TMD DISCUSSION PAPER NO. 25

POLICY BIAS AND AGRICULTURE:
PARTIAL AND GENERAL EQUILIBRIUM MEASURES

Romeo M. Bautista
Sherman Robinson
International Food Policy Research Institute

Finn Tarp
University of Copenhagen

Peter Wobst
University of Hohenheim
International Food Policy Research Institute

TMD Discussion Paper No. 25

Policy Bias and Agriculture:

Partial and General Equilibrium Measures

Romeo M. Bautista
Sherman Robinson
Finn Tarp
Peter Wobst

May 1998

MACRO
  ECONOMIC
    REFORMS AND
      REGIONAL
        INTEGRATION IN
          SOUTHERN
            AFRICA

Table of Contents

Abstract

The paper examines the impact of industrial protection, agricultural export taxes, and overvaluation of the exchange rate on the balance between the agricultural and non-agricultural sectors. A variety of agricultural terms-of-trade indices are constructed to measure the policy bias against agriculture in a general equilibrium framework that incorporates traded and non-traded goods. These general equilibrium measures are compared to earlier work in a partial equilibrium framework assuming perfect substitutability between domestic and traded goods. Starting from a stylized computable general equilibrium (CGE) model of Tanzania, we simulate a 25 percent tariff on non-agriculture and a 25 percent export tax on agriculture. We also consider the impact of changes in the equilibrium exchange rate. The results indicate that the partial equilibrium measures miss much of the action operating through indirect product and factor market linkages, while overstating the strength of the linkages between changes in the exchange rate and prices of traded goods on the agricultural terms of trade.

1. Introduction

In the early post-World-War-II period, rapid industrialization was widely considered to be the key to development. Historical and cross-country studies showing the declining relative weight of the agricultural sector in the transformation process from poor to rich seemed to reinforce this conclusion, and the view was also central to Marxist analysis in socialist countries. During this period, many countries pursued a development strategy of import substituting industrialization (ISI), which included a variety of policy measures such as: (1) high import tariffs on manufacturing to protect "infant" industries and export taxes on agriculture; (2) quantitative import controls, when tariff protection was viewed as providing inadequate protection; and (3) chronically overvalued exchange rates. Measures directly affecting the agricultural sector were also added, including: (1) agricultural marketing boards with monopoly powers, (2) centrally set producer and consumer prices, and (3) input subsidies. The ISI development strategy led to agriculture being both heavily taxed and neglected relative to industry.

The neglect of agriculture was heavily criticized in the 1960s (Schultz 1964), but ISI policies were not effectively criticized for another decade. In a different, complementary vein, it was later pointed out by Lipton (1977), who coined the term "urban bias", that the most important class conflict in poor countries was neither between labor and capital, nor between foreign and national interests, but between the rural and urban classes. The "Berg Report" (World Bank 1981) identified inappropriate domestic economic policies as the fundamental cause of the deepening agricultural crisis in Sub-Saharan Africa. "Getting prices right" became an influential catch phrase and it was suggested that this policy approach should be the key piece of advice to policy-makers in troubled economies. The neoclassical counter-revolution (Toye 1993) had arrived, and price reforms became a central component in the wide ranging economic reforms which African countries initiated from the mid-1980s onwards.

In addition, it gradually became clear to academics and policy makers alike that whatever the theoretical merits of the variety of interventionist measures employed by governments, they often led to seriously distorted incentives, inefficiencies, and rent seeking. The difference between the nominal and effective rates of protection afforded by tariff rates was analyzed theoretically and scrutinized empirically — and for good reasons. Empirical work indicated that effective protection of industrial products was often much higher than indicated by nominal protection rates, and the costs of intervention were shown to be very high indeed. Other macro policies and their impact on the performance of the agricultural sector, including the exchange rate, also came into focus.

Empirical studies on the effects of government price interventions in developing countries, especially those undertaken since the early 1980s, support the view that there was substantial policy bias against agriculture.[1] First, producer prices are often found to have been suppressed *directly* by sector-specific policies, commonly in the form of agricultural export taxation or the pricing policy of parastatal marketing organizations. Second, economywide policies, including trade and macroeconomic policies that influence the real exchange rate, are shown to have had significant *indirect* effects, invariably adverse, on agricultural incentives. In most cases, the indirect impact of economywide policies is found to be more important than the effect of direct government interventions.

In taking into account the additional effect on agricultural incentives arising from indirect government interventions, these studies have gone beyond the narrow, sectoral orientation of traditional agricultural policy analysis. However, in general, they have relied on analytical frameworks that are partial equilibrium. Economists have long recognized that the partial measures used in applied work are incomplete and that a general equilibrium framework is needed to capture all the interactions that determine the net relative impact of a mix of policies on the agricultural and non-agricultural sectors. "Policy bias" is inherently an economywide, general equilibrium concept. Nevertheless, to date there has been no systematic evaluation of the extent of agricultural bias of government interventions using a general equilibrium framework.

Another critical problem with partial equilibrium approaches is that they typically assume perfect substitutability between domestically produced and imported goods, as well as between domestic products for export and for internal use. Under these assumptions, we should never observe two-way trade ("cross hauling") at the commodity level. If a good is tradable, the "law of one price" holds and changes in world prices should be completely translated into changes in domestic prices. Furthermore, the responsiveness of sectoral domestic prices to changes in world prices or in trade policies does not depend on the shares of trade in sectoral demand or supply. It matters only that the good is "tradable", not how much it is traded.

---

[1] The findings of a World Bank comparative study during 1987-90 involving 18 countries are reported in Krueger (1992) and Schiff and Valdes (1992). Eight country studies done at the International Food Policy Research Institute (IFPRI) from 1981 to 1990 are contained in Bautista and Valdes (1993), together with regional surveys of the literature in Africa, Asia, and Latin America.

All these implications of the law of one price are empirically suspect.[2] For example, two-way trade is observed in highly disaggregated sectoral data for virtually all countries (de Melo and Robinson 1981; de Melo and Tarr 1992). Within agriculture in developing countries, there are also significant shares of non-traded goods or goods with very low trade shares. In any case, the transmission elasticities vary widely across sectors. Evidence for major traded agricultural commodities indicates that price transmission elasticities are close to one for developed countries, although significantly lower for developing countries (Mundlak and Larson 1992). Ardeni (1989), on the other hand, finds that changes in world prices or trade policy measures are generally only partially transmitted through to prices of domestic substitutes.[3] In general, elasticities of substitution and transformation are much lower for industrial goods in developing countries, especially intermediates and capital goods.

By contrast, a widely used specification in multisector, trade-focused, computable general equilibrium (CGE) models is that imports are imperfect substitutes for domestically produced goods with the same sectoral classification. Similarly, in many models, exports are also differentiated from domestically produced goods sold on the domestic market. This formulation removes the extreme dichotomy between tradable and non-tradable goods, allowing differing degrees of tradability corresponding to different values of the substitution and transformation elasticities (which are either infinite or zero in the partial equilibrium approach, depending on whether the good is traded or not). This specification gives some realistic autonomy to the domestic price system in the model and can account for cross-hauling.[4]

In this paper, we use a computable general equilibrium (CGE) model that incorporates the more realistic assumption of imperfect substitutability to provide a comprehensive framework to capture the various repercussions of policy interventions and measure their impact on agriculture.[5] Assuming that the economic environment is characterized by trade policy distortions such as the ones in focus in Krueger, Schiff, and

---

[2] An extended discussion on empirical testing of the law of one price started from an article by Peter Isard (1977); see Ceglowski (1994); Blaffes (1991); and Ardeni (1989).

[3] Peterson, Hertel, and Stout (1994) consider the violation of the law of one price in the context of a partial equilibrium, multi-commodity, agricultural trade model.

[4] For a description of this CGE model specification see Deverajan et al. (1997) and de Melo and Robinson (1989).

[5] For a recent survey on general equilibrium analysis applied to agriculture, see Hertel (1997).

Valdes (1988), we will consider the differences between general equilibrium measures of the agricultural sector bias as compared to the results of partial equilibrium analysis.[6] Following this introduction, the partial equilibrium measures used in previous work are presented. Section 3 discusses how the bias against agriculture can be measured in a CGE model (fully specified in Annex II), and indicates why this frame of reference is preferable to the partial equilibrium approach. The results of a series of policy experiments designed to provide answers to the questions raised above are reported in Section 4, and Section 5 concludes.

2. Agricultural bias: partial equilibrium, no product differentiation

If a country is small and there is perfect substitutability between domestically produced and imported goods, a change in the import price will — under competitive conditions — lead to the same change in the domestic producer price of the importable good. Likewise, if domestic products for export and for internal use are perfect substitutes, the domestic producer price of the exportable good will be equal to its domestic-currency border price equivalent. However, in practice, government policies can drive wedges between foreign and domestic prices.

Krueger, Schiff, and Valdes (1988) — KSV for short — developed measures of the impact of these policies on agricultural producer prices. These measures are used to assess whether the policy-induced incentive structure favors or discriminates against agricultural production, *i.e.* whether the sector is protected or not relative to non-agriculture. They distinguish between policies that have direct and indirect effects on agricultural incentives.

Policies with direct effects include agricultural sector-specific import and export taxes, price controls, and production taxes and subsidies, all of which affect the wedge between producer and border prices of agricultural products. Policies with indirect effects on agricultural incentives, on the other hand, include the exchange rate, which affects the economywide balance between traded and non-traded goods, and import tariffs on non-agricultural products. Contrary to the assumption used by KSV, we recognize below the latter's influence on the exchange rate.

---

[6] A related measure of government support to agriculture, the Producer Subsidy Equivalent (PSE), was developed during the Uruguay Round GATT negotiations and includes both trade and non-trade policies. It is also a partial equilibrium measure which treats trade basically the same way as the Krueger, Schiff, Valdes approach (FAO 1975; Josling and Tangermann 1989; Webb et al. 1990).

Following KSV (but using different notation), let PX_{iag} be the domestic producer price of a specific tradable agricultural product iag, PX'_{iag} the border-price equivalent at the official exchange rate E_0, and P_X^{AGN} the nonagricultural producer price index defined as the weighted average of non-agricultural producer prices. The relative producer prices of agricultural products vis-a-vis the non-agricultural aggregate price are given by

$$P_{iag} = \frac{PX_{iag}}{P_X^{AGN}} \quad \text{and} \quad P'_{iag} = \frac{PX'_{iag}}{P_X^{AGN}} \, .$$

The direct agricultural bias against products indexed by iag is defined as the proportionate deviation of relative prices from what they would have been without direct interventions:

$$DAB_{iag} = \frac{P_{iag}}{P'_{iag}} - 1 = \frac{PX_{iag}}{PX'_{iag}} - 1 \, . \tag{1}$$

This measure is meant to capture the impact on producer incentives of commodity-specific policies, and it corresponds to the widely used "nominal protection rate" in the empirical trade literature.

Let PX_{iag}^* be the border price evaluated at the equilibrium exchange rate E^*, and define $\left(P_X^{AGN}\right)^*$ as the nonagricultural price index where the tradable part is evaluated at E^*, defined as a situation with a sustainable trade balance and no trade restrictions. In this case, E^* differs from E_0 to the extent that the current account is set at an unsustainable level and trade interventions are in place. The relative price is given by $P_{iag}^* = \dfrac{PX_{iag}^*}{\left(P_X^{AGN}\right)^*}$ where

$\left(P_X^{AGN}\right)^* = \alpha \left(P_{Xt}^{AGN}\right)^* + (1 - \alpha) P_{Xnt}^{AGN}$, and Xt refers to tradable goods (whose price is evaluated at the equilibrium exchange rate, E^*) and Xnt refers to non-traded, non-agricultural goods.

The indirect agricultural bias against the sector indexed by iag is the proportionate deviation of PX'_{iag} from PX_{iag}^*:

$$IAB_{iag} = \frac{P'_{iag}}{P_{iag}^*} - 1 = \frac{E_0 \left(P_X^{AGN}\right)^*}{E^* \, P_X^{AGN}} - 1 \, . \tag{2}$$

This measure is meant to capture the indirect effects on producer incentives of the exchange rate disequilibrium (E_0 differing from E^*) and of trade policy affecting P_X^{AGN} (*e.g.*, industrial protection). Notably, PX_{iag} does not appear in the right-hand side of equation (2). Hence, the indirect agricultural bias is the same for all tradable agricultural goods. The implicit assumption that $\dfrac{P_X^{AGN}}{\left(P_X^{AGN}\right)^*}$ and $\dfrac{E_0}{E^*}$ are independent shows that the partial equilibrium framework does not capture intersectoral price linkages and also assumes no repercussion through changes in the exchange rate induced by the price changes.[7]

The exchange rate affects the terms-of-trade ratio depending on the shares of traded and non-traded goods within the agricultural and non-agricultural sectors. If all goods in the economy are tradable, then the exchange rate is irrelevant since, in that case, all domestic relative prices are set by world prices. The exchange rate is important precisely because there are non-traded goods. In the KSV studies, the agricultural products considered were tradable (*i.e.*, some observed exports or imports) and some non-agricultural goods were not tradable. In that environment, exchange rate changes affect tradable agriculture much more than partially non-traded non-agriculture. Considering agriculture as a whole, it is important to consider non-traded agricultural goods in defining aggregate terms-of-trade indices.

The total agricultural bias against sector *iag* can be represented by the proportionate deviation of PX_{iag} from PX_{iag}^*:

$$TAB_{iag} = \frac{P_{iag}}{P_{iag}^*} - 1 \tag{3}$$

which captures the effects of both direct and indirect government interventions.

The three measures are related as follows:

$$TAB_{iag} = DAB_{iag}\left(\frac{P'_{iag}}{P_{iag}^*}\right) + IAB_{iag} \tag{4}$$

---

[7] In some of the IFPRI country studies referred to above, trade restrictions (including import tariffs and export taxes) are systematically examined as a major source of real exchange rate distortion; see, for example, Cavallo and Mundlak (1982) and Bautista (1987), for an empirical investigation of the Argentine and Philippine cases, respectively.

The first term on the right-hand side of equation (4) is a modified measure of the direct agricultural bias, which is usually smaller (in absolute value) than the nominal protection rate since PX'_{iag} is typically less than PX^*_{iag} in developing countries.

In contrast with the partial equilibrium measures used in the World Bank studies, which are concerned with producer price incentives only, a general equilibrium approach will capture intersectoral resource shifts, product differentiation in production and demand, and the effect of induced price changes on the equilibrium exchange rate. The result is a richer specification of the price system and a more complete concept of agricultural bias.

3. Agricultural bias: general equilibrium and product differentiation

If domestically produced and imported goods (DC_i and M_i respectively) are imperfect substitutes, the price of the domestic good, PDC_i, will no longer be equal to the domestic-currency price of the import substitute, PM_i, as in the partial equilibrium framework. Similarly, if there is imperfect substitutability between domestic products for export (e_i) and for internal use, their prices — PE_i and PDA_i respectively — will not be identical. It follows that the domestic prices of exported and imported products are not determined by the law of one price.

3.1. Structure of the applied CGE approach

Following Armington (1969), we can introduce product differentiation by defining a composite good Q_i which is a CES (constant elasticity of substitution) function of the domestic product DC_i and the import substitute M_i. Likewise, a production good X_i can be defined as a CET (constant elasticity of transformation) function of the domestic product in sector i for internal use DA_i and for export E_i. Under the small country assumption, *i.e.*, the country's imports have an infinitely elastic world supply and its exports have an infinitely elastic world demand, world prices of imports pwm_i and of exports PWE_i are exogenously determined. The domestic prices of imported and exported products are given by

$$PM_i = pwm_i \left(1 + tm_i \right) EXR \quad \text{and} \tag{5}$$

$$PE_i = PWE_i \left(1 - te_i \right) EXR \tag{6}$$

respectively, where *EXR* is the exchange rate (in domestic currency per unit of foreign currency), and tm_i and te_i are the implicit tariff and export tax rates, respectively, that take account of the legal tariffs and export taxes as well as any quantitative trade restrictions and direct price controls that affect the disparity between the domestic and border prices of traded goods.

From the underlying general equilibrium model used here (see Annex II for a complete specification), the relationships between relative prices and quantities are:

$$\frac{M_i}{DC_i} = CES^* \left(\frac{PM_i}{PDC_i} \right) \quad \text{and} \tag{7}$$

$$\frac{E_i}{DA_i} = CET^* \left(\frac{PE_i}{PDA_i} \right). \tag{8}$$

We use the convention that CES and CET refer to "constant elasticity of substitution" and "constant elasticity of transformation" functions, while CES* and CET* refer to the corresponding first-order conditions for utility maximization and profit maximization.

Sectoral composite good prices are the weighted averages of the domestic prices of their component products:

$$PQ_i = \frac{PDC_i \cdot DC_i + PM_i \cdot M_i}{Q_i} = CES \left(PDC_i, PM_i \right) \quad \text{and} \tag{9}$$

$$PX_i = \frac{PDA_i \cdot DA_i + PE_i \cdot E_i}{X_i} = CET \left(PDA_i, PE_i \right) \tag{10}$$

where the CES and CET functions refer to cost functions relating the composite prices to their component prices. They reflect the first-order conditions described above.

Equations 5 - 10 are imbedded in the structure of a computable general equilibrium (CGE) model incorporating differentiated products. This model permits the determination of the direct effects of government interventions (captured in tm_i and te_i) on agricultural

prices, and also their indirect effects through intersectoral linkages and induced changes in the exchange rate.

To make the CGE agricultural bias results derived in this study as comparable as possible to the partial measures described above, we adapt the CGE model to provide a "clean" theoretical starting point for measuring policy bias and also use the framework for doing controlled experiments that isolate particular effects.

First, in the model, factor markets have been segmented with respect to aggregate agricultural and non-agricultural sectors. Labor and capital can move between sectors within agriculture and non-agriculture, but cannot move between agriculture and non-agriculture. In this model, the derived agricultural sector bias measures reflect only price changes and intra-sectoral resource shifts. The partial equilibrium measures focus only on prices, and so indicate potential resource pulls if factors were free to move between agriculture and non-agriculture. In the CGE model, by restricting factor mobility between agriculture and non-agriculture, the resulting equilibrium prices, and measures of bias based on them, should be comparable to the partial equilibrium measures. In an "unrestricted" CGE model, allowing inter-aggregate-sector factor mobility, adjustment would include both price and quantity effects. In general, allowing quantity adjustment will reduce price adjustment, so the segmentation should lead to price effects which are upper bounds. Indeed, the most appropriate measure of bias would be to allow full factor mobility and measure changes in value added across sectors with removal (or addition) of distorting policies.

Second, as the base for our experiments, we create a distortion-free benchmark solution of the model to provide the theoretically best reference point for the analysis. As reflected in our preliminary data, the economy has a variety of distorting taxes — sectoral tariffs and domestic indirect taxes. Given these existing distortions, analysis of policy experiments is made difficult because there are potential "second best" effects from imposition of new taxes. Given our focus on comparing measures of policy bias, it is convenient to start from an undistorted base. To achieve this undistorted economic environment, all production, sales, and trade taxes in the base data are removed. The lost revenue is made up by means of a non-distorting, lump-sum income tax on households, yielding the base value of government revenue — the standard approach in public finance models. This undistorted base solution is the starting point against which we compare all our experiments.

Third, the general equilibrium model incorporates the indirect effect of changes in tariffs and export subsidies on the economy through their impact on the equilibrium exchange rate — an indirect effect ignored in the partial equilibrium approach. To isolate this effect, we run a variant of the tariff and export subsidy experiments in which we fix the

exchange rate, and so "turn off" this mechanism. In order to fix the exchange rate, we have specified a different macro "closure" and assumed that the trade balance adjusts endogenously.

Fourth, in the KSV methodology, overvaluation of the exchange rate is a major source of policy bias against agriculture.[8] In a general equilibrium context, *EXR* represents the equilibrium exchange rate that is jointly determined by the remaining variables of the model, including especially the balance of trade. The equilibrium exchange rate corresponding to a situation with no trade distortion and a "sustainable" (perhaps zero) trade balance *E** can be calculated with the CGE model, which provides a unified framework incorporating all relative prices, including the real exchange rate. Unlike KSV, no separate model is required to estimate the equilibrium real exchange rate. To measure the effect of changes in the exchange rate only (*i.e.*, with no changes in distorting sectoral taxes), we report on a set of additional experiments where we systematically reduce the trade balance to zero, and solve for the resulting equilibrium exchange rates, and all other prices and quantities. The results show the sensitivity of the various agricultural terms-of-trade measures with respect to depreciation of the exchange rate arising from the elimination of the trade deficit.

Finally, since the focus of the analysis is on the production rather than the consumption side, the non-traded producer price index of goods sold on the domestic market has been chosen as the numeraire of the model. For this choice, the solution value of the exchange rate measures the relative price of traded goods to non-traded goods — the "real" exchange rate of trade theory.[9] In public finance models, it is common to use the consumer price index as numeraire, which is convenient for welfare analysis. The choice is only a matter of convenience. The model is a neoclassical general equilibrium model and only determines relative prices.

An overview on the underlying domestic price transmission mechanism is presented in Figure 1.

---

[8] In fact, in most of their country studies, overvaluation was the greatest source of policy bias against agriculture.

[9] See Devarajan, Lewis, and Robinson (1993) for a discussion of the real exchange rate in this class of CGE models.

Figure 1
Domestic Price Transmission Mechanism

Export Price (PE)

Producer Price (PX)

Value-added Price (PVA)

CES Function

Factor Prices

CET Function

Fixed Proportion

Domestic Price (PD)

Aggregate Intermediate Input Price

Composite Good Price (PQ)

Fixed Proportion

CES Function

Import Price (PM)

Sales Tax

Consumer Price (PC)
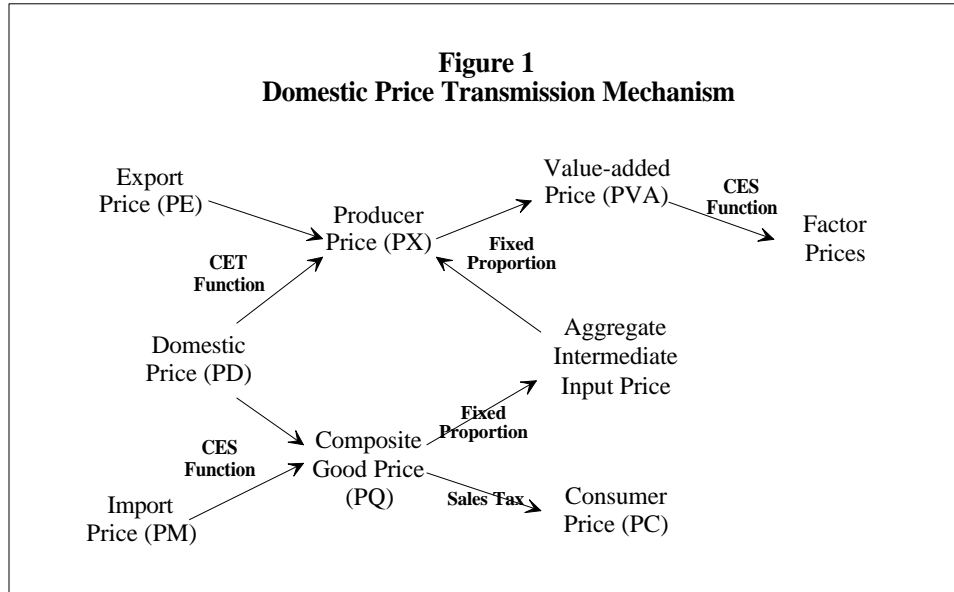
As discussed in the introduction, a major shortcoming of the partial equilibrium approach is the assumed complete transmission of world price changes to domestic prices. Figure 1 shows the price links in the CGE model. Domestic prices of exported and imported products are determined by world market prices plus any trade taxes (given the small country assumption). However, domestic sectoral producer prices (*PX*) are CET cost functions of export prices (*PE*) and domestic prices (*PDA*, *PDC*). Similarly, the composite good prices (*PQ*) are CES cost functions of import prices (*PM*) and domestic prices. The strength of price transmission effects depends both on elasticities (of substitution and transformation) and on trade shares. There are also links working through intermediate inputs, which include imported and domestic goods, and finally to factor prices. In this model, the policy bias against agriculture will depend on differences in policies, trade shares, and the degree of tradability between agricultural and non-agricultural sectors.

3.2. Measures and policy experiments in the CGE framework

In the general equilibrium approach used here, the measure of agricultural bias is captured through various measures of the terms of trade between *aggregate* agriculture and *aggregate* non-agriculture. They are defined as the ratio of the relevant price indices. For example, the agricultural terms of trade with respect to gross output X in domestic producer prices can be represented as follows:

$$AG_X^{TOT} = \frac{\sum_{iag} PX_{iag} \cdot S_{iag}^x}{\sum_{iagn} PX_{iagn} \cdot S_{iagn}^x} \tag{11}$$

where

$$S_{iag}^X = \frac{X_{iag}}{\sum_{iag} X_{iag}} \quad \text{and} \quad S_{iagn}^X = \frac{X_{iagn}}{\sum_{iagn} X_{iagn}} \tag{12}$$

The share parameters are the gross output shares of individual sub-sectors in the agricultural and non-agricultural sectors. The sum of these shares within each aggregate sector equals one.

The aggregate sectoral producer price indices are defined as:

$$P_X^{AG} = \sum_{iag} PX_{iag} \cdot S_{iag}^X \quad \text{and} \quad P_X^{AGN} = \sum_{iagn} PX_{iagn} \cdot S_{iagn}^X \tag{13}$$

The terms-of-trade measures within the CGE framework are constructed using the following prices and corresponding quantity weights:

PM	M	domestic market price and quantity of imports
PE	E	domestic market price and quantity of exports
PQ	Q	composite good price and quantity
PX	X	producer price and gross output
PVA	X	value added price and quantity

Agricultural bias in the CGE framework is measured by various agricultural terms-of-trade indices:

$$AG_M^{TOT} \qquad \text{Agricultural TOT regarding PM and M}$$

$$AG_E^{TOT}$$ Agricultural TOT regarding PE and E.

$$AG_Q^{TOT}$$ Agricultural TOT regarding PQ and Q

$$AG_X^{TOT}$$ Agricultural TOT regarding PX and X

$$AG_{VA}^{TOT}$$ Agricultural TOT regarding PVA and X

A 28 sector — of which 13 are agricultural sectors — social accounting matrix (SAM) for Tanzania (base year 1990) provides the starting data base for our policy simulations.[10] Given that the data are preliminary and that we start from a distortion-free base solution, the model should be seen as reflecting a "stylized" version of a Tanzania-like economy. The SAM was developed as part of a research project which is developing comparative SAM data for a number of African countries, including: Botswana, Madagascar, Malawi, Mozambique, South Africa, Tanzania, Zambia, and Zimbabwe. The model can be seen as characterizing a highly-agricultural, trade-dependent, developing country.

The structure of the economy is presented in Table 1, which provides sector-specific information on production, value-added, and trade shares; export and import ratios with respect to total production and absorption; and elasticities of substitution and transformation. The characteristics of this economic structure that significantly influence the results of the analysis can be summarized as follows:

• The share of agriculture in total gross production is 42 percent, and 56 percent in value-added at market prices. This economy is dominated by agriculture.

• The share of agriculture in total exports is only 26 percent, but the two most important agricultural export sectors (coffee and tea) have export-production ratios of around 80 percent. Most exports are non-agricultural, but there are some very export-dependent agricultural sectors.

• There are virtually no agricultural imports. Most imports are intermediate and capital goods for which elasticities of substitution with domestic production is low. One sector, "fuel", which includes petrochemicals, has high import and export ratios, indicating the existence of "pass-through" exports.

---

[10] The SAM is based on preliminary and incomplete data for Tanzania. A major work program is underway to improve the data base. See Wobst (1998) for a description of an updated 1992 SAM. Note that the reported economic structure is for the distortion-free base solution of the model.

Table 1: Structure of the Model Economy							
	Composition (%)				**Ratios (%)**		**Elasticities**	
	X	**VA**	**EX**	**IM**	**EX/X**	**IM/Q**	**SIGT**	**SIGC**
Cotton	0.5	0.3	-	-	-	-	-	-
Sisal	0.3	0.3	0.8	-	22.6	-	3.0	-
Tea	0.2	0.2	2.6	-	79.7	-	3.0	-
Coffee	0.8	0.8	9.7	-	82.9	-	2.0	-
Sugar	0.4	0.3	1.4	-	27.8	-	3.0	-
Tobacco	0.1	0.0	0.8	-	53.2	-	3.0	-
Cashew	0.1	0.1	0.7	-	46.5	-	3.0	-
Pyrethrum	0.1	0.1	0.5	-	44.1	-	3.0	-
Maize	7.5	10.7	1.5	-	1.5	-	3.0	-
Wheat	0.1	0.2	-	0.0	-	5.4	-	4.0
Paddy	1.9	2.8	-	-	-	-	-	-
Other Agri.	21.8	29.3	5.4	0.1	1.8	0.1	3.0	1.1
Livestock	8.0	11.3	2.2	0.1	2.0	0.2	3.0	1.1
Mining	1.5	1.8	1.4	6.7	6.7	44.9	1.1	4.0
Food & Bever.	5.4	3.2	4.9	7.1	6.5	21.2	1.1	4.0
Textiles	5.8	4.0	27.3	7.8	33.5	25.2	4.0	1.1
Fuel	0.1	0.1	0.8	4.8	62.4	95.7	1.1	0.8
Other Chemicals	0.9	0.6	0.9	9.5	6.5	64.5	1.1	0.8
Non-Metal	1.0	0.4	1.5	3.5	10.7	40.1	1.1	0.8
Metal	2.2	1.4	2.9	31.9	9.5	73.2	1.1	0.8
T&M Equipment	2.1	2.5	0.1	22.4	0.2	64.1	1.1	0.8
Electr. & Water	1.1	0.2	0.0	0.0	0.3	0.1	4.0	1.1
Construction	5.4	1.5	-	0.0	-	0.1	-	4.0
Commerce	16.6	12.3	21.0	0.3	9.0	0.3	4.0	1.1
Trans. & Comm	5.9	8.3	4.8	0.4	5.8	1.3	4.0	1.1
Financial Inst.	4.7	5.6	-	0.9	-	3.2	-	4.0
Other Services	0.7	0.7	8.6	4.4	83.2	85.6	1.1	4.0
Public Admin.	4.9	0.8	0.1	-	0.2	-	4.0	-
Total/Avg. AG	41.8	56.4	25.7	0.2	3.4	0.1	-	-
T./Avg. non-AG	58.2	43.6	74.3	99.8	8.7	23.3	-	-

Notes: **X** = Output, **VA** = Value-Added, **EX** = Exports, **IM** = Imports, **Q** = Absorption, **SIGT** = Elasticity of Transformation, and **SIGC** = Elasticity of Substitution.
Source: Distortion-free base solution of the CGE model for Tanzania using a preliminary 1990 SAM (Wobst 1998).

Four experiments are carried out to simulate the impact of introducing significant industrial protection and taxation of agricultural exports, with and without a fixed exchange rate.[11] The first experiment simulates an "import substitution industrialization" (ISI) strategy by imposing a 25 percent import tariff (*tm(iagn)* = 25%) on all non-agricultural imports. This sort of ISI strategy should hurt agriculture by: (a) raising the relative price of non-agricultural goods, which are import substitutes, compared to agriculture; (b) increasing the costs of production in agriculture (since non-agricultural commodities are used as intermediate inputs in agriculture); and (c) inducing an appreciation of the exchange rate which will hurt export-oriented agricultural sectors producing tradable goods.

The induced appreciation of the exchange rate represents an indirect effect which is considered to be independent in the partial equilibrium approach to measuring agricultural bias. To estimate the separate effect of this appreciation, in experiment 2 we also increase the non-agricultural tariff as in experiment 1, but fix the exchange rate, which serves to isolate the indirect exchange-rate effect. With the exchange rate fixed, the model is solved by endogenously adjusting the trade balance (as discussed above). This additional experiment allows comparison with the partial equilibrium measures which analyze the effects of taxation under the assumption of a fixed exchange rate.

The third and fourth experiments simulate the implementation of a 25 percent tax on all agricultural exports, again with a free and fixed exchange rate (*te(iag)* = 25% and *EXR* is either free or fixed). The impact of an export tax on agriculture in a partial equilibrium framework with a fixed exchange rate is referred to as the *direct* bias against agriculture. In the general equilibrium framework, the effect of an export tax can be divided into two components: (a) price changes due to trade price transmission effects, given the CES-CET functional structure of the model; and (b) price changes due to the induced exchange-rate effect.

In the partial equilibrium literature, a major source of policy bias is the overvaluation of the exchange rate, even with no sectoral price distortions. To assess this effect, we perform a series of five experiments where we leave all sectoral taxes at zero but reduce the base value of the trade balance in 20 percent increments, reaching zero in the last experiment. In these experiments, the real exchange is solved endogenously, given the exogenous trade

---

[11] Other government policies such as sales taxes or fixed producer prices could also be investigated within the CGE framework. However, in the present analysis, we focus on trade policy-induced distortions.

balance.[12] A trade balance of zero is often specified as defining the "appropriate" equilibrium value of the exchange rate in the partial equilibrium literature. Defining an equilibrium or "sustainable" trade balance is a macro issue, outside the scope of our static general equilibrium model. In the CGE model, there is a functional relationship between the exchange rate and the trade balance, and hence between the trade balance and measures of policy bias arising from changes in the equilibrium exchange rate. The five experiments indicate this relationship.

4. Results

4.1. Industrial protection and agricultural export taxes

Table 2 presents the impact on the various agricultural terms-of-trade measures of the imposition of the 25 percent non-agriculture import and agriculture export taxes, with and without a fixed exchange rate. The agricultural terms-of-trade measures and their underlying aggregate price indices are shown in the rows. The first two agricultural terms-of-trade measures with regard to traded goods (AG_M^{TOT} and AG_E^{TOT}) capture price-incentive effects which are close to the partial equilibrium measure. The last three measures (AG_Q^{TOT}, AG_X^{TOT}, and AG_{VA}^{TOT}) capture the transmission of price changes from traded goods through commodity, output, and value-added prices, reflecting general equilibrium linkages, the Armington specification of imperfect substitutability, and finally the operation of factor markets.

The last row shows that the exchange rate, which is fixed in experiments 2 and 4, appreciates by approximately 5 percent in experiment 1 and depreciates by 5 percent in experiment 3. The signs of the induced changes are predictable from theory — the magnitudes depend on model parameters and the structure of the economy.

---

[12] We could also have fixed (and varied) the exchange rate and "closed" the model by solving for the corresponding equilibrium trade balances endogenously. The qualitative results would be the same — we trace out the functional relationship between the real exchange rate and the balance of trade.

Table 2				
Industrial Protection and Export Taxes in Agriculture with Free and Fixed Exchange Rate				
Price Indices (Base=100)	**tm(iagn) = 25 %**	**tm(iagn) & EXR fix**	**te(iag) = 25 %**	**te(iag) & EXR fix**
AG_M^{TOT}	**80.0**	**80.0**	**100.0**	**100.0**
P_M^{AG}	94.7	100.0	105.3	100.0
P_M^{AGN}	118.3	125.0	105.3	100.0
AG_E^{TOT}	**100.0**	**100.0**	**75.0**	**75.0**
P_E^{AG}	94.7	100.0	78.9	75.0
P_E^{AGN}	94.7	100.0	105.3	100.0
AG_Q^{TOT}	**94.4**	**90.2**	**93.9**	**98.8**
P_Q^{AG}	98.9	96.9	96.8	99.3
P_Q^{AGN}	104.7	107.3	103.1	100.5
AG_X^{TOT}	**98.3**	**94.9**	**93.7**	**98.0**
P_X^{AG}	98.7	96.9	96.2	98.5
P_X^{AGN}	100.4	102.2	102.7	100.6
AG_{VA}^{TOT}	**100.1**	**96.0**	**92.4**	**97.5**
P_{VA}^{AG}	98.1	96.1	95.8	98.4
P_{VA}^{AGN}	98.0	100.1	103.7	100.9
EXR	**0.95**	**1.00**	**1.05**	**1.00**

The first agricultural terms-of-trade measure (AG_M^{TOT}) shows a 20 percent deterioration for experiment 2 due to the 25 percent increase of the non-agricultural price index P_M^{AGN}. World market prices in equation 5 are fixed in all experiments, given the small-country assumption, and the exchange rate is fixed as part of experiment 2. In the first two experiments, the 25 percent increase in import tariffs on non-agricultural production $(tm(iagn) = 25\%)$ leads to a 20 percent decrease in the terms of trade $(1/1.25 = 80\%)$. In

experiment 2, with a fixed exchange rate, the tariff directly increases P_M^{AGN} while agricultural import prices remain unchanged. In experiment 1, the induced appreciation of the exchange rate changes all import prices, leaving relative prices and hence the agricultural terms of trade, unchanged. Experiments 3 and 4, in which the domestic prices of agricultural exports are changed, have no influence on AG_M^{TOT} (as can be seen from equation 5). With a fixed exchange rate, the export tax does not affect domestic import prices. Moreover, with a flexible exchange rate, as in experiment 1, P_M^{AG} and P_M^{AGN} change proportionately, leaving the terms of trade unaffected.

Tracing the effects of the four experiments on AG_E^{TOT} is equivalent to tracing the effects on AG_M^{TOT} as shown above. A 25 percent export tax on all agricultural sectors leads (see equation 6) to a decrease in P_E^{AG} of 25 percent in experiment 4, where the exchange rate is fixed. Since P_E^{AGN} remains unchanged, AG_E^{TOT} decreases by 25 percent. With a flexible exchange rate (in experiment 3), the depreciation of the exchange rate following the relative price decrease of exports affects P_M^{AG} and P_M^{AGN} equally and therefore has no additional effect on AG_E^{TOT}. Experiments 1 and 2 have no influence on AG_E^{TOT}, as can be seen from equation 6. With a fixed exchange rate, the import tariff does not affect domestic export prices. With a flexible exchange rate, the induced appreciation in experiment 1 leads to the same relative changes of P_E^{AG} and P_E^{AGN}.

We now turn to the impact of the experiments series on AG_Q^{TOT}, AG_X^{TOT}, and AG_{VA}^{TOT}. The third measure of the agricultural terms of trade (AG_Q^{TOT}) is defined with respect to composite good prices and captures the Armington specification, *i.e.* the imperfect substitutability between imports and domestic products (equation 9). The imposition of a 25 percent non-agricultural import tariff reduces AG_Q^{TOT} to 90.2 percent when the exchange rate is fixed. The composite good price index of non-agricultural commodities (P_Q^{AGN}), which is effected by domestic import prices (*PM*) as well as domestic supply prices (*PDC*), increases by only 7.3 percent instead of the 25 percent increase of P_M^{AGN}. For a "semi-tradable" good, both the import share and the substitution elasticity affect how changes in import prices are transmitted through to the price of domestic substitutes, and hence to the price of the composite good.

The agricultural price index drops to 96.9 percent. When the exchange rate is free, these effects are dampened and AG_Q^{TOT} drops to only 94.4 percent. The effect of not allowing the exchange rate feedback on AG_Q^{TOT} amounts to 4.2 percent points. Allowing exchange rate flexibility means that agriculture gets hurt less.

The 25 percent export tax on agricultural commodities affects the composite good price index of agriculture by only 0.7 percent due to the limited magnitude of agricultural exports as compared to domestic supply — most of agriculture is not traded. When exchange rate feedback is allowed, *EXR* depreciates and the agricultural composite good price index drops while non-agriculture gains. The net result is that the export tax affects AG_Q^{TOT} relatively little when the exchange rate is fixed, but substantially more — and negatively — with a flexible exchange rate.

The fourth agricultural terms-of-trade measure (AG_X^{TOT}) is defined with respect to producer prices (px), reflecting the imperfect transformation between domestic produce and exports in the CET function. The 25 percent import tariff in experiments 1 and 2 lowers P_X^{AG} in a similar way as P_Q^{AG}. Moreover, allowing for exchange rate flexibility results in an appreciation of the exchange rate and improves P_X^{AG} compared to the fixed exchange rate scenario. This result is a reflection of the very large share of non-traded agricultural products in total agriculture, which implies that aggregate agriculture is favored when the exchange rate appreciates. In addition, the price index of non-agricultural producer prices is higher under a fixed exchange rate.

In sum, AG_X^{TOT} is 98.3 percent under a flexible exchange rate and 94.9 percent under a fixed exchange rate. In case of the 25 percent export tax on agricultural products in experiments 3 and 4, the agricultural terms of trade are affected more under a flexible exchange rate than under a fixed exchange rate, while the direct impact of the export tax appears relatively limited. The depreciation following the imposition of the export tax in experiment 3 has a negative influence on the agricultural terms of trade AG_X^{TOT}. This result again is linked to the high share of non-traded agriculture, which is hurt in relative terms by a depreciation. In the partial equilibrium literature, most agricultural commodities are treated as perfectly substitutable tradable goods for which eliminating an overvaluation of the exchange rate is beneficial.

Changes in the terms of trade in value-added prices AG_{VA}^{TOT} provide the most appropriate bias measure because it indicates relative incentives to "pull" productive factors between sectors. A non-agricultural tariff combined with a flexible exchange rate slightly improves the terms of trade of agriculture, whereas agriculture is hurt in relative terms under a fixed exchange rate. As noted above, agriculture is relatively non-traded, and therefore benefits from an appreciation of the exchange rate. Similarly, in the export tax experiment, exchange rate flexibility implies that AG_{VA}^{TOT} drops compared to the situation with fixed exchange rate.

4.2. Impacts of an overvaluation of the exchange rate

The results of the experiment series in which we gradually reduce the trade balance to zero are reported in Figures 2, 3, and 4.
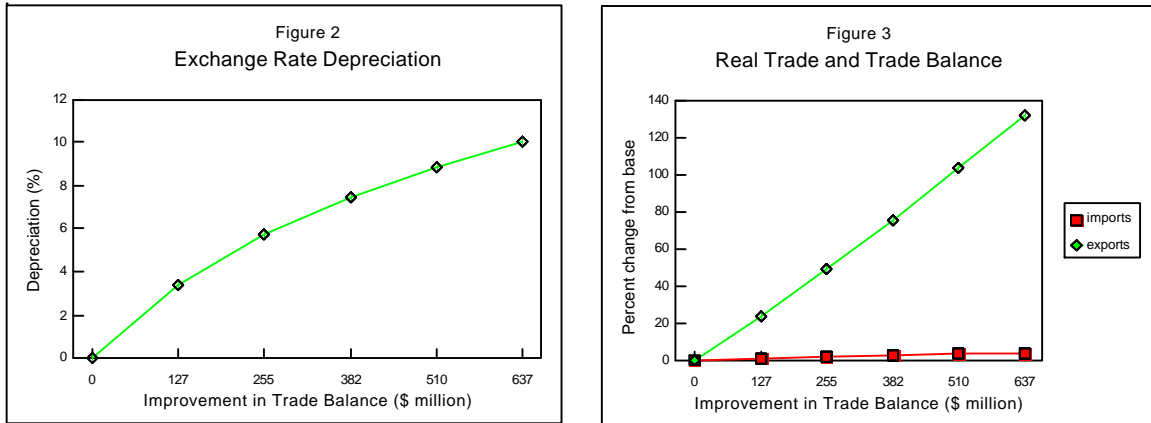
Figure 2 shows that the trade balance is eliminated in five consecutive steps, resulting in exchange rate depreciations starting at almost 4 percent at the beginning and declining to about 1 percent at the last step. Elimination of the trade deficit leads to a depreciation of 10 percent. The corresponding adjustments in real imports and exports are shown in Figure 3. Imports move very little while exports increase by around 130 percent — the improvement of the balance of payments is mainly a consequence of export performance. The import-dependent nature of the economy, with high trade shares and low substitution elasticities for intermediates and capital goods, makes it difficult to reduce imports. They even increase a little in spite of the depreciation, which reflects the import-intensive nature of exports. This

result, which is typical of many developing countries, underlines the need to maintain imports at an adequate level if export promotion is to succeed.[13]

Finally, Figure 4 demonstrates that although the last three agricultural terms of trade indices fall as the exchange rate depreciates, the changes are small — under 5 percent. The first two indices, AG_M^{TOT} and AG_E^{TOT}, do not change since changes in the exchange rate effect agriculture and non-agriculture symmetrically. The other three agricultural terms-of-trade measures (AG_Q^{TOT}, AG_X^{TOT}, and AG_{VA}^{TOT}) decrease in the beginning due to the induced depreciation of the exchange rate. However, the effect tapers off in the middle of the experiment series, and the measures improve a little at the end. The turnaround is due to the fact that agricultural exports increase with depreciation and, by the last two experiments in the series, grow to be a significant share of agricultural output. With depreciation, traded agriculture becomes more important as can be seen from Figure 5.

Figure 4
Agricutlure Terms of Trade and Trade Balance

Figure 5
Real Output for Some AG Sectors

1) LFFH = Lifestock, Forestry, Fishing, and Hunting
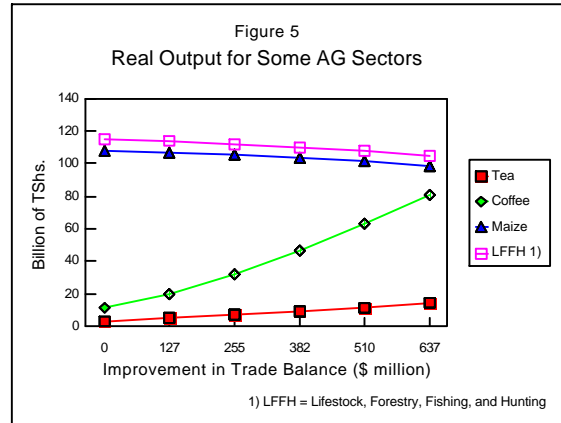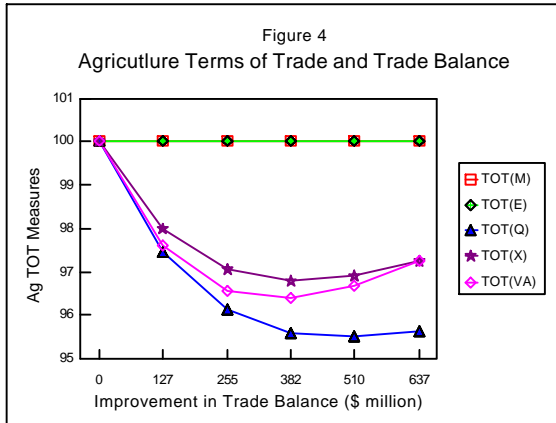
5. Conclusion

This paper analyzes the extent of the policy bias against agriculture in a general equilibrium framework. Various measures of the agricultural terms of trade are constructed to assess the impact of industrial protection, agricultural export taxes, and overvaluation of the exchange rate on the balance between agriculture and non-agriculture. The general

---

[13] The development of the relative export shares of total agriculture and non-agriculture throughout the experiment series is shown in Figure 6 and 7 of Annex I.

equilibrium measures are compared with earlier work measuring policy bias in a partial equilibrium framework.

Our results indicate that trade policies — in particular, 25 percent non-agricultural tariffs and 25 percent agricultural export taxes — have a significant but much lower negative impact on relative prices in agriculture than would be indicated by partial equilibrium measures. The general equilibrium framework captures indirect effects of trade policies that work through induced changes in the equilibrium exchange rate — an effect that is not captured in partial equilibrium analysis. We use the model to compute the empirical importance of this indirect effect, which is potentially significant. The imposition of a non-agricultural tariff with a fixed exchange rate leads to a much stronger deterioration of the terms-of-trade measures as compared to a flexible exchange rate scenario since the appreciation of the exchange rate actually benefits agriculture. The imposition of an export tax on all agricultural sectors with a fixed exchange rate leads to a much lower deterioration as compared to a flexible exchange rate scenario since the export tax induced depreciation of the exchange rate hurts the relatively non-traded aggregate agriculture in the case of a flexible exchange rate.

A separate series of experiments is carried out to assess the impact of overvaluation of the exchange rate — characteristic of many developing countries. In earlier work in a partial equilibrium framework, comparative work in a number of countries identified exchange rate overvaluation as the largest source of policy bias. In a general equilibrium framework incorporating non-traded goods and imperfect substitutability between domestic and foreign goods, these results are seriously qualified.

In our archetype model of Tanzania, agriculture has a large share of non-traded goods and traded non-agriculture goods have relatively low substitution elasticities. These characteristics reflect many developing countries. In this environment, we find a much smaller impact on agriculture of depreciating the exchange rate than is indicated by partial equilibrium measures. Actually, our results are contrary to the "conventional wisdom" that a depreciation benefits agriculture. General equilibrium effects are indeed important.

This paper deals only with trade policies and their impact on aggregate agriculture. It is straightforward to expand the analysis to include sector-specific domestic tax and subsidy policies and their impacts on particular agricultural sectors. The CGE model is an appropriate analytical framework for such analysis.

References

Ardeni, P. G. 1989. Does the law of one price really hold for commodity prices? *American Journal of Agricultural Economics*, 71(3): 661-669.

Armington, P. S. 1969. A theory of demand for products distinguished by place of production. *IMF Staff Papers*, 16: 159-176.

Baffes, J. 1991. Some further evidence on the law of one price: The law of one price still holds. *American Journal of Agricultural Economics*, 73(4):1264-1273.

Ceglowski, J. 1994. The law of one price revisited: New evidence on the behavior of international prices. *Economic Inquiry*, 32:407-418.

Bautista, R. M. 1987. *Production incentives in Philippine agriculture: Effects of trade and exchange rate policies.* Research Report 59. Washington, D.C.: International Food Policy Research Institute.

Bautista, R. M. and A. Valdes. 1993. *The bias against agriculture: Trade and macroeconomic policies in developing countries.* San Francisco: Institute for Contemporary Studies Press.

Cavallo, D. and Y. Mundlak. 1982. *Agriculture and growth in an open economy: The case of Argentina.* Research Report 36. Washington, D.C.: International Food Policy Research Institute.

de Melo, J. and S. Robinson. 1981. Trade policy and resource allocation in the presence of product differentiation. *Review of Economics and Statistics*, 63: 169-177.

_____. 1989. Product differentiation and the treatment of foreign trade in computable general equilibrium models of small economies. *Journal of International Economics*, 27: 47-67.

de Melo, J. and D.Tarr. 1992. *A general equilibrium analysis of US foreign trade policy.* Cambridge: Massachusetts Institute of Technology Press.

Devarajan, S., D. S. Go, J. D. Lewis, S. Robinson, and P. Sinko. 1997. Simple general equilibrium modeling. In: *Applied methods for trade policy analysis: A handbook*, ed. J. F. Francois and K. A. Reinert. Cambridge: Cambridge University Press.

Devarajan, S., J. D. Lewis, and S. Robinson. 1993. External shocks, purchasing power parity, and equilibrium real exchange rate. *The World Bank Economic Review*, 7(1): 45-63.

Food and Agriculture Organization of the United Nations. 1975. *Agricultural protection and stabilization policies: A framework of measurement in the context of agricultural adjustment.* Rome.

Hertel, T. W. 1997. Applied general equilibrium analysis of agricultural policies. In: *Handbook of agricultural economics,* ed. B. Gardner and G. Rausser. Amsterdam: North Holland Press, forthcoming.

Isard, P. 1977. How far can we push the law of one price? *The American Economic Review*, 67(5): 942-948.

Josling, T. and S. Tangermann. 1989. Measuring levels of protection in agriculture: A survey of approaches and results. In: *Agriculture and governments in an independent world,* ed. A. Maunder and A. Valdes. Proceedings of the Twentieth International Conference of Agricultural Economists held in Buenos Aires, 24-31 August, 1988. Aldershot, pp. 343-352.

Krueger, A. O. 1992. *The political economy of agricultural pricing policy. Volume 5: A synthesis of the political economy in developing countries.* Washington, D.C.: The World Bank.

Krueger, A. O., M. Schiff, and A. Valdes. 1988. Agricultural incentives in developing countries: Measuring the effect of sectoral and economywide policies. *The World Bank Economic Review*, 2(3): 255-271.

Lipton, M. 1977. *Why poor people stay poor: Urban bias in world development.* Cambridge: Harvard University Press.

Mundlak, Y. and D. F. Larson. 1992. On the transmission of world agricultural prices. *The World Bank Economic Review*, 6(3): 399-422.

Peterson, E. B., T. W. Hertel, and J. V. Stout. 1994. A critical assessment of supply-demand models of agricultural trade. *American Journal of Agricultural Economics*, 76(4): 709-721.

Schiff, M. and A. Valdes. 1992. *The political economy of agricultural pricing policy. Volume 4: A synthesis of the economics in developing countries*. Washington, D.C.: The World Bank.

Schultz, T. W. 1964. *Transforming traditional agriculture*. New Haven: Yale University Press.

Toye, J. F. J. 1993. *Dilemmas of development: Reflections on the counter-revolution in development economics*. Oxford: Oxford University Press.

Webb, A. J., M. Lopez, and R. Penn. 1990. Estimates of producer and consumer subsidy equivalents: Government intervention in agriculture, 1982-87. Economic Research Service. *Statistical Bulletin No. 803*. Washington, D.C.: U.S. Department of Agriculture.

Wobst, P. 1998. A social accounting matrix (SAM) for Tanzania. Trade and Macroeconomics Division. TMD Discussion Paper Series. Washington, D.C.: International Food Policy Research Institute, forthcoming

World Bank. 1981. *Accelerated development in Sub-Saharan Africa: An agenda for action*. Washington, D.C.

Annex I: Export shares

Figure 6
Export Share of Total Agriculture

Figure 7
Export Share of Total Non-Agriculture
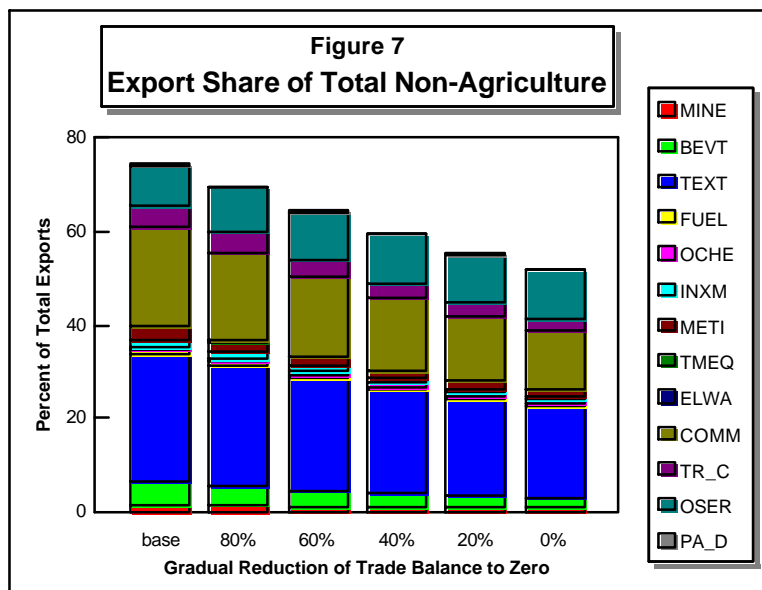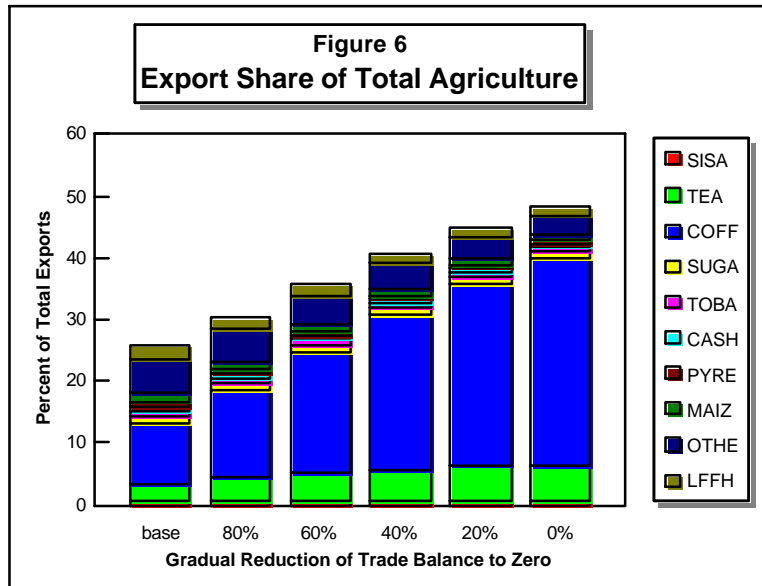
An explanation of the applied sector abbreviations is presented in Table 1.1. of Annex II

Annex II: CGE model equations

Table 1.1. Definition of Model Indices, Parameters, and Variables

Indices

i, j	Sectors	Cotton (Cott)	Processed Food, Beverages
		Sisal (Sisa)	& Tobacco (Bevt)
		Tea (Tea)	Textiles (Text)
		Coffee (Coff)	Petroleum (Fuel)
		Sugar (Suga)	Other Chemicals (Oche)
		Tobacco (Toba)	Non-metal Products (Inxm)
		Cashew (Cash)	Metal products (Meti)
		Pyrethrum (Pyre)	Transport & Mach. Equ. (Tmeq)
		Maize (Maiz)	Electricity & Water (Elwa)
		Wheat (Whea)	Construction (Cnst)
		Paddy (Padd)	Commerce (Comm)
		Other Agriculture (Othe)	Transport & Communication (Tr_c)
		Livestock, Forestry, Fishing	Financial Institutions (Fi_i)
		& Hunting (Lffh)	Other Services (Oser)
		Mining (Mine)	Public Administration (Pa_d)

iag	Agricultural	Cotton	Sisal
	sectors	Tea	Coffee
		Sugar	Tobacco
		Cashew	Pyrethrum
		Maize	Wheat
		Paddy	Other Agriculture
		Livestock, Forestry, Fishing & Hunting	

iagn	Non-agricultural sectors (iagn = i - iag)
im	Import sectors
imn	Non-import sectors
ie	Export sectors
ien	Non-export sectors

f	Factors of	Agriculture Rural Paid labor	Urban Prof & Tech & Supervisor
	production	Urban Unskilled Paid labor	Land
		Urban Production & Transport & Manual	Capital
		Urban Clerical & Sales & Services	Government Capital

hh, h	Households	Rural Farmer	Rural Non-farmer
		Urban Farmer	Urban Non-farmer

Table 1.1 (cont.)

Parameters (in lower case)

a_i^C	Armington function shift parameter
a_i^D	CES shift parameter
$\alpha_{i,f}$	CES factor share parameter
a_i^T	CET function shift parameter
$a_{i,j}$	Input-output coefficients
$b_{i,j}$	Capital composition matrix
$cles_{i,hh}$	Household consumption shares
δ_i	Armington function share parameter
$fmap_{hh,f}$	Factors to household map
γ_i	CET function share parameter
gdtot0	Initial real government spending
$gles_i$	Government consumption shares
ids0	Initial total demand for investment
$kshr_i$	Shares of investment by sector of destination
$make_{i,j}$	Make matrix coefficients
pwm_i	World market price of imports (in US$)
$pwts_i$	Non-traded producer price weights
ρ_i^C	Armington function exponent
ρ_i^P	CES production function exponent
ρ_i^T	CET function exponent
$sremit_{hh}$	Remittance shares
$strans_{hh}$	Government transfer shares
$syenth_{hh}$	Share of enterprise income to households
$syent_f$	Enterprise shares of factor income
tc_i	Consumption tax (+) or subsidy (-) rates
te_i	Tax (+) or subsidy (-) rates on exports
th_{hh}	Household tax rate
tm_i	Tariff rates on imports
tx_i	Indirect tax rates
$wfdist0_{i,f}$	Initial factor price sectoral proportionality ratios

Variables (in upper case)

CD_i	Final demand for private consumption
CH_{hh}	Household consumption / disposable income
CONTAX	Consumption tax revenue
DA_i	Domestic activity sales
DC_i	Domestic commodity sales
DK_i	Volume of investment by sector of destination
DST_i	Inventory investment by sector
ENTSAV	Enterprise savings
ENTTAX	Enterprise tax revenue
ENTTF	Enterprise transfers abroad
ESR	Enterprise savings rate
ETR	Enterprise tax rate

EXPTAX	Export subsidy payments
EXR	Exchange rate (TShs. per US$)
E_i	Exports
FBOR	Government foreign borrowing
$FDSC_{i,f}$	Factor demand by sector
FLABTF	Labor transfers abroad
FSAV	Net foreign savings
FS_f	Factor supply
$FSAG_f$	Factor supply in agriculture
FXDINV	Fixed capital investment
GDTOT	Total volume of government consumption
GD_i	Final demand for government consumption
GOVSAV	Government savings
GOVTH	Government transfers to Households
GR	Government revenue
HHSAV	Household savings
HHTAX	Household tax revenue
ID_i	Final demand for productive investment
IDS	Total final demand for investment
INDTAX	Indirect tax revenue
INT_i	Intermediates uses
INVEST	Total investment
MPS_h	Marginal propensity to save by Household
M_i	Imports
PC_i	Consumption price of composite goods
PDA_i	Domestic activity goods price
PDC_i	Domestic commodity goods price
PE_i	Domestic price of exports
PINDEX	Non-traded producer price index
PK_i	Price of capital goods by sector of destination
PM_i	Domestic price of imports
PQ_i	Price of composite good
PV_i	Value-added price
PWE_i	World price of exports
PX_i	Average output price
Q_i	Composite goods supply
REMIT	Remittances
REMITENT	Enterprise remittances
SAVING	Total savings
TARIFF	Tariff revenue
WALRAS	Slack variable
$WFDIST_{i,f}$	Factor price sectoral proportionality ratios
$WFAGDIST_f$	Factor price sectoral proportionality ratios for agricultural sectors
WF_f	Average factor price
X_i	Domestic output
YENT	Enterprise income
$YFCTR_f$	Factor income
YH_{hh}	Household income

Table 1.2. Price Equations

#	Equation	Description
1	$PM_i = pwm_i \cdot (1 + tm_i) \cdot EXR$	Import prices
2	$PE_i = PWE_i \cdot (1 - te_i) \cdot EXR$	Export prices
3	$PDC_j = \sum_i make_{i,j} \cdot PDA_i$	Definition of commodity prices
4	$PQ_i = \dfrac{PDC_i \cdot CD_i + PM_i \cdot M_i}{Q_i}$	Composite good prices
5	$PX_i = \dfrac{PDA_i \cdot DA_i + PE_i \cdot E_i}{X_i}$	Producer prices
6	$PC_i = PQ_i \cdot (1 + tc_i)$	Consumer prices
7	$PV_i = PX_i \cdot (1 - tx_i) - \sum_j PC_j \cdot a_{j,i}$	Value-added prices net of in. taxes
8	$PK_i = \sum_j b_{j,i} \cdot PC_j$	Composite capital good prices
9	$\overline{PINDEX} = \sum_i pwts_i \cdot PDA_i$	Non-traded producer price index

Note that exogenous variables in the model, like $\overline{PINDEX}$, are over-lined.

Table 1.3. Quantity Equations

#	Equation	Description
10	$X_i = a_i^D \cdot \left[\sum_f \alpha_{i,f} \, FDSC_{i,f}^{-\rho_i^P} \right]^{-\frac{1}{\rho_i^P}}$	CES production function
11	$FDSC_{i,f} = X_i \cdot \left[\dfrac{\alpha_{i,f} \cdot PV_i}{(a_i^D)^{\rho_i^P} \cdot WF_f \cdot WFDIST_{i,f}} \right]^{\sigma_i^P}$	Demand function for primary factors (profit maxamization)
12	$WFDIST_{i,f} = WFAGDIST_f \cdot wfdist0_{i,f}$	Factor market segmentation for $iag \in i$
13	$INT_i = \sum_j a_{j,i} \cdot X_j$	Total intermediate use
14	$DA_i = \sum_j make_{i,j} \cdot DC_i$	Commodity/activity relationship
15	$X_i = a_i^T \left[\gamma_i E_i^{\rho_i^T} + (1 - \gamma_i) DA_i^{\rho_i^T} \right]^{\frac{1}{\rho_i^T}}$	Gross domestic output as a composite good for $ie \in i$

Table 1.3. Quantity Equations (cont.)

#	Equation	Description
16	$X_i = DA_i$	Gross dom. output for ien $\in$ i
17	$E_i = DA_i \left[\dfrac{PE_i(1-\gamma_i)}{PDA_i \cdot \gamma_i} \right]^{\frac{1}{\rho_i^T - 1}}$	Export supply
18	$Q_i = a_i^C \left[\delta_i M_i^{-\rho_i^C} + (1-\delta_i) DC_i^{-\rho_i^C} \right]^{-\frac{1}{\rho_i^C}}$	Total supply of composite good - Armington function for im $\in$ i
19	$Q_i = DC_i$	Total supply for imn $\in$ i
20	$M_i = DC_i \left[\dfrac{PDC_i \cdot \delta_i}{PM_i(1-\delta_i)} \right]^{\frac{1}{1+\rho_i^C}}$	F.O.C for cost minimization for composite good for im $\in$ i

Table 1.4. Income Equations

#	Equation	Description
21	$YFCTR_f = \sum_i WF_f \cdot FDSC_{i,f} \cdot WFDIST_{i,f}$	Factor income
22	$YENT = \sum_f syent_f \cdot YFCTR_f + \overline{REMITENT} \cdot EXR$	Capital income
23	$YH_{hh} = \sum_f fmap_{hh,f} \cdot (1 - syent_f) \cdot YFCTR_f$ $+ sremit_{hh} \cdot (\overline{REMIT} - \overline{FLABTF}) \cdot EXR + strans_{hh} \cdot \overline{GOVTH}$ $+ syenth_{hh} \cdot (YENT - ENTTAX - ENTSAV - \overline{ENTTF} \cdot EXR)$	Household income
24	$CH_{hh} = (1 - th_{hh}) \cdot (1 - MPS_{hh}) \cdot YH_{hh}$	Disposable household income
25	$TARIFF = \sum_i tm_i \cdot pwm_i \cdot M_i \cdot EXR$	Tariff revenue
26	$CONTAX = \sum_i tc_i \cdot PQ_i \cdot Q_i$	Consumption taxes
27	$INDTAX = \sum_i tx_i \cdot PX_i \cdot X_i$	Indirect taxes
28	$EXPTAX = \sum_i te_i \cdot PWE_i \cdot E_i \cdot EXR$	Export tax
29	$HHTAX = \sum_h th_h \cdot YH_h$	Household taxes
30	$ENTTAX = ETR \cdot YENT$	Enterprise taxes

Table 1.4. Income Equations (cont.)

#	Equation	Description
31	$ENTSAV = ESR \cdot YENT$	Enterprise savings
32	$HHSAV = \sum_h MPS_h \cdot YH_h \cdot (1 - th_h)$	Household savings
33	$GR = TARIFF + CONTAX + INDTAX + HHTAX + \overline{FBOR} \cdot EXR + ENTTAX + EXPTAX$	Government revenue
34	$SAVING = HHSAV + ENTSAV + GOVSAV + EXR \cdot FSAV$	Total savings

Table 1.5. Expenditure Equations

#	Equation	Description
35	$PC_i \cdot CD_i = \sum_{hh} cles_{i,hh} \cdot CH_{hh}$	Private consumption
36	$GD_i = gles_i \cdot GDTOT$	Government consumption
37	$GR = \sum_i PC_i \cdot GD_i + GOVSAV + GOVTH$	Government savings
38	$FXDINV = INVEST - \sum_i PC_i \cdot DST_i$	Fixed investment
39	$PK_i \cdot DK_i = kshr_i \cdot FXDINV$	Real fixed investment by sector of destination
40	$ID_i = \sum_j b_{i,j} \cdot DK_j$	Investment final demand by sector of origin
41	$IDS = \sum_i ID_i$	Total final investment demand

Table 1.6. Market clearing

#	Equation	Description
42	$Q_i = INT_i + CD_i + GD_i + ID_i + DST_i$	Goods market equilibrium (eq)
43	$FS_f = \sum_i FDSC_{i,f}$	Factor market eq for iagn $\in$ i
44	$FSAG_f = \sum_i FDSC_{i,f}$	Factor market eq for iag $\in$ i
45	$\sum_i pwm_i \cdot M_i = \sum_i PWE_i \cdot E_i + FSAV + \overline{FBOR} + \overline{REMIT} + \overline{ENTTF} - \overline{FLABTF} + \overline{REMITENT}$	External balance

Table 1.6. Market Clearing Conditions (cont.)

#	Equation	Description
46	*SAVING = INVEST + WALRAS* [14]	Saving- investment balance

Table 1.7. Macro economic closures

#	Equation	Description
47	*IDS = ids0*	Fix total real investment
48	*GDTOT = gdtot0*	Fix real government spending

---

[14] The model is square and satisfies Walras' law. The set of market clearing equations is functionally dependent, and one can be dropped. Instead of dropping an equation, we add a "slack" variable to the savings-investment equation (*WALRAS* in equation 46). This specification is convenient for checking model consistency, since *WALRAS* should always equal zero.

LIST OF TMD DISCUSSION PAPERS

No. 1 - "Land, Water, and Agriculture in Egypt: The Economywide Impact of Policy Reform" by Sherman Robinson and Clemen Gehlhar (January 1995)

No. 2 - "Price Competitiveness and Variability in Egyptian Cotton: Effects of Sectoral and Economywide Policies" by Romeo M. Bautista and Clemen Gehlhar (January 1995)

No. 3 - "International Trade, Regional Integration and Food Security in the Middle East" by Dean A. DeRosa (January 1995)

No. 4 - "The Green Revolution in a Macroeconomic Perspective: The Philippine Case" by Romeo M. Bautista (May 1995)

No. 5 - "Macro and Micro Effects of Subsidy Cuts: A Short-Run CGE Analysis for Egypt" by Hans Löfgren (May 1995)

No. 6 - "On the Production Economics of Cattle" by Yair Mundlak, He Huang and Edgardo Favaro (May 1995)

No. 7 - "The Cost of Managing with Less: Cutting Water Subsidies and Supplies in Egypt's Agriculture" by Hans Löfgren (July 1995, Revised April 1996)

No. 8 - "The Impact of the Mexican Crisis on Trade, Agriculture and Migration" by Sherman Robinson, Mary Burfisher and Karen Thierfelder (September 1995)

No. 9 - "The Trade-Wage Debate in a Model with Nontraded Goods: Making Room for Labor Economists in Trade Theory" by Sherman Robinson and Karen Thierfelder (Revised March 1996)

No. 10*- "Macroeconomic Adjustment and Agricultural Performance in Southern Africa: A Quantitative Overview" by Romeo M. Bautista (February 1996)

No. 11 - "Tiger or Turtle? Exploring Alternative Futures for Egypt to 2020" by Hans Löfgren, Sherman Robinson and David Nygaard (August 1996)

No. 12*- "Water and Land in South Africa: Economywide Impacts of Reform - A Case Study for the Olifants River" by Natasha Mukherjee (July 1996)

No. 13 - "Agriculture and the New Industrial Revolution in Asia" by Romeo M. Bautista and Dean A. DeRosa (September 1996)

No. 14 - "Income and Equity Effects of Crop Productivity Growth Under Alternative Foreign Trade Regimes: A CGE Analysis for the Philippines" by Romeo M. Bautista and Sherman Robinson (September 1996)

No. 15*- "Southern Africa: Economic Structure, Trade, and Regional Integration" by Natasha Mukherjee and Sherman Robinson (October 1996)

No. 16 - "The 1990's Global Grain Situation and its Impact on the Food Security of Selected Developing Countries" by Mark Friedberg and Marcelle Thomas (February 1997)

No. 17 - "Rural Development in Morocco: Alternative Scenarios to the Year 2000" by Hans Löfgren, Rachid Doukkali, Hassan Serghini and Sherman Robinson (February 1997)

No. 18 - "Evaluating the Effects of Domestic Policies and External Factors on the Price Competitiveness of Indonesian Crops: Cassava, Soybean, Corn, and Sugarcane" by Romeo M. Bautista, Nu Nu San, Dewa Swastika, Sjaiful Bachri, and Hermanto (June 1997)

No. 19 - "Rice Price Policies in Indonesia: A Computable General Equilibrium (CGE) Analysis" by Sherman Robinson, Moataz El-Said, Nu Nu San, Achmad Suryana, Hermanto, Dewa Swastika and Sjaiful Bahri (June 1997)

No. 20 - "The Mixed-Complementarity Approach to Specifying Agricultural Supply in Computable General Equilibrium Models" by Hans Löfgren and Sherman Robinson (August 1997)

No. 21*- "Estimating a Social Accounting Matrix Using Entropy Difference Methods" by Sherman Robinson and Moataz-El-Said (September 1997)

No. 22 - "Income Effects of Alternative Trade Policy Adjustments on Philippine Rural Households: A General Equilibrium Analysis" by Romeo M. Bautista and Marcelle Thomas (October 1997)

No. 23 - "South American Wheat Markets and MERCOSUR" by Eugenio Díaz-Bonilla (November 1997)

No. 24 -   "Changes in Latin American Agricultural Markets" by Lucio Reca and Eugenio Díaz-Bonilla (November 1997)

No. 25 -   "Policy Bias and Agriculture: Partial and General Equilibrium Measures" by Romeo M. Bautista, Sherman Robinson, Finn Tarp and Peter Wobst (May 1998)

No. 26 -   "Estimating Income Mobility in Colombia Using Maximum Entropy Econometrics" by Samuel Morley, Sherman Robinson and Rebecca Harris (May 1998)

No. 27 -   "Rice Policy, Trade, and Exchange Rate Changes in Indonesia: A General Equilibrium Analysis" by Sherman Robinson, Moataz El-Said, and Nu Nu San (June 1998)

No. 28* -   "Social Accounting Matrices for Mozambique - 1994 and 1995" by Channing Arndt, Antonio Cruz, Henning Tarp Jensen, Sherman Robinson, and Finn Tarp (July 1998)

No. 29* -   "Agriculture and Macroeconomic Reforms in Zimbabwe: A Political-Economy Perspective" by Kay Muir-Leresche (August 1998)

No. 30* -   "A 1992 Social Accounting Matrix (SAM) for Tanzania" by Peter Wobst (August 1998)

No. 31* -   "Agricultural Growth Linkages in Zimbabwe: Income and Equity   Effects" by Romeo M. Bautista and Marcelle Thomas (September   1998)

No.32* -   "Does Trade Liberalization Enhance Income Growth and Equity in Zimbabwe? The Role of Complementary Polices" by Romeo M.   Bautista, Hans Lofgren and Marcelle Thomas (September 1998)

No.33 -   "Estimating a Social Accounting Matrix Using Cross Entropy Methods" by Sherman Robinson, Andrea Cattaneo, and Moataz El-Said (October 1998)

* TMD Discussion Papers marked with an "*" are MERRISA-related papers.

Copies can be obtained by calling
Maria Cohan at 202-862-5627
or e-mail m.cohan@cgnet.com