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A Quantitative Analaysis Of The
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"His fellow servant fell to his knees and begged him, ‘Be patient with me, and I will pay you back.’ But he refused. Instead, he went off and had the man thrown into prison until he could pay his debt." Matthew 18:29

Previous studies of the debt crisis have examined either the impact of “overhangs” on developing economies or the effect of the depressed growth in these countries on developed nations through trade and financial linkages. In this paper, these two approaches are synthesised by encompassing debtors’ supply and demand behaviour in a partial equilibrium framework. The preliminary results indicate both the significance of the debt overhang in debtor nations’ production and consumption decisions, and tend to suggest that debt write-offs could lead to increases in demand for agricultural goods. The investigation of overhang reduction can potentially be used to help settle the current controversy on the size and distribution of impacts from debt forgiveness policies, thus contributing valuable insights into targeting and institutional debates.

Keywords: partial equilibrium model, debt, overhang, agricultural trade

1. Introduction

The developing country debt crisis has been one of the dominant issues in North-South relations over the last decade. Even though the world recovery began in 1984, high rates of rescheduling, reduced rates of developing economy growth, and depressed agricultural trade, have continued well into the present. Concern over the repercussions of this situation for trade and financial markets in developed nations, primarily the United States, has been the driving force behind many of the previous and proposed policies aimed at ending this problem. Early actions, primarily restructuring under tough IMF conditionality, were designed to restore confidence in severely overexposed US financial markets (Sachs 1990, p19). However, since this situation stabilised in the mid-1980s, the primary impetus for policy has become the hypothesised impact of the high levels of sovereign debt on the world trade patterns generally, and agricultural trade in particular (Shane and Stallings 1988; United States Congress 1986). It is surprising that in this environment, there has been little formal empirical analysis of the trade implications of developing country indebtedness.

Previous analytical approaches have emphasised either the effects of debt burdens on domestic developing country performance, or trade issues, with little attempt at synthesis. Of the former, the influence of capital-centred growth models of the 1960s served to perpetuate the allure of investment as the key to economic growth, an idea prominent in many analyses of the domestic impact of high levels of sovereign debt. For example, Krugman (1988), Bird (1989), Frenkel, Dooley and Wickham (1989), Borensztein (1993), and Hofman and Reisen (1991), relate indebtedness directly to domestic
investment problems. Travelling down an independent path, Stern (1992) and Snape (1986) both introduce the debt crisis as a major issue in trade policy, a theme which is further taken up by Kreuger (1987), Saunders (1986), Larsen (1983), Shane et al (1988), Bhagwati (1992), Dornbusch (1989), Petit and Subramanian (1990), Evans and Greenaway (1991), Gunasekera Bowen and Andrews (1990), and UNCTAD (1994b). There is a clear dichotomy between the approaches with a domestic focus and those with an international focus. Although some have tried to synthesise these two by using traditional or modified trade models (see, for example, MacKellar 1987, Dittus and O’Brien 1991), or by presenting a collection of smaller studies (see, for example, Cline 1984), as yet there seems to be little work linking research on the impact of the developing country debt on the debtor’s economy with that on the burden on trade.

Added to the demand for such analysis is the continual flux in the policy debate. It was ten years ago when Cline (1984, p.xvi) noted that public policy on this issue was at a turning point, yet today there are still hundreds of policy proposals on the table (Faber 1990). The Baker Plan (1985) and Brady Plan (1989), for example, were introduced with much fanfare, however, as neither of these was highly successful in resolving debt issues, the validity of the debt / trade hypothesis remained untested. Despite this, trade benefits continued to be touted as incentives behind the growing interest in debt forgiveness and the creation of an international institution to take care of this (see symposium in Rogoff 1990). These ideas were also strongly reflected in current forecasts of negative growth in many developing regions, and the related concerns about the continuing effect of this growth on commodity prices (for example, World Bank 1993). Linked with ongoing development objectives, these considerations are behind the forthcoming submission for the 1995 World Summit for Social Development from UNCTAD, which will again place debt relief proposals back on the international agenda (UNCTAD 1994a, p.2).

In sum, it seems that there is much interest in the impact that debt has on economic growth in the developing countries, and growth of the world economy through intercountry linkages. This interest has led to many developments in policy, both realised and proposed, that are hampered by a shortage of empirical analyses that encompass both growth and trade impacts. Perhaps one of the reasons for this dearth of empirical work is the fact that the theory of debt relief, as will be seen in section 2, is still subject to contention.

The main objective of this paper is to quantify the impact of the debt overhang on international agricultural trade. A review of previous research into the nature of potential debt impacts is presented in section 3, both as an overview of empirical issues associated with debt theory, and as a precursor to section 4, where a trade model is outlined that will allow the testing of debt relief policies. This is followed in section 5 which details solution procedures and section 6 which analyses preliminary results. The final section highlights a number of key observations emerging from the analysis.
2. Theory of Debt Relief

As Corden (1991) suggests, when discussing the theoretical issues of sovereign debt, creditors may support debt relief if a reduction in the face value of debt increases the actual repayments made; effectively bringing a Pareto improvement. This case, which is obviously of particular interest to policy analysts, could arise from a variety of incentive-based arguments (Corden 1991,p138).

Firstly, it avoids costly punishment for default; secondly, it increases investment and subsequently capacity and willingness to pay; and thirdly, it removes some of the unwillingness to undergo the adjustment or sacrifices necessary to facilitate repayment. Krugman adds to this the possibility of removing a debt that could take away the possible positive trade impact of currency devaluations, by making the increase in domestic currency cost of debt cause a deficit blowout (Rogoff 1990). Central to the possibility of a gain in expected value is that the ability to repay is linked closely to income. Although the exact nature of this relationship is controversial, it is an outcome of any reasonable incentive-based theory (Rogoff 1992,p476). What is also strongly debated is whether these possibilities for gain are sufficiently high to displace concerns creditors have about lowering payoff ceilings, and the nature of any potential market failure associated with the productivity gains from debt forgiveness.

Evident in these arguments is that the notion of incentives is central to the behaviour of investment capacity, the decision to repudiate, and the ability to pay. Krugman and Sachs are often cited with providing the theoretical underpinning for a “disincentive model” through the debt overhang hypothesis (see Krugman 1989 and Rogoff 1990). The hypothesis postulates that if debtors’ obligations are sufficiently large the expected value of their debt will decrease dramatically, opening the way for mutually beneficial outcomes from debt relief (Kenen, 1990,p11).

These concepts are summed up in Krugman’s Debt Relief Laffer curve, presented in Figure 1. If debt is at a level which is expected to be fully repaid, then its expected value would equal the face value of the debt, and the outcome would lie on the 45 degree line. As the possibility of non-payment grows, so too the expected value will fall below the face value of the debt, following the curve CLRD. At any point, such as L, the ratio of expected value to nominal debt is given by the slope of the ray from the origin, which could be seen as an approximation of secondary market prices for debt. If there were a reduction in debt by forgiveness at L [that is, a movement to the left around the CLRD curve], there would be a decline in the expected value of the debt, and creditors would have been ill-advised in their generosity. If, however, the reduction took place on the right hand side of the curve (if at point R, for example), the subsequent movement around the curve would increase the expected value of the debt, implying a distinct payoff from forgiveness.

Whilst it would not be contentious which side of the curve many highly indebted countries (HICs) are on, Krugman acknowledges that this is a difficult device to use in practice. There are, however, some useful insights provided by this framework; namely that there are some cases when debt should be forgiven, as there are some cases when it should not (see Krueger 1987, p163-164). Additionally,
since secondary discounts cannot always be passed on to debtors (if at point L, for example), market based debt reduction schemes may not work. In fact, from the curve, Krugman argues that the conditions for success of alternative debt reduction schemes are the same as those for forgiveness (1989).

![Figure 1. The Debt Relief Laffer Curve](image)

It appears, then, that the theory of debt relief points to the possibility of forgiveness actually bringing about gains to all players through removal of a debt overhang. This provides the link between high levels of indebtedness and economic growth that has been the focus of many analysts' concerns.

3. Previous Approaches and Findings

Whilst the debt overhang hypothesis provides a convenient link between heavy debt burdens and economic performance, support for the Debt Relief Laffer Curve is by no means universal. Although broadly consistent with theory and with observations of falling investment, output and demand, empirical tests of this hypothesis are rare. The most common form of analysis of domestic impacts of the debt overhang looks at the changes in investment behaviour, making only implicit links to output and trade markets. Studies by Faini and De Melo (1990), Savvides (1992) and IMF (1989) all find strong evidence of debt disincentives on investment, whilst research by Eaton (1990), and Hofman et al (1991), is inconclusive. More rigorous attempts at macro-economy modelling in Borensztein (1990), Morisset (1991), and Otani and Villanueva (1989 and 1990), again emphasising investment, have supported an hypothesis of negative impacts on debtor country performance. While these investment declines are generally assumed to be linked directly to output, the nature of the links involved is unclear, as is the appropriateness of focussing solely on investment as the site of overhang impacts. It has been argued that many factors including the use of smooth neoclassical investment functions, difficulties in overhang measurement, the use of average rather than marginal overhang variables, absence of bargaining costs, and the possibility of output market impacts from
other forms of overhang, may have masked the true scope of performance impacts in previous analyses (see, for example, Perasso 1991, McDonald 1982, and Borensztein 1990). However, empirical studies provide general support for the notion that debt impacts not only on investment and capital flows, but also through a variety of linkages to output and trade. The literature also provides support for there being strong differences in debt influences among countries and within countries, implying that the incentives for debt relief may be best captured by a disaggregated multi-country analysis.

In a multi-country, multi-commodity framework, Gunasekera et al used the SWOPSIM model to look at impacts of income changes from debt service relief and restoring pre-crisis growth rates on agricultural trade (1990). Whilst investment and consumption are not modelled explicitly, relief policies are treated as shocks to permanent income (proxied by changes in interest payments on debt) and higher growth rates of GDP. Although the results for different countries were varied, they strongly indicated an increase in commodity prices following a debt write-off. Another multi-country analysis conducted by Dittus and O’Brien (1991) developed macroeconomic models of four major Latin American debtors, and simpler models for other HICs, which were integrated into the structure of the OECD’s INTERLINK model. Although not explicitly used for analysis of debt policies, it has been employed to illustrate relationships between OECD nations and debtor countries. In a similar vein, MacKellar (1987) incorporated seven less-developed country (LDC) regions into the general equilibrium Wharton World Econometric Model, and found a debt reform plan linked to US deficit reduction yielded results that were generally supportive of the partial equilibrium approach of Gunasekera et al (1990).

From a policy perspective, the two central developments aimed at ameliorating the international debt crisis were the Baker Plan (1985) and the Brady Plan (1989). Whilst the Baker plan followed more traditional measures of new lending under high conditionality, the Brady Plan realised that debt service reduction was going to be an essential part of any policy reform. Many authors have suggested that principles of the Brady Plan, the implementation of which has been hampered by inappropriate institutional frameworks, could be redeemed by the formation of a new international debt reduction facility, which would have the principle role of purchasing and financing developing country debt (for example, see Kenen 1990 or Sachs 1990, and Buitier, Kletzer and Srinivasan, 1989). The current debate appears to be leading to a policy package that would include the three basic components of formation of an international debt institution financed by subscription from donor nations, the involvement of this body in repurchases and phased in forgiveness of public and publicly-guaranteed debt in exchange for policy reforms, and ceilings on new lending.

The model presented below is designed to test empirically the link between such a debt relief package and agricultural trade. Specifically, the hypothesis to be tested is that a proposed debt write-off package, based on retiring debt stocks of developing countries, will increase the value of agricultural trade to all regions. To this end, a dynamic trade model that incorporates debt impacts is developed that can be used to forecast trade responses over the study period.
4. Model

Based on a traditional partial equilibrium trade model structure, the LDC country specification captures the essence of the impact of the debt crisis on these economies using a microeconomic model based on macroeconomic underpinnings. The output and trade markets are drawn largely from the World Food Model developed by Tyers and Anderson (1992). The full model (see Appendix 1 for description of notations), containing the debt overhang equations, only applies to low and middle income debtor nations, as defined by the World Bank (1993, Table 2). Other regions are assumed to have no overhang, allowing the equations for the output market to collapse back to the original format described by Tyers and Anderson (1992). A schematic representation of the model components appears in Figure 2.

![Figure 2. Model Components](image)

4.1 Output Market

The output market is based on a neoclassical microeconomic model of firm supply and household demand with macroeconomic foundations similar to those of the more traditional growth models. Supply and demand functions which are influenced by the presence of a debt overhang are determined and used to procure excess demand volumes. These two models are described independently.
Supply

The model developed for desired supply in the developing countries uses a production function that includes capital as an input. To capture the process of investment in the supply process, a simple neoclassical investment model is used (see Junankar 1972, and Plasmans 1975) which derives demand for investment through maximisation of a profit function subject to a production constraint and an identity which describes investment (similar to Ott, Ott and Yoo 1975). The agent is assumed to be a multiproduct firm trying to optimise profit over time, where investment is taxed from a debt overhang, subject to the production constraint. The supply curve that follows from the optimisation process would be a function that includes own and cross-prices, and a shift variable that is influenced by an overhang "tax" (see Locke and Ahmadi-Esfahani 1994 for derivations).

The resulting reduced-form supply is based on three influences, a price system that takes into account prices of output and substitutes, a production shifter that encompasses the non-price variables from the previous debt overhang derivations, and a production trend. The price system treats each price as a deviation from its real base period value and, as with the production shifter, the functions are specified as power functions. This supply function, which in the partial adjustment context represents desired supply, is given by equation (1).

\[ q_{mt}^p = q_{nt}^p \prod \left( \left( \frac{p_{mt}}{p_{nt}} \right)^\beta_{m} \left( \frac{p_{mt}}{p_{nt}} \right)^\beta_{v} \left( \frac{DO_{mt}}{DO_{nt}} \right)^d_v \right) \]  

A partial adjustment mechanism, solves for period t's output.

\[ q_{mt}^e = q_{nt}^{\mu} \left( \frac{q_{mt-1}^{\mu}}{q_{nt-1}^{\mu}} \right) \left( \frac{q_{mt-1}^p}{q_{nt-1}^p} \right)^\beta \left( 1 - \mu_{nt}^p \right) e^{\tau_{mv}} \]  

The production trend implicit in equation (2) is determined as the function of the initial production trend, with allowance for the impacts of set-aside programs, and stochastic influences which are log normally distributed on the basis of the supply equation residuals (equations 3 & 4). These risks are assumed not to influence desired production levels.

\[ q_{nt}^{\mu} = q_{nt}^{\mu} \left( 1 - \mu_{nt}^p \right) e^{\tau_{mv}} \]  

where \( \mu_{nt}^p \) is a fraction by which output is reduced by set aside programs and \( g_{nt} \) is the growth rate sustainable with constant prices. Normal random production disturbances are given by equation (4).

\[ Z_{nt} = N(0, VC_r) \]
**Demand**

In a manner analogous to the supply side derivations, the demand side of the output market is based on a neoclassical model of aggregate household demand. Demand considerations in developing countries have generally stimulated less interest than those of supply, partly as a result of the dismissal of aggregate demand (and government for that matter) in many of the growth models of the 1960s. Whilst several hypotheses on consumption in LDCs have been proposed, many authors have noted the significance of the permanent income hypothesis in explaining consumption patterns in developing countries (for example, Gunasekera et al 1990, Hofman et al 1991). Within this framework, expectations on permanent income become important when one considers an expenditure system with subsistence consumption and dynamic wealth constraints, such as the extended linear expenditure system (as discussed in Powell 1974 and Johnson, Hassan and Green 1984). It is assumed in this model that the debt overhang acts as a tax on direct consumption through these income expectations (see Locke and Ahmadi-Esfahani 1994).

Many authors have noted that livestock in developing countries are treated not as a source of food but, rather, as an economic asset (see, for example, Locke and Ahmadi-Esfahani 1993, p368). Given that this has implications for production that may lead to price-responsiveness of a very different nature to direct consumption, and that livestock provide a useful example of an intermediate input in the model system, the Tyers and Anderson (1992) option of dividing demand into direct demand and that for animal feed is maintained.

\[ q_{dm}^d = q_{dm}^{dn} + q_{dm}^{de} \]  \hspace{1cm} \ldots 5

Direct demand operates in a similar manner to the supply side, where a price system is acted upon by a demand shifter based on the non-price components of population, income and debt overhang. The basic form of the demand equation is given in equation (6)

\[ q_{rn}^{dD} = q_{rn}^{dD} \prod (\frac{p_{mt}^r}{p_{rn0}^r})^{\eta_m} \]  \hspace{1cm} \ldots 6

The debt overhang, population and income effects work through the demand shifter in equation (7).

\[ q_{rn}^{dD} = q_{rn0}^{dD} \left( \frac{N_m}{N_{rn0}} \right)^{\xi_m} \left( \frac{DO_m}{DO_{r0}} \right)^{\lambda_n} \]  \hspace{1cm} \ldots 7

Indirect demand as animal feed, relating only to wheat and coarse grains, is a function of the share of the input in production (input-output coefficient), the fraction of the livestock in a country that requires that input (ie. grainfed) and the steady state livestock output given the animal population in year \( q^{live} \).
The calculation of the livestock steady state stems from using a moving average on the basis of over-trend production running down livestock populations in the short-run, under-trend increasing them.

\[ q_{rt}^{\text{liv}} = \bar{q}_{rt}^e \left[ 1 + \tau_{rt} \left( \frac{q_{rt}^e}{\bar{q}_{rt}^e} - 1 \right) + \tau_{rt-1} \left( \frac{q_{rt-1}^e}{\bar{q}_{rt-1}^e} - 1 \right) + \tau_{rt-2} \left( \frac{q_{rt-2}^e}{\bar{q}_{rt-2}^e} - 1 \right) \right] \]

The \( \tau \)'s, which act as adjustment coefficients, are simply the fraction of the total response (that is, the sum of the elasticities) attributable to a single year.

\[ \tau_{rt} = \left( \frac{b_{tn}}{b_{tn0} + b_{tn1} + b_{tn2}} \right) \text{ where } v \in t, \text{ denoting the lag} \]

The steady state calculated is acted upon by exogenous production shifters which are determined on the basis of a three year moving average device to determine the production change not attributable to the trend. Namely.

\[ \bar{q}_{rt}^e = \frac{1}{3} \left( q_{rt}^e + q_{rt-1}^e + \frac{q_{rt}^p}{q_{rt-1}^t} + q_{rt-1}^e + \frac{q_{rt}^p}{q_{rt-2}^t} \right) \]

As a combination of direct and indirect movements, the total consumption shifter is given by

\[ q_{rt}^{\text{ct}} = \bar{q}_{rt}^{\text{ct}} + \sum_i \alpha_i B_i q_{rt}^{pl} \]

4.2 Stocks

Because of the importance of stocks in maintaining stability of the world trading system, the stock specifications from the Tyers and Anderson model have been included. The stocks at the close of each year are given by a function of the expected profits from stock holding, a stock holding decision or quantity trigger, and an exogenous constant that represents changes in the average level of public stocks equation (13).

\[ w_{rt} = \frac{s_{rt}}{z_{rt}} = \pi_n \left[ p_{rt+1} - (1 - r_p) p_{rt} - \theta_n \frac{s_{rt}}{s_{rit}} \right] + \varphi_n \frac{q_{rt}^e + q_{rt-1}^e - \bar{q}_{rt}^e - \bar{q}_{rt-1}^e + \omega_n (1 + \mu^e_{rt})}{z_{rt}} \]

The stocks are impacted by a shift variable \( z_{rtl} \), which is given by the maximum of the steady state production (11) and consumption (15).
\[ z_m = \begin{cases} \bar{q}_m^p, & \bar{q}_m > \bar{q}_m^d \\ \bar{q}_m^d, & \bar{q}_m < \bar{q}_m^d \end{cases} \] ...

In a manner analogous to the exogenous production shifters in equation (11), the consumption not attributable to trend is calculated from a three year moving average.

\[ \bar{q}_m^d = \frac{1}{3} \left( q_m^d + q_{m-1}^d + \frac{q_{m}^{df}}{q_{m-1}^{df}} + q_{m-2}^d + \frac{q_{m-1}^{df}}{q_{m-2}^{df}} \right) \] ...

Stockholders form expectations on stock prices based on a four year moving average, equation 16.

\[ p_{m+1}^* = \frac{1}{4} \left( p_m^* + p_{m-1}^* + p_{m-2}^* + p_{m-3}^* \right) \] ...

where the actual stock price in the current year depends on where it is traded

\[ p_m^* = \begin{cases} p_m^i & \text{where stocks are traded domestically} \\ p_m^b & \text{where stocks are traded at the border} \end{cases} \] ...

The stock level moving average, adjusted for changes in quantity shifter \( z \), is given by

\[ \bar{z}_m = \frac{1}{3} \left( z_{m-1} + z_{m-2} + z_{m-3} \right) \] ...

4.3 Price Transmission

The price system works via border prices being determined directly from world prices through exogenous real exchange rates (19) with any distortion of the price system occurring within the borders of the country. Border prices are determined instantaneously as a fixed ratio of real world price in local currency terms.

\[ p_m^b = h_r \cdot \frac{P^{n^0}}{X^{n^0}} \] ...

The base period being given by

\[ \bar{P}^{n^0} = h_r \cdot \frac{P^{n^0}}{X^{n^0}} \] ...

Starting with consumers, prices are impacted by policy distortions, and adjust towards border prices in a partial adjustment model framework. The extent of the distortion reflects the speed of adjustment towards the equilibrium price.
Similarly for producer prices

\[ p'_{n,t} = \rho'_{n,t} \bar{P}_{n,t} \left( \frac{p'_{n,t-1}}{\rho'_{n,t-1} \bar{P}_{n,t-1}} \right) \left( \frac{P^n_{t-1}}{P^n_{t}} \right)^{\alpha^n_{t}} \]  

...21

\[ p^n_{n,t} = \rho^n_{n,t} \bar{P}_{n,t} \left( \frac{p^n_{n,t-1}}{\rho^n_{n,t-1} \bar{P}_{n,t-1}} \right) \left( \frac{P^n_{t-1}}{P^n_{t}} \right)^{\alpha^n_{t}} \]  

...22

4.4 National Income

National income can be determined as the sum of value added in all sectors of the economy. This being the case, national income available for production and consumption purposes is a result of the value added in agriculture for the previous period over its constant share in GDP.

\[ N_{n,t} = \frac{VA^a_{n,t-1}}{AG} \]  

...23

Assuming that value added is a fixed proportion of gross output, we can use a specification suggested by input-out analysis (in MacKellar (1987, p. 18), following the works of Bherman and Klein). The general relationship estimated is in the form of equation (24)

\[ VA^a_{n,t} = f_{n}, PC_{n} + f_{1}, GC_{n} + f_{2}, FI_{n} + f_{3}, IA_{n} + f_{4}, IM_{n} + f_{5}, EX_{n} \]  

...24

Equation (24) describes value added in a sector as a function of its private consumption expenditure (PC), government consumption expenditure (GC), fixed investment (FI), inventory adjustment (IA), imports (IM) and exports (EX). If we assume that private consumption expenditure and fixed investment are constant, primarily due to data limitations, value added in agriculture becomes a function of some constant, government consumption expenditure, change in inventory and imports and exports. Further assuming that the government is under budget constraints that are binding, we can postulate that government consumption expenditure is a function of their debt service obligations, transfers from other nations, and revenue from trade.

\[ GC_{n} = f(DS_{n}, TR_{n}, GR_{n}) \]  

...25

Given that the excess demand figures generated by the model include not only changes in stocks, but also changes in supply and demand, it is convenient to combine imports, exports and inventory adjustment into this one figure. Excess demand for agricultural goods in a region is determined by the sum of the excess demand for each commodity, equation (32), valued at border prices, otherwise known as the monetary trade balance.
\[ MTB_{it} = -\sum_i m_i p_i^b \] ...26

By substituting these into equation (24) the general form for value added in agriculture appears as

\[ VA_{it} = f_i, + f_{i,} DS_{it} + f_{it,} TR_{it} + f_{it,} GR_{it} + f_{it,} MTB_{it} \]

Which from (23) gives per capita income

\[ \gamma_r = \left( f_{i,} + f_{i,} DS_{it} + f_{it,} TR_{it} + f_{it,} GR_{it, -1} + f_{it,} MTB_{it, -1} \right) \]

\[ \frac{N_r}{AG_r} \] ...27

Expected debt service is the result of a simple value of payment loan calculation that works out repayments on the basis of the interest rate on the loan, the loan period, and the value of the debt stock at this point. Actual debt service would be only a fraction of this based on the past experience of required versus furnished repayments (RP).

\[ DS_r = RP \left( D_{n,} \frac{r^{n,} \left( 1 + \frac{r^{n,}}{1 + r^{n,}} \right)^n}{\left( 1 + \frac{r^{n,}}{1 + r^{n,}} \right)^n - 1} \right) \] ...28

In the format of the Tyers and Anderson surplus calculation, the government earns the difference between the supply (imports at border prices, production at producer prices, and stock releases at stock prices) and demand (at consumer prices). These represent gains from protection and price transmission delays.

\[ GR_{it} = \sum_i \left( q_{it,} p_{it}^f + (s_{it,} - s_{it-1}) p_{it}^f - q_{it,} p_{it}^p - m_{it,} p_{it}^b \right) \] ...29

4.5 Debt

The debt stock is a result of the debt at time \( t \), the fraction not repaid which goes into the debt stock, plus new drawings.

\[ D_{n,} = D_{n, 0} + \sum_t \left[ DS_{n, t} \left( 1 - \frac{RP_t}{RP_t} \right) + DW_{n, t} \right] \] ...30

The debt overhang is the ratio of debt stock to national income, the latter being at least partially endogenously determined.

\[ DO_{n,} = \frac{D_{n,}}{\gamma_r, N_{n,}} \] ...31
4.6 Solution Algorithm, Excess Demand & Market Clearing

The basic closure of the model is that world prices adjust until the trade market clears. Accordingly, excess demand is defined by equation (32)

\[ m_{nt} = q_{nt}^d - q_{nt}^f + s_{nt} - s_{n,t-1} \]  

...32

The related global market clearing condition is given by equation (33)

\[ \Delta m_{nt} = \sum m_{nt} = 0 \]  

...33

In any year, world indicator prices are set at their previous period values and used to calculate global excess demands. These excess demands are deemed acceptable if all meet the following criteria:

\[ \Delta m_{nt} \leq 0.0001Q_{it} \quad \forall i,t \]  

...34

where \( Q_{it} \) is the sum of all the production trends across all regions, that is

\[ Q_{it} = \sum \theta_{nt} \]  

...35

If, however, equation (34) is not satisfied in one or more markets, world indicator prices are adjusted in an iterative fashion via equation (36).

\[ P_{it}^{new} = P_{it}^{old}(1 - E^{-1}u') \]  

...36

where \( u \) is a vector which represents the change in international excess demand relative to its total international production

\[ u = \left( \frac{\Delta m_{t1}}{Q_{t1}}, \ldots, \frac{\Delta m_{nt}}{Q_{nt}} \right) \]  

...37

and the matrix of global excess demand elasticities is

\[ E = \left[ e_{ij} \right] \]  

...38

The negative sign in equation (36) relates to the way that we are dealing with excess demands that would require price decreases to clear if they were positive. Here, positive excess demand must induce higher market prices to bring the market into clearance. The global excess demand elasticities need to take into account a complex structure of relationships between changes in international excess demand for a commodity \( i \), and a change in world prices. These are determined endogenously from
the other model parameters to speed the convergence of the model, in a manner analogous to the approximations described in Tyers and Anderson (1988 and 1992).

5. Data and Estimation Procedures

Given the limitations inherent in developing countries, the data set was based on annual country figures, covering a time series from 1960 to 1990. In areas that described regions, rather than single countries, a pooled cross-section of time series for individual countries was used to improve the degrees of freedom. Within regions, some countries did not have sufficient data available for them to be included in the estimation process.

The quantity data came from the USDA Production, Supply and Distribution Database (PS&D), which holds balance sheet variables for agricultural commodities in 190 countries and regions for 1960 to 1991 (USDA 1994a). The commodities in the model were the same as those used in this database: Barley, Coarse Grains, Rice, Sugar and Wheat. Livestock products are Ruminant Meat (which is Beef and Veal plus Lamb and Mutton), Non-ruminant Meat (which is Pork plus Poultry) and Dairy (which is Fluid Milk). For Wheat and Coarse Grains, demand in the context of these estimations refers to direct consumption (not as feed), whereas all others refer to total consumption.

Debt data are in $US millions from the World Bank’s World Debt Tables on Disk database (World Bank 1991a). All nominal figures were converted, where appropriate, to real values via the US CPI index. The debt represents the sum of public and publicly guaranteed debt stocks. As debt statistics are not available for the 1960 to 1970, and the 1970 to 1975 data were stable in all cases, the real debt stock for the 1960 to 1970 period was assumed constant at real 1970 levels. Income was provided by GDP figures from the FAO State of Food and Agriculture Tables (SOFAT, FAO 1993). Population figures were also derived from the SOFAT database.

Prices were derived from a series of world reference prices which are used in the model. The world indicator prices for Rice were those for the average prices in $US for 5% broken Thai white rice (f.o.b. Bangkok. FAO Production Yearbook issues 1991, 1987, 1982, 1977, 1972, 1967 and 1965). For Coarse Grains, the prices were the published ABARE world coarse grains indicator prices, in $US/T, which were based on the Export prices of US No. 2 Yellow Corn (f.o.b. Gulf) (ABARE 1991, Table 105). The Wheat prices were the US (f.o.b. Gulf) prices of No.1 Hard Red Winter, ordinary protein, calendar year monthly average, as reported by the USDA in the WATI database (USDA 1994b). Sugar prices were the average of monthly ISA prices (f.o.b. Caribbean) converted to SUS/T from USC/lb (ABARE 1991, Table 147 and FAO production yearbook for pre 1970, issues 1972, 1967 and 1965). Dairy product prices were the average prices for exports of butter and cheese (f.o.b. ABARE 1991, Table 67). Ruminant meat prices were based on the Australian Beef Prices (f.o.b. New York) published by the USDA in the WATI database. Non-ruminant prices were the Prices for Pork, based on the EC wholesale average slaughter weight from

Using the real exchange rates available from the USDA WATI database, and the domestic to border price ratio used in the World Food Model database (Tyers 1994a), the world reference prices were converted to border prices for the relevant countries and regions (equation 19). This border price was assumed to be the f.o.b. price experienced by the countries, and thus used as a proxy for producer prices. Consumer prices were found by adding to this a margin on the world price that represented transfer costs that contribute to the c.i.f. prices that would be more appropriate as a consumers price proxy. From the wheat data available in the FAO Trade Yearbooks, it appeared that a reasonable assumption that transport costs could be proxied by a range of values which follow a linear trend from 15% of World Price in 1960, to 10% in 1990. These values were then translated into real domestic currency terms and added to the border price to form the consumer price. These percentages were then gradually increased up to fourfold to then determine if the stability of the results depended on their values. Even though transfer costs for goods which were not handled by bulk facilities are undoubtedly higher that those for Wheat, it is argued that the range of margins considered here would still be appropriate.

Generally speaking, the data appeared of reasonable quality because of the length of series available and the efforts made by the USDA to be as consistent as possible through time, however, there were some obvious caveats associated with their use. The first is that only country aggregates are being used. While it is ostensibly reasonable to have sovereign debt acting at a country level, intra-regional biases are commonplace in developing countries, and it is likely that the debt overhang also acts in significantly different ways on different locales and occupations within each country. The second is that the commodity classifications described by the USDA and FAO are for an aggregate good, which may be composed of very different commodities with varying economic characteristics among regions. And thirdly, the price series are simulated in a way that makes fairly restrictive assumptions about distortions that lead to prices that are experienced by producers and consumers, and especially how these change over time. This was addressed to some extent by trying a range of transfer costs and testing for the stability of the elasticities experienced, however the data prevent comparison with more accurate figures.

The debt elasticities were estimated for all the countries and regions in the model that are reported as Middle-Income Debtors or lower in the World Bank's Debtor Reporting System (World Bank 1991b,p16-17). Although not a complete list of heavily indebted countries, the reporting system provides the most useful database of consistent debt related statistics. The countries that are included in the model are listed in Appendix 2, however, whole countries were often omitted from the estimation process due to breaks in these series.

A variety of linear and non-linear forms were tested, however it was found that the constant elasticity of substitution models were as good as or superior to other forms in all cases. Estimation was carried
out using ordinary least squares. In most cases first order autocorrelation was detected and corrected for using a Cochrane-Orcutt type procedure.

Initially pre- and post-1980 time period dummy variables were included to test the stability of the functional form over time, however, it was found that these contributed significantly to multicollinearity problems. *A priori*, it was expected that the pre- and post-crisis debt elasticities may be different so those dummies allowing variation in these coefficients were maintained. Additionally, significant country indicating intercept dummy variables were also maintained in pooled regions, however, as a trade-off, cross price and dynamic own price effects had to be omitted. A time trend was introduced to account for technological change. Splitting the data series for the Other Latin America regions found that the estimates appeared stable over the estimation period. Changes in transfer cost margins did not significantly alter the size of the price elasticities, and so only the base 15-10% is reported here. The estimates appear fairly stable here despite multicollinearity. Only the results that did not show a significant Durbin’s H, indicating they were not autocorrelated or misspecified, were reported. Similarly, those with low degrees of freedom were also excluded. Regressions were estimated both with and without debt variables (see Tables 1-6). All variables are in logs unless otherwise indicated.

6. Preliminary Results and Implications

In the previous estimations the problems posed by the data and multicollinearity were readily apparent. Aggregation both at the country and commodity levels disguised intra-regional or commodity influences, which made *a priori* expectations of the results difficult to formulate. Some of these issues were addressed by trying changes in transfers cost margins, and testing sensitivity of the estimates to the periods studied, however, the results were not significantly altered. Because of the apparent stability of the estimates, a number of conclusions could be drawn, the most obvious of which is that debt burdens were a significant explanatory variable of production and consumption behaviour in many of the regions studied. The elasticities that correspond to these coefficients are referred to as “Debt Elasticities” and are displayed in Tables 1 and 4. In addition, Tables 5 and 6 report the estimated price elasticities of supply and demand from these debt overhang models.

The debt elasticities provide interesting insights into the nature of the debt overhang impacts on supply and demand. In an *a priori* sense, it would be expected that the debt elasticity of supply (Table 1) would be negative as debt diverted resources away from capital intensive forms of production. This observation would seem to be borne out by the estimates obtained, which suggest a range of inelastic negative debt responses, with notable negative results seen in Coarse Grains in Other Asia, and Sugar in Other North Africa and Middle East. These results may reflect the infrastructure required to produce these goods in these regions, or the action of government distortions. which themselves, are likely to be influenced by the debt overhang. Secondly, it can be noted that there are a minority of strong positive responses to the overhang, including Wheat in Other Sub-Saharan Africa, Sugar in Other Asia, Ruminant production in India, and to a lesser extent the production of Non-ruminant
meats in the latter country. These, again, may be reflecting government or producer biases in response to debt problems, for example in the case of India, where ruminant supply increases may reflect producers disposal of assets in order to purchase other inputs, rather than a traditional supply response. Within regions there appear significant differences in response among countries that are not reflected in these weighted averages. However, Table 1 tends to suggest an overall positive impact on supply for debt overhang reduction.

It would appear reasonable to assume that the negative influence of the debt overhang would be more pronounced after the eighties crisis, and may in fact have a positive influence prior to this. Tables 2 and 4 show the results for the debt elasticities in this second period, obtained using dummy variables which permitted a test for structural change in these coefficients. The results from Table 2 show little

<table>
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<tr>
<th>Table 1. Debt Elasticities of Supply, Pre 1980</th>
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Notes: * Indicates insignificant at 20% or greater level of significance. † Indicates insignificant, however, R-squares were greater than 95%, implying multicollinearity may have biased results.

<table>
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</tbody>
</table>

Notes: * Indicates insignificant difference from the Table 1 estimates at 20% or greater level of significance. † Indicates insignificant, however, R-squares were greater than 95%, implying multicollinearity may have biased results.
sign of variation in the estimates from their pre- to post-1980s values, implying the data do not strongly support the notion of structural change in the overhang relationship over time. While there are some exceptions to this conclusion, this result may also reflect the way expectations varied largely between regions, as did the nature and timing of policy responses.

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</table>

Notes: * Indicates insignificant difference from the Table 3 estimates at 20% or greater level of significance. † Indicates insignificant, however, R-squares were greater than 95%, implying multicollinearity may have biased results.

On the demand impact of the debt overhang, there appears a mixture of price and income effects with strong inter-country and inter-commodity differences in debt responses (Table 3). A priori, we could expect that the debt overhang initially could encourage increases in consumption or hoarding by encouraging expectations of price inflations, but in the long run would discourage consumption through taxing permanent income. The income effect itself, which should be captured by the

<table>
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<th>Table 4. Debt Elasticities of Demand, Post 1980</th>
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<td>Other LA</td>
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</table>

Notes: * Indicates insignificant difference from the Table 3 estimates at 20% or greater level of significance. † Indicates insignificant, however, R-squares were greater than 95%, implying multicollinearity may have biased results.
inclusion of income variables, would be expected to bias consumption toward more traditional crops for the poorest countries, thence to grains and cereals, and finally toward higher protein food for the wealthier nations.

Although the demand effect is predominantly negative, some positive results are evident for each commodity. Whilst this may reflect the nature of consumer preferences in these countries, it is important to note that the aggregation of commodities used in the model may be disguising different goods, with different economic characteristics to each nation. The second period results, shown in Table 4, suggest that the estimates are again fairly stable across the two periods, the data revealing very few significant differences. Overall, the results in Table 3 are suggestive of positive increases in demand in response to removal of the debt overhang.

Given that the debt elasticities in Tables 1 and 3 were often significant, and could be reasonably assumed to be correlated to other variables used in more traditional supply and demand equations, it would be safe to assume that the omission of the overhang in previous studies may have led to bias and inconsistency in price elasticity estimates. Whilst all equations are to some degree likely to be misspecified, this finding has implications for future analyses. The supply and demand elasticities determined in the estimation process appear in Tables 5 and 6. The most appropriate values for comparison, given the way in which the price series have been generated, would be those from the Tyers and Anderson model (1989). However, as indicated previously, the problems associated with multicollinearity meant that the dynamics and cross-price effects included in the Tyers and Anderson estimates were not included, introducing a potential source of bias in these results and creating difficulties in direct comparison.

### Table 5. Own Price Elasticities of Supply

<table>
<thead>
<tr>
<th></th>
<th>Rice</th>
<th>Wheat</th>
<th>Coarse Grains</th>
<th>Sugar</th>
<th>Dairy</th>
<th>Ruminant</th>
<th>Non-Ruminant</th>
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</table>

Notes: * Indicates insignificant at 20% or greater level of significance. † Indicates insignificant, however, R-squares were greater than 95%, implying multicollinearity may have biased results.
On the whole, the instantaneous supply response estimates in Table 5 appear highly inelastic, often negative and demonstrating strong inter-country and interregional differences. The comparable Tyers and Anderson results imply that the supply response is near zero in most cases, with a similar negative response to ruminant prices. The perverse nature of the estimated supply responses in Table 5 is consistent with the notion that the prices calculated, whilst encompassing some hypothesised market distortions, do not fully represent the nature of actual prices faced by producers. As, in developing nations, some of these distortions relate directly to the debt overhang, this becomes a further argument that the omission of debt related variables has biased price elasticities.

Beyond data problems, perverse supply response and the strong interregional differences can be easily justified by looking at the two key areas of infrastructure and policy influences. Proportional changes in output from smaller producers do not require the same absolute shifts in production as larger ones, and therefore do not require significant shifts in production. As such, larger producers, to obtain a comparable shift in output, require larger changes in infrastructure and other inputs, the availability of which is more likely to be influenced by debt disincentives.

If government policy were biased towards agricultural production, we would expect increased indebtedness to firstly increase production, as the borrowed money expands the inputs available, and then decrease production, when the burden associated with growing indebtedness is felt. These production increases would be likely to coincide with increased price responsiveness. Even under high austerity conditions, it might be expected that exportable goods are supported by diverting resources from other sectors in order to raise revenue. The implication is that some agricultural goods may face positive debt impacts if resources are diverted into their production, or conversely, that draining resources from some agricultural commodities, particularly into other sectors such as in industrialisation programs, would mean that the negative impacts are exacerbated. It is here that the role of policy becomes very pronounced, and where one could see that more traditional products in a region would be more likely to have lower (negative) debt elasticities due to the inertia associated with the political environment. There is also the implication that where sovereignty is violated by tough conditionality, diversion of resources from non-traditional sectors may be more pronounced.

Looking finally to the own price elasticities of demand estimates (Table 6) again there are some discrepancies with those presented in the Tyers and Anderson study, whose values are generally much closer to unity, and are exclusively negative. The positive, and predominantly highly inelastic values in Table 6, represent a significant decrease in price responsiveness from the previous model estimates, and in many cases a change in sign. For a country under increasing levels of indebtedness, we would expect that the demand for essential goods, such as food staples, would become more inelastic or even positive. This is similar to the Giffen good scenario where inferior goods make up a large proportion of the budget, and as such are subject to large income effects. By implication, an increase in price of the inferior good causes such a large drop in income that consumption of inferior goods actually increases, leading to a lower or positive demand elasticity. If the share of the budget were small, the increase in price would lead to a lower income effect and the price response would be...
more conventional. If debt burdens could bring about this scenario by leading to either a dominance of inferior goods in the household’s budget, or to constraints on income such that changes in the prices of these goods have a larger real effect, the debt burden could lead to a lower or positive price elasticity of demand for inferior goods.

Table 6. Own Price Elasticities of Demand

<table>
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<tr>
<th></th>
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Notes: * Indicates insignificant at 20% or greater level of significance. † Indicates insignificant. However, R-squares were greater than 95%, implying multicollinearity may have biased results.

For less essential or more durable goods, we would expect debt burdens to make consumers more price responsive whilst remaining conventionally signed. A caveat to this is the case where refusal or rescheduling of repayments means that there is a positive income effect sufficient to outweigh the negative impacts of the debt overhang, or where there is an expectation that prices will increase, in which case demand may increase in the current period. For this reason, the consumption results are mixed, perhaps conflicting even within the same commodity classifications, mitigating or reversing anticipated results. Whatever forces are at play, it would be reasonable to expect that the omission of the significant debt overhang variables in determining previous estimates has generally made consumers in these regions appear more price responsive, and has masked perverse price findings.

The overriding implication of the results presented in Tables 1 to 6 is that removal of the debt overhang has a potentially large impact on agricultural trade through a variety of regional and commodity-specific effects. The results also imply that the estimates of price elasticities from previous studies may have been biased by the omission of significant debt impacts which not only changes the direction of some supply and demand responses, but also indicates that the supply may be more responsive in the current period, and demand more price inelastic.

More importantly, the inclusion of these estimates within the trade model structure will allow experimentation with a variety of debt relief proposals. Where the significance of the estimates is low, a range of values for these elasticities will be experimented with. Dynamic simulations will be run...
from a base period of 1989 to 2000, using the various debt write-off scenarios foreshadowed in section 3. The results, the primary interest being on value of trade, will be compared with a baseline projection in which debt stocks will continue to grow at their forecast levels (in real terms), exchange rates will continue at projected levels, developing country protection will not be altered, and the transfers variable for creditor nations will be set to zero. The baseline scenario, then, reflects the alternative to debt relief, that is, following the observed and forecast paths of continued structural adjustment.

Although by no means complete, some preliminary trade results can be used to foreshadow the net effects of these varying influences. A preliminary simulation where the debt overhang is reduced by 10% each year over a ten year period, with the implied increase in income growth rates, found a real increase in the value of excess demand from developing countries in the order of US$10 billion. While by no means complete, the calculation does support the hypothesis that a reduction in debt could have a significant positive impact on excess demand for agricultural commodities. Simulations such as this can also provide insights into the relative benefits over costs of debt forgiveness. For the base period, the long-run debt outstanding by public and publicly-guaranteed debtors to official sources was around US$400 billion, which, using Sachs optimistic valuations, would have a secondary market value of no more than US$100 billion (Sachs 1990, p27). Given that the share of the agricultural goods studied averages around 10% of all commodity trade (Tyers and Anderson 1989, p17) potential commodity trade gains from a total overhang write-off will be around the same value as the costs. Given that this benefit would continue, presumably at a diminishing rate, over many years, and that the cost of financing the buy-backs could be amortised over a longer duration, the very preliminary results suggest that the debt write-off could be an extremely profitable exercise on the basis of commodity trade alone.

Whilst the estimates in Tables 1 to 6 are suggestive of positive trade results, there is clearly a requirement for more detailed analysis. Key issues are the need to account for income changes, the dynamics that follow phased debt relief and the lagged response in supply and stock releases that would follow the initial increase in excess demand. Related to this is the price effects, which obviously depend on many factors, not the least of which is the volume of these goods that is traded on the world market, and the impacts that the debt burden has on the supply and demand elasticities revealed in the debtor countries. The model also has no endogenous accounting of structural changes in government action that would occur in relation to debt relief. Governments may act against increases in demand through import restrictions, bias the direction of investment away from or toward the agricultural sector, or may undergo economic reforms that were obstructed by the presence of the overhang. And, above all, there is a need to determine the robustness of the model for forecasting, and sensitivity of the model results to the size of these elasticities.

In summary, the estimation results reported in Tables 1 to 4, show significant signs of different regional and commodity responses to debt overhangs. The mixture of income and price effects that are intertwined with indebtedness appears to result in a significant negative impact on supply and
changes in households demand that reflect both the economic characteristics of the good under consideration, the scale of production considered and the nature of sectoral biases in policy, both domestic and imposed. It would also appear that, in countries suffering from high debt burdens, the price responsiveness of both consumers and producers is significantly altered, indicating that previous estimates of these elasticities may have been biased. The results also indicate that, given the size of overhang effect, it may be possible to support forgiveness of debt burdens on the basis of agricultural trade benefits alone. The diffuse nature of these benefits also provides two additional policy implications. Firstly, it may be possible to target more extreme debtors as aid to maximise production effects, or alternatively to target those with more responsive consumption to maximise demand effects for self interest purposes. Secondly, this may suggest the need for intervention in debt reduction programs in order to overcome the market failure that would be associated with creditors trying to capture benefits from forgiveness that are otherwise going to producers, consumers, traders and governments.

7. Conclusion

The analysis of the trade effect promises to be, once again, a growing issue, even though many major debtors are now well into a tough structural adjustment process. With international resources under increasing pressure from various structural changes including those in Eastern Europe, there is now a greater need for long-run financial stability in developing countries in order to maintain the investment environment. This is clearly at odds with the notion of problems associated with the continuing debt overhang, suggesting that debt forgiveness is to remain high on the agenda both in adjusting and non-adjusting economies well into the future.

Of all the attempts that have been made to analyse the impact of the debt crisis, there has been a traditional dichotomy between approaches which have looked at how debt affects the developing economy, and those which have treated this as an international trade problem. Of the former approaches, the concept of the debt overhang seems to be the most widely accepted link between developing country debt and economic performance. In an attempt to synthesise the debt overhang with a trade model, this analysis employs a simple partial equilibrium model of debt impacts, which could be used to demonstrate the possibility of gains or losses in income from world agricultural trade for both debtors and creditors as a result of debt forgiveness. Preliminary results suggest that the strong impacts of debt overhangs on supply and demand in developing countries are likely to yield a large increase in agricultural trade volumes and values in response to debt forgiveness, which could serve as incentives for action on this issue. Further analysis of the debt relief package with the trade model is not only to confirm these effects, but to demonstrate their dynamics and the magnitude and distribution of potential gains. It is expected that these findings will be able to help settle the thorny issue of debt forgiveness.
References


FAO (various issues). Production Yearbook, Rome, Food and Agriculture Organisation.


Appendix 1: Description of Notations

$q_{rt}^p$ Supply of commodity $i$ in country $r$ and year $t$.
$q_{rt}^e$ Target supply of commodity $i$ in country $r$ and year $t$.
$q_{rt}^{pl}$ Price independent supply trend.
$Z_{rt}$ Proportional random production disturbance.
$VC_r$ Variance-covariance matrix of random production disturbances across commodities in country $r$.
$q_{rt}^{live}$ Steady state livestock output in year $t$.
$q_{rt}^d$ Consumption of commodity $i$ in country $r$ and year $t$.
$q_{rt}^{dp}$ Direct, non-animal feed, consumption.
$q_{rt}^{ag}$ Consumption as animal feed for Wheat and Coarse Grains.
$q_{rt}^{DTP}$ Price independent direct consumption shifter.
$q_{mt}$ Total consumption shifter.
$s_{rt}$ Closing stock of commodity $i$ in country $r$ and year $t$.
$m_{rt}$ Excess demand for commodity $i$ in country $r$ and year $t$.
$p_{rt}^p$ Domestic producer price of commodity $i$ in country $r$ and year $t$.
$p_{rt}^c$ Domestic consumer price of commodity $i$ in country $r$ and year $t$.
$\overline{p}_{rt}^p$ Base period (1980-82) average domestic price
$p_{rt}^e$ Price at which stocks are traded, from equation (17).
$p_{rt}^b$ Border price of $i$ in country $r$.
$p_{rt}^w$ Standard international trading price of commodity $i$ in year $t$. From section 6.1.
$\overline{p}_{rt}^w$ Base period (1980-82) standard international trading price.
$b_{vijr}$ Elasticity of target supply of commodity $i$ with respect to the price of $j$. Subscript $v$ indicates the length of lag response.
$d_{vijr}$ Debt elasticity of target supply of commodity $i$ in country $r$.
$\delta_{vri}$ Partial adjustment elasticity for the supply of commodity $i$ in country $r$.
$g_{vri}$ Price independent growth rate in the trend of supply.
$a_{vri}$ Elasticity of direct demand for commodity $i$ with respect to the consumer price of $j$.
$\eta_{vri}$ Income elasticity of demand for commodity $i$ in country $r$.
$\lambda_{vri}$ Debt elasticity of demand for commodity $i$ in country $r$.
$\alpha_{vijr}$ Quantity of commodity $i$ used in the production of one unit of commodity $j$.
$\beta_{vri}$ Fraction of the production of livestock product $i$ which is grainfed in country $r$ and year $t$.
$\tau_{rivi}$ Fraction of the total target livestock supply response which occurs $v$ years after the price change.
$r_{vri}^d$ Real rate of interest in country $r$.
$r_{vri}^{loan}$ Average rate of interest on debt outstanding in country $r$.
$yr$ Average term of debt outstanding in country $r$. 

29
\( \theta_r \)  
Steady-state marginal cost of storage of commodity i in country r.

\( \pi_r \)  
Response of closing stocks of commodity i to expected speculative storage profits in country r.

\( \varphi_r \)  
Response of closing stocks to the carry-in level of commodity i in country r.

\( \omega_r \)  
Steady-state level of working stocks of commodity i, as a proportion of trend consumption in importers and of production in exporters.

\( h_r \)  
The ratio of the border price of commodity i in country r, to the standard or indicator international price.

\( y_r \)  
National per capita income in country r in year t.

\( V_A^{ag} \)  
Value added from the agriculture sector.

\( f_{ov} \)  to \( f_{ov} \)
Coefficients of the agriculture value adding equation, described in (27)

\( AG_r \)  
Fraction by which agriculture contributes to GDP in country r

\( MTB_r \)  
Monetary trade balance in country r at time t, valued on border (f.o.b.) basis.

\( GR_r \)  
Government revenues as a result of changes to agricultural production and trade, calculated in (29)

\( TR_r \)  
The value of transfers to in a year to a country that exists as grants and are not repayable as part of the debt service

\( RP_r \)  
The ratio of actual to expected repayments, based on present value calculations, that is given on average by country r

\( DS_n \)  
The real value of debt service payments actually made by country r in time t

\( DW_n \)  
New drawings of debt made in year t by country r

\( D_r \)  
Real stock of public and publicly guaranteed debt held by country r in time t

\( DO_r \)  
Overhang of public and publicly guaranteed debt held by country r in time t

\( z_{rn} \)  
Production or consumption trend shift variable as defined by (14)

\( N_r \)  
Population of country r in year t.

\( x_r \)  
Real exchange rate in US dollars per unit of local currency.

\( \rho_{nr} \)  
Target nominal protection coefficient for producers of commodity i in country r.

\( \rho_r \)  
Ratio indicating the degree to which consumer prices are distorted by government policy.

\( \phi_{psr} \)  
Short-run elasticity of price transmission for the producer price of i in country r.

\( \phi_{pkr} \)  
Long-run elasticity of price transmission for producer prices of i in country r.

\( \phi_{csr} \)  
Short-run elasticity of price transmission for the consumer price of i in country r.

\( \phi_{CLR} \)  
Long-run elasticity of price transmission for consumer prices of commodity i in country r.

\( \mu_r \)  
Fraction by which set-aside policies shift the supply curve of commodity i in country r to the left.

\( \mu_r \)  
Fraction by which changes in government-held stocks shift the mean level of stocks from its base period value.
Appendix 2: Country Coverage of the Model

Australia
Canada
EC-10 - European Community: Belgium, Denmark, Germany FDR / West, France, Greece, Ireland, Italy, Luxembourg, Netherlands, United Kingdom
EFTA-5 - European Free Trade Association: Austria, Finland, Norway, Switzerland and Sweden
Japan
New Zealand
United States
USSR
Spain and Portugal
† Other East Europe - those current or former CPE's outside the former USSR: Albania, Bulgaria, Czechoslovakia, German DR / East, Hungary, Poland, Romania, Yugoslavia
† Egypt
† Nigeria
South Africa
† Other North Africa Middle East*: Algeria, Iran, Iraq, Jordan, Lebanon, Libya, Morocco, Oman, Saudi Arabia, Syria, Tunisia, Turkey, Yemen AR / Nth, Yemen PDR / South.
† Bangladesh
China
‡ India
‡ Indonesia
‡ Korea
‡ Pakistan
‡ Philippines
Taiwan
† Thailand
† Other Asia*: Afghanistan, Burma, Korea PDR / North, Laos / PDR, Malaysia, Mongolia, Nepal, Sri Lanka, Vietnam
† Argentina
† Brasil
Cuba
‡ Mexico
‡ Other Latin America: Bolivia, Barbados, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Belize / Honduras, Jamaica, Nicaragua, Panama, Paraguay, Peru, Trinidad/Tobago, Uruguay, Venezuela

* Several countries have been omitted from the Tyers and Anderson (1989) specification of Other North Africa and Middle East and Other Asian group countries in order to make these predominantly debtor regions.
† Regions or countries considered as debtors in the trade model, classification based on being low or middle income debtors in the World Bank's Debtor Reporting System (World Bank 1991b,p.16-17).