

Trade Liberalisation and Poverty in Nepal
A Computable General Equilibrium Micro Simulation Analysis*

John Cockburn[†]

Concern is growing regarding the impacts on income distribution and poverty of macroeconomic policies such as fiscal reform and trade liberalization. By their nature, these types of macroeconomic shocks have strong general equilibrium effects that can only be properly analysed in the context of a CGE model. However, CGE models generally contain only very aggregate household categories, which limit their usefulness for poverty and income distribution analysis. Indeed, the most widespread indicators used in poverty and income distribution analysis – density functions, Lorenz curves, dominance analyses, Atkinson and Gini inequality indicators, FGT poverty indices, etc. – are generally based on household- or individual-level data. In this study we attempt to bridge the gap between CGE models and poverty/distribution analysis by constructing a CGE model that explicitly models all the households from a nationally representative household survey. This is equivalent to constructing a CGE model with as many household categories as the number of households in the survey, except that each household category is modelled by actual households, thus avoiding the representative agent hypothesis. In this context, households are characterised primarily by their sources of income and their consumption patterns, which in turn determine how they are individually affected by macroeconomic shocks. We find that trade liberalization has quite complex poverty and distributional impacts, which can only be properly understood in this type of fully disaggregated model. Urban households are the big winners as initial tariffs were highest in agricultural sectors. Poverty falls in urban areas and increases in rural areas, particularly among the moderately poor. The strength of the impacts increases with the level of income and especially strong, mostly positive, effects are observed in the highest income levels. This may explain the apparent increase in income inequality in the urban and rural hills and mountains region.

Keywords: computable general equilibrium modelling, international trade, poverty, Nepal.

JEL: D33, D58, E27, F13, F14, I32, O15, O53

3 October, 2001

^{*}I would like to acknowledge financial support from Canada's Social Sciences and Humanities Research Council (SSHRC) and the International Development Research Centre's (IDRC) Micro Aspects of Macro Adjustment Policies (MIMAP) program. I am very grateful to Abdelkrim Araar, Louis-Marie Asselin, Bernard Decaluwé, Véronique Robichaud and Prakash Sapkota for their assistance and suggestions. This research builds on research performed by Bernard Decaluwé, Jean-Christophe Dumont and Luc Savard at CREFA (Université Laval). All remaining errors and omissions are my own responsibility. All comments are welcome: john.cockburn@nuf.ox.ac.uk

[†] Centre for the Study of African Economies and Nuffield College (Oxford University) and CREFA, jcoc@ecn.ulaval.ca

1. Introduction

In recent years, the impacts of macro-economic shocks, such as fiscal reform and trade liberalisation, on income distribution and poverty have become the subject of intense debate. Which tax regime is most equitable? Do the poor share in the gains from freer trade? What alternative or accompanying policies could be used to ensure a more equitable distribution? What are the mechanisms involved?

From a research perspective, the analysis of macroeconomic shocks and the analysis of income distribution and poverty use very different techniques and sources of data. Given its economy-wide nature and the strong general equilibrium effects they imply, the impacts of macroeconomic shocks are ideally examined in the context of a computable general equilibrium (CGE) model based on national accounting data. In contrast, income distribution and poverty issues are generally analysed on the basis of household or individual data in recognition of the heterogeneity of these agents and the importance of capturing their full distribution. A variety of income, consumption and, recently, multidimensional indicators are used in this poverty analysis.

In this study we attempt to meld these two currents. By explicitly integrating into a CGE model **all** households from a national household survey, we are able to simulate how each individual household is affected by trade liberalisation. Each household is characterised primarily by its sources of income and consumption patterns. Conceptually speaking, we replace the representative household(s) of a conventional CGE by a nationally representative sample of actual households to construct a CGE micro-simulation model. In this way, we are able to simulate the impact of macroeconomic shocks on conventional poverty and distributional indicators. Indeed, we generate all the individual household income and consumption data required to calculate and compare these indicators under alternative policy scenarios. Furthermore, we demonstrate that the technique is easy to implement and requires only a standard CGE model and a nationally representative household survey with information on household income and consumption.

The technique is illustrated through the analysis of the elimination of all import tariffs in Nepal. We use a conventional CGE model of Nepal that was constructed by Prakash Sapkota of the Himalayan Institute of Development (HID) in collaboration with us. Household data is obtained from the Nepalese Living Standards Survey (NLSS), a nationally representative survey of 3373 households.

2. Survey of the literature

There have been numerous attempts to adapt CGE models to the analysis of income distribution and poverty issues. The simplest approach is to increase the number of categories of households. In this context, it is possible to examine how different types of households (rural vs. urban, landholders vs. sharecroppers, region A vs. region B, etc.) are affected by a given shock. However, nothing can be said about the relative impacts on households within any given category as the model only generates information on the representative (or "average") household. There is increasing evidence that households within a given category may be affected quite differently according to their asset profiles, location, household composition, education, etc. Of course, this problem of intra-category variation decreases with the degree of disaggregation of household categories. Yet even in the most disaggregate versions – Piggott and Whalley (1985) have over 100 household categories – substantial intra-category heterogeneity in the impacts of a given shock are likely to subsist.

A popular alternative is to assume a lognormal distribution of income within each category where the variance is estimated using base year data (see De Janvry, Sadoulet et Fargeix, 1991). In this approach, the CGE model is used to estimate the change in the average income for each household category, while the variance of this income is assumed to be fixed. Decaluwé et al. (2000) argue that a beta distribution is preferable as, unlike the lognormal, it can be skewed left or right and thus better represent the different types of intra-category income distributions commonly observed.

Regardless of the distribution chosen, one must assume that all but the first moment is fixed and unaffected by the shock analysed. This assumption is hard to defend given the heterogeneity of income sources and consumption patterns of households even within very disaggregate categories. Indeed, it is often found that intra-category income variance amounts to more than half of total income variance.

The alternative, of course, is to model each household individually. As we explain below, this poses no particular technical difficulties as it simply implies constructing a model with as many household categories as there are in the household survey providing the base data. An independent strand of literature performs such individual-level analysis, commonly referred to as micro-simulations, of macro shocks. This literature traces its origins to research by Orcutt (1957 and 1961). More recently, some authors have developed micro-simulation models using household surveys to study issues of income distribution (Bourguignon, Fournier and Gurgand, 2000). However, these models are not in a general equilibrium framework.

Decaluwé, Dumont and Savard (1999) present a CGE micro-simulation model for 150 households based on fictional archetypal data. They construct the model so as to allow comparisons with the earlier approaches with multiple household categories and fixed intra-category income distributions. They show that intra-category variations are important, at least in this fictional context.

The only general equilibrium micro-simulations with true data are Tongeren (1994), Cogneau (1999) and Cogneau and Robillard (2000). Tongeren models individual firms rather than individual households. Cogneau's study concerns a city, Antananarivo, rather than a nation and is primarily concerned with labour market issues. Cogneau and Robillard examine the impact of various growth shocks, such as increases in total factor productivity, on poverty and income distribution in the context of a national model of Madagascar. They find that "although mean income and price changes are significant, the impact of the various growth shocks on the total indicators of poverty and inequality appears relatively small". They show that the neglect of general equilibrium effects, as in standard micro-simulations, and the assumption of a fixed intra-group income distribution, as in standard CGE models, both strongly bias results. However, their model's disaggregation of the household account is obtained at the cost of sectoral disaggregation as the model distinguishes only three branches and four goods. As the poverty and income distribution effects of macroeconomic shocks are mediated primarily by differences in household income and consumption patterns, this level of aggregation fails to capture many of the intra-household differences.

In this paper, we develop a CGE micro-simulation model that is simple in structure – maintaining the characteristics of an archetypal CGE model – while allowing full integration of 3373 households. Furthermore, this household disaggregation is obtained without sacrificing the disaggregation of factors, branches and products required to capture the links between trade liberalisation and household-level welfare. Indeed, we trace the impacts of trade liberalisation as it affects production in 45 separate branches (15 branches, 3 regions), with quite different initial tariff rates. These sectoral effects in turn influence the remuneration of 15 separate factors of production (skilled and unskilled labour, agricultural and non-agricultural capital, and land; all broken down into three regions). As the household survey data provide information on each household's income from each of these factors and each household's consumption of each of the 15 goods produced by the branches, the links between trade liberalisation and household welfare are complete.

3. Methodology

The construction of a basic CGE micro-simulation model is technically straightforward although, obviously, more sophisticated approaches can be envisaged. The objective is to integrate every household from a nationally representative household survey directly into an existing CGE model. In the case of Nepal, we use an existing CGE model constructed by Prakash Sapkota of the Himalayan Institute of Development in Kathmandu, in collaboration with us. This model is itself based on an archetypal CGE training model developed by Martin, Souissi and Decaluwé (1995). Household income, expenditure and savings data is obtained from the Nepalese 1995 Living Standards Survey (NLSS), based on a nationally representative sample of 3373 households.

The Nepalese CGE model is based on a 1986 social accounting matrix (SAM) of Nepal that includes the following 50 accounts:

Factors: skilled and unskilled labour, land, agricultural and non-agricultural capital.

Agents: households (urban; small, large and non-farm Terai; small, large and non-farm Hills and Mountains), firms, government, savings and the rest of the world.

Branches of production: paddy; other food crops; cash crops; livestock & fisheries; forestry; mining and quarrying; manufacturing; construction; gas, electricity and water; hotel and restaurant; transportation and communication; wholesale and retail trade; banking, real estate and housing; government services and other services.

Goods for domestic consumption: same as above, plus non-competing imports.

Export goods: other food crops; cash crops; livestock and fisheries; forestry; manufacturing; hotel and restaurant; transportation and communication; wholesale and retail trade; and other services

In a first stage, the household categories in the existing CGE models were aggregated to three categories (urban, Terai, and hills/mountains) to facilitate reconciliation with the NLSS data¹. The household income and expenditure vectors in the aggregate SAM were then recalculated using the NLSS data. This involved first establishing links between each of the 15 domestic final consumer goods in the SAM and the consumption categories used in the NLSS. In the same way, links were established between the household income sources in the SAM (remuneration of the five factors; dividends; net transfers from government and from the rest of the world) and the sources of income identified in the NLSS. Once these links were established, we calculated aggregate values for the three household categories by multiplying individual house-

¹ The Terai region is an area of fertile plains.

hold values by their respective NLSS sampling weights and summing over all households in each region².

With the introduction of the NLSS data, the SAM inevitably becomes unbalanced. To re-establish equilibrium, we fixed the NLSS-based household income and expenditure vectors, and modified all other values in the SAM until row and column sums were all equal. For this purpose, we prepared a simple program that seeks to establish equilibrium while minimising the variations in all SAM cells. Several optimisation criteria could be imagined. We chose to minimise the sum of the square of the rates of variation between the original (A_{0ij}) and new (A_{ij}) SAM values: $\text{Min } \sum_i \sum_j ((A_{ij}-A_{0ij})/A_{0ij})^2$

subject to $\sum_i A_{ij} = \sum_j A_{ij}$ and: $A_{hj} = A_{0hj}$ where h represent the household account in the SAM.

When the aggregate SAM was balanced and coherent with the household survey data, we increased the number of household categories in the CGE to 3373, the number of households in the NLSS survey, and introduced individual household income, consumption and savings data. Income and expenditure vectors for each household were first multiplied by their sample weights before introduction into the model. The rest of model calibration and resolution remains unchanged with respect to a standard CGE.

Household consumption is modelled using a LES expenditure function:

$$CH_{hh,i} = \text{MINI}_{hh,i} + \beta_{hh,i}^C (CTH_{hh} - \sum_j PC_j \text{MINI}_{hh,j}) / PC_i$$

where, for household hh, $CH_{hh,i}$ is its consumption of good i, $\text{MINI}_{hh,i}$ is its minimum subsistence requirement of commodity i, $\beta_{hh,i}^C$ is the marginal share of good i in its consumption, CTH_{hh} is its total consumption and PC_j is the composite price of good j. Calibration of this function is obtained using estimates of income elasticities and Frisch parameters from the literature³. This

² A number of adjustments were required in the process. Income data in the NLSS were not clearly distinguished between labour (skilled and unskilled) and capital (land, agricultural capital and non-agricultural capital) remuneration. Shares of remuneration of these factors from the base SAM were applied to the NLSS data in order to separate out these sources. Total income data appeared to be under-estimated, as is often observed in household survey data. We first increased all income by a region-specific rate so as to ensure that average regional savings rate were equal to those in the base SAM. Even with this change, total income was not sufficient to cover reported consumption for a large number of households (roughly 30%). We assume that this is due to the failure of the household survey data to capture inter-household transfers. Consequently, we increased the income of these households to equal their reported consumption and compensated this income increase by a reduction in the income of the other households that was applied at a uniform region-specific rate. As the SAM underlying the CGE model dates to 1986 and the NLSS data concerns 1995, all NLSS income, consumption and savings data were also deflated by a uniform rate so that total household income, summed over the three household categories, is equal to its 1986 value. A 1996-97 SAM will be available shortly and used in future research.

³ See Dervis, de Melo and Robinson (1982), Frisch (1959) and Lluch, Powell and Williams (1977).

specification captures differential impacts on households of trade liberalisation-induced changes in relative consumer prices.

Household income comes from factor remuneration and from transfers by firms (dividends), government (transfers minus income tax) and the rest of the world. Factor payments to households are a fixed share of the total remuneration of each factor, where the shares for each household are calibrated from the household survey data. As macro shocks modify the relative returns to these factors, households are affected according to their factor endowments. Transfers from the government and the rest of world are assumed fixed. Income tax is a small fixed share (1.5 to 5.0%; depending on the household's region of residence) of income. Dividends are a fixed share of firm capital income.

In order to better capture the channels through which trade liberalisation affects households, all sectors and factors of production are separated into the same three regions as households: urban, Terai, and hills/mountains⁴. Factors are mobile between sectors within each region but not between regions⁵. Agricultural capital is only mobile among agricultural sectors⁶, just as non-agricultural capital is mobile between all other sectors. National production in each sector is a CET combination of regional productions. As they are expected to be close substitutes, we use high elasticities of substitution ($=10$). Investment volume is fixed to avoid intertemporal welfare effects and foreign savings is also fixed. The numeraire is the "nominal exchange rate". Government consumption volume is fixed as welfare analysis is based on household consumption alone. Imported and domestic goods are imperfect substitutes in domestic consumption (Armington hypothesis), and exports and local sales are imperfect substitutes from the viewpoint of local producers. World prices for Nepal's imports and exports are fixed (small country hypothesis).

The rest of the model is standard (see Appendix A). Poverty and income distribution analysis is performed using DAD software (Duclos, Araar et Fortin, 2001)⁷.

4. Simulation results

To illustrate the analysis that can be performed with this type of model, we study the impact of the elimination of all import tariffs with a compensatory uniform consumption tax de-

⁴ See Fafchamps and Shilpi (2001) for a discussion of the spatial division of labour in Nepal.

⁵ The introduction of a migration function would be an interesting extension of the model.

⁶ Agricultural sectors are: paddy; other food crops; cash crops; livestock & fisheries; forestry.

⁷ This program is available free of charge with a user's manual at: www.mimap.ecn.ulaval.ca.

signed to maintain government revenue constant. Of course, this is just one example of the numerous policies that could be studied using this model.

Generally speaking, we might expect that the elimination of import tariffs will be pro-poor if the tariffs initially protect sectors that use factors (capital, etc.) that provide a small share of income for the poor. On the other hand, the poor may consume proportionately less of import (or import-competing) goods and thus benefit less from the resulting reduction in the prices of these goods⁸. In this general equilibrium framework, the resulting income and consumption effects will, in turn, feed back into the model and influence the overall results.

We begin with the initial tariff rates and trace the impacts of their elimination through the model, from sectoral supply and demand to factor remuneration and, finally, household income and consumption, bearing in mind that in a CGE model all variables interact and are determined simultaneously. We examine the case where the elimination of import tariffs is compensated by the introduction of a uniform 1.1% consumption tax, endogenously determined so as to maintain revenue neutrality. As the consumption tax is applied uniformly to all goods, it does not create any distortions in the relative consumption prices allowing us to focus on the impacts of the elimination of all tariffs.

Table 1 presents sectoral supply and demand effects. Initial tariff rates (t_m) are highest in the paddy, other food crop, mining and gas/electricity/water sectors and it is these sectors that experience the greatest increase in import volumes ($\bar{\Delta}M$) following the elimination of tariffs. However, imports represent a small share of local consumption (M/Q) in all but the manufacturing sector and, to a lesser degree, the transport/communication, mining and trade sectors. Thus, despite the use of high Armington elasticities of substitution between imported and local goods ($=5$), the impact on local demand for domestic production ($\bar{\Delta}D$) is small for all but the mining and manufacturing sectors, and the decline in producer prices for local sales (PD) is moderate.

Faced with a moderate reduction in local prices and fixed export prices, producers of exportable goods divert a portion of their sales to the export market with a CET elasticity of 5. In sectors where a large share of local production is initially exported (EX/XS) – hotel and restaurant, transport/communication, trade and manufacturing – this export response leads to an increase in total sectoral production ($\bar{\Delta}XST$) or, in the case of manufacturing, partially offsets the decline in local sales. In the other sectors, the change in total sectoral production ($\bar{\Delta}XST$) is roughly equal to the change in local sales ($\bar{\Delta}D$). Sectors with high export shares also experience

⁸ Chan, Ghosh and Whalley (forthcoming) study the consumption effects of trade liberalisation.

a reduction in their output price (δPT) that is inferior to that of their local sales given that export prices are fixed. As elasticities of substitution between regions in sectoral production are assumed to be high ($=10$), there is little regional variation in the production response (δXS ($=\delta VA$)) or producer price changes (not shown) within any given sector.

Table 1: Effects of trade liberalisation on sectoral production (%)

	Imports/local sales					Exports/Production				$\delta XS=\delta VA$		
	tm	δM	M/Q	δD	δPD	δEX	EX/XS	δXST	δPT	Urban	Terai	Hills
AGRICULTURE												
Paddy	13.5	52.4	0.2	-0.8	-4.0	21.6	0.1	-0.7	-4.0	-0.7	-0.5	-1.4
Other food crops	12.2	43.4	0.6	-0.8	-4.0	21.9	0.2	-0.8	-4.0	0.8	0.4	-1.7
Cash crops	7.0	11.7	3.5	-0.7	-4.3	23.8	2.0	-0.2	-4.2	-1.3	-0.8	0.4
Livestock/fisheries	4.4	-1.5	1.2	-0.9	-4.4	24.0	1.9	-0.4	-4.3	-1.0	-0.9	0.0
Forestry				0.8	-4.2	25.1	0.1	0.9	-4.2	-0.5	0.6	1.6
NON-AGRICULTURE												
Mining	12.3	39.8	8.6	-10.4	-2.6			-10.4	-2.6	-12.2	-11.8	-9.8
Manufacturing	8.1	15.8	47.0	-8.1	-3.1	7.8	16.8	-5.4	-2.6	-6.0	-5.4	-3.5
Construction				-0.9	-2.4			-0.9	-2.4	-1.2	-0.7	-0.6
Gas, electricity, water	10.9	47.7	2.4	-2.3	-2.0			-2.3	-2.0	-2.4	-1.9	-1.9
Hotel and restaurant				1.6	-2.4	14.9	55.9	9.1	-1.0	9.2	10.1	6.6
Transport/commun.	6.0	13.8	13.3	-1.4	-2.9	14.4	30.5	3.5	-2.0	3.4	4.0	3.0
Trade	3.4	2.2	6.8	1.5	-3.1	18.9	20.9	5.2	-2.4	3.2	6.4	10.0
Banking and real estate				0.9	-2.1			0.9	-2.1	0.5	1.6	0.5
Government services				-0.1	-2.5			-0.1	-2.5	-0.1	-0.3	0.3
Other services				-0.1	-2.2	11.6	0.8	0.0	-2.2	1.6	0.2	-2.7

In summary, trade liberalisation engenders a clear sectoral reallocation of resources from the mining and manufacturing sectors, where initial tariffs and import shares were relatively high, in favour of the hotel/restaurant, trade and transport/communication sectors, with the other sectors remaining relatively unaffected. Prices decline the most in the agricultural sectors, although the differences are small.

Let us now see how these production effects influence factor remunerations (Table 2). The general decline in nominal factor remuneration rates should be considered in the framework of a trade liberalisation-induced fall in consumer and producer price indices⁹. In this context, we are most interested in how the rates of remuneration of factors change relative to one another. To understand these results, we take into account, for each factor, the share of each sector in its total remuneration (Table 3).

⁹ The consumer and producer price indices decline by roughly 3.2%.

Table 2: Effects of trade liberalisation on factor remuneration

	Wage rate		Returns to:			Change in other income
	Unskilled	Skilled	Ag. Cap.	Non-ag. Cap.	Land	
Urban	-2.9	-2.3	-5.4	-1.7	-5.4	0.02
Terai	-4.1	-2.3	-5.1	-0.6	-5.1	0.02
Hills and Mountains	-4.3	-2.3	-4.4	-0.8	-4.4	0.02

Notes: Ag. cap=Agricultural capital; Non-ag. Cap.=Non-agricultural capital

Table 3: Sectoral breakdown in total factor remuneration (%)

	Unskilled labour				Skilled labour				Capital				Land			
	U	T	H	TOT	U	T	H	TOT	U	T	H	TOT	U	T	H	TOT
Paddy	11	28	11	17	1	6	3	3	31	34	13	23	32	35	13	23
Other food crops	5	9	20	14	0	2	6	3	10	7	14	11	9	6	13	10
Cash crops	4	17	21	18	0	5	8	5	16	27	36	31	16	29	36	32
Livestock/fisheries	10	16	28	22	0	2	4	2	27	16	27	23	28	15	28	23
Forestry	3	7	5	6	0	2	2	2	16	16	10	13	16	15	10	12
TOTAL AGRICULTURE	34	77	84	76	2	18	23	15	100	100	100	100	100	100	100	100
Mining	0	0	0	0	0	0	0	0	0	0	2	1				
Manufacturing	8	2	1	2	2	3	2	2	18	18	12	16				
Construction	22	8	6	8	1	3	2	2	22	26	28	25				
Gas, electricity, water	1	0	0	0	2	0	0	1	2	1	1	1				
Hotel and restaurant	3	1	0	1	0	0	0	0	4	3	2	3				
Transport/communication	11	4	3	5	4	7	7	6	14	17	21	17				
Trade	2	0	0	0	1	1	1	1	20	12	10	15				
Banking and real estate	14	5	4	5	4	8	7	6	18	21	23	20				
Government services	0	0	0	0	82	56	55	63	0	0	0	0				
Other services	5	2	1	2	3	4	4	3	1	2	2	2				
TOTAL NON-AGRICULTUR	66	23	16	24	98	82	77	85	100	100	100	100				

Leg-

end: U=Urban; T=Terai; H=Hills and mountains; TOT=Total

Unskilled labour is primarily remunerated by agricultural sectors except in urban regions where construction, banking/real estate, transport/communication and manufacturing are important employers. As output prices fall by roughly 4% in the agricultural sector, we see similar declines in the remuneration of unskilled labour¹⁰. The decline is smaller for urban unskilled labour as it is not so tightly linked to the agricultural sector. Skilled labour is employed primarily by the government services sector and, consequently, the variation in skilled wage rate closely follows that of the government sector output prices. Agricultural capital (upper half of column "Capital") and land are remunerated primarily by the cash crops, paddy and livestock/fisheries sectors. As agricultural output prices decline the most following trade liberalisation, these purely agricultural factors are the biggest losers, particularly in the urban region where agricultural production experiences the largest declines. Non-agricultural capital is the biggest relative winner.

¹⁰ Variation in value added prices may differ from those of output prices according to the intermediate consumption patterns of each sector. We do not find large differences and so do not present the variations in value added prices.

How do changes in the factor remunerations affect nominal household income? This depends on the share of income the household draws from each factor. In Table 4 we decompose the average income changes for households in each region into changes in income from each factor¹¹. The latter are equal to the factor's share in the household income multiplied by the change in the factor's remuneration rate (drawn from Table 2).

Table 4: Sources of household income by region

	Income shares (%)			Change in factor Remuneration rates			Income change		
	U	T	H	U	T	H	U	T	H
WAGES									
Unskilled	24.5	33.8	36.1	-2.9	-4.1	-4.3	-0.7	-1.4	-1.6
Skilled	22.0	10.4	9.2	-2.3	-2.3	-2.3	-0.5	-0.2	-0.2
RETURNS TO:									
Ag. Capital	0.4	1.9	1.8	-5.4	-5.1	-4.4	0.0	-0.1	-0.1
Non-ag. Capital	32.5	18.8	11.6	-1.7	-0.6	-0.8	-0.6	-0.1	-0.1
Land	6.2	30.5	34.1	-5.4	-5.1	-4.4	-0.3	-1.6	-1.5
OTHER INCOME	14.27	4.65	7.14	0.0	0.0	0.0	0.30	0.08	0.14
TOTAL	100.0	100.0	100.0				-1.8	-3.3	-3.3

Legend: U=Urban; T=Terai; H=Hills and mountains

Terai and hill/mountain households derive their income from similar sources, primarily unskilled labour and land. As the remuneration of these two factors undergoes the largest declines, we can understand that households in these two regions have a more substantial loss in nominal income than do urban households. Indeed, urban households receive nearly one-third of their income from non-agricultural capital, which experiences the smallest reduction in terms of remuneration rates.

In summary, on the income side we find that trade liberalisation in Nepal encourages a reallocation of resources from the agricultural sector, particularly the heavily-protected and inward-oriented paddy and other food crop sectors, to the service and non-manufacturing industrial sector. This, in turn, leads to a fall in the remuneration of land and unskilled labour relative to skilled labour wages and, a fortiori, non-agricultural capital. These changes tend, in turn, to favour urban households over rural households.

Now let us look how trade liberalisation affects these households on the consumption side (Table 5). Sectoral consumer prices reflect changes in import prices ($\bar{\delta}PM$), changes in the prices of local sales by domestic producers ($\bar{\delta}PD$) and the share of imports in local consumption (M/Q). They also reflect the 1.1% uniform consumption tax. We have already seen that initial tariff rates are highest – and, consequently, the fall in import prices is greatest, in the paddy,

¹¹ Bernard Decaluwé suggested this decomposition.

other food crops, mining and gas/electricity/water sectors. We also saw that import intensities are highest in the manufacturing and transport/communication sectors and how the combination of these factors determines how the domestic producers' local prices evolve. On this basis, it is easy to understand that consumer prices fall most in the initially highly protected agricultural sector and the initially moderately protected but import-intensive manufacturing sector.

Table 5: Effects of trade liberalisation on consumer prices

	δPM	δPD	M/Q	δPC	Urban	Terai	Hills/Mtns
AGRICULTURE					65.0	79.2	79.0
Paddy	-11.9	-4.0	0.2	-3.0	14.1	32.1	18.2
Other food crops	-10.9	-4.0	0.6	-3.1	5.9	13.5	18.1
Cash crops	-6.5	-4.3	3.5	-3.4	24.1	24.2	28.8
Livestock/fisheries	-4.2	-4.4	1.2	-3.4	4.4	4.0	5.0
Forestry	0.0	-4.2	0.0	-3.2	16.5	5.4	8.8
NON-AGRICULTURE					35.0	20.8	21.0
Mining	-10.9	-2.6	8.6	-2.5	0.0	0.0	0.0
Manufacturing	-7.5	-3.1	47.0	-3.7	19.5	13.2	15.1
Construction	0.0	-2.4	0.0	-1.4	0.0	0.0	0.0
Gas, electricity, water	-9.8	-2.0	2.4	-1.2	0.5	0.1	0.0
Hotel and restaurant	0.0	-2.4	0.0	-1.4	0.3	0.1	0.1
Transport/communication	-5.7	-2.9	13.3	-2.2	2.9	1.1	1.1
Trade	-3.2	-3.1	6.8	-2.1	0.0	0.0	0.0
Banking and real estate	0.0	-2.1	0.0	-1.1	0.2	0.5	0.1
Government services	0.0	-2.5	0.0	-1.4	10.0	5.0	4.0
Other services	0.0	-2.2	0.0	-1.1	1.6	0.8	0.6
				Total	100.0	100.0	100.0
				Consumer price indices	-3.1	-3.1	-3.2

While urban households consume a smaller share of agricultural goods than Terai or hill/mountain households (65% vs. 79%), they consume more manufacturing goods (19% vs. 13-15%). Consequently, there is practically no difference in the impacts of trade liberalisation on the consumer price indices of households in these three regions. This said, it should be underlined that all households consume almost exclusively the goods that experience the greatest price declines, which implies a strong consumption payoff from trade liberalisation, despite the imposition of a uniform 1.1% consumption tax.

Combining income and consumption effects in equivalent variations, we find that revenue-neutral trade liberalisation has practically no aggregate welfare effects. This is not surprising as we are replacing a moderately distortionary import tariff, varying from 3.4 to 13.5% (Table 1), by a uniform consumption tax in a second-best framework where distortionary income and production taxes remain. In terms of its distributive effects, urban households benefit from liberalisation, whereas Terai and Hill-Mountain households lose out (Table 6). This result can be traced to the pro-urban income effects above.

Table 6: Equivalent variations (as % of base income)

	Urban	Terai	Hills/Mountains	All
Equivalent variation	0.47	-0.09	-0.06	0.01

What conclusions can we draw in terms of poverty? If, for example, we consider the urban poor, we might conclude that trade liberalisation is beneficial. However, we saw that the smaller reduction in nominal incomes observed among households in the urban sector was due in large part to their greater endowment of non-agricultural capital and their lesser dependency on income from land and unskilled labour. Yet it is likely that among urban households, the poor are precisely those households with the least access to capital and the greatest dependency on unskilled wages. We may therefore suspect that households **within** this region will be affected quite differently. Indeed, when we examine the distribution (standard deviation) of the above nominal income variations and equivalent variations, there is an enormous degree of heterogeneity in the impacts of trade liberalisation among households in each region (Table 7).

Table 7: Distribution of Income Variations and Equivalent Variations By Region

		Income Variation	Equivalent Variation
Urban	Mean	-1.81	0.50
	Standard deviation	(5.61)	(2.25)
Terai	Mean	-3.32	-0.10
	Standard deviation	(2.29)	(0.76)
Hills/Mountains	Mean	-3.32	-0.09
	Standard deviation	(2.18)	(0.77)

One solution is to disaggregate households in each region into the poor and non-poor with, presumably, quite different factor endowments and consumption patterns. While this may reduce the intra-household heterogeneity, it would be difficult to eliminate heterogeneity altogether in a model with five production factors and 16 consumer goods. When we adopt one-half the nationwide median income as the poverty line, we see that the urban poor appear to be affected more favourably than the non-poor. However, there remain substantial differences in the effects of trade liberalisation not only between poor and non-poor within a region, but also **within** these categories (Table 8).

An alternative is to assume a fixed income distribution, estimated on the base year data, within each region. However, it is unlikely that the income of all households will increase in the same proportion or in such a way that the income distribution shifts in parallel. In our urban example, it is likely that the increase in the returns to non-agricultural capital relative to unskilled

wages will result in an increase in income disparities. We examine these issues as we analyse various poverty and distributional indicators below.

Table 8: Distribution of Income Variations and Equivalent Variations By Region

		Income Variation	Equivalent Variation
Urban non-poor	Mean	-1.89	0.39
	Standard deviation	(5.51)	(2.44)
Urban poor	Mean	-1.42	0.59
	Standard deviation	(6.02)	(2.08)
Terai non-poor	Mean	-3.33	-0.12
	Standard deviation	(2.31)	(0.77)
Terai poor	Mean	-2.97	0.06
	Standard deviation	(1.78)	(0.70)
Hills/Mountains non-poor	Mean	-3.32	-0.12
	Standard deviation	(2.23)	(0.83)
Hills/Mountains poor	Mean	-3.25	0.00
	Standard deviation	(1.34)	(0.53)

The advantage of the micro-simulation approach is its capacity to incorporate all the heterogeneity of household income sources and consumption patterns directly in the model so that we can model the impacts of trade liberalisation on each individual household. In effect, we use the micro-simulation model to generate the data from a hypothetical new household survey if it were to be executed after trade liberalisation. We then use these data and the base year data (drawn from the NLSS) to calculate and compare standard income-based poverty and distribution indicators before and after the simulation.

We convert all data in terms of individuals, rather than households, using the following standard equivalence scale (ES): $ES_i = 1 + 0.7(Z_i - 1 - K_i) + 0.5K_i$ where i is the household index, Z is the number of household members and K is the number of children. Thus the first adult counts as 1, the other adults are each 0.7 and children are 0.5, to take account of scale economies and age.

Foster-Greene-Thorbecke (FGT) indices are the most common poverty indicators:

$$P_{\alpha} = \frac{1}{Nz^{\alpha}} \sum_{j=1}^J \left(z - y_j \right)^{\alpha}$$

where j is a sub-group of individuals with income below the poverty line (z), N is the total number of adult equivalents in the sample, y_j is the income of individual j and α is a parameter that allows us to distinguish between the alternative FGT indices. When α is equal to 0, the expression simplifies to X/N or the headcount ratio, a measure of the incidence of poverty. Poverty

depth is measured by the poverty gap, which is obtained with α equal to 1. The severity of poverty is measured by setting α equal to 2¹².

We define the poverty line as one-half of the nationwide median income and thus ours is a measure of relative rather than absolute poverty¹³. Further on, we will present FGT curves, which map out these results for a wide range of possible values for the poverty line. Our analysis is based on both real income and real consumption data. Post-liberalisation income and consumption data are deflated by household-specific Laspeyres consumer price indices to account for the general fall in these prices¹⁴.

These results suggest that the impacts of this fiscal reform on poverty are quite small and statistically insignificant (Table 9). As we will see, given the substantial heterogeneity of households and individuals within each region, poverty results are extremely sensitive to the choice of poverty line and the use of FGT curves is preferable.

Table 9: Normalised FGT poverty indices (%)

Index	All			Urban		
	Before	After	Change	Before	After	Change
Head count ratio ($\alpha= 0$)	7.16 (0.49)	7.15 (0.49)	-0.01 (0.11)	3.64 (1.03)	3.57 (1.03)	-0.07 (0.57)
Poverty gap ($\alpha= 1$)	1.40 (0.13)	1.41 (0.13)	0.01 (0.01)	0.63 (0.22)	0.59 (0.21)	-0.04 (0.02)
Poverty severity ($\alpha= 2$)	0.45 (0.06)	0.45 (0.06)	-0.00 (0.00)	0.18 (0.08)	0.15 (0.07)	-0.03 (0.02)
Index	Terai			Hills/Mountains		
	Before	After	Change	Before	After	Change
Head count ratio ($\alpha= 0$)	6.52 (0.79)	6.33 (0.78)	-0.19 (0.18)	8.21 (0.71)	8.36 (0.71)	0.15 (0.13)
Poverty gap ($\alpha= 1$)	1.02 (0.18)	1.02 (0.18)	-0.00 (0.01)	1.84 (0.20)	1.86 (0.20)	0.02 (0.02)
Poverty severity ($\alpha= 2$)	0.26 (0.08)	0.26 (0.07)	-0.00 (0.00)	0.65 (0.09)	0.65 (0.09)	-0.00 (0.01)

Notes: Standard deviations in parentheses. Poverty line = 0.5*median income of individuals in region.

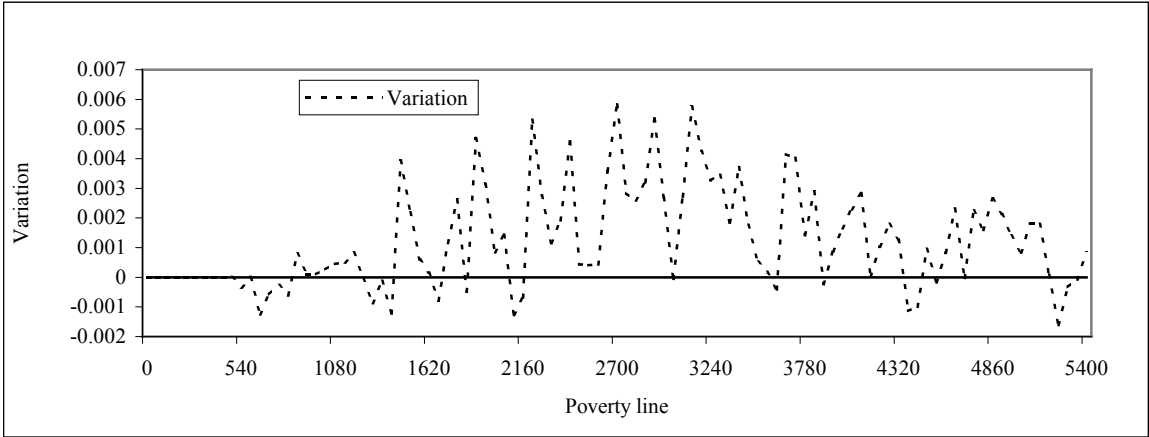
¹² See Ravallion (1984) for a full discussion of poverty indicators.

¹³ This is equal to 1350 Nepalese rupees, which in 1986 currency (21 rupees=\$1US), was roughly equal to \$US 65 per person. A common alternative measure of absolute poverty is obtained when the poverty line is defined as the minimum income required to cover "basic needs".

¹⁴
$$CPI_{hh} = \frac{\sum_i PC_i CH_{hh,i}^0}{\sum_i PC_i^0 CH_{hh,i}^0}$$
, where PC_i is the consumer price in sector i , $CH_{hh,i}$ is household hh 's consumption of good i and superscript 0 refers to base year values.

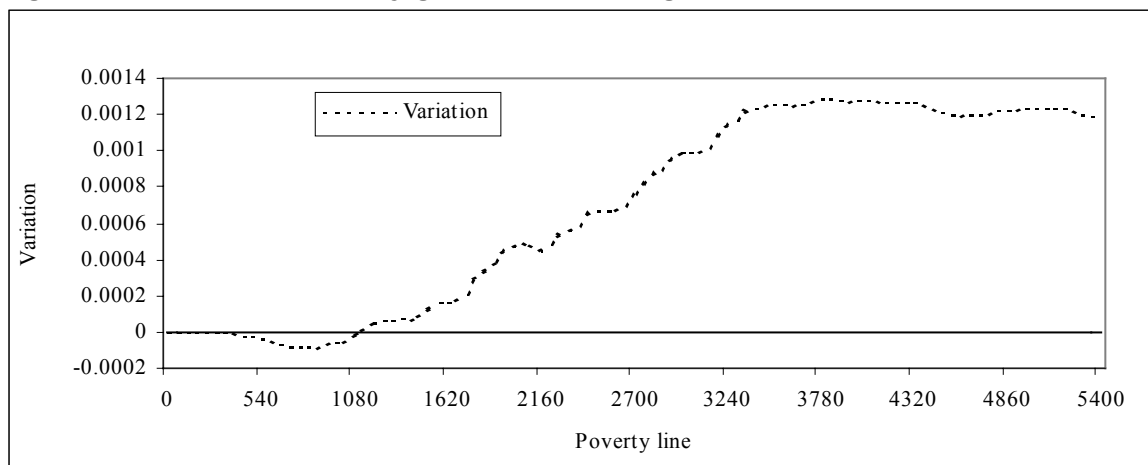
As the choice of poverty line (one-half median income) is debatable, we present the variation in the headcount ratios and poverty gaps for a wide range of poverty lines (from zero to twice the median income) in the figures below. The results are highly sensitive to the choice of poverty line. While there is some evidence of a slight reduction in the number of the very poorest (under 900 rupees, or \$US 43, per capita annual income), the number of moderately poor appears to increase as a result of trade liberalization. At the regional level (Figures A1-A3 in Appendix B), trade liberalization appears to reduce the incidence of poverty in urban areas and to increase its incidence in the two rural areas.

Figure 1: Variation in headcount ratio curves (All regions)



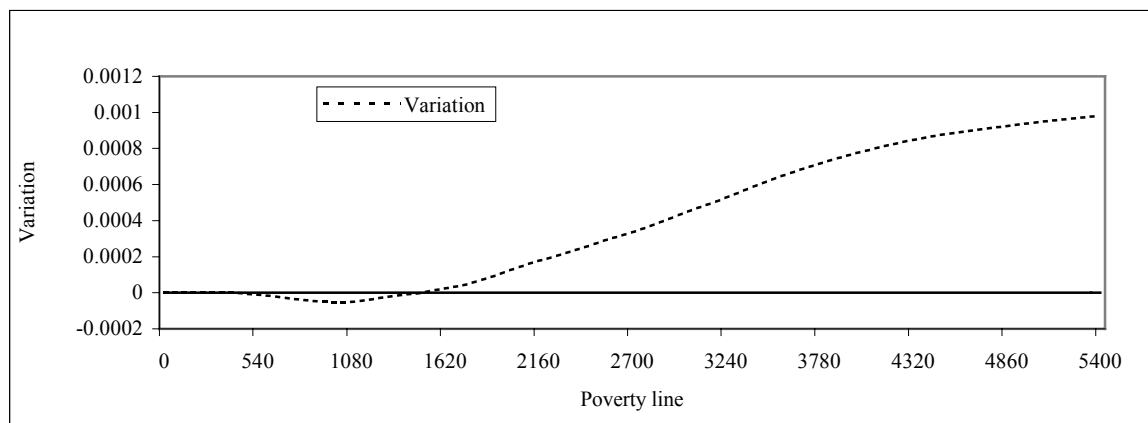
Examination of poverty gap curves reinforces the message from the head count ratio: a slight reduction in the depth of poverty among the very poorest and a clear increase in poverty among the moderately poor (Figure 2). Indeed, as we will see further on, it appears that the very wealthiest individuals are the main beneficiaries of trade liberalization. At the regional level, the results contrast dramatically (Figures A4-A7 in Appendix B). Urban-dwellers are the clear winners, with the exception of a group of moderately poor. In rural areas, the very poorest are relatively unaffected but there is a clear increase in the depth of poverty among the moderately poor.

Figure 2: Variation in poverty gap curves (All regions)



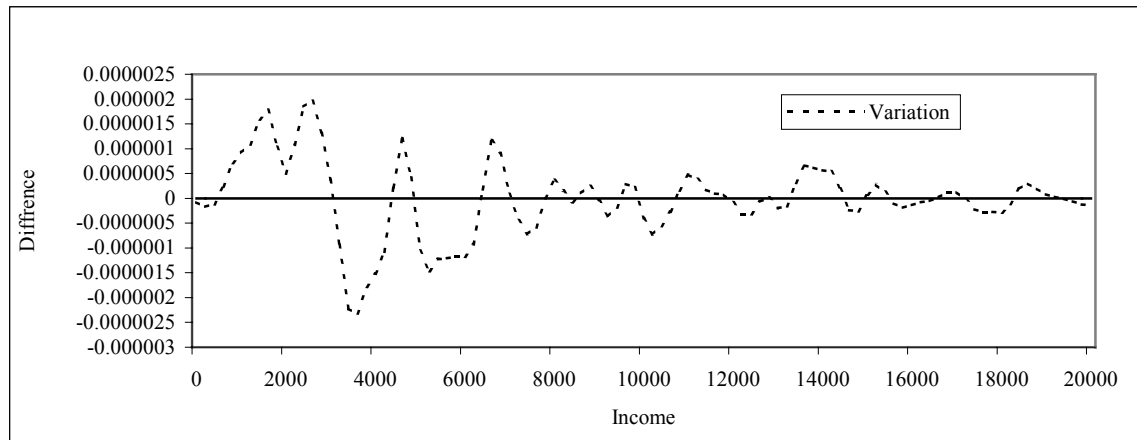
Similar results are observed when we examine poverty severity (Figure 3). Regional results resemble those for the poverty gap and are therefore not presented.

Figure 3: Variation in poverty severity curves (All regions)



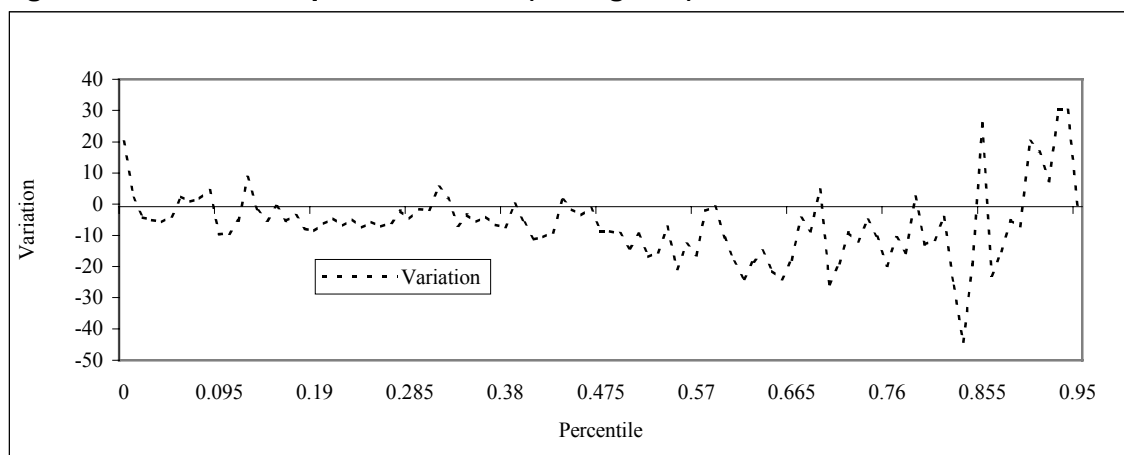
To obtain a broader perspective on the distributive effects of trade liberalization, we look at changes in the density function for income (Figure 4). The density function measures the percentage of individuals with a given income. With some exceptions, there seems to be a movement of individuals from the middle-income brackets (3000-6500 rupees annual per capita income) toward lower income brackets (1000-3000 rupees). This suggests that further trade liberalisation would increase income disparities in Nepal. There is also a clear urban-rural dichotomy (Figures A7-A10 in Appendix B). In urban areas, there is a clear movement of individuals from the lower and middle income brackets (1000-6000 rupees) toward the highest income brackets (8000-15000 rupees). In contrast, there is an increase in the density of income among the very poorest (1000-3000 rupees) and an increase among the moderately poor (3,000 to 5,000-6,000 rupees).

Figure 4: Variation in density functions



We can see how income levels change according to income ranking using quantile curves (Figure 4). This analysis generates quite striking results. Individuals in most quintiles experience a loss of income as a result of trade liberalization, with the notable exception of the very richest percentiles. Indeed, we truncated the quantiles at 0.95 as the increases among the highest five percentiles went off the scale. Regional results allows us to see that the gains in the urban region tend to increase with the level of income and that the very poorest actually see their incomes fall (Figures 10-12 in Appendix B). In the rural areas, income losses also appear to increase, as does the variability of the impacts of trade liberalization.

Figure 5: Variation in quantile curves (All regions)



The above results suggest that income inequality may be affected by trade liberalization. Two popular inequality indicators are the Atkinson and Gini indices. They clearly show that inequality increases as a result of trade liberalization, primarily in the urban areas but also in the hills and mountains region (Table 10).

Table 10: Inequality indices

Index	All			Urban		
	Before	After	Change	Before	After	Change
Atkinson index ($\epsilon = 0.5$)	13.17 (1.19)	13.31 (1.19)	0.14 (0.04)	19.78 (2.22)	19.96 (2.23)	0.18 (0.09)
Atkinson index ($\epsilon = 0.75$)	17.74 (1.40)	17.91 (1.40)	0.17 (0.04)	26.75 (2.65)	26.98 (2.66)	0.23 (0.13)
Gini index	37.85 (1.38)	38.03 (1.38)	0.18 (0.04)	47.52 (2.63)	47.74 (2.63)	0.23 (0.13)
Index	Terai			Hills/Mountains		
	Before	After	Change	Before	After	Change
Atkinson index ($\epsilon = 0.5$)	6.19 (0.46)	6.18 (0.46)	-0.01 (0.02)	12.65 (2.10)	12.71 (2.09)	0.06 (0.05)
Atkinson index ($\epsilon = 0.75$)	8.85 (0.62)	8.83 (0.62)	-0.01 (0.02)	17.19 (2.46)	17.26 (2.46)	0.07 (0.06)
Gini index	26.99 (0.93)	26.95 (0.93)	-0.04 (0.04)	37.04 (2.43)	37.12 (2.42)	0.08 (0.06)

5. Conclusion

We have shown that it is straightforward to adapt a standard CGE model to explicitly integrate a large number of households (over 3000 in this case). Using data on household income sources and consumption patterns collected in most standard household surveys, we are able to model the impacts of trade liberalisation (or any other macroeconomic shock) on **individual households** and how these impacts feed back into the general equilibrium of the economy.

Combining household data from the Nepalese Livings Standards Survey and a standard CGE model, we are able to simulate the elimination of all tariffs. As the model estimates income for each individual household, we are able to effectively generate all the data required to carry out standard income-based poverty and income distribution analysis. We conclude that trade liberalisation in Nepal favours urban households as opposed to Terai (fertile plains) and Hill/Mountain households. This result is traced mainly to the high initial tariffs in agricultural sectors.

However, these average results disguise an enormous variation in the impacts on individuals within each geographic region, even when we separate households into poor and non-poor. In this context, traditional poverty and inequality indicators can be useful to better understand these impacts. Generally speaking, the impacts of trade liberalisation on income distribution appear to be small, however some interesting results emerge.

Poverty falls in urban areas and appears to increase in rural areas, particularly among the moderately poor as opposed to the very poorest. The absolute impact of trade liberalization, whether it is positive (in the urban areas) or negative (in the rural areas), generally increases with the level of income. Indeed, there appear to be very strong, mostly positive, impacts on the very richest individuals. This may explain our finding of increased income inequality in the urban and hills/mountains regions.

We conclude that CGE-based micro-simulations can be constructed with very little technical difficulty and that this type of model is indispensable for studying the poverty/distributional impacts of any macro-economic policy or shock, such as trade liberalisation, that is likely to have general equilibrium effects.

6. References

- Bourguignon, F., M. Fournier and M. Gurgand (2000), "Fast Development with a Stable Income Distribution: Taiwan, 1979-1994", Working paper 2000-07, DELTA, Paris.
- Chan, Nguyen, Madanmohan Ghosh, John Whalley (forthcoming), "Evaluating Tax Reform in Vietnam Using General Equilibrium Methods", Journal of Policy Modeling
- Cogneau, D. (1999), "Labour Market, Income Distribution and Poverty in Antananarivo: A General Equilibrium Simulation", mimeo, DIAL, Paris.
- Cogneau, D. and A.S. Robillard (2000), "Growth Distribution and Poverty in Madagascar: Learning from a Microsimulation Model in a General Equilibrium Framework", mimeo, DIAL, Paris.
- Decaluwé, B., J.-C. Dumont and L. Savard, "Measuring Poverty and Inequality in a Computable General Equilibrium Model", Working paper 99-20, CREFA, Université Laval.
- Decaluwé, B., M.-C. Martin and M. Soussi (1995), École PARADI de Modélisation des Politiques Économiques de Développement, 3^{ième} éd., Université Laval. Québec.
- Decaluwé, B., A. Patry, L. Savard et E. Thorbecke (1999), "Poverty Analysis within a General Equilibrium Framework", Working paper 9909, Department of Economics, Laval University.
- De Janvry, A., E. Sadoulet and A. Fargeix (1991), "Politically Feasible and Equitable Adjustment: Some Alternatives for Ecuador", World Development, 19(11):1577-1594.
- Dervis, Kemal., James de Melo and Sherman. Robinson (1982), General Equilibrium Models for Development Policy, Cambridge University Press, 484p.
- Duclos JY., A. Araar et Carl Fortin (2001), DAD: A Software for Distributional Analysis/Analyse Distributive, MIMAP Programme, International Development Research centre, Government of Canada and CREFA, Université Laval.
- Fafchamps, M. and F. Shilpi (2001), The Spatial Division of Labour in Nepal, mimeo, Oxford, University of Oxford: 45.
- Frisch, R. (1959), "A Complete Scheme for Computing All Direct and Cross Demand Elasticities in a Model with Many Sectors," Econometrica 27, 177-196.
- Lluch, Powel and Williams (1977), Patterns in Household Demand and Savings, London, Oxford University Press.
- Orcutt, G. (1957), "A New Type of Socio-Economic System", Review of Economics and Statistics, 58: 773-797.
- Orcutt, G. M. Greenberg, J. Korbel and A. Rivlin (1961), Microanalysis of Socioeconomic Systems: A Simulation Study, Urban Institute Press, Washington.
- Piggott, J. and J. Whalley (1985), UK Tax Policy and Applied General Equilibrium Analysis, Cambridge, Cambridge University Press.
- Ravallion, M. (1994), Poverty Comparisons, Harwood Academic Publisher, New York.
- Tongeren, F.W. van (1994), "Microsimulation Versus Applied General Equilibrium Models", mimeo, presented at 5th International Conference on CGE Modeling, October 27-29, University of Waterloo, Canada.

7. Appendix A: Specification of core CGE Model Equation for Nepal

PRODUCTION

Total sectoral production (XST_i) is a CES aggregate of regional productions ($XS_{i,reg}$):

$$(1) XST_i = b_{XS_i} * (\sum_{reg} dx_{S_i,reg} * XS_{i,reg}^{\rho_{XS_i}})^{-1/\rho_{XS_i}}$$

Urban and Terai production are derived from the above expression:

$$(2) XS_{i,"URB"} = ((dx_{S_i,"HMT"}) / (dx_{S_i,"URB"}))^{\sigma_{XS_i}} ((p_{i,"HMT"}) / (p_{i,"URB"}))^{\sigma_{XS_i}} * XS_{i,"HMT"}$$

$$(3) XS_{i,"TER"} = ((dx_{S_i,"HMT"}) / (dx_{S_i,"TER"}))^{\sigma_{XS_i}} ((p_{i,"HMT"}) / (p_{i,"TER"}))^{\sigma_{XS_i}} * XS_{i,"HMT"}$$

Regional indices are suppressed in the rest of the presentation of the production block to lighten the text as all production variables are regional. Regional production follows a Leontief technology on a first level:

$$(4) XS_i = VA_i / v_i$$

VA is value added and the v_i are Leontief technical coefficients of value added. Intermediate consumption (IC) is also Leontief:

$$(5) IC_i = (1 - v_i) XS_i$$

Sectoral intermediate consumption (ICJ) is derived from sectoral Leontief coefficients:

$$(6) IC_{ij} = a_{ij} IC_j$$

Intermediate imports (ICNCI) are treated as non-competitive given the absence of domestic production of the bulk of capital equipment and industrial raw materials. Demand for non-competitive imports is modelled as a Leontief technology.

$$(7) ICNCI_i = noi_i XS_i$$

where the noi are the Leontief technical coefficients for non-competitive imports. Value added (VA) is a CES of capital (KT) and labour (LD) in the non-government sector branches (n).

$$(8) VA_n = b_n (\delta_n KT_n^{-\rho(n)} + (1 - \delta_n) LD_n^{-\rho(n)})^{-1/\rho(n)}$$

Total labour demand is derived from cost minimisation and (8):

$$(9) LD_n = ((1 - \delta_n) / \delta_n)^{\sigma(n)} (r_n / w_n)^{\sigma(n)} KT_n$$

where r is the price of composite agricultural capital. In agricultural sectors, composite capital is a Cobb-Douglas aggregate of land (LAND) and other agricultural capital (KD):

$$(10) KT_{ag} = A_{ag} KD_{ag}^{\alpha_{ag}} LAND_{ag}^{1 - \alpha_{ag}}$$

where A and α are the Cobb-Douglas scale and elasticity parameters. Agricultural capital demand is derived from cost minimisation subject to the above Cobb-Douglas function:

$$(11) KD_{ag} = (\alpha_{ag} r_{ag} KT_{ag}) / r_a$$

where ra is the rate of return on agricultural capital. Total labour demand in non-government sectors is a CES aggregate of unskilled (LDNQ) and skilled (LDQ) labour:

$$(12) \quad LD_n = b_n^{lb} (\delta_n^{lb} LDNQ_n^{-\rho lb} + (1 - \delta_n^{lb}) LDQ_n^{-\rho lb})^{-1/\rho lb}$$

where δ are the distributional shares and ρ the elasticity of substitution of labour types. Demand for skilled labour is derived from cost minimisation and (12):

$$(13) \quad LDQ_n = ((1 - \delta_n^{lb}) / \delta_n^{lb})^{\sigma lb} (wnq/wq)^{\sigma lb} LDNQ_n$$

where wnq and wq are the wage rates for unskilled and skilled labour. Value added of the government sector is simply the skilled labour wage bill as this is the only production factor used in this sector:

$$(14) \quad VA_{ad} = LDQ_{ad}$$

Skilled labour demand in the government sector is determined by the ratio of value added at the government sector to the wage rate.

$$(15) \quad LDQ_{ad} = (P_{ad} X S_{ad} - \sum_j PC_j | C J_{jad} - PC N_{ad} | C N C I_{ad}) / wq (1 + tv)$$

For simplicity, we assume that all the government employees are skilled:

$$(16) \quad LD_{ad} = LDQ_{ad}$$

INCOME AND SAVINGS

Household income consists of wage income, returns to capital and land, dividends (DIV) and indexed transfers:

$$(17) \quad YH_{hh} = \sum_{reg} ((\gamma_{hh,reg}^{nq} wnq_{reg} \sum_n LDNQ_{n,reg}) + (\gamma_{hh,reg}^q wq_{reg} \sum_n LDQ_{n,reg}) \\ + \gamma_{hh,reg}^{kd} (r_{reg} \sum_{in} KT_{in,reg} + ra_{reg} \sum_{ag} KD_{ag,reg}) + \gamma_{hh,reg}^{ld} r_{reg} \sum_{ag} LAND_{ag,reg}) \\ + DIV_{hh} + ER * TRH_{hh} + PINDEX * TGH_{hh}$$

where hh is the household index, YH is total household income, TGH is exogenous government transfer payments to households, TRH is exogenous foreign transfer payments to households and ER is the nominal exchange rate (or foreign currency conversion factor). $\gamma_{hh,reg}^{nq}$ and $\gamma_{hh,reg}^q$ are the shares of unskilled and skilled labour remuneration going to household hh in region reg . $\gamma_{hh,reg}^{kd}$ and $\gamma_{hh,reg}^{ld}$ are the shares of capital and land remuneration going to household hh in region reg ; ra and r are rates of return on agricultural and non-agricultural capital and rt is the rental on land. Disposable income (YDH) is derived as household income net of income taxes applied at the rate ty :

$$(18) \quad YDH_{hh} = (1 - ty_{hh}) * YH_{hh}$$

Firm income (YF) consists of its capital income (YK), exogenous government transfers to firms (TGF) indexed by the producer price index (PINDEX) and exogenous foreign transfers to firms (TRF), evaluated in local currency:

$$(19) \quad YF = YK + \text{PINDEX} * \text{TGF} + \text{ER} * \text{TRF}$$

Firm capital income (YK) is the sum of firm capital income and land remuneration:

$$(20) \quad YK = \sum_{\text{reg}} ((1 - \sum_{\text{hh}} \gamma_{\text{hh,reg}}^{\text{kd}}) (r_{\text{reg}} \sum_{\text{in}} \text{KT}_{\text{in,reg}} + r_{\text{ag,reg}} \sum_{\text{ag}} \text{KD}_{\text{ag,reg}}) \\ + (1 - \sum_{\text{hh}} \gamma_{\text{hh,reg}}^{\text{ld}}) r_{\text{reg}} \sum_{\text{ag}} \text{LAND}_{\text{ag,reg}})$$

Dividends (DIV) are a share (dvr) of firm capital income:

$$(21) \quad \text{DIV}_{\text{hh}} = \text{dvr}_{\text{hh}} YK$$

Household saving (SH) is a fixed share (mps) of household disposable income (YDH):

$$(22) \quad \text{SH}_{\text{hh}} = \text{mps}_{\text{hh}} \text{YDH}_{\text{hh}}$$

Firm savings (SF) are derived by deducting capital taxes (tkYK) and dividends:

$$(23) \quad \text{SF} = \text{YF} - \text{tkYK} - \sum_{\text{hh}} \text{DIV}_{\text{hh}}$$

Exogenous government revenue (YG) is indexed by the producer price index. It is equal to the sum of income taxes (TXY_{hh}), capital income taxes on firms (tk*YK), transfers from rest of the world (TRG) expressed in local currency, production taxes (TXS_{i,reg}), import tariffs (TXM_m and TMNI_{i,reg}), export duties (TXE_x) and the consumption tax revenue (TC_i):

$$(24) \quad \text{PINDEX} * \text{YG} = \sum_{\text{hh}} \text{TXY}_{\text{hh}} + \text{tk} * \text{YK} + \text{ER} * \text{TRG} + \sum_{\text{reg}} \sum_{\text{i}} \text{TXS}_{\text{i,reg}} + \sum_{\text{m}} \text{TXM}_{\text{m}} \\ + \sum_{\text{reg}} \sum_{\text{i}} \text{TMNI}_{\text{i,reg}} + \sum_{\text{x}} \text{TXE}_{\text{x}} + \text{TC}_{\text{i}}$$

where x (m) is the exportable (importable) branch index. Government savings (SG) are equal to government income less exogenous government transfers to firms (TGF), to households (TGH) and to the rest of the world (TGR), less public consumption (CTG):

$$(25) \quad \text{SG} = \text{PINDEX} (\text{YG} - \text{TGF} - \sum_{\text{hh}} \text{TGH}_{\text{hh}}) - \text{ER} * \text{TGR} - \text{CTG}$$

TAXES

Indirect taxes are equal to the tax revenue generated from total output at producer price.

$$(26) \quad \text{TXS}_{\text{i,reg}} = \text{tx}_{\text{i,reg}} \text{P}_{\text{i,reg}} \text{XS}_{\text{i,reg}}$$

where tx_i is indirect tax rate. Import duty revenue (TXM_m) is equal to the tariff rate (tm_m) levied on imports (M_m) expressed in domestic prices:

$$(27) \quad \text{TXM}_{\text{m}} = \text{tm}_{\text{m}} \text{ER} * \text{PWM}_{\text{m}} \text{M}_{\text{m}}$$

where PWM_m is the world price of imports. Export duty revenue (TXE_x) is equal to rate of export duty (te_x) applied to the domestic value of export sales (EX_x):

$$(28) \quad \text{TXE}_{\text{x}} = \text{te}_{\text{x}} \text{PE}_{\text{x}} \text{EX}_{\text{x}}$$

where PE_n is the domestic price of exports. Tariff revenue from non-competitive imports (TMNI) is equal to the rate of non-competitive tariff (tmi) applied to the CIF value of non-competitive imports converted to the domestic currency by nominal exchange rate (ER):

$$(29) \quad TMNI_{i,reg} = tmi_{i,reg} ER * PCNW_i * ICNCl_{i,reg}$$

where $PCNW_i$ ($ICNCl_i$) is the world price (volume) of non-competitive imports. The compensatory consumption tax revenue (TC) is equal to the endogenously determined uniform consumption tax (tc) multiplied by the total value of household consumption:

$$(30) \quad tc \sum_{hh} \sum_i PC_i CH_{hh,i}$$

where PC is the consumer price and CH is the volume of household consumption.

DEMAND

Household consumption (CTH) is equal to disposable income (YDH) less savings (SH).

$$(31) \quad CTH_{hh} = YDH_{hh} - SH_{hh}$$

Household consumption (CH) is modelled using Linear Expenditure System (LES). It has two components: minimum subsistence consumption (MINI) and supernumerary consumption above the household minimum.

$$(32) \quad CH_{hh,i} = MINI_{hh,i} + \beta_{hh,i}^C (CTH_{hh} - \sum_j PC_j MINI_{hh,j}) / PCF_i$$

where $\beta_{hh,i}^C$ is marginal share of good i in household consumption by household group hh, PC_j is the composite consumer price of good j and PCF_i is the composite consumer price of good i including the consumption tax. Government consumption by good (CG_i) is fixed. Final consumption of good i (C_i) is comprised of household and government consumption.

$$(33) \quad C_i = \sum_{hh} CH_{hh,i} + CG_i$$

Total government consumption (CTG) is the sum of government consumption by good:

$$(34) \quad CTG = \sum_i CG_i$$

Intermediate demand of good i ($INTD_i$) is derived from the input-output relations.

$$(35) \quad INTD_i = \sum_{reg} \sum_j |C_{j,reg}|$$

Investment demand for good i (INV_i) is a fixed value share of total investment.

$$(36) \quad INV_i = \beta_i^I IT / PC_i$$

where β_i^I is the share of good i in total investment demand and IT is total investment. Total investment is equal to exogenous investment volume (ITVOL), multiplied by the investment price index (PINV).

FOREIGN TRADE

Total composite output in the exportable sectors is defined as a constant elasticity of transformation (CET) function between domestically and export markets.

$$(37) \quad XS_x = b_x^T ((\delta_x^T EX_x^{\rho^T(x)} + (1 - \delta_x^T) D_x^{\rho^T(x)})^{1/\rho^T(x)}$$

where D_x is local demand for domestically produced goods (volume), b_x^T is the scale parameter, δ_x^T is the distributive share parameter and ρ_x^T is the transformation parameter. Export supply is derived from by profit maximisation subject to the above CET function:

$$(38) \quad EX_x = ((PE_x(1 - \delta_x^T)) / (PD_x \delta_x^T))^{\sigma^T(x)} D_x$$

where $\sigma^T(x) = 1 / (1 + \rho^T(x))$ is the CET elasticity. In the non-exportable sectors (nx), composite output is sold solely on the local market:

$$(39) \quad XS_{nx} = D_{nx}$$

In importable branches, the composite consumption good (Q_m) is an Armington CES function of domestic and imported goods,

$$(40) \quad Q_m = b_m^s (\delta_m^s M_m^{-\rho^s(m)} + (1 - \delta_m^s) D_m^{-\rho^s(m)})^{-1/\rho^s(m)}$$

where b_m^s is the scale parameter, δ_m^s is the distributive share parameter and ρ_m^s is the substitution parameter. Import demand is derived from cost minimization and the CES:

$$(41) \quad M_m = (PD_m \delta_m^s / PM_m (1 - \delta_m^s))^{\sigma^s(m)} D_m$$

where $\sigma^s(m) = 1 / (1 + \rho^s(m))$ is the Armington elasticity. In non-importable branches, only domestic goods are consumed:

$$(42) \quad Q_{nm} = D_{nm}$$

The exogenous current account balance (CAB) is equal to the trade balance plus exogenous transfer payments from the rest of the world (TGR) less exogenous transfers from the rest of the world to households (TRH_{hh}), firms (TRF) and government (TRG):

$$(43) \quad CAB = (\sum_m PWM_m M_m + \sum_i PNCW_i \sum_{reg} ICNCI_{i,reg} - \sum_x PWE_x EX_x) + TGR - \sum_{hh} TRH_{hh} - TRF - TRG$$

PRICES

The aggregate composite producer price (PT) is equal to the weighted sum of the regional producer prices (P) multiplied by the production tax rate (tx):

$$(44) \quad PT_i = \sum_{reg} (XS_{i,reg} / XST_i) P_{i,reg} (1 + tx_{i,reg})$$

The value-added price (PVA) is the ratio of total output less intermediate consumption to the value added in the sector.

$$(45) \quad PVA_{n,reg} = (P_{n,reg} XS_{n,reg} - \sum_j PC_j IC_{jn,reg} - PCN_{reg} ICNCI_{n,reg}) / (VA_{n,reg})$$

The rental rate (r) on capital is the operating surplus per unit of composite capital:

$$(46) \quad r_{n,reg} = (PVA_{n,reg}VA_{n,reg} - w_{n,reg}LD_{n,reg}) / KT_{n,reg}$$

The rental rate of land is the ratio of differential rental income between composite agricultural capital and other capital demand in agriculture to that of land.

$$(47) \quad rt_{ag,reg} = (r_{ag,reg}KT_{ag,reg} - raKD_{ag,reg}) / LAND_{ag,reg}$$

where rt is the rate of return on land. The average wage rate (w) is the total wage bill of the skilled and unskilled labour per unit of labour demand:

$$(48) \quad w_n = (wqLDQ_n + wnqLDNQ_n) / LD_n$$

The domestic price of imports is equal to world prices of imports evaluated at nominal exchange rate inclusive of import tariffs.

$$(49) \quad PM_m = (1 + tm_m)ER.PWM_m$$

The domestic price of exports is equal to world price of exports evaluated at nominal exchange rate and adjusted for the export taxes.

$$(50) \quad PE_x = ER.PWE_x / (1 + te_x)$$

The after-tax consumer price (PCF) is equal to the pre-tax consumer price (PC) multiplied by one plus the uniform compensatory consumption tax rate (tc):

$$(51) \quad PCF_i = PC_i(1 + tc)$$

The composite consumer price (PC_m) in importable sectors is defined as the weighted average price of domestic and import prices, the weights being the share of domestic and imported output in the composite commodity:

$$(52) \quad PC_m = (D_m/Q_m)PD_m + (M_m/Q_m)PM_m$$

In non-importable sectors this price is simply equal to the price of domestic goods:

$$(53) \quad PC_m = PD_m$$

The domestic price of non-competitive imports (PCN) is equal to product of their world price (PCNW), the nominal exchange rate and one plus the tariff rate.

$$(54) \quad PCN_{i,reg} = (1 + tmi_{i,reg})PCNW_iER$$

The aggregate composite producer price (PT) in exportable sectors is a weighted average of the producer prices on domestic and export sales, with the volume weights equal to the respective weights of these sales in total production:

$$(55) \quad PT_x = ((D_x/XS_x)PD_x + (EX_x/XS_x)PE_x)$$

In non-exportable sectors this price is simply equal to the price of domestic goods:

$$(56) \quad PT_{nx} = PD_{nx}$$

The producer price index is the weighted average of domestic prices, the weights being the share of goods in the total domestic production.

$$(57) \quad \text{PINDEX} = \sum_{\text{reg}} \sum_i \beta_i^X P_{i,\text{reg}}$$

The investment price index (PINV) is the weighted average of consumer prices where the weights are the shares of each good in investment:

$$(58) \quad \text{PINV} = \sum_i \beta_i^I P C_i$$

MARKET EQUILIBRIUM

The composite commodity Q_{zz} is equal to the total domestic absorption of consumption demand, intermediate demand and investment demand.

$$(59) \quad Q_{zz} = C_{zz} + \text{INTD}_{zz} + \text{INV}_{zz}$$

The sum over sectors of the demand for skilled labour in each region (LDQ_{reg}) is equal to the exogenously fixed regional skilled labour supply (LSQ_{reg}) and, similarly, the sum of sectoral demands for unskilled labour by region (LDNQ_{reg}) is equal to the exogenously fixed regional supply (LSNQ_{reg}).

$$(60) \quad \text{LSNQ}_{\text{reg}} = \sum_n \text{LDNQ}_{n,\text{reg}}$$

$$(61) \quad \text{LSQ}_{\text{reg}} = \sum_i \text{LDQ}_{i,\text{reg}}$$

The sum of sectoral demands for agricultural and non-agricultural capital by region ($\text{KD}_{\text{ag,reg}}$ and $\text{KT}_{\text{in,reg}}$) are equal to their respective exogenous regional supplies (KSD_{reg} and KST_{reg})

$$(62) \quad \text{KSD}_{\text{reg}} = \sum_{\text{ag}} \text{KD}_{\text{ag}}$$

$$(63) \quad \text{KST}_{\text{reg}} = \sum_{\text{in}} \text{KD}_{\text{in}}$$

Total land supply (LANDS) is also fixed by region and equal to the sum of sectoral demands from agricultural sectors ($\text{LAND}_{\text{ag,reg}}$)

$$(64) \quad \text{LANDS}_{\text{reg}} = \sum_{\text{ag}} \text{LAND}_{\text{ag,reg}}$$

Total investment is equal to the sum of total household savings, firms savings, government savings and foreign savings (as represented by current account balance converted at nominal exchange rate ER).

$$(65) \quad \text{IT} = \sum_{\text{hh}} \text{SH}_{\text{hh}} + \text{SF} + \text{SG} + \text{ER.CAB}$$

8. Appendix B: Regional poverty/distribution indicators

