprocity and Altruism, Kolm, S. C. and J. Mercier-Ythier, eds., North-Holland: Elsevier.

47. Levinsohn, J., Berry, S., and J. Friedman (1999) Impacts of the Indonesian Economic Crisis: Price Changes and the Poor, in M. Dooley and J. Frankel, eds, *Managing Currency Crises in Emerging Markets*, Chicago, The University of Chicago Press.

48. Lï¿½fgren, H., Robinson, S. and El-Said, M. (2003) Poverty and Inequality Analysis in a General Equilibrium Framework: The representative Household Approach, unpublished, The World Bank.

49. Lucas, E. B. and Stark, O. (1985) Motivations to Remit: Evidence from Botswana Robert Journal of Political Economy , Vol. 93, No. 5, pp. 901-918

50. Mistiaen, J.A. and Ravallion, M. (2003), Survey Compliance and the Distribution of Income. World Bank, Washington DC.

51. Narayanan B.G. and T.L. Walmsley, eds. (2008) *Global Trade Assistance and Production: The GTAP 7 Data Base*, Center for Global Trade Analysis, Purdue University.

52. Nissanke, M. and Thorbecke, E. (2006) Channels and Policy Debate in the Globalization–Inequality–Poverty Nexus World Development Vol. 34, No. 8, pp. 1338–1360.

53. Piggott, J. and Whalley, J. (1985), UK Tax Policy and Applied General Equilibrium Analysis, Cambridge, Cambridge: Cambridge University Press.

54. Ravallion, M., and Chen, S. (1997). What Can New Survey Data Tell Us About Recent Changes in Distribution and Poverty?, *World Bank Economic Review*, 11.

55. Ravallion, M. (2005) Looking Beyond Averages in the Trade and Poverty Debate. Research Paper No. 2005/29, World Bank, UNU-WIDER.

56. Reimer, J.J. (2002) Estimating the Poverty Impacts of Trade Liberalization, *GTAP Working Paper* 20.

57. Robillard, A.-S., Bourguignon, F., and S. Robinson (2001). Crisis and Income Distribution: A Micro-Macro Model for Indonesia. Paper prepared for the ESRC Development Economics / International Economic Conference, Nottingham University, April 5-7, 2001.

58. Sanchez, M.V. and Vos, R. (2004). Rising inequality and falling poverty in Costa Rica's agriculture during trade reform. A macro-micro general equilibrium analysis, Maastricht: Shaker.

59. Sanchez, M.V. and Vos, R. (2005) Impacto del Tratado de Libre Comercio con Estados Unidos en el crecimiento, la pobreza y la desigualdad en Panama: Una evaluacion ex ante usando un modelo de equilibrio general computable dinamico, Project Report prepared for the

Government of Panama, The Hague, Mexico and Panama City: Institute of Social Studies, Sub-regional Office of ECLAC in Mexico and UNDP (August, mimeo).

60. Savard, L. (2003) Poverty and Income Distribution in a CGE-Household Microsimulation Model: Top-Down/ Bottom-Up Approach. CIRPï¿½E Working Paper 03-43. Centre interuniversitaire sur le risque, les politiques ï¿½conomiques et l'emploi, Quebec.

61. Savard, L. (2004). Poverty and Inequality Analysisis within a CGE Framework: a Comparative Analysis of the Representative Agent and Micro- Simulation Approaches. CIRPï¿½E Centre interuniversitaire sur le risque, les politiques ï¿½conomiques et l'emploi Cahier de recherche/Working Paper 04-12.

62. Viner, J. (1950) The customs union issue. New York: Carnegie Endowment for International Peace.

63. Vos, R., Ganuza, E., Morley, S. and Robinson, S., eds. (2006). Who gains from Free Trade? Export-led Growth, Income Distribution and Poverty in Latin America, London: Routledge.

64. Winters, L. A. (2002), Trade Liberalisation and Poverty: What are the Links?. The World Economy, 25: 1339–1367.

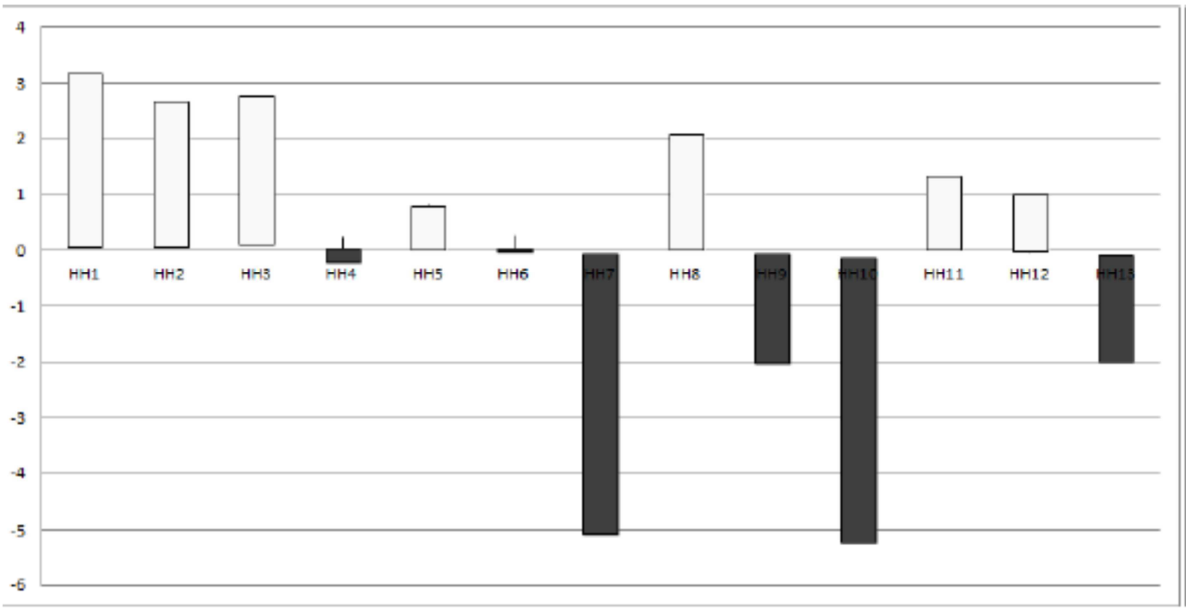
65. Winters L.A., McCulloch N., and A. McKay (2004) Trade liberalization and poverty: the evidence so far. *Journal of Economic Literature*, XLII, March 72-115.

Annex: Supplementary tables and figures

Pattern of households' gains and losses are depicted in "Open-High-Low-Close" figures presented in this section. For each household in the five countries with household disaggregation, this graph indicates the welfare gain/loss in 2011, the highest variation and the lowest variation over the 2011/2025 period of time and the final variation (in 2025). If bars are white-colored, it means that the final welfare variation is larger than the initial one, while dark-colored bars means the opposite. The largest welfare variation may not be either the final one (white-colored bar) or the initial one (dark-colored one). In this case a tick mark is above the bar and indicates the largest variation occurred at some point during the 2011-2025 period. The opposite holds for the smallest variation.

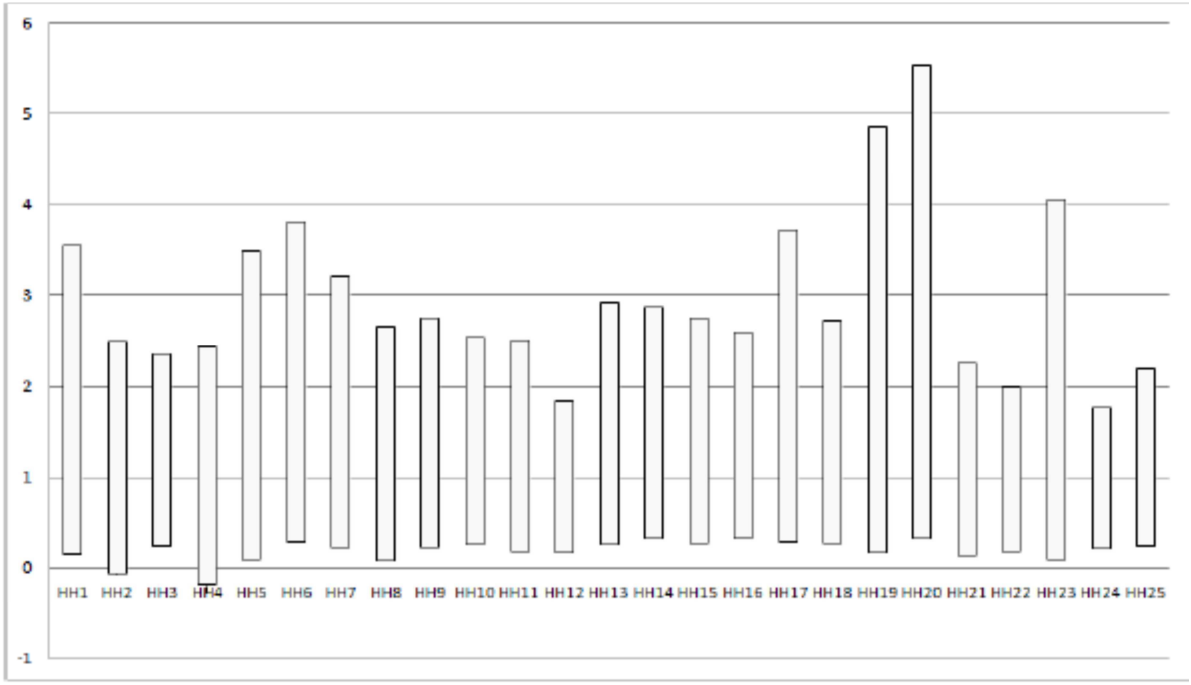
For example concerning $HH1$ in Pakistan (figure 21) the variation in 2011, $+1.51$ percent, is less than the variation in 2025 3.55 percent: the initial variation is also the smallest one and the final one is also the largest one. If we take the example of $HH29$ in Vietnam (figure 24) the impact of full trade liberalization on this household's welfare is a gain by 0.19 percent in 2011 and a loss by 1.03 percent in 2025 (since the "Close figure" is lower than the "Open figure", the bar is dark-colored). The gain by 0.19 percent in 2011 is not the highest variation which is 0.52 percent in 2014: this is why there is a tick mark at the top of the bar. In that sense there is an overreaction of $HH29$ welfare variation implied by trade reform. The five graphs show that in a majority of cases there is no overreaction of welfare variation, but overreaction may occur. A household can also be hurt by this reform before gaining from it.

Figure 20: Brazil - 2010/2025 - Dynamic impact of full trade liberalization on households' welfare



Source: Authors' elaboration from MIRAGE results

Figure 21: Pakistan - 2010/2025 - Dynamic impact of full trade liberalization on households' welfare



Source: Authors' elaboration from MIRAGE results

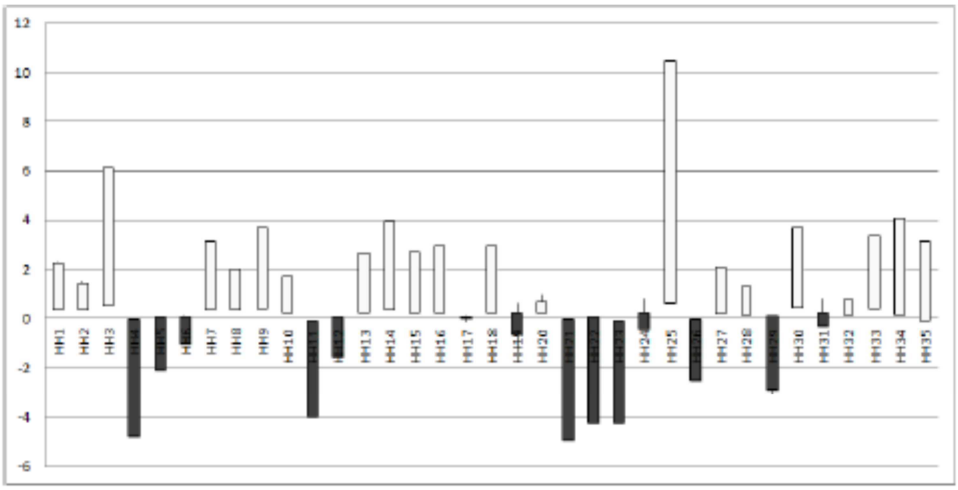
Public transfers constant in real terms	Vietnam	Pakistan	Brazil	Uruguay	Tanzania
HH1	4.12	3.54	3.85	6.63	0.62
HH2	4.24	2.5	1.85	5.81	2.96
HH3	6.01	2.29	3.26	6.88	0.62
HH4	0.05	2.44	0.72	6.08	1.06
HH5	0.86	3.5	0.79	7.45	2
HH6	3.4	3.77	0.31	6.48	1.32
HH7	4.57	3.2	-3.78	8.16	1.55
HH8	3.36	2.66	2.35	4.9	2.68
HH9	5.35	2.74	-1.31	5.16	0.97
HH10	4.05	2.52	-4.04	9.24	1.98
HH11	1.09	2.51	1.93	6.6	2.94
HH12	2.8	1.85	1.33	11.64	1.71
HH13	5.25	2.91	-1.13	5.51	1.37
HH14	5.38	2.88		5.76	1.55
HH15	4.52	2.73		7.51	0.82
HH16	4.48	2.59		9.25	0.52
HH17	4.97	3.72		14.77	1.15
HH18	4.94	2.65		1.05	1.14
HH19	0.56	4.86		5.48	0.62
HH20	1.97	5.53		6.48	0.47
HH21	-0.57	2.25		11.04	0.3
HH22	-0.88	1.98		4.51	-0.01
HH23	-1.42	4.05		9.77	0.43
HH24	2.51	1.77		11.42	-0.31
HH25	12.33	2.19		2.96	0.97
HH26	-0.94			16.2	3.6
HH27	3.55			-0.13	-0.26
HH28	2.78			4.07	4.37
HH29	-1.01			2.82	2.55
HH30	2.46			2.6	2.59
HH31	3.1			9.48	2.83
HH32	0.96			8.55	4.71
HH33	3.79			9.07	1.9
HH34				9.07	1.77
HH35				1.91	1.84
HH36				2.81	
HH37				12.34	
HH38				9.11	
HH39				1.85	

Source: Authors' elaboration from MIRAGE results

Public transfers constant in percent of each household's income	Vietnam	Pakistan	Brazil	Uruguay	Tanzania
HH1	4.16	3.56	3.51	6.59	0.62
HH2	4.26	2.49	2.54	5.82	2.96
HH3	6.11	2.37	3.38	6.97	0.62
HH4	0.03	2.43	-0.14	6.14	1.06
HH5	1.04	3.49	0.53	7.42	2
HH6	3.9	3.84	-0.2	6.46	1.32
HH7	4.66	3.21	-5.49	8.79	1.55
HH8	3.44	2.66	2.17	4.86	2.67
HH9	5.43	2.74	-2.32	5.26	0.97
HH10	4.14	2.54	-5.66	9.15	1.98
HH11	1.56	2.5	1.47	6.78	2.94
HH12	3.43	1.84	1.05	11.3	1.71
HH13	5.4	2.91	-2.11	5.45	1.37
HH14	5.45	2.87		5.43	1.55
HH15	4.6	2.74		7.29	0.81
HH16	4.58	2.59		9.12	0.52
HH17	6.44	3.71		14.62	1.14
HH18	5.09	2.78		0.74	1.05
HH19	0.56	4.88		5.3	0.62
HH20	2.01	5.53		6.01	0.47
HH21	-0.63	2.24		10.24	0.29
HH22	-0.96	1.98		4.17	-0.02
HH23	-1.38	4.05		9.16	0.42
HH24	2.49	1.76		10.72	-0.32
HH25	12.57	2.19		2.55	0.97
HH26	-0.68			16.01	3.59
HH27	3.7			-0.14	-0.27
HH28	2.86			4.06	4.37
HH29	-1.02			3.53	2.55
HH30	2.52			2.16	2.59
HH31	3.08			8.72	2.83
HH32	1.2			8.23	4.71
HH33	3.86			8.5	1.9
HH34				8.32	1.77
HH35				1.51	1.84
HH36				2.39	
HH37				11.41	
HH38				8.35	
HH39				1.41	

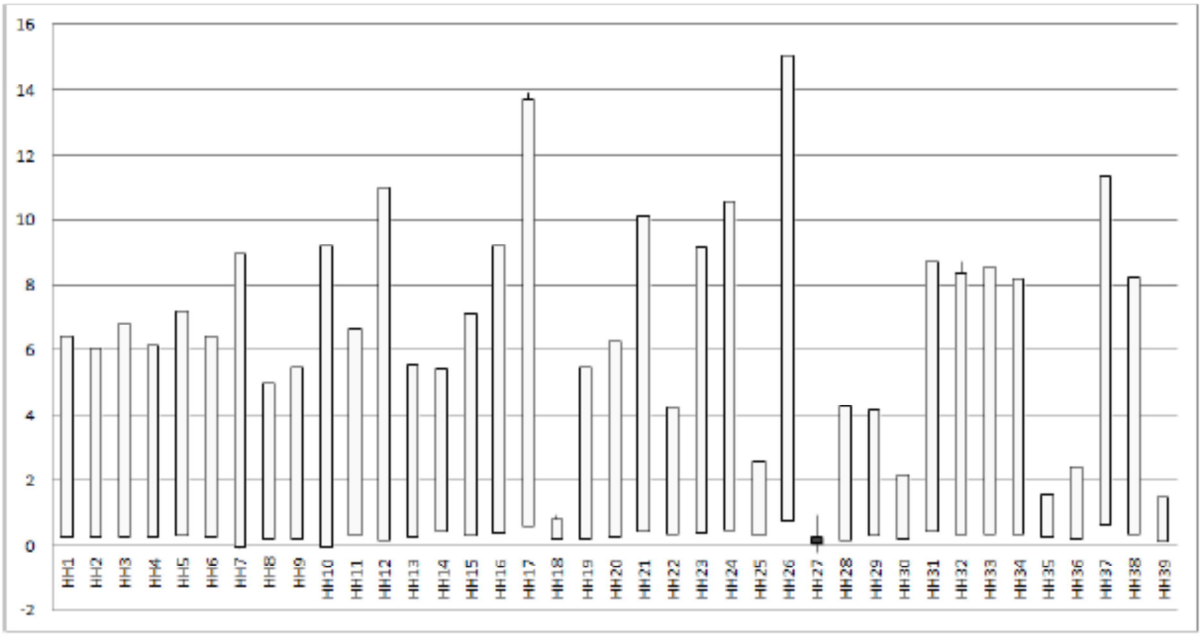
Source: Authors' elaboration from MIRAGE results

Figure 22: Tanzania - 2010/2025 - Dynamic impact of full trade liberalization on households'welfare



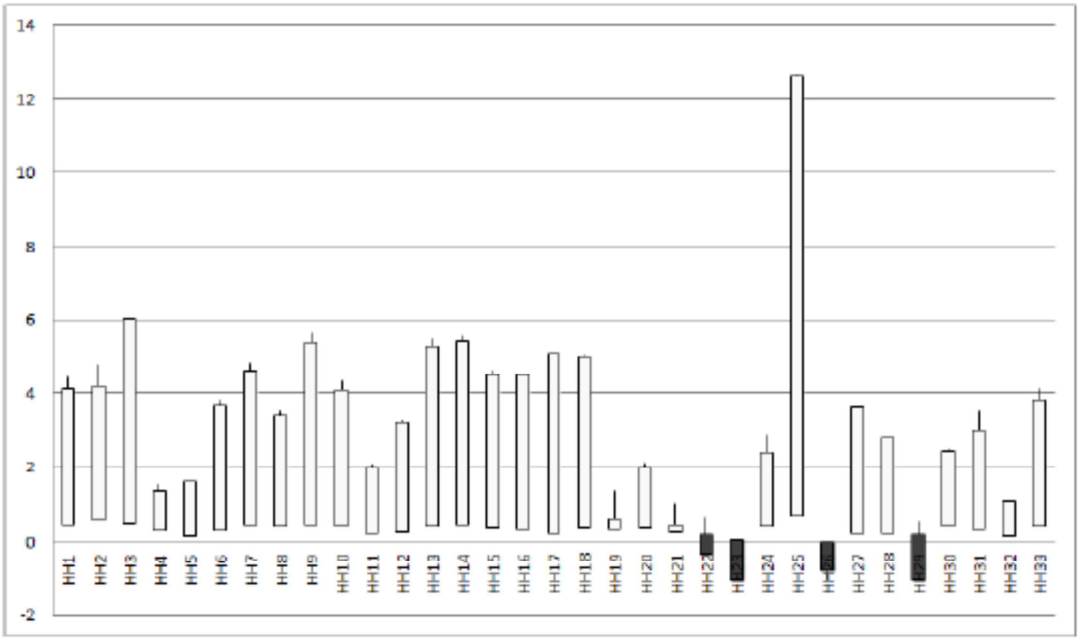
Source: Authors' elaboration from MIRAGE results

Figure 23: Uruguay - 2010/2025 - Dynamic impact of full trade liberalization on households'welfare



Source: Authors' elaboration from MIRAGE results

Figure 24: Vietnam - 2010/2025 - Dynamic impact of full trade liberalization on households'welfare

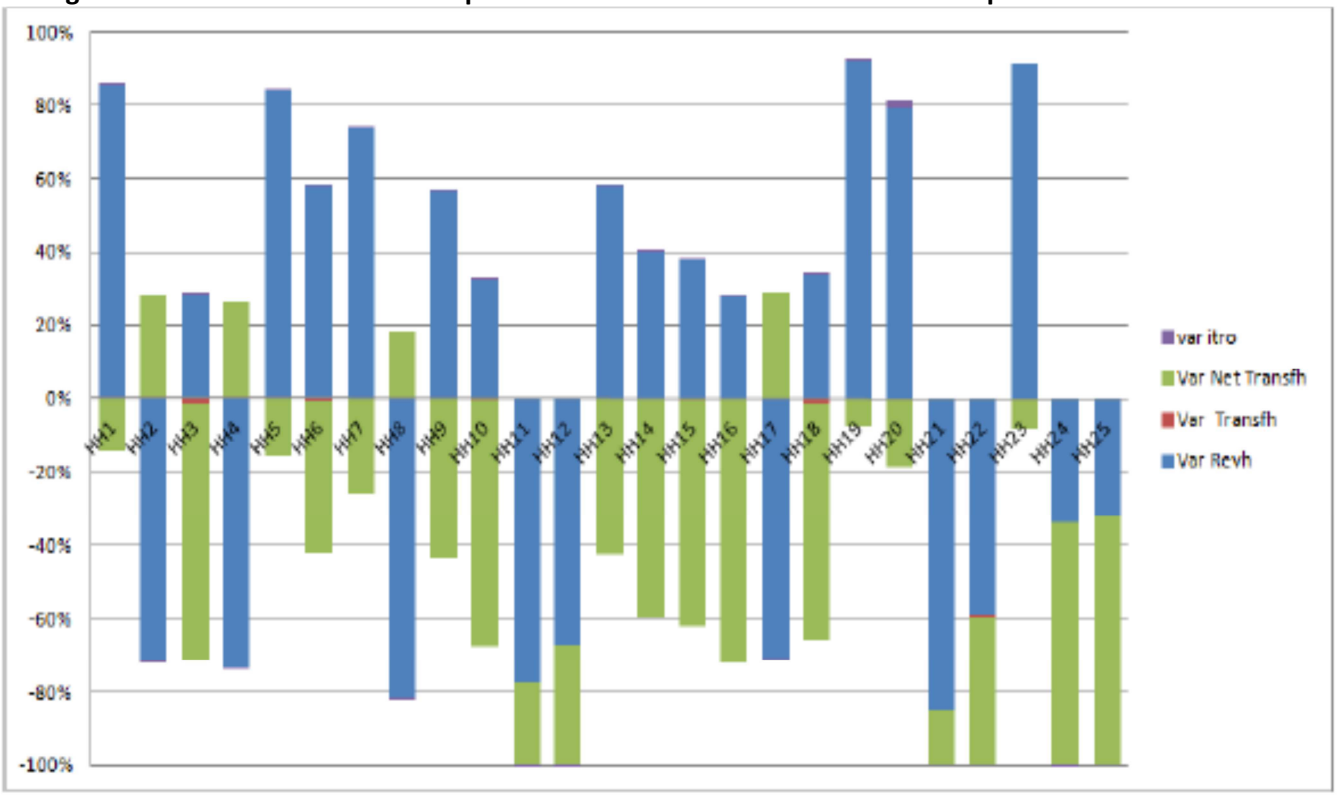


Source: Authors' elaboration from MIRAGE results

Figure 25: Brazil - 2025 - Decomposition of the variation of households' disposable income

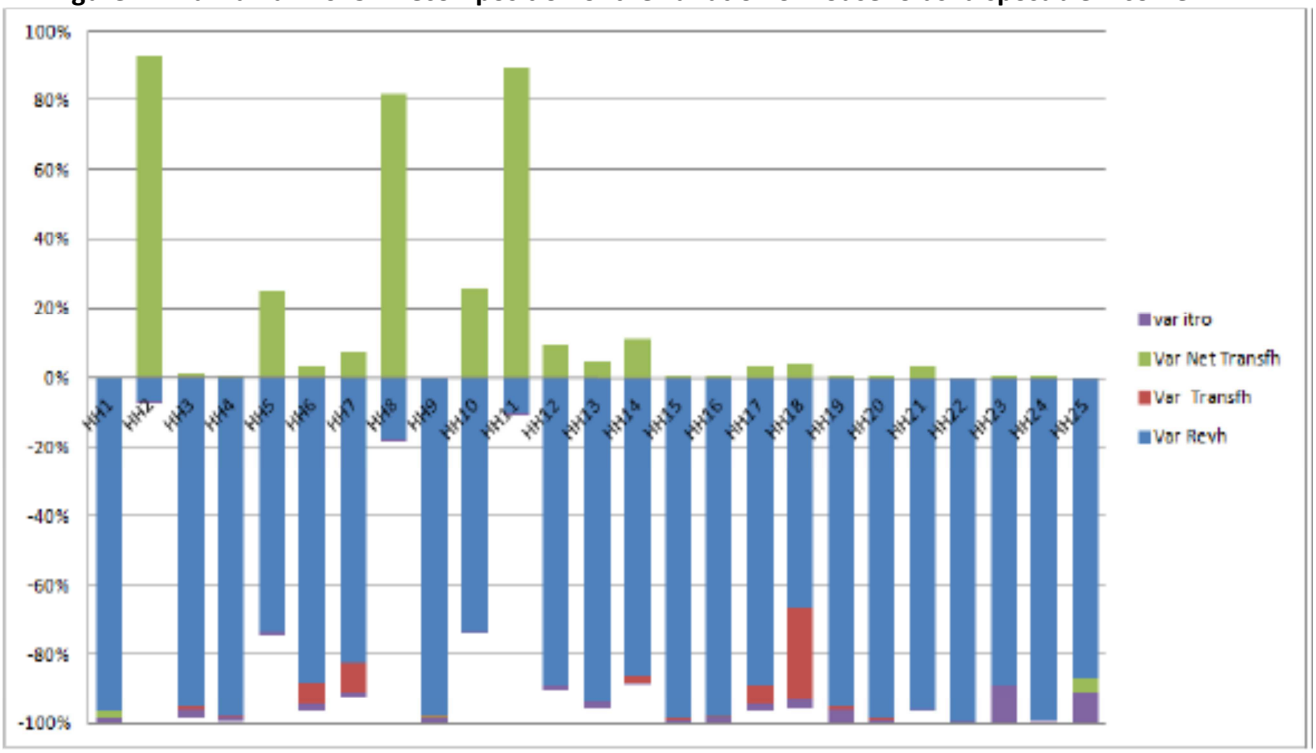
Source: Authors' elaboration from MIRAGE results

Figure 26: Pakistan - 2025 - Decomposition of the variation of households' disposable income



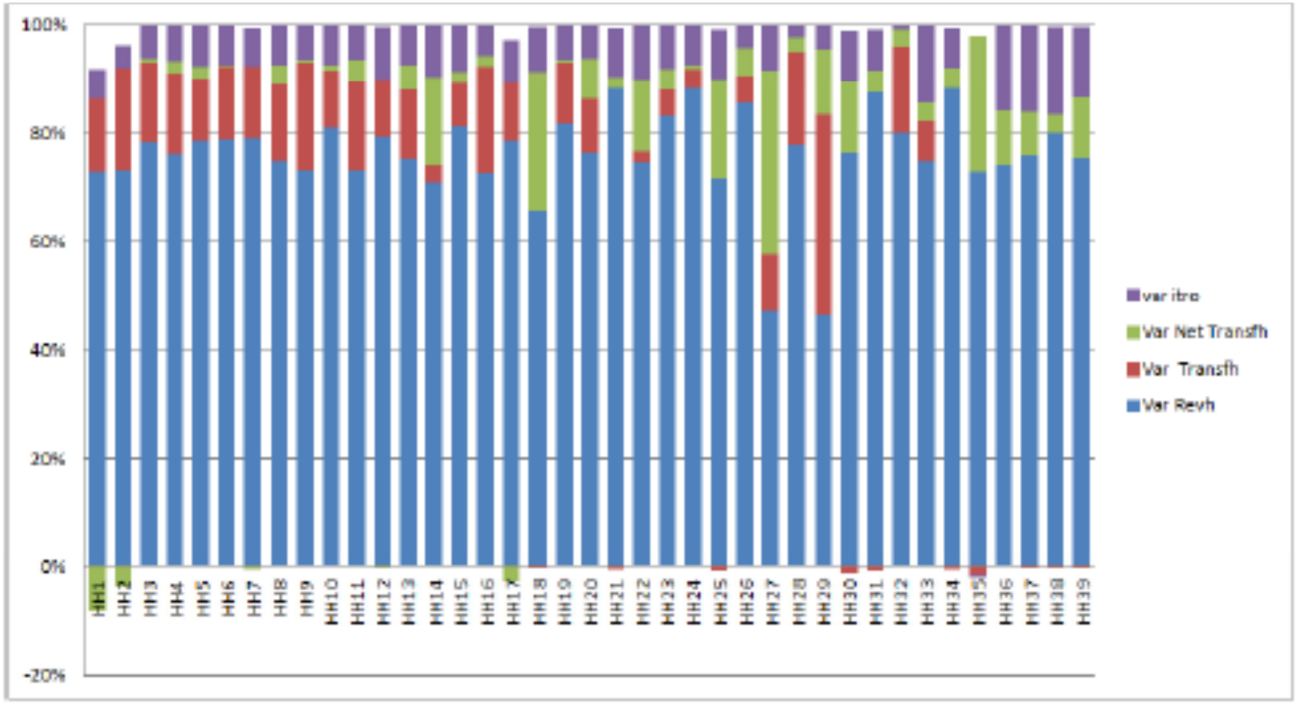
Source: Authors' elaboration from MIRAGE results

Figure 27: Tanzania - 2025 - Decomposition of the variation of households' disposable income



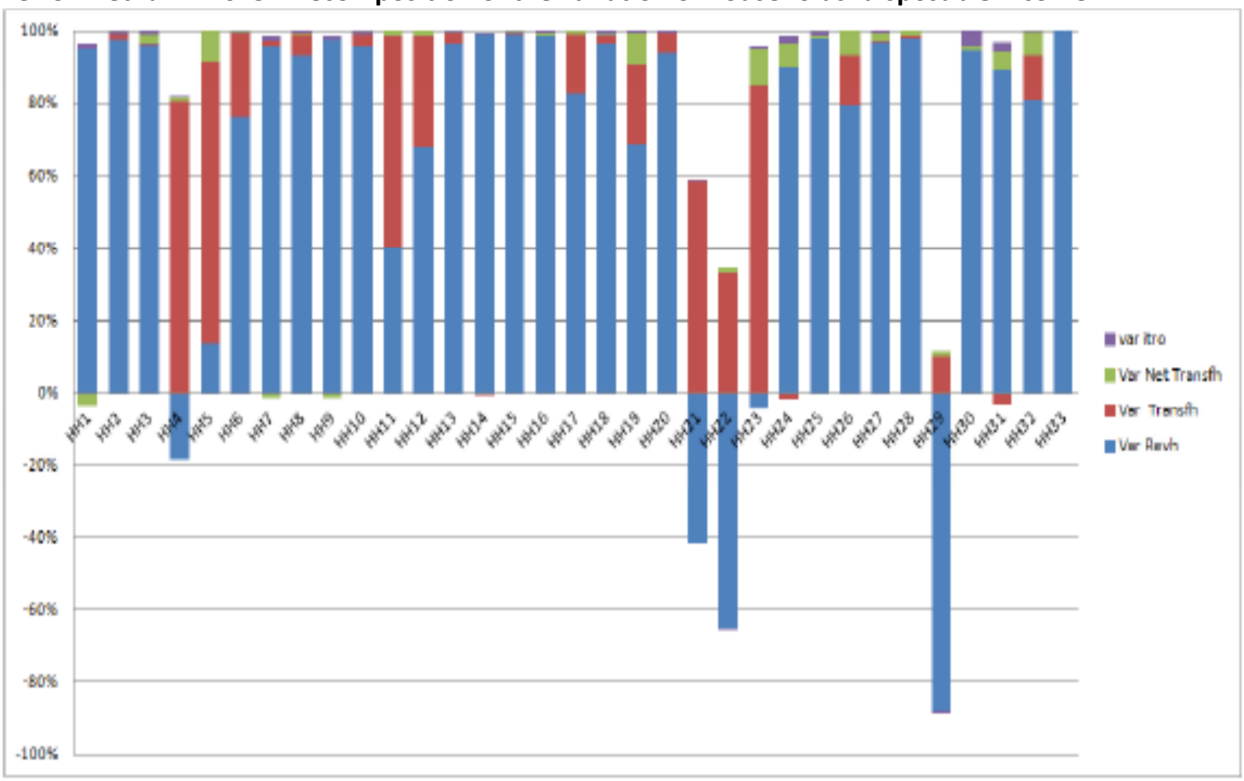
Source: Authors' elaboration from MIRAGE results

Figure 28: Uruguay - 2025 - Decomposition of the variation of households' disposable income



Source: Authors' elaboration from MIRAGE results

Figure 29: Vietnam - 2025 - Decomposition of the variation of households' disposable income



Source: Authors' elaboration from MIRAGE results

RECENT LAREFI WORKING PAPERS

For earlier LAREFI Working Papers, please go to http://lare-efi.u-bordeaux4.fr

All Discussion Papers can be downloaded free of charge

CR12-EFI/05 Chiappini, R., , "Les indices composites sont-ils de bonnes mesures de la compétitivité des pays ?"

CR12-EFI/04 Chiappini, R., , "Un réexamen de la relation entre commerce et Investissement Direct à l'étranger (IDE) à partir d'un modèle en panel dynamique. Le cas de l'Allemagne, la France et l'Italie"

CR12-EFI/03 Brana, S., Djibenou, M-L., Prat, S., "Global excess liquidity and asset prices in emerging countries : a pvar approach"

CR12-GED/171 Roca T., "A Methodology for Comparing Governance Database, Institutional Profiles Database Robustness. An example using corruption data, from simple graph representation to advanced econometrics"

CR12-EFI/02 Musson A., "Construire l'attractivité durable régionale : l'exemple de l'Aquitaine"

CR12-EFI/01 Dupuy L., "International Trade and Sustainability : A survey"