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A dual-dual CGE model of an archetype African economy: trade reform, migration and poverty

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Abstract

We build a CGE model of an archetype African economy to simulate the welfare effects of trade liberalization specifically on poverty. The economy is modeled following a dual-dual framework (Thorbecke, 1993, 1994, 1997) that is characteristic of the structure of a developing country in its middle development phase. This provides the basis for analyzing the distribution of modern and informal sector activities in both rural and urban areas. The interdependence of these four broadly defined sectors is modeled not only in terms of production and consumption decisions within them, but also in terms of labor migration among them, adding a richness which is missing in the standard CGE models. Poverty analysis is integrated in the CGE methodology by endogenizing both intra-group income distributions and the nominal poverty line. The application of standard poverty measures to the pre- and post-simulation poverty lines and distributions of income for each socio-economic group, allows the assessment of policy-induced changes on group specific poverty and national poverty. Simulations with a model calibrated from a social accounting matrix (SAM) of a prototype African economy, show that an important contribution of the dual-dual model vis-à-vis poverty analysis in a CGE model is the inter-group migration it incorporates. Changes in the population shares of the socio-economic groups that follow population shifts have important implications for the magnitudes of changes in national poverty.

Keywords: CGE; Dual; Poverty; Africa; Migration; Trade liberalization

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1. Introduction

The dual-economy models of Lewis (1954) and Fei and Ranis (1964) provided a fundamental tool with which to better understand the dynamics of the development process. At the same time these two-sector models could not distinguish between different aspects of dualism that are endemic to developing countries. They assumed, at least implicitly, that the backward sector was rural and agricultural and that the modern sector was urban and industrial. In fact, a clear understanding of the various types of dualism and their various forms is crucial to an understanding of the development process and poverty dynamics.

The two most important manifestations of dualism in large parts of the developing world appear to be related, first, to the physical and locational environment, and, second, to the technology and forms of organization adopted. The first manifestation captures the dichotomy between rural and urban areas and the second between traditional technologies and family farms or enterprises, on the one hand, and modern technologies adopted in more complex forms of organization, on the other. This yields a four-way classification that identifies and delineates four broad sectors, that is, (i) subsistence (small-scale) agriculture applying traditional labor-intensive technologies on family farms and producing mainly domestic food crops; (ii) commercial, large-scale (for example, plantation-type) agriculture using more capital-intensive technology and being oriented more toward export crops; (iii) the informal urban sector; and (iv) urban modern industry and services. This gives rise to what Thorbecke (1993, 1994, 1997) terms a *dual-dual* economy.

The standard models of dualism tend to highlight the difference between modern (formal) industry and traditional (informal) agriculture. In contrast, the dual-dual framework extends the standard dualistic model by incorporating regional dimensions. Such a framework thus allows one to analyze the distribution of modern and informal sector activities in both rural and urban areas. Through such a framework, therefore, one can incorporate the rural formal sector as well as the urban informal sector into the discussion of dualism. These two sectors have been relatively ignored in standard discussions of dualism, but are now widely recognized as being very important analytical categories to understand poverty.

In this paper we use the dual-dual framework to simulate the welfare effects of policy reform in a CGE model of an archetype African economy. The dual-dual economy provides a rich conceptual framework in which to examine the distributional impacts of such policy changes. The interdependence of the four broadly defined sectors is modeled not only in terms of production and consumption decisions within them, but also in terms of labor migration among them, adding a richness which is missing in the standard CGE model.

Further, poverty analysis is integrated into the CGE methodology using an innovative technique developed by Decaluwe, Patry, Savard, and Thorbecke (1999) that allows the endogenous determination of both the intra-group income distributions and the monetary poverty line. By applying standard poverty measures to the pre- and post-simulation national poverty lines and distributions of income for

each socio-economic group, policy induced changes in group-specific and national poverty can be assessed. We show that an important contribution of the dual-dual model *vis-à-vis* poverty analysis in a CGE model is the inter-group migration it incorporates. We find that the changing population shares of the socio-economic groups that follow population shifts have important implications for the magnitudes of changes in national poverty.

We now turn to a description of the social accounting matrix (SAM) and the pre-reform economy that it describes. Then in Section 3, the intra-group income distributions, the endogenously derived monetary poverty line and the method of poverty analysis are explained in detail. The model is described fully in Section 4, and the simulation results and policy implications are discussed in Section 5. We end with brief concluding remarks.

2. An archetype African SAM

Table 1a presents the transaction social accounting matrix (SAM) for an archetype Sub-Saharan African developing country which provides the initial conditions for our model. It was constructed to roughly approximate the socio-economic conditions of Côte d'Ivoire, and to represent an example of the characteristics of an archetype African country using the dual-dual framework. To this end, the four production activities are defined in a manner consistent with the dual-dual model. The rural sector is characterized by an informal sector that is devoted entirely to the production of staple foods for domestic consumption (hereafter "Food"), and a formal sector that produces exclusively for export (hereafter "Export"). The production of the former consists of non-imported staples such as cassava, yams, and the like, while the latter are exports of such commodities as cocoa and coffee from estate farms. The urban sector is also comprised of informal and formal production activities. The former provides services exclusively to the urban sector (hereafter "Urban Services"), while the latter produces import-competing goods such as labor-intensive manufacturing (hereafter "Importables"). Three broadly defined commodities are available in the domestic market. These are food, importables and urban services. The four factors of production identified in the SAM include unskilled labor, skilled labor, capital and agricultural capital (which includes land). Finally, households are disaggregated into nine socio-economic categories, i.e., (i) rural small-holders; (ii) rural low-education formal sector workers (hereafter "Rural Unskilled Workers"); (iii) rural high-education formal sector workers (hereafter "Rural Skilled Workers"); (iv) rural large landholders; (v) urban informal; (vi) urban low-education formal sector workers (hereafter "Urban Unskilled Workers"); (vii) urban high-education formal sector workers (hereafter "Urban Skilled Workers"); (viii) capitalists; and (ix) bureaucrats.

The matrix of average expenditures propensities (Table 1b) displays the information of the SAM in a manner that highlights the structure of the economy. For instance, in this simplified economy, unskilled labor accounts for 75% of total

Table 1a
Transaction SAM for an archetype African country

			Factors				Households								Activities				Commodities						
			Unsk. Labor	Skilled Labor	Capital	Agr. Cap	Rural own sm	Rural unskll	Rural skilled	Rural own lg	Urban inf	Urban unskll	Urban skilled	Captlst	B'cat	Food	Exports	Urban Srvce	Imptable	Food	Exports	Urban Srvce	Imptable	Accum.	ROW	*Total*
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
Factors	Unskilled labor	1														111.3	19.1	22.9	10.6							*163.9*
	Skilled labor	2															5.4		25.8							*31.2*
	Capital	3																7.6	47.3							*54.9*
	Agr. capital	4														37.1	30.0									*67.1*
H'holds	Rural land-owners (small	5	111.32			37.11																				*148.4*
	Rural unskilled workers	6	19.07																							*19.1*
	Rural skilled workers	7		5.45																						*5.4*
	Rural land-owners (large)	8				29.96																				*30.0*
	Urban informal	9	22.89		7.63																					*30.5*
	Urban unskilled worker	10	10.63		11.83																					*22.5*
	Urban skilled worker	11		25.79																						*25.8*
	Capitalists	12			35.48																					*35.5*
	Bureaucrats	13																					18.2			*18.2*
Activities	Food	14																		148.4						*148.4*
	Exports	15																						8.99	45.5	*54.5*
	Urban Services	16																				30.5				*30.5*
	Importable	17																					73.1	10.65		*83.7*
Comm.	Food	18					85.8	11.0	1.9	5.2	18.3	12.4	6.4	4.3	3.1											*148*
	Exports	19																								*0*
	Urban Services	20									5.3	4.4	7.1	7.8	5.7											*31*
	Importable	21					62.6	8.0	3.5	15.7	6.9	5.7	12.3	12.7	9.3											*137*
	Accumulation	22								8.99				10.64												*19.6*
	ROW	23																					45.5			*45.49*
	Total		*163.9*	*31.2*	*54.9*	*67.1*	*148.4*	*19.1*	*5.4*	*30.0*	*30.5*	*22.5*	*25.8*	*35.5*	*18.2*	*148.4*	*54.5*	*30.5*	*83.7*	*148*	*0*	*31*	*137*	*19.6*	*45.49*	

Table 1b
Matrix of average expenditure propensities for an archetype African country

			Factors				Households									Activities				Commodities					
			Unsk. Labor	Skilled Labor	Capital	Agr. Cap	Rural own sm	Rural unskll	Rural skilled	Rural own lg	Urban inf	Urban unskll	Urban skilled	Captlst	B'cat	Food	Exports	Urban Srvce	Imptable	Food	Exports	Urban Srvce	Imptable	Accum.	ROW
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Unskilled labor	1														0.75	0.35	0.75	0.13						
Factors	Skilled labor	2															0.10		0.31						
	Capital	3																0.25	0.57						
	Agr. capital	4														0.25	0.55								
	Rural land-owners (small	5	0.68			0.55																			
	Rural unskilled workers	6	0.12																						
	Rural skilled workers	7		0.17																					
H'holds	Rural land-owners (large)	8				0.45																			
	Urban informal	9	0.14		0.14																				
	Urban unskilled worker	10	0.06		0.22																				
	Urban skilled worker	11		0.83																					
	Capitalists	12			0.65																				
	Bureaucrats	13																					0.13		
	Food	14																		1.00					
Activities	Exports	15																						0.46	1.00
	Urban Services	16																				1.00			
	Importable	17																					0.53	0.54	
	Food	18					0.58	0.58	0.35	0.18	0.60	0.55	0.25	0.12	0.17										
Comm.	Exports	19																							
	Urban Services	20									0.18	0.20	0.28	0.22	0.32										
	Importable	21					0.42	0.42	0.65	0.53	0.23	0.25	0.48	0.36	0.51										
	Accumulation	22								0.30				0.30											
	ROW	23																					0.33		
	Total		*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*0.0*	*1.0*	*1.0*	*1.0*	*1.0*

Table 2
Factorial source of household income (%)

	Unskilled labor	Skilled labor	Capital	Agricultural capital	Total
Rural small-holders	75.0			25.0	100.0
Rural unskilled	100.0				100.0
Rural skilled		100.0			100.0
Rural large holders				100.0	100.0
Urban informal	75.0		25.0		100.0
Urban unskilled	100.0				100.0
Urban skilled		100.0			100.0
Urban capitalists			100.0		100.0

Source: Based on SAM in Table 1a.

value added in the informal production of food, whereas this group accounts for only 35% of value added in export production, and 13% in domestic production of importables. In addition, roughly 55% of total value added in the formal sectors is in the form of returns to capital or agricultural capital. We can also see that food consumption patterns are consistent with Engel's law. The shares of total income allocated to the consumption of food for each household group appear in row 18, columns 5 through 13. These shares range from 60% for the poorest group (urban informal), to 12% (17% of disposable income) for the richest group (urban capitalists), and decline monotonically with mean incomes of the groups (see the next section).

The transaction SAM in Table 1a also provides information about the distribution of income across socio-economic household groups (the row totals for rows 5 through 13). Here we observe that the largest income group is the rural small-holders, which follows from the fact that this group accounts for the largest share of the population (roughly 60% in this fictitious country). The SAM also illustrates the source of household income by factors of production. Table 2 presents the sources of income for socio-economic groups in terms of percentage of total income. Here the simplified nature of this economy is highlighted. For instance, the sole source of income for unskilled and skilled workers in the rural sector and for urban skilled workers is wage labor. Conversely, the incomes of rural large landholders and urban capitalists derive entirely from their capital holdings. Informal sector workers receive 75% of their income in the form of wage income, or more accurately, imputed wage income.

This SAM provides the consistent set of numerical relationships upon which the CGE model discussed in Section 4 is based. As such, the baseline solution presented in Section 5 is calibrated to be consistent with the SAM in Table 1a.

3. Income distribution and measurement of poverty

Information on total incomes of the socio-economic household groups in the SAM is insufficient to permit direct statements about poverty in the economy

Table 3
Initial income and demographic characteristics of households in the labor market

	Mean income	Population share	Percent poor
Rural small-holders	1.00	0.59	83.4
Rural unskilled	1.05	0.07	82.5
Rural skilled	2.92	0.03	4.4
Urban informal	0.97	0.14	88.1
Urban unskilled	2.06	0.05	26.4
Urban skilled	5.85	0.07	0

being modeled. For useful poverty analysis, the SAM must be supplemented with information about mean incomes and population shares of each of the groups, as well as with their respective intra-group distributions of income. In the absence of any knowledge about intra-group income distributions, the best that a CGE modeler can say regarding poverty is how the mean incomes of the poorest groups are affected by the exogenous shocks applied to the baseline model. We thus provide the type of information that, in an applied setting, can be acquired from household (or even labor force) surveys.

Table 3 provides descriptive data on initial mean incomes and population shares prior to the policy shock, as well as poverty rates for each of the household groups that supply labor in the labor market (hereafter "working class households"). Rural large landholders, urban capitalists and bureaucrats are ignored because none of these households are assumed to be in poverty, nor will any incremental shock to the economy lead to poverty in these groups.

The mean incomes range from 0.97 for the urban informal workers, to 5.85 for the urban skilled workers.[1] Among the unskilled workers, the urban unskilled workers have the highest mean income. And among the skilled workers, those in the urban sector are the richest. While rural small-holders account for roughly 60% of the population, as a whole, households with low education levels (e.g., rural small-holders, rural unskilled, urban informal, and urban unskilled) make up 85% of the population and account for almost all of the poverty. Workers with high levels of education (i.e., skilled workers) account for 10% of the population and only 0.4% of those below the poverty line.

While the information in Table 3 is necessary for incorporating poverty analysis into a CGE model, it is not sufficient. Distributional information at the micro-level is crucial. We thus postulate a functional form — Beta distribution function[2] — for

[1] These incomes are defined relative to the numeraire in this model which is the pre-tariff price of imports.

[2] We follow Decaluwe et al. (1999), by adopting the Beta distribution because of its flexibility in allowing the densities to be either symmetric or asymmetric, and to be skewed to the right or to the left. Parameter values for each working-class socio-economic group are chosen to provide income distributions (see equation in appendix) that are consistent with the authors' priors based on previous analyses of household surveys. The parameter values are available from the authors upon request.

the intra-group income distributions based on the socio-economic characteristics of each group, and permit these distributions to change in a systematic way following an exogenous shock to the model. Of course, when available, household surveys can provide observed intra-group sample distributions. While non-parametric methods can also be used to derive these distributions using household data, we map out how a parametric approach can be applied when such direct non-parametric methods are not feasible. We show how to apply poverty measures to the income distributions of each socio-economic group once they are established, and then how to simulate changes in poverty following an exogenous shock to the model.

3.1. Poverty measurement and simulation method[3]

Given income distributions for the relevant socio-economic groups, we calculate group and national poverty levels using Foster–Greer–Thorbecke (FGT) poverty measures (Foster, Greer, & Thorbecke, 1984). These measures, expressed in terms of the Beta density function, can be written for socio-economic group j as:

$$P_{\alpha}^{j} = \int_{0}^{z} \left(\frac{z - y_j}{z} \right)^{\alpha} f^{j}(y_j; p_j, q_j) \mathrm{d}y_j,$$

where z is the poverty line, α is the poverty-aversion parameter,[4] and p_j and q_j are the parameters of the Beta density function, f. We use this class of measures to calculate the headcount ratio (P_0), poverty depth (P_1), and poverty severity (P_2). The additively separable nature of the P_α class of poverty measures permits us to measure poverty for each household group and then calculate national poverty as the weighted sum of the group levels:

$$P_{\alpha} = \sum_{j} \mathrm{pop}_j P_{\alpha}^{j},$$

where pop_j is the share of group j in the national population (see Table 3). We do not need to postulate a national income distribution, and more importantly, can avoid modeling changes in the national distribution directly.

To measure changes in poverty following shocks to the CGE model, we depart from standard poverty measurement practice by keeping all values in nominal terms. As such, the poverty line is determined endogenously within the model, and is defined as the value of a basket of goods that reflects the basic needs of households (Ravallion, 1994). The basic needs basket is universal to all groups, is made up of food and importables (urban services are not available in the rural

[3] Much of this discussion follows Decaluwe et al. (1999), with the exception of the treatment of the post-shock distribution.

[4] We do not elaborate on the interpretation of the poverty-aversion parameter, α, as it is well discussed in the poverty literature (see Ravallion, 1994, for a comprehensive overview).

sector), and remains constant over the simulations. The value of this basket,[5] i.e., the poverty line (z), is defined for this model as:

$$z = P_{\text{food}} \bar{X}^{\text{BN}}_{\text{food}} + P_{\text{im}} \bar{X}^{\text{BN}}_{\text{im}},$$

and varies with changes in the endogenously determined prices.

The advantage of measuring poverty dynamics within a CGE framework in nominal terms is that it circumvents the contentious issue of choosing the correct set of price deflators. Changes in nominal income will be compared to changes in the nominal value of the poverty line, hence the change in poverty will be real. On the other hand, if the poverty line is held constant and nominal incomes are converted to real values, the changes in poverty will be sensitive to the choice of the deflators used to convert the nominal incomes to real incomes.[6] A disadvantage to keeping income in nominal terms is that poverty analysis employing dominance tests is ruled out. Nonetheless, as will become apparent, dominance tests in a CGE framework are uninformative because following an exogenous shock, first order dominance (either worsening or improving distributions) is implied by construction.

The final piece of the poverty analysis puzzle is the treatment of the income distributions following simulated shocks that are exogenous to the economy. We assume distributional neutrality in that the intra-group income distributions change proportionately to the change in the mean income of the respective groups. That is, if the mean income of group j increases by μ_j percent, then the incomes of each household in group j increases by μ_j percent.[7] This mechanism imposes, rather strongly, invariance of intra-group inequality to changes in group mean income. Studies by Datt and Ravallion (1992), Huppi and Ravallion (1991), and Ravallion and Huppi (1991) show empirically that changes in the distribution can contribute significantly to changes in poverty. Nonetheless, modeling intra-group income distributions in a CGE framework remains a major challenge, and in the light of findings by Ravallion and Chen (1997) that for 67 developing countries between 1981 and 1994, changes in inequality were uncorrelated with changes in average living standards, we fall back to distribution neutrality as a first order approximation. Finally, while we assume invariant intra-group inequality, by modeling inter-group labor migration, national income inequality is permitted to vary.

[5] We note that unlike Decaluwe et al. (1999), who adopt household category-specific consumption bundles, we adopt a national bundle, and consequently a national poverty line.

[6] Experimentation was done by converting incomes into their real values using various combinations of deflators, with the unsurprising result that all of the results differed from those using nominal values.

[7] This is where we depart from Decaluwe et al. (1999), who assume a shift of constant magnitude as opposed to a proportional change. The former arbitrarily causes intra-group inequality to drop (increase) with growth (contraction) of group mean income. In the case of constant shifts, it is straightforward to show that if the mean income and the poverty line, say, decrease by the same absolute amount, the depth and severity of poverty increase while the headcount remains unchanged. See footnote 5 of Decaluwe et al. (1999) for a recognition of the limitation of constant shifts.

4. A general equilibrium model of a dual-dual economy

The dual-dual approach to analyzing the patterns of exchange can be particularly useful in a comparative statics sense. We employ it here in a simulation exercise to gain insight into the effect of trade reform on poverty in a developing country. The origin of this general equilibrium model is a simple two-sector model of an "archetype African economy" developed by Rodrik (1997) in which one type of labor is used to examine the size of the redistributions relative to the efficiency benefits stemming from trade reforms.

For this four-sector extension of Rodrik's model, consider a simple small country whose economy corresponds to the SAM presented in Section 2. This economy is characterized by four production sectors (food, exports, urban services, and import competing) and perfect labor mobility within two labor types — unskilled and skilled. The urban formal, or import competing sector, receives protection from the government in the form of tariffs and/or quantitative restrictions. The level of protection, however, is not sufficient to eliminate all consumption of goods imported from abroad. Since the elasticity of substitution between domestic and foreign goods is assumed to be infinite, domestic households consume both domestically and foreign produced importable goods provided that the prevailing price charged by domestic producers is equivalent to the c.i.f. price of imports inflated by the tariff equivalent. The urban informal sector provides urban services that are consumed only by urban agents. While goods produced in the rural informal sector (e.g., staple foods) are consumed throughout the economy, all of the rural formal production is exported. The urban sectors have fixed stocks of capital, and the rural sectors have fixed stocks of agricultural capital.

4.1. Production

Table 4 provides a dual-dual schematic of the production sector of the economy. This illustrates that formal sectors employ both skilled (LS) and unskilled (LU) labor. The substitution between the two labor types is assumed to be perfectly inelastic, and only unskilled labor is employed in the informal sectors. Skilled, or

Table 4
Sectoral breakdown in the dual-dual model: type of goods (services) produced and household categories

Informal	Formal
Rural	
Food (food)	**Export crops (ex)**
Unskilled: "Rural Small-holders"	Unskilled: "Rural Unskilled"
	Skilled: "Rural Skilled"
Urban	
Urban services (srvc)	**Import competing (im)**
Unskilled: "Urban Informal"	Unskilled: "Urban Unskilled"
	Skilled: "Urban Skilled"

high-education workers prefer to take bad draws in the market for skilled labor rather than accept jobs which unskilled, or low-education, workers are capable of performing. Thus unskilled labor can flow freely between the four sectors of the economy, while skilled labor is limited to the formal sectors. The labor market is discussed in more detail below.

Production in the economy is specified by neoclassical production functions which we assume to be described by Cobb–Douglas technologies.[8] These are illustrated in Table 5 as Eqs. (1) and (2) for the two formal sector commodities (fc), and Eqs. (3) and (4) for the two informal sector commodities (ic), where $\bar{K}$ represents the fixed capital stocks in each of the sectors.

4.2. Labor market

To motivate the modeling of the labor market, we consider some stylized facts for a "typical" Sub-Saharan African economy. First, among unskilled workers, wages in the informal rural sectors are generally lower than wages in formal rural sectors. This arises in part from transaction costs; workers accept the inconveniences of working in the rural formal sector (export crops) provided that they are compensated for them. Further, shared income per unit of labor in the rural informal (domestic food production) sector is also marginally lower than wages for unskilled workers in the (rural) export sector. These observations imply that disguised unemployment exists in the rural informal sector, where the marginal revenue product of labor is lower than the prevailing alternative wage. While Lewis' (1954) notes about this redundant labor in the "traditional" agricultural sector provided the foundation for his model of the dual economy, prior records of the existence of surplus laborers in this sector were also made by Rosenstein-Rodan (1943) and Nurkse (1953).

Second, as in the labor market in Kenya described by Harris and Todaro (1967), wage premia exist in the urban formal (import competing) sector. For unskilled workers, urban formal sector wages exceed rural wages, which in turn exceed urban informal (services) wages. And for skilled labor, urban wages exceed rural wages. Finally, roughly 80% of the uneducated labor force resides in the rural sector.

Given our production technologies that have perfectly inelastic substitutability between skilled and unskilled labor, we model the labor market as if it were two distinct markets. Although rural large landholders, urban capitalists and government bureaucrats carry much political clout, they constitute a very small share of the population, and as such are ignored as participants in the labor market. We begin by describing the market for workers with low levels of education. As Table 4 illustrates, unskilled workers are "hired" in all four sectors of the economy, and can flow freely between them.

[8] Since capital and agricultural capital are assumed fixed within the time frame of the model, and skilled and unskilled labor are not substitutable, specifying technologies as Cobb–Douglas is reasonable in light of their characteristic zero cross-price elasticities of demand for inputs.

Table 5
Equations for the dual-dual model

Production and labor market

$$X_{\mathrm{fc}} = A_{\mathrm{fc}} \bar{K}_{\mathrm{fc}}^{\beta_K^{\mathrm{fc}}} \mathrm{LS}_{\mathrm{fc}}^{\beta_{\mathrm{LS}}^{\mathrm{fc}}} \mathrm{LU}_{\mathrm{fc}}^{\beta_{\mathrm{LU}}^{\mathrm{fc}}} \quad (1) \text{ and } (2)$$

$$X_{\mathrm{ic}} = A_{\mathrm{ic}} \bar{K}_{\mathrm{ic}}^{\beta_K^{\mathrm{ic}}} \mathrm{LU}_{\mathrm{ic}}^{\beta_{\mathrm{LU}}^{\mathrm{ic}}} \quad (3) \text{ and } (4)$$

$$i_{\mathrm{ic}} = \frac{P_{\mathrm{ic}} X_{\mathrm{ic}}}{\mathrm{LU}_{\mathrm{ic}}} \quad (5) \text{ and } (6)$$

$$\mathrm{wu}_{\mathrm{ex}} = \frac{P_{\mathrm{ex}} \beta_{\mathrm{LU}}^{\mathrm{ex}} X_{\mathrm{ex}}}{\mathrm{LU}_{\mathrm{ex}}} \quad (7)$$

$$\mathrm{wu}_{\mathrm{ex}} = i_{\mathrm{food}}(1 + \delta) \quad (8)$$

$$i_{\mathrm{srvc}} = \frac{P_{\mathrm{im}} \beta_{\mathrm{LU}}^{\mathrm{im}} X_{\mathrm{im}}}{\mathrm{LU}_{\mathrm{im}}} \quad (9)$$

$$w_{\mathrm{im}} = i_{\mathrm{srvc}} + \gamma \frac{\Pi}{\mathrm{LU}_{\mathrm{im}}} \quad (10)$$

$$\Pi = P_{\mathrm{im}} X_{\mathrm{im}} - i_{\mathrm{srvc}} \mathrm{LU}_{\mathrm{im}} - \mathrm{ws}_{\mathrm{im}} \mathrm{LS}_{\mathrm{im}} \quad (11)$$

$$\mathrm{wu}_{\mathrm{ex}} = \left(1 - \frac{h\mathrm{LU}_{\mathrm{im}}}{\mathrm{LU}_{\mathrm{srvc}} + \mathrm{LU}_{\mathrm{im}}}\right) \mathrm{wu}_{\mathrm{srvc}} + \left(\frac{h\mathrm{LU}_{\mathrm{im}}}{\mathrm{LU}_{\mathrm{srvc}} + \mathrm{LU}_{\mathrm{im}}}\right) \mathrm{wu}_{\mathrm{im}} \quad (12)$$

$$\mathrm{ws}_{\mathrm{fc}} = \frac{P_{\mathrm{fc}} \beta_{\mathrm{LS}}^{\mathrm{fc}} X_{\mathrm{fc}}}{\mathrm{LS}_{\mathrm{fc}}} \quad (13) \text{ and } (14)$$

$$\mathrm{ws}_{\mathrm{im}} = \left[\frac{1 - \beta_{\mathrm{LU}}^{\mathrm{im}}}{(1-\theta)\,\beta_{\mathrm{LS}}^{\mathrm{im}} + \theta\left(1 - \beta_{\mathrm{LU}}^{\mathrm{im}}\right)}\right]^{1/1-\theta} \mathrm{ws}_{\mathrm{ex}} \quad (15)$$

Disposable income and savings

$$I_{\mathrm{rih}} = i_{\mathrm{food}} \mathrm{LU}_{\mathrm{food}} \quad (16)$$

$$I_{\mathrm{ruh}} = \mathrm{wu}_{\mathrm{ex}} \mathrm{LU}_{\mathrm{ex}} \quad (17)$$

$$I_{\mathrm{rsh}} = \mathrm{ws}_{\mathrm{ex}} \mathrm{LS}_{\mathrm{ex}} \quad (18)$$

$$I_{\mathrm{rlh}} = P_{\mathrm{ex}} X_{\mathrm{ex}} - \mathrm{ws}_{\mathrm{ex}} \mathrm{LS}_{\mathrm{ex}} - \mathrm{wu}_{\mathrm{ex}} \mathrm{LU}_{\mathrm{ex}} - S_{\mathrm{ex}} \quad (19)$$

$$I_{\mathrm{uih}} = i_{\mathrm{srvc}} \mathrm{LU}_{\mathrm{srvc}} \quad (20)$$

$$I_{\mathrm{uuh}} = \mathrm{ws}_{\mathrm{im}} \mathrm{LU}_{\mathrm{im}} \quad (21)$$

$$I_{\mathrm{ush}} = \mathrm{ws}_{\mathrm{im}} \mathrm{LS}_{\mathrm{im}} \quad (22)$$

$$I_{\mathrm{ukh}} = P_{\mathrm{im}} X_{\mathrm{im}} - \mathrm{ws}_{\mathrm{im}} \mathrm{LS}_{\mathrm{im}} - \mathrm{wu}_{\mathrm{im}} \mathrm{LU}_{\mathrm{im}} - S_{\mathrm{im}} \quad (23)$$

$$I_{\mathrm{bch}} = tM \quad (24)$$

$$S_{\mathrm{fc}} = \lambda_{\mathrm{fc}}[P_{\mathrm{fc}} X_{\mathrm{fc}} - \mathrm{ws}_{\mathrm{fc}} \mathrm{LS}_{\mathrm{fc}} - \mathrm{wu}_{\mathrm{fc}} \mathrm{LU}_{\mathrm{fc}}] \quad (25) \text{ and } (26)$$

Demand

$$C_c^h = \frac{\alpha_c^h I_h}{P_c} \quad (27)\text{–}(49)$$

Foreign trade

$$M = \textstyle\sum_h C_{\mathrm{im}}^h + \dfrac{S_{\mathrm{im}}}{P_{\mathrm{im}}} - X_{\mathrm{im}} \quad (50)$$

$$\mathrm{EX} = X_{\mathrm{ex}} - \frac{S_{\mathrm{ex}}}{P_{\mathrm{ex}}} \quad (51)$$

Table 5 (*Continued*)

Equilibrium conditions	
$\sum_c \mathrm{LU}_c = \mathrm{LU}$	(52)
$\sum_{\mathrm{fc}} \mathrm{LS}_{\mathrm{fc}} = \mathrm{LS}$	(53)
$X_{\mathrm{ic}} = \sum_h C^h_{\mathrm{ic}}$	(54) and (55)
$P_{\mathrm{im}} \equiv 1 + t$	(56)
$P_{\mathrm{ex}} \equiv 1$	(57)

In the informal sectors, the income of each worker is just his/her average revenue product. Rural small-holders cultivate common land and farming households share their total income equally among family members, while urban informal workers work atomistically supplying all of their labor. We will see below that leisure is not an argument of the worker's utility function. Hence labor is supplied inelastically. Further, since each of the workers in the informal sectors works atomistically, the result is a tragedy of the commons where external effects are ignored. In the absence of a benign social planner or manager, the informal sector workers supply all of their labor to the extent where marginal revenue product falls below the alternative wage in the market. Thus income per unit of labor in these sectors is the value of the average product of labor, the returns perceived by the individual workers (Eqs. (5) and (6)).

Because workers in the informal sectors also capture the returns to capital (among the small-holders this is imputed rent on land, and among the urban informal this is imputed rent on capital), the relevant variable is total income per unit of labor rather than solely the return to labor (the wage rate).

Since rural large landholders are assumed to be profit maximizers, wages for unskilled workers in the export sector are equated to the marginal revenue product of the hired unskilled labor (Eq. (7)).

In equilibrium, unskilled labor will allocate itself in the rural sector so that income per unit of labor in the informal sector is equal to wages in the formal sector less a constant percent of the former. This is shown in Eq. (8), where δ represents the transactions costs associated with taking a job in the (rural) export sector.

In the urban sector, owners of capital in the import competing sector are also profit maximizers and pay their unskilled workers their marginal revenue product. But, in addition, they share their profits with these workers. This accounts for the observed wage premium. As Rodrik (1997) points out, a profit-sharing model of this sort is efficient since "urban [formal] employers equate the value marginal product of labor to its opportunity cost, which is the [urban informal] wage." The motivation for the distribution of profits in this manner is partly for efficiency wage purposes. With high monitoring costs, the wage premium raises the cost of shirking for the unskilled workers in the import sector. A firm in this sector offers a higher wage to induce more effort, refusing to hire workers who offer to work

for lower wages because of the moral hazard (promises of not shirking cannot be interpreted as credible for these rational agents).[9]

In equilibrium, the marginal revenue product of import sector unskilled workers equals their opportunity cost, i.e., the income per unit of labor in the urban services sector (Eq. (9)). The actual wage received by these unskilled workers (Eq. (10)) is this wage plus a share (γ) of profits distributed to workers. Profits are illustrated in Eq. (11), and are defined as the returns to capital, where ws_{im} is the wage rate for skilled workers in the import-competing sector.

Rural-urban migration of unskilled labor is modeled along the lines of Harris and Todaro (1967) to incorporate the urban-rural wage gap described in the stylized facts. Migrant workers in the urban sectors of Sub-Saharan African nations can often be observed queuing up for formal sector jobs. In this model, those presently in the urban sector who are not fortunate enough to find formal sector jobs (which are assumed to be assigned randomly), work in the informal sector with the hope of being hired in the high paying import sector in the next period. Unskilled workers migrate either to urban areas or to rural areas until the rural wage is equated with the expected wage in the urban sector. This equilibrium condition is described by Eq. (12), where the probability of landing a job in the import sector is the share of the urban uneducated labor force in that sector multiplied by a scale parameter, h.[10]

Now turning to the market for workers with high levels of education, we see from Table 4 that skilled labor is employed only in the formal sectors. Since employers in these sectors are assumed to be intra-temporal profit maximizers, skilled workers are hired in the import and export sectors until their marginal revenue products are equal to the sector-specific wages (Eqs. (13) and (14)).

The wage differentials among skilled workers (i.e., $ws_{im} > ws_{ex}$) described in the stylized facts is modeled to follow from the presence of labor unions in the urban sector, but not in the rural sector. Nelson (1994) argues that while union membership is generally low, unions are capable of exercising tremendous leverage in a few strategic sectors in Africa. Typically, these strategic sectors are those that are heavily protected and fall into the urban formal category of this model. Skilled labor in the urban sector is assumed to be capable of collectivizing and forming strong unions. Thus the monopoly union model is applied (Booth, 1995). This is depicted by a powerful representative union that, knowing the firms' aggregate demand schedules for labor in the urban sector, sets the urban wage for skilled labor (ws_{im}) so that it maximizes its utility:

$$\max_{ws} U(ws, LS),$$

$$\text{s.t. } LS = LS(ws).$$

[9] An additional explanation for the profit-sharing mechanism is that a significant number of firms in the urban formal sector may be owned by foreign nationals who for public relations purposes in the developing country and back home, are compelled to pay higher wages.

[10] The scale parameter permits a more realistic (i.e. lower) calibration of the probability of getting a high paying job while allowing this probability to remain endogenous to the model.

The representative union is assumed to have utilitarian preferences, giving equal weight to all actual and potential union members, including those skilled workers not employed in the import sector. Thus the union's utility function can be represented as:

$$U(\mathrm{ws_{im}}) = [\mathrm{LS_{im}}(\mathrm{ws_{im}})]u(\mathrm{ws_{im}}) + [\mathrm{LS} - \mathrm{LS_{im}}(\mathrm{ws_{im}})]u(\mathrm{ws_{alternative}}). \tag{15a}$$

In this case, the alternative wage is just the prevailing wage for skilled labor in the (rural) export sector ($\mathrm{ws_{ex}} = \mathrm{ws_{alternative}}$), which follows from the perfectly inelastic substitutability of skilled and unskilled workers, the full employment among skilled workers, and the fact that skilled labor is employed in only the formal sectors. The union takes the alternative wage rate as exogenous. Assuming that skilled workers have constant levels of relative risk aversion, then preferences over wages (as opposed to consumption bundles) can be described by:

$$u(\mathrm{ws}) = \frac{\mathrm{ws}^{1-\theta}}{1-\theta}.$$

Now the union's maximization problem can be solved with a considerable amount of algebraic manipulation to derive the equilibrium condition describing the relationship between urban and rural wages for skilled workers (Eq. (15)).

4.3. Income, savings, and demand

Turning to the demand side of the economy, we start by discussing the sources of income of the nine household groups defined in the SAM in Table 1a. In the rural sector, it follows from Eq. (5) that small-holders (rih — rural informal households) total income is simply their total revenue (Eq. (16)). Workers in the export sector (rural unskilled households — ruh — and rural skilled households — rsh) receive their total labor income (Eqs. (17) and (18)), and the disposable incomes of rural large landholders (rlh) are their returns to capital less savings (Eq. (19)).

Urban sector incomes are defined analogously. Urban informal households' (uih) incomes are their total revenue (Eq. (20)), unskilled (uuh) and skilled (ush) workers in the import-competing sector earn their wages (Eqs. (21) and (22)), and the disposable incomes of urban capitalists (ukh) are their returns to capital less savings (Eq. (23)).

The last household group, government bureaucrats, is assumed to capture the totality of the rents from the trade policy. It is modeled as a socio-economic group positioned to reap the benefits of the rent seeking efforts of the urban capitalists who pay off the bureaucrats to maintain protection from imports (Krueger, 1974). Thus the bureaucrats' incomes from these rents (Eq. (24)) are defined simply as the tariff rate or tariff equivalent (t) multiplied by the level of imports (M). Given the relative security of government jobs, this household group does not enter or leave the labor force modeled here. The rental incomes are received in addition

to their salaries, and since the latter are invariant to exogenous shocks examined here, we only parsimoniously model the endogenous rental incomes.

Only formal sector employers (rural large land owners and urban capitalists) save in this model,[11] and their savings are constant shares (λ_{fc}) of their nominal incomes (Eqs. (25) and (26)).

We assume that household preferences can be described by Cobb–Douglas utility functions,

$$U_{uh} = C_{food}^{\alpha_{food}^{uh}} C_{srvc}^{\alpha_{srvc}^{uh}} C_{im}^{\alpha_{im}^{uh}}, \qquad \text{for urban households, and}$$

$$U_{rh} = C_{food}^{\alpha_{food}^{rh}} C_{im}^{\alpha_{im}^{rh}}, \qquad \text{for rural households,}$$

which gives rise to Marshallian demand functions for each of the commodities available to each of the household groups (Eq. (27)–(49)). There are only 23 such demand equations because the four rural socio-economic groups have access only to the broadly defined food and importable goods (eight equations), and the five urban groups have access to food, importables and urban services (15 equations). The zero cross-price elasticities of demand for commodities associated with these preferences are unobjectionable given that we need only assume weak separability for this broad degree of commodity aggregation. These preferences also permit us to define deflators to be used to calculate real incomes for each socio-economic group:

$$\text{Def}_h = P_{food}^{\alpha_{food}^{h}} P_{srvc}^{\alpha_{srvc}^{h}} P_{im}^{\alpha_{im}^{h}}.$$

4.4. Foreign trade

The elasticity of substitution between imports and goods produced by the import-competing sector is assumed to be infinite, thus the volume of imports in this model is the residual between consumption demand for the importable and savings of urban capitalists (in the form of the importable) on the one hand, and production in the import-competing sector on the other (Eq. (50)). Since this is a small country, exports from this economy do not affect world prices or international

[11] Lewis' (1954) seminal paper introducing the concept of the dual economy includes a passage that is relevant today and provides a rationale for this assumption about savings:
Practically all saving is done by people who receive profits or rents. Workers' savings are very small. The middle-classes save a little, but in practically every community the savings of the middle-classes out of their salaries are of little consequence for productive investment. Most members of the middle-class are engaged in the perpetual struggle to keep up with the Jones's (sic); if they manage to save enough to buy a house in which they live, they are doing well. They may save to educate their children, or to subsist in their old age, but this saving is virtually offset by the savings being used for the same purposes [by others].
In other words, when modeling the working class groups as aggregate units, savings can be ignored because while some households are saving, others are disaving.

demand, and the international market will absorb any and all of the production of the export sector supplied to it. Thus exports are equal to output less savings of the rural large landholders (Eq. (51)).

4.5. Equilibrium conditions and solution algorithm

Two equilibrium conditions characterize this model. The first — demand for labor equals the supply (Eqs. (52) and (53)) — implies that there is no unemployment in the labor markets in the formal sense. Disguised unemployment in the informal sectors, however, is modeled consistently with the income sharing described previously. Full employment is assumed for the workers with higher levels of education because of their relative scarcity.

The second equilibrium condition is that the domestic demand for informal sector goods and services is met by the domestic supply. Equilibrium conditions in the markets for formal sector commodities was described previously in the previous section on foreign trade (Eqs. (50) and (51)).

Since this small country has no impact on international markets, prices in the urban and rural formal sectors are dictated by world prices which are normalized to one. Since the exchange rate is assumed fixed, the price of imports facing domestic consumers inflated by the tariff equivalent therefore is:

$$P_{\text{im}} \equiv 1 + t. \tag{56}$$

While the price that rural large landholders receive for their exports is:

$$P_{\text{ex}} \equiv 1. \tag{57}$$

Finally, the current account balance is exogenous to the model. In the absence of foreign savings, this balance is zero and consequently the trade balance is restricted to zero.

The 57 endogenous variables (X_c, Lu_c, LS_{fc}, P_c, i_{ic}, wu_{fc}, ws_{fc}, I_h, S_{fc},C_c^h, Π, EX, M) just described are determined as functions of the fixed factor endowments and the trade policy, t, by the 57 equations above.

The model was calibrated with the help of the SAM in Table 1a. Following common calibration practice, output (or more appropriately for this model, value added) and capital are defined in units of measure such that prices and rental rates are equal to one. Since differences in wage (income) rates are a crucial component of the model, this cannot be done for units of measure for labor. Instead, the rural informal average income is initially normalized to one, and wage ratios for the other sectors are defined so that the units of measure for labor are consistent. For instance, wages for unskilled labor in the import sector are roughly twice the average income of rural small-holders, thus the initial wage rate for the former group is set at two. The units of measure are consistent between the two sectors so that when one unit of labor leaves the import sector for the food sector, it is indeed the same unit of labor received by the latter. Wage and income rates are set in a similar fashion for the remaining sectors.

Once the wage (income) ratios are defined, and given calibrated values for parameters such as relative risk aversion ($\theta = 0.8$, see Carruth & Oswald, 1985), share of import-competing sector profits distributed to unskilled workers ($\gamma = 0.25$, see Rodrik, 1997), and scale parameter for probability of getting a formal sector job ($h = 0.6$), the quantities of labor supplied to each of the sectors can be calibrated consistently with the model. Finally, the model was solved using the GAMS program.[12]

5. Simulation results and policy implications

The initial conditions prevailing in the economy prior to the trade reform are summarized in the first column of Table 6 and the second column of Table 3. Briefly, it can be seen at the outset that including capitalists and bureaucrats (who can realistically be assumed to reside in urban areas), 29% of the population is urban based, and 71% is rural based. Eighty-five percent of the population lives in households consisting of unskilled labor, and 10% lives in households consisting of skilled labor. Rural smallholders constitute the largest household group with 59% of the population, followed by the urban informal (14%), the urban skilled and rural unskilled (each with 7%), the urban unskilled (5%) and the rural skilled (3%).

Domestic food production (in the rural informal sector) contributes approximately one-half of the total output of the economy. The protected urban formal sector producing the import-competing good and the rural formal sector producing export crops each account for approximately one-fifth of the total output, while the urban informal (service) sector accounts for the remaining 10%.

In the baseline (pre-reform), the urban skilled workers' relative average income is more than double that of the rural skilled, two and one-half times greater than that of the urban unskilled, and more than five times higher than that of the workers and in the other three household groups.

We simulate the impact of a trade liberalization shock on this stylized economy. It is assumed that the prevailing 40% ad valorem tariff on the imported good is reduced by half to 20%.[13] The immediate effect is that the price of the importable

[12] The programs and calibrated parameter values are available upon request from the authors.

[13] An immediate complete elimination of tariffs would be an unrealistic exercise for two reasons. First, for developing countries with rudimentary taxation systems that rely on tariff revenue for a large portion of general revenue, and given the political influence of entrenched groups who stand to lose such a drastic reform would appear infeasible given the prevailing political economy. Second, non-marginal changes arguably transform and alter the structure of the economy reflected in the parameter values that are calibrated from the baseline SAM. Maintaining the same set of parameter values from the baseline (pre-reform) economy in the face of a complete tariff elimination would no longer reflect a new structure of the underlying economy, and changing the parameter's to accommodate the evolving structure can only be done arbitrarily. Since CGE models can only be employed to simulate marginal exogenous shocks that leave the structure of the economy unchanged, even an 8.5% drop in the exogenous price of the importable (from 1.4 to 1.2) is a large shock.

Table 6
Simulation results

	Baseline level	Simulation ($t = 0.2$)		
		Level	Change	Percent change
Real national income	273.12	275.00	1.88	0.69
Real incomes				
Urban capitalists	20.92	20.64	−0.28	−1.34
Rural large landholders	16.30	20.92	4.62	28.35
Bureaucrats	15.32	10.10	−5.22	−34.05
Real per capita incomes				
Rural small-holders	0.87	0.88	0.01	1.04
Rural unskilled	0.91	0.92	0.01	0.99
Rural skilled	2.35	2.47	0.13	5.32
Urban informal	0.90	0.92	0.02	1.99
Urban unskilled	1.89	1.94	0.04	2.27
Urban skilled	4.98	5.38	0.40	7.95
Nominal incomes				
Rural small-holders	148.38	129.93	−18.45	−12.44
Rural unskilled	19.07	21.09	2.02	10.60
Rural skilled	5.45	6.03	0.58	10.59
Urban informal	30.51	23.31	−7.20	−23.60
Urban unskilled	22.43	18.54	−3.89	−17.36
Urban skilled	25.80	21.32	−4.48	−17.36
Output				
Food	148.43	148.37	−0.06	−0.04
Export good	54.48	60.25	5.78	10.60
Urban services	30.52	29.52	−1.00	−3.29
Importable	59.81	57.67	−2.14	−3.58
Prices				
Food	1.000	0.876	−0.12	−12.40
Export good	1.000	1.000	0.00	0.00
Urban services	1.000	0.790	−0.21	−21.00
Importable	1.400	1.200	−0.20	−14.29
Nominal wage rates				
Rural small-holders[a]	1.000	0.877	−0.12	−12.30
Rural unskilled	1.050	0.921	−0.13	−12.29
Urban informal[a]	0.974	0.850	−0.12	−12.73
Urban unskilled	2.061	1.800	−0.26	−12.66
Rural skilled	2.923	2.659	−0.26	−9.03
Urban skilled	5.846	5.317	−0.53	−9.05
Labor shares				
Rural small-holders	0.711	0.710	0.00	−0.14
Rural unskilled	0.087	0.110	0.02	26.44
Urban informal	0.150	0.131	−0.02	−12.67
Urban unskilled	0.052	0.049	0.00	−5.77
Rural skilled	0.297	0.361	0.06	21.55
Urban skilled	0.703	0.639	−0.06	−9.10

Table 6 (*Continued*)

	Baseline level	Simulation ($t = 0.2$)		
		Level	Change	Percent change
Disguised unemployment				
Rural	0.527	0.527	0.00	−0.09
Urban	0.111	0.098	−0.01	−11.71
Poverty line	1.70	1.48	−0.22	−12.94

[a] Average income.

drops correspondingly and the price of the export crop increases relatively as its nominal price remains constant having been chosen as numeraire. The end result is that production in the former sector falls, and rises in the latter. This follows because the fall in the price of the importable leads to a drop in demand for both skilled and unskilled labor in this sector, and consequently to an increase in the supply of labor to all of the other sectors. With its output price fixed at the world price for exports (the numeraire), and with the fall in wages, the rural formal sector's output expands as lower wage labor is employed. Thus the change in the composition of output triggers a reverse migration of workers from the urban formal sector to the rural formal sector.

As Table 6 shows the share of the rural skilled workers increases by almost 22% and that of the urban skilled falls by 9%. Likewise, there is a movement of urban unskilled from the urban importable sector to the rural exportable sector with the share of the former increasing by 26% and the latter falling by about 6%. Interestingly enough the fall in aggregate income in the urban formal sector translates into a reduction in the demand for urban services provided by the urban informal sector and a consequent out-migration of informal sector workers to the rural formal sector as well.

In addition to the migratory effects of the trade reform, it is interesting to observe the changes in the income distribution brought about by the trade reform. The greatest beneficiaries, in a relative sense, are the rural large landholders who see their real incomes rise by about 28%. The big losers are the bureaucrats whose income falls by 34%, as their income is tied directly to the import tax revenue (see Eq. (24)). What might appear somewhat surprising at first glance is that urban capitalists only suffer a marginal loss of income. This can be explained by the fact that although their revenues go down after the reform, so do their labor costs as they employ fewer skilled and unskilled workers at lower wages (see Eq. (23)). As such their profits fall only marginally.

It is interesting to note that the real average per capita incomes of all labor household groups rise following the reform.[14] However, this does not mean that some groups of workers are not made worse off. Indeed, both the urban skilled and

[14] Notice that although nominal incomes of a number of labor groups falls following the trade reform the greater relative fall in prices (particularly that of the importable) improves the purchasing power of rural workers and actually leads to higher per capita incomes for all groups.

unskilled workers who migrate to the rural formal sector see their real incomes fall by approximately half (from 4.98 to 2.47 for the former and from 1.89 to 0.92 for the latter).[15]

On the other hand the greatest beneficiaries of the reforms are the skilled workers who remain employed in the urban formal sector (their real incomes rise by about 8%). It should be recalled that the mechanism that yields the above results is that we assume that all in-migrating workers adopt the characteristics of the workers of the sector in which they enter.

Real national income rises, as expected, with a reduction in the distortionary trade restrictions. Nonetheless, the efficiency gains are small amounting to only 0.69% of GNP. This is an especially small gain given the relatively large changes in the inter-group income distributions following the simulation just discussed earlier. The relatively small efficiency gains can be put into perspective by considering the costs associated with compensating the losers so that no single group is made strictly worse off. Let us consider the urban capitalists and the bureaucrats, whose real incomes in the baseline period account for 13.3% of national income. The real income loss of 15.1% for these groups represents 2.1% of GNP (0.133×0.155). So, in order to compensate these two urban groups, the government would have to collect 2.1% of national income in taxes, which of course introduces an efficiency loss of its own (after all, the efficiency gains that arise from the trade liberalization simulation stem from reducing such distortions in the first place). The magnitude of these distortions can be assessed by considering the marginal excess burden (MEB) for African economies, which Rodrik (1997) argues cannot be any lower than 0.60. This means that for each CFA 1.00 in revenue raised via taxes, the cost to the rest of society resulting from government inefficiency, waste and corruption is at least CFA 0.60. Applying this ratio to our example above compensatory transfer to the urban capitalists would entail an administrative and efficiency cost of at least 1.23% of GNP (0.60×0.021). In summary, with total efficiency gains from the reform yielding only a 0.69% increase in real national income, the cost of redistribution would swamp the gains from reform.

At this stage two other points need to be made. First, it would indeed be counter-productive for the government to compensate the losers when, in fact, the purpose of the reform is to improve allocative efficiency. The second point is that the estimate of the increase in real national income is only due to the effects of *static* efficiency gains. The model, as such, cannot capture *dynamic* gains that may arise over the long run from increased competition in the import-competing sector and an increase in the relative price of the export crop — both factors which are consistent with dynamic comparative advantage. In any case, what the above calculation reveals is how difficult, from a political economy viewpoint, the initiation and implementation of a trade liberalization reform are for a government in a country with the socio-economic structure corresponding to that of an arch-type African economy.

[15] The real incomes of the urban informal sector workers who migrate to the rural export crop sector and in the process become unskilled workers remains approximately constant.

However, if a government manages (in all likelihood with the help of international agencies) to embark on a trade liberalization process, the consequent changes in the income distribution and relative power of the groups induced by the reform should facilitate a continuation of this process (i.e., successive rounds) of liberalization. Those groups which initially benefit most from protection (particularly the bureaucrats and the urban union) are hurt significantly by a first round of tariff reduction. Bureaucrats' incomes falls drastically as they are linked directly to import tax revenues (bureaucrats are realistically assumed to capture the rents generated by the tariffs). The union, whose constituency comes primarily from the urban skilled workers becomes weaker as a number of those workers move to the rural export sector. The level of utility derived by the union drops following the policy shock (see Eq. (15a) in the text). This does not necessarily imply that the union would actively devote resources to preventing such policy reforms in the first place. Only when the perceived costs associated with successfully lobbying the government are considered to be less than the perceived benefits from maintaining the status quo, would the representative union be likely to challenge the reform. The present model does not shed light on these magnitudes. We can only conclude that there is a trade-off for the union and that this might be a potential source of resistance and that once the process of liberalization has started the extent of the union's resistance is weakened.

The process of liberalization once started (which is modeled in our simulation exercise through a 50% reduction in the ad valorem tariff rate) not only weakens the resistance of the bureaucrats and the union to a next round of liberalization but it also strengthens the power and resolve of the gainers (the rural export producers) for such a move. As such, this analysis appears to reinforce the case for a gradual, as opposed to a "cold turkey" approach to reform.

The simulation results illustrated in Table 6 provide information on how the policy shock affects individual socio-economic groups on average, but tells us nothing about changes in poverty. The reform brings about declines in mean per capita nominal incomes for each of the working-class groups (as represented by the nominal wage rates and average incomes), which leads to leftward shifts in the intra-group nominal income distributions that were initially illustrated in the equation in the appendix. This does not necessarily imply more poverty, because prices also fall. In fact, the endogenously derived nominal poverty line drops 13% from 1.7 to 1.48. To see what this means for poverty, in general, let us first closely examine how the simulated changes in the poverty line and the intra-group income distribution affect poverty for one of the groups (i.e., the rural smallholders).

The upper panel of Fig. 1 illustrates the extent of poverty among smallholders in the baseline economy. This figure plots household income on the vertical axis and the cumulative percentage of households ranked by their per capita income on the horizontal axis. This is simply the cumulative distribution function with the axes rotated. A nice feature of plotting the distribution in this manner is that it directly and clearly illustrates the poverty headcount ratio (P_0) and it provides an approximation of the depth of poverty (P_1). The dotted line represents the poverty line ($z = 1.7$), and P_0 can be read directly from the value on the horizontal axis

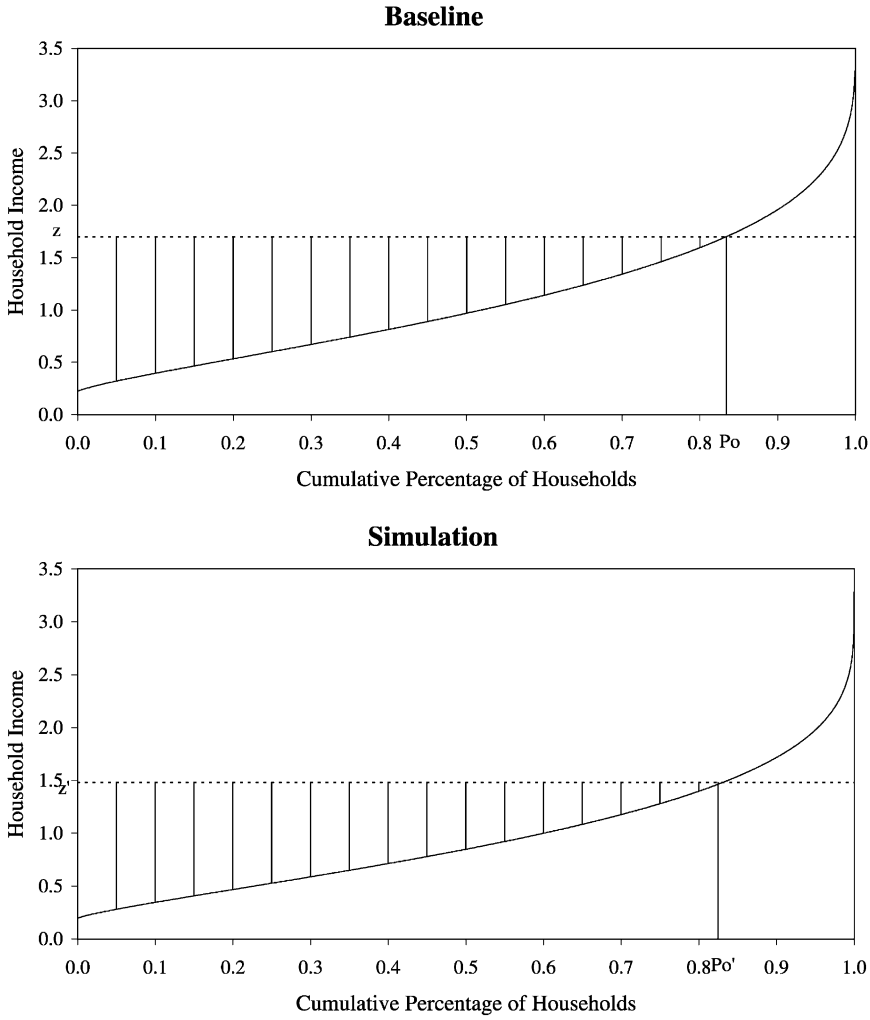

Fig. 1. Poverty of rural small holder households.

where the poverty line intersects the distribution function. The vertical distance between the poverty line and the income distribution at every point to the left of P_0 represents the absolute poverty gap. Thus P_1 is approximately the area marked by vertical lines (or in a discrete world, this is the sum of the poverty gaps up to the poverty line).[16]

[16] This is an approximation because P_1 is the integral of the relative poverty gaps normalized by the poverty line, not of the absolute poverty gaps. Nonetheless, this allows a visual interpretation of how poverty changes in the aftermath of an exogenous shock to the economy.

The lower panel of Fig. 1 shows the post-shock distribution of per capita incomes for rural smallholder households in which all nominal incomes drop by 0.14% from their baseline levels. The new endogenously derived poverty line ($z' = 1.48$) is also represented in the lower panel as the dotted horizontal line. This illustrates that the headcount ratio falls from $P_0 = 83.40\%$ in the baseline (upper panel) to $P_0 = 82.86\%$ in the simulation (lower panel). The shaded area in the upper panel is marginally smaller than the area in the lower panel so that the depth of poverty falls from $P_1 = 0.402$ to $P_1' = 0.399$.[17] Essentially Fig. 1 shows that the downward shift in the poverty line more than makes up for the downward shift in the nominal income of the smallholders.

The same simulation exercise was undertaken and corresponding figures (not shown but available upon request from the authors) derived for all other household groups. The results are summarized in Table 7. It can be seen that the poverty headcount falls for each of the groups, except for the urban informal households where P_0 remains at 88%, and for the urban skilled workers for which no members live in poverty.[18]

Two implicit and interrelated assumptions are made in conducting this poverty exercise in the presence of migration. First, individuals are assumed to take on the socio-economic characteristics of the group to which they migrate. Second, the form of migration is stochastic in the sense that neither the income distribution of the group from which workers emigrate, nor the income distribution of the group to which workers immigrate changes. For example, those workers who leave the urban import sector for the rural export sector, are not exclusively those members of the former group who make up the lower tail of the income distribution, nor do they make up the upper tail of the income distribution of the latter group. Intra-group distributions, in this model, are altered only with the changes in the mean per capita income of the group. Thus migration, per se, does not affect intra-group poverty, though it does affect national poverty by changing the share of population represented by each socio-economic group.

Given this caveat, the poverty depth (P_1) declines for each income group, with the largest drop being recorded for the rural unskilled. Note that despite the absence of change in the headcount ratio for the urban informal workers, P_1 dropped marginally for this group. Similarly, poverty severity (P_2) falls for each of the household groups, except for urban unskilled workers, who started with

[17] Note that for P_1 to fall, the shaded area in the lower panel must be small enough to compensate for the drop in the poverty line. For instance, if the shaded area in the upper and lower panel were exactly the same, P_1 would actually rise because each of the relative gaps would rise with the fall in the poverty line (from 1.7 to 1.48).

[18] For the headcount ratio, the fall in poverty for rural unskilled and skilled workers contributed roughly 12% each to the drop in the national poverty rate. For the more distributionally sensitive measures (P_1 and P_2), the contribution of the fall in poverty for the rural skilled workers drops considerably since the initial poverty gaps for all of the workers this group are already significantly smaller than for the unskilled workers.

Table 7
Changes in poverty

	Baseline level	Simulation ($t = 0.2$)	
		Level	Change
National poverty[a]			
Poverty headcount (P_0)	68.92	68.65	−0.27
Poverty gap (P_1)	32.91	32.63	−0.28
Poverty severity (P_2)	19.53	19.28	−0.25
Poverty headcount (P_0)			
Rural small-holders	83.40	82.86	−0.54
Rural unskilled	82.53	82.09	−0.44
Rural skilled	4.37	3.15	−1.22
Urban informal	88.08	88.08	0.00
Urban unskilled	28.64	28.47	−0.17
Urban skilled	0.00	0.00	–
Poverty depth (P_1)			
Rural small-holders	40.22	39.85	−0.37
Rural unskilled	37.04	36.62	−0.42
Rural skilled	0.45	0.29	−0.16
Urban informal	45.27	45.26	−0.01
Urban unskilled	4.35	4.33	−0.02
Urban skilled	0.00	0.00	–
Poverty severity (P_2)			
Rural small-holders	23.91	23.63	−0.28
Rural unskilled	20.52	20.21	−0.31
Rural skilled	0.07	0.04	−0.03
Urban informal	28.02	28.01	−0.01
Urban unskilled	0.95	0.95	0.00
Urban skilled	0.00	0.00	–

Note: Poverty measures are all multiplied by 100.
[a] National poverty is defined in Section 3 of this paper.

a relatively low level of 0.95.[19] At the national level, each measure of poverty falls.

Finally, Table 8 shows a decomposition of changes in national poverty into the contributions made by changes in poverty within each socio-economic group and by the effects of migration between the groups using the baseline as the point of reference (Ravallion & Huppi, 1991). Appendix provides a detailed description of the decomposition. The decline in poverty among rural smallholders accounts for

[19] These results differ if the income distributions are shifted by constants rather than by proportional changes. For instance, if each rural skilled and urban unskilled worker's income fall by 0.26 (the fall in per capita mean incomes for these two groups), then the headcount ratio and the poverty depth actually rise for these income groups because the poverty line falls by a smaller absolute amount of only 0.22. Because of these counter-intuitive results and because constant shifts change the Lorenz curves, the method of proportional changes in income used in the paper is preferred.

Table 8
Decomposition of changes in national poverty

Percentage contribution to total change	P_0	P_1	P_2
Total change	100.0	100.0	100.0
Intra-group effects			
Rural small-holders	118.7	78.4	66.4
Rural unskilled	11.8	10.8	9.0
Rural skilled	13.4	1.7	0.4
Urban informal	0.0	0.5	0.5
Urban unskilled	3.0	0.3	0.0
Urban skilled	0.0	0.0	0.0
Migration effect	−53.4	5.7	21.5
Interaction effect	6.6	2.6	2.2

the bulk of the fall in national poverty because roughly 60% of the population falls into this group.[20]

The interesting result of this decomposition is that migration dampens the total change in the national headcount ratio. In the absence of migration the reduction in poverty resulting from the trade reform would have been significantly overestimated. This results from the unskilled and skilled workers losing jobs in the import sector and migrating to the rural areas where they earn much lower wages. Note also that the migration result is negative despite the fact that 1.6% of the population migrates out of the poorest socio-economic group, the urban informal sector, into the better paying export sector. For $P_1$and P_2, the positive effect on national poverty of workers leaving the urban informal sector swamps the negative effect of workers leaving the import sector for lower paying jobs in the rural sector.

The implications of these results are that had migration between socio-economic groups not been modeled in this exercise, the simulation results would have indicated a larger fall in the percentage of the population in poverty, and a smaller change in poverty depth and severity. In the absence of migration, the total change in poverty is just the sum of the intra-group effects,[21] and Table 8 makes clear the importance of the migration effect on the change in national poverty.

6. Concluding remarks

This paper shows how CGE techniques can be developed using a dual-dual model to analyze changes in poverty following trade reforms in an archetype African country. We extend upon Decaluwe et al.'s (1999) work which incorpo-

[20] Because national poverty fell for all three measures, positive values in the table represent contributions to the fall in national poverty.

[21] These are the total intra-group changes weighted by the baseline population shares.

rates the analysis of intra-group income distribution and poverty into the CGE methodology. With initial intra-group nominal income distributions for the relevant socio-economic groups, and a national nominal poverty line as the points of departure, the effects of exogenous shocks to the economy on poverty are simulated by simultaneously shifting the income distributions and the monetary poverty line and by applying standard poverty measures to these distributions.

The methodological contribution of this work is twofold. The first extension is the way in which the intra-group per capita income distributions are shifted. To maintain distributional neutrality within each socio-economic group (i.e., constant levels inequality), all per capita incomes are shifted by the same percentage — the percent change in the mean of the group per capita income. Until we can satisfactorily model the effect of an exogenous shock on the intra-group distribution of incomes around the mean, this assumption of invariance of the Lorenz curves to changes in mean income remains the least arbitrary method of simulating changes in poverty with CGE models. It is therefore preferred to additive shifts in the intra-group distributions.

The second extension follows from the explicit modeling of migration between socio-economic groups implied by the theory of the dual-dual economy (Thorbecke, 1993, 1994, 1997), and its consequent effects on national poverty. Using a decomposition method proposed by Ravallion and Huppi (1991), this paper shows that the effects of migration on poverty analysis in a CGE model can be significant. Ignoring the changes in the population shares of the socio-economic groups that follow from population shifts, can lead to unpredictable biases in simulated poverty effects. For example, the fall in the national poverty rate in this model is dampened by roughly one-third of what would have prevailed in the absence of such migration, while the fall in poverty severity is about one-fourth greater as a result of the migration effect. Because the direction of the bias is not apparent *ex ante*, general statements cannot be made with regard to the over- or under-estimation of changes in poverty in a model that ignores the effects of migration. Our findings therefore suggest that to capture poverty dynamics more accurately following exogenous shocks, population shifts between socio-economic groups must be explicitly incorporated into the model.

The dual-dual structure of the model also allows the exploration of some important policy issues. First, the impact of the process of trade liberalization on the income distribution of the different socio-economic groups is seen to affect the relative economic and political power of those groups.

The difficulty of initiating a trade reform can be ascertained by computing the hypothetical costs to the government of compensating the losers through a redistributive scheme. We showed that those costs would swamp the small static efficiency gains. However, once the process of liberalization has actually started the protectionist constituencies (mainly the bureaucrats, the union, and the urban capitalists) lose some of their economic and political power, thereby weakening their resistance to a continuation of the process. This trend is further reinforced by

the increase in power of the gainers (mainly the rural export producers) who stand to benefit from further rounds of tariff reduction.

The strong initial resistance to trade liberalization by potential losers that typically form the major constituencies supporting the government in power in an arch-type African country, combined with the earlier described tendency, argues in favor of a gradual approach to liberalization.

Finally, although the major objective of a trade reform is to improve allocative efficiency (and not poverty alleviation per se) and to lay the foundations for dynamic growth, it is important in an endemically poor country to assess the consequences of liberalization on poverty. Our model makes it possible to determine the impact of a reform on the composition and the poverty incidence of the different socio-economic groups. If, as our model indicates, trade liberalization leads to some reduction in poverty this could provide an additional reason for initiating it.

Appendix

We illustrate the poverty decomposition proposed by Ravallion and Huppi (1991) for two sectors (u for urban, and r for rural) for simplicity. The extension to six socio-economic groups is straightforward. If we have national P_α poverty measures for the baseline (B) and for the simulation (S), simple mathematical manipulations can be used to break the difference in these poverty measures into four components:

$$P_\alpha^S - P_\alpha^B = \underbrace{(P_{\alpha u}^S - P_{\alpha u}^B)\mathrm{pop}_u^B}_{\text{Intrasectoral effects: Change in urban poverty at baseline population share}} + \underbrace{(P_{\alpha r}^S - P_{\alpha r}^B)\mathrm{pop}_r^B}_{\text{Change in rural poverty at baseline population share}} + \underbrace{\sum_{j=u}^{r}(\mathrm{pop}_j^S - \mathrm{pop}_j^B)P_{\alpha j}^B}_{\text{Change in poverty arising from migration}} + \underbrace{\sum_{j=u}^{r}(P_{\alpha j}^S - P_{\alpha j}^B)(\mathrm{pop}_j^S - \mathrm{pop}_j^B)}_{\text{Interaction between sectoral changes and migration}}$$

where $P_{\alpha j}^t$ is the poverty measured in sector j for the baseline or the simulation, denoted t, and pop_j^t is the population share of sector j for t. The first two components, the urban and rural intrasectoral effects, show how changes in poverty in each of the sectors contribute to the aggregate change in poverty. The third component is the contribution of migration across the two sectors. Ravallion and Huppi (1991) note that the final component can be interpreted as a measure of the correlation between migration and changes in poverty within the sectors.

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