

Trade Policy, Staple Food Price Variability, and the Vulnerability of Low-Income Households*

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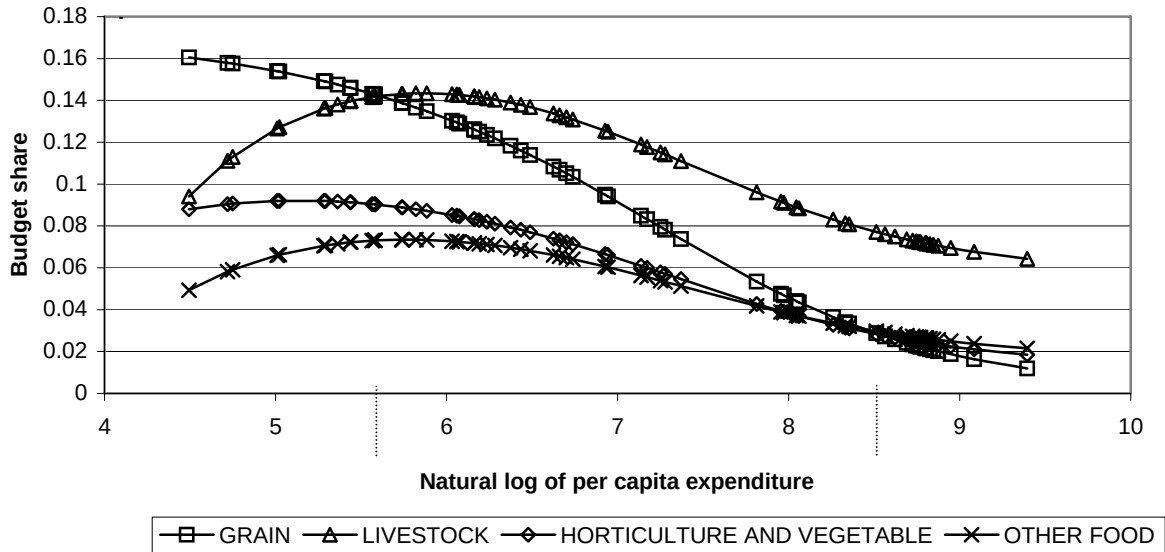
I. Introduction

Recently there has been renewed interest in the impact of trade policy on developing countries in general and on low-income households in particular. There are more than 1.1 billion people living in poverty in developing countries, and more than 700 million people worldwide who do not have access to sufficient food to meet their needs for a healthy and productive life (Pinstrup-Anderson, 1994). Furthermore, the accumulating evidence indicates that trade policies affect the rate of economic growth, and hence the extent to which households may be lifted out of poverty (Edwards, 1998). Trade policies also affect variability in food prices and hence the vulnerability of low-income households (Tyers and Anderson, 1992). Responding to this increased interest in poverty alleviation, the new Director General of the World Trade Organization (WTO) has proposed that the upcoming round of trade negotiations should be the “Development Round” (Moore, 1999). The Vice-President of the World Bank, Joseph Stiglitz, reinforced this call for a Development Round of trade negotiations (Stiglitz, 1999), and the latest World Development Report from the World Bank has poverty reduction as its central theme.

In spite of this strong interest at the political level, research into the impact of trade policy on low-income households has been relatively scarce in the last decade. Most analyses still focus only on the average, national impact. This can be seen by reviewing the papers from two recent conferences on the 1999 WTO round held in Geneva (Hoekman and Martin, 1999; Ingco, 1999). None of these papers provided an assessment of the impact of potential trade policy changes on income distribution or on the welfare of households at the low end of the distribution. Of particular concern is impact of agricultural trade policy on the price of food and hence on the well being of poor households.

Figure 1 presents estimates of the share of household income spent on various food products, based on an international cross-section study (Cranfield et al., 1998). Fitted points at the lowest levels of expenditure/income represent an average household in Ethiopia in 1985. At the other end of the spectrum are households with incomes at the level of the United States in 1985.

Figure 1. Expenditure shares for food products, by income level (1985)



Two points stand out in Figure 1. The first is that at lower income levels, households spend about half their income on food, which underscores the importance of food prices to household well-being at the lower end of the income spectrum. The second point is the relative importance of grains in the consumption bundle of low-income households. At the lowest income levels, the estimated budget share for grains is around 15%, whereas it drops to only 1% at upper income levels. In view of the fact that grains prices are highly volatile (Tyers and Anderson, 1992), this is another count against low-income households. Not only do they spend a large share of their income on food, but a good part of it is tied up in goods for which prices are extremely volatile. It is no wonder that many developing countries have devoted scarce resources to attempts to stabilize grains prices.

Despite the importance of the issue of commodity price volatility, trade policies and poverty, little research has been done in this area. There is an extensive literature on commodity price stabilization (e.g. Williams and Wright). Also, the link between commodity stabilization and food security in developing countries is well-developed (Berck and Bigman, 1993; Claessens and Duncan, 1993). Furthermore, some authors have explored the link between trade policy and food price variability (Vanzetti, 1998). However, the further link from food price variability and trade policy to

poverty and the distribution of income within the developing countries remains largely unexplored. In a paper commissioned by the UN Conference on Trade and Development, L. Alan Winters includes this area as among the most pressing needs for research in agricultural trade (Winters, 1999). The objective of this research is to provide an assessment of the interaction between food price volatility, agricultural trade policy, and the well being of low-income households.

The rest of the paper is organized as follows. In section II we consider previous work that has dealt with the variable nature of grain production, and lay the groundwork for the study at hand. Section III describes the methods used to measure volatility in grains supplies and prices. Sections IV and V address the modeling framework, model calibration, and specification of base case trade policies. Sections VI, VII, and VIII describe the experimental design, results, and conclusions, in turn.

II. Previous Research on Volatility of World Grains Markets

Volatility in grain prices is due to the relative lack of price responsiveness in demand, coupled with the fact that short run supplies are quite volatile, and largely pre-determined. Therefore, an adverse development in the weather that reduces supply in a major producing region can require a large price adjustment to clear the market. This volatility of prices has led to an important line of research on commodity market stabilization (Williams and Wright, 1991; Timmer, 1991). It has also led governments to hold substantial stocks of grain in an effort to cushion markets in the face of volatile supplies.

It is expensive to hold stocks, however, and it is very expensive to hold sufficient stocks to make up for “worst case” scenarios (Abbott *et al.*, 1993). Vanzetti (1998) estimates that minimum stocking costs amount to about 17 % of the purchase price, under the best of circumstances. These costs are even higher than the return that could be earned from speculation in the market. This point is reinforced by Abbott *et al.* (1993), who also points out that public stockholding has an important disincentive effect on private stockholding. Furthermore, those authors conclude that the impact of stockholding on food security of the poorest households is relatively weak, since the problem for these

households is largely one of insufficient income. Thus it is hardly surprising that the size of publicly held stocks has greatly diminished in recent years, and the estimated stocks/use ratio for grains worldwide recently reached its lowest level in thirty years (Vanzetti 1998, Table A4).

Commodity storage seeks to reduce price variation by spreading availability of grains over time. International trade offers an alternative by spreading supplies across geographically dispersed markets. Tyers and Anderson (1992) and Vanzetti (1998) provide evidence of the potential for agricultural trade to substitute for commodity storage in world food markets. The more widely spread are the adjustments to a given supply shock, the smaller is the requisite adjustment in world prices. This risk sharing feature has benefits for all, which leads Kindleberger (1986) to point out that an efficient international market is a public good, the existence of which benefits all. However, like any public good, international trade is subject to free riding (Tyers, 1991). Some countries take advantage of international markets to absorb their own production surpluses or shortfalls, while failing to participate in the adjustments to changes in world market conditions (Timmer, 2001). For example, the European Union has historically shielded its markets via use of a system of variable import levies and variable export subsidies/taxes. Import quotas have been common in East Asia and elsewhere. Price bands are now widespread in Latin America. These measures dilute the scope for international markets to spread the risk of uncertainty in regional supply (or demand) – indeed, they enable countries to export their instability to other markets, thereby exacerbating the volatility in unprotected markets.

Tyers and Anderson (1992) have documented the cost of these market insulation measures to the world economy. They use a global model of agricultural trade to show that the coefficient of variation in world food prices would be reduced by two-thirds if all countries ceased to insulate their domestic markets. In the case of rice prices, they find that variation of consumer and producer prices in the heavily insulated economies would be little changed – and in some countries might even fall – when world prices are fully transmitted into domestic markets in all regions¹. In a more recent analysis

¹ Of course the variation in markets without extensive insulation would be much lower under this counterfactual scenario.

of the world wheat market, Vanzetti (1998) finds a similar drop in variability in world prices when insulating policies are removed. He also explores the case in which trade is liberalized and public stocks are fully eliminated. He finds that this fully liberalized trading environment still delivers a lower coefficient of variation for world wheat prices than does the “business as usual” scenario. There may be much to be gained from eliminating the current “tragedy of the commons” in which world agricultural markets are used to pursue price insulation policies.

The World Trade Organization (WTO) offers the potential to help solve this public good problem. By offering a venue in which most countries of the world can agree to cooperate by opening up their markets, all countries can potentially be made better off. This was the idea behind the Uruguay Round Agreement on Agriculture that sought to convert all border protection to tariffs. However, the process of converting existing protection to tariffs was fraught with problems and the ensuing “dirty tariffication” has left ample room for the *de facto* continuation of variable levies and price band regimes (Ingco, 1996). Some countries (most notably Japan and Korea imports of rice) were exempted from tariffication altogether, in exchange for commitments to import a certain percentage of domestic consumption. In addition, the door was left open for the use of tariff rate quotas that can also insulate markets in many circumstances (Abbott and Paarlberg, 1998). Thus the problem of trade policies leading to market insulation and excessive volatility in international food prices persists, despite the Uruguay Round. Furthermore, there is a strong need to assess the impact of such volatility on the most vulnerable households.

A natural starting point for such analysis is provided by the contributions of Vanzetti (1998) and Tyers and Anderson (1992). However, neither of these studies comes to grips with the potential impact on low-income households, because their analyses are pitched in terms of impacts on the average producer, or a representative consumer. Poor households often wear both hats – being both agricultural producers and significant consumers of food products -- so it is necessary to consider both the impacts on consumption prices as well as factor returns. In fact, a general-equilibrium analysis of agricultural supplies and poverty in the Philippines by Coxhead and Warr (1995) shows that two-thirds

of poverty reduction is transmitted through factor markets (*e.g.* via unskilled wages). Poor households typically rely heavily on their own (typically unskilled) labor for income – as compared with wealthy households, where much of the income derives from assets. Furthermore, as noted above, low-income households tend to spend a disproportionately high share of their income on food. Therefore, in order to accurately assess the impact of food price volatility and trade policies on poor households, more detail on both their consumption and factor earnings profiles is needed.

III. Measuring Volatility in Grains Supplies and Prices

Examination of time series data for staple grains reveals two characteristics common to nearly every region of the world: overall production has been steadily trending upward over the last four decades, and year-to-year production is quite volatile (FAO 2001). World staple grain production was 133 % higher in 2000 compared to 1961. This was mainly due to productivity improvements – yields were 124 % higher in 2000 compared to 1961, while area cropped was only 4 % higher. Annual volatility is also largely due to variation in yields.

To characterize year-to-year instability while abstracting from the overall trend, we follow Vanzetti (1998) and estimate a linear trend model of grain production for individual regions. An illustration of this procedure for the case of Zambia is given in Figure 2, which displays both the trend line for grains production and actual production from 1961 to 2000. We focus on the residuals from this regression, which we assume to be normally distributed. Using the standard deviation of residuals and mean level of production over this period, we derive a distribution of staple grain production for individual regions. For purposes of this paper, we divide the world into 10 major producing regions, and break out four focus countries: India, Indonesia, Thailand, and Zambia. The standard deviation of residuals divided by mean production levels for each of the 14 regions is given in the first column of Table 1. Zambia, in particular, must contend with tremendous variation in staple grains production from year to year. The other three focus regions have relatively less instability. As major exporters

with volatile production, Australia/New Zealand, the Former Soviet Union, and North America are substantial sources of instability in the world market.

Figure 2. Zambia production of staple grains, and trendline

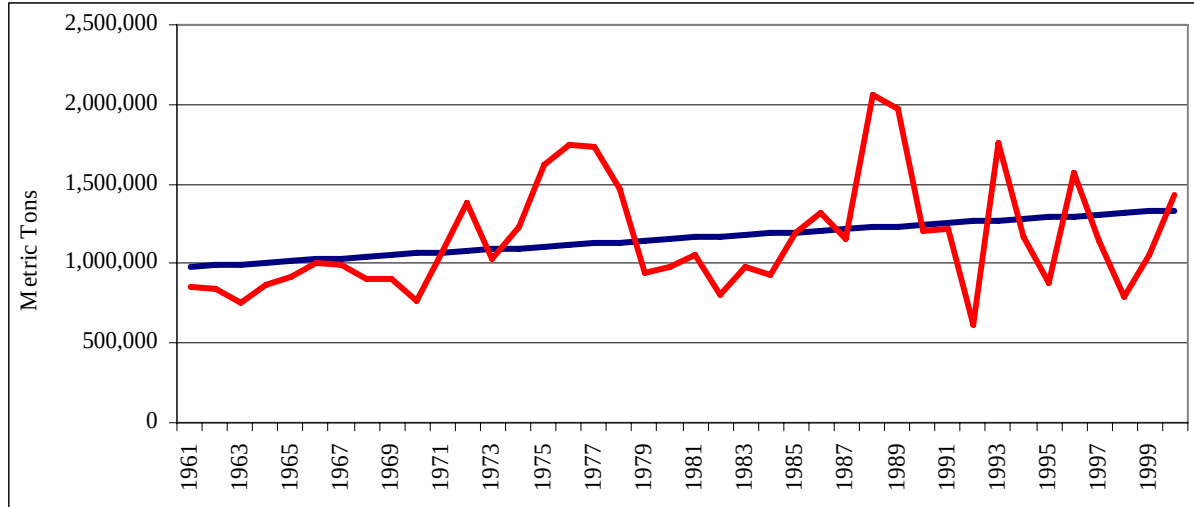


Table 1. Selected characteristics of grain production, prices, stocks, and demand

	Std. deviation of production divided by mean (observed)	Std. deviation of year-to-year % price changes (observed)	Largest obs. % stock reduction (SR_{min})	Largest observed % stock increase (SR_{max})	Own-price elasticity of demand for grains
India	6.2	14.3	-24	19	-0.329
Indonesia	7.0	38.0	-12	9	-0.378
Thailand	7.8	19.8	-20	14	-0.076
Zambia	29.3	149.4 ²	-81	38	-0.354
China	5.4	11.4	-3	4	-0.127
North America	12.0	24.6	-38	18	-0.208
Austral. & New Zeal.	20.0	17.8	-80	45	-0.365
Latin Amer. & Carib.	5.3	55.6	-51	29	-0.271
Europe	7.8	8.2	-49	23	-0.176
South Asia	5.6	25.5	-19	16	-0.332
East Asia	5.5	9.8	-32	38	-0.089
Former Soviet Union	19.9	8.4	-22	31	-0.170
Mid. East & N. Africa	8.7	41.6	-86	49	-0.240
Sub-Saharan Africa	9.2	10.1	-88	34	-0.459

Source: FAO, 1993; 2001.

² This is calculated over the full period for which data is available, 1966 through 1995. In the latter half of this period there was tremendous inflation. We tried to account for this with a cubic trend line, to limited success. For comparison, in the period 1966 through 1980, the standard deviation of year-to-year price changes was only 19.1.

Table 1 reports the normalized standard deviation associated with staple grains price changes in each of the 14 regions in our study. In order to avoid aggregation bias, we have computed this for a key staple grains product in each of the 14 regions. In the case of India, Indonesia, Thailand, China, Rest of East Asia, and Rest of South Asia, this key staple grain is rice. Wheat is the chosen staple for North America, Europe, Middle East/North Africa, Latin America, the Former Soviet Union, and Australia/New Zealand. Maize is selected for Zambia and the rest of Sub-Saharan Africa. The number reported in Table 1 is the standard deviation of the percentage departure for this staple grain price, relative to the trend price.

It is hardly surprising that the region with the most volatile supplies, Zambia, also exhibits the greatest volatility in prices. However, the correlation between supply volatility and price volatility is by no means perfect³. For example, Latin America has a relatively low level of supply volatility, but relatively high price volatility. Clearly there are other factors at work here. First of all, there is the question of stockholding. Some regions have relatively active stockholding – both private and public – which helps to stabilize grains availability in the face of volatile production. Table 1 reports the maximum and minimum values for annual changes in staple grains stocks, relative to production⁴. The column headed $SR_{\max}$ denotes the maximum accumulation of stocks (as a percent of production) in any year over the period: 1966 – 1995. Similarly the entries in $SR_{\min}$ correspond to the maximum percent de-cumulation of stocks that ever occurred. These bounds indicate relatively modest stockholding activity in China and Indonesia, whereas Zambia, Australia/New Zealand, Middle East and North Africa and Sub-Sahara Africa all show maximum stock de-cumulation rates of 80% or more. These same margins also show quite substantial maximum stock increases over the 1961 - 2000 period⁵.

³ At this stage of the paper's development, the price and stocks data are given in terms of the key staple grain of a region. Production and elasticity data correspond to aggregate cereal grains for a region.

⁴ Stockholding data are from the Food and Agricultural Organization of the United Nations (FAO, 2001). Private and public stockholding are not distinguished in these data.

⁵ The fact that the maximum percent decrease in stocks tends to be greater than the maximum percent increase does not imply that the *absolute* change is necessarily different. In calculating the percent change from year to year, production is the denominator. Since stocks are accumulated when production is high, and de-cumulated when production is low, percent stock decreases will appear larger, even if they are not in absolute terms.

A more detailed look at stockholding activity in Zambia is provided in Figure 3. Here, the most volatile top line refers to maize production. Domestic use is much less volatile, particularly in the 1980s. Whereas much of the production variability in the 1970s was absorbed by change in domestic use, since that time, stocks have played an important role in offsetting volatile output.

International trade can also decouple the close link between domestic supplies and price volatility. Regions that are open to trade can use this as a vehicle for offsetting domestic production instability. For example, during a production shortfall, imports may be increased as is the case recently in Zambia (1992, 1993 and 1998: see Figure 3). Figure 4 displays the relative importance of imports in domestic usage of grains for three of our focus countries. Here, again, the sporadic use of imports by Zambia is highlighted. Indonesia's imports are also rather volatile. However, this is not the case in India for which imports have remained steady at a low level over the entire period. Of course a heavy reliance on imports may not stabilize domestic prices. In a region that imports a large share of its grains requirements from a volatile supplier, these imports might destabilize domestic prices. On the other hand, if they are sourced from a wide range of countries, then they may serve to mitigate domestic price variability. Countries that are export-oriented are also vulnerable to overseas shocks. On the other hand, by rendering export demand more price-responsive, exports can also stabilize domestic prices in a country such as Australia, which exhibits highly volatile domestic supplies.

In addition to stockholding and international trade, a third reason for differing price volatility, at a given level of supply uncertainty, traces back to differences in the demand elasticity for grains. The own-price elasticities in Table 1 are based on the FAO's world food model. More details are provided in Section IV below. Suffice it to say that, while all of these elasticities are less than 0.5 in absolute value, there is considerable variation across regions. For a given level of production uncertainty, trade and stockholding activity, these will give rise to significant differences in price variation. Estimates of the elasticities used in our model are discussed in section IV below. In summary, in order to capture key features of world grains markets, it is important that the analytical framework used be capable of dealing with volatile productions, stockholding behavior, differences in

consumer demand characteristics across regions, as well as patterns of bilateral trade in grains. The next section of the paper outlines the modeling framework developed for this study.

Figure 3. Zambia maize production, net imports, stock changes, and supplies

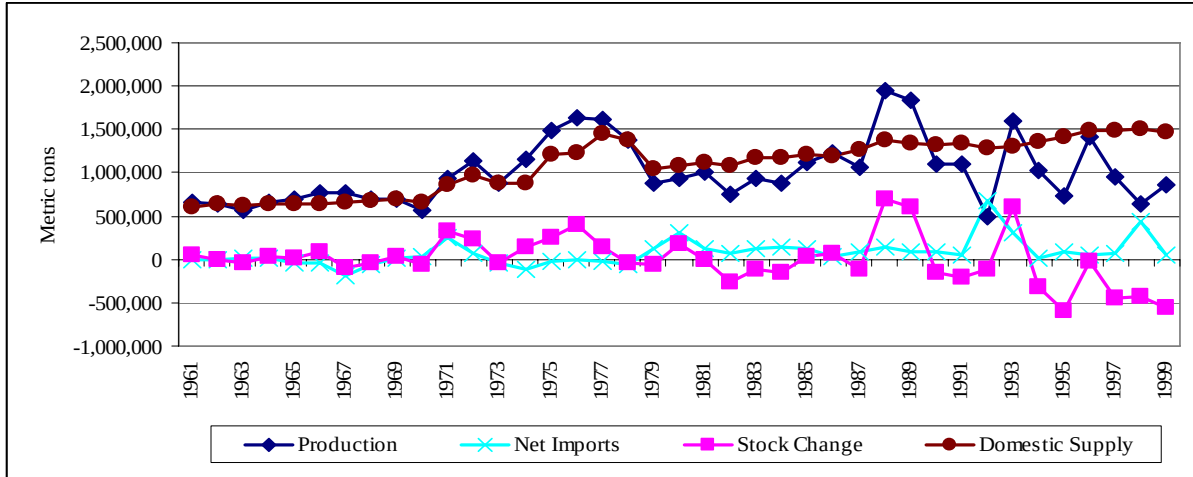
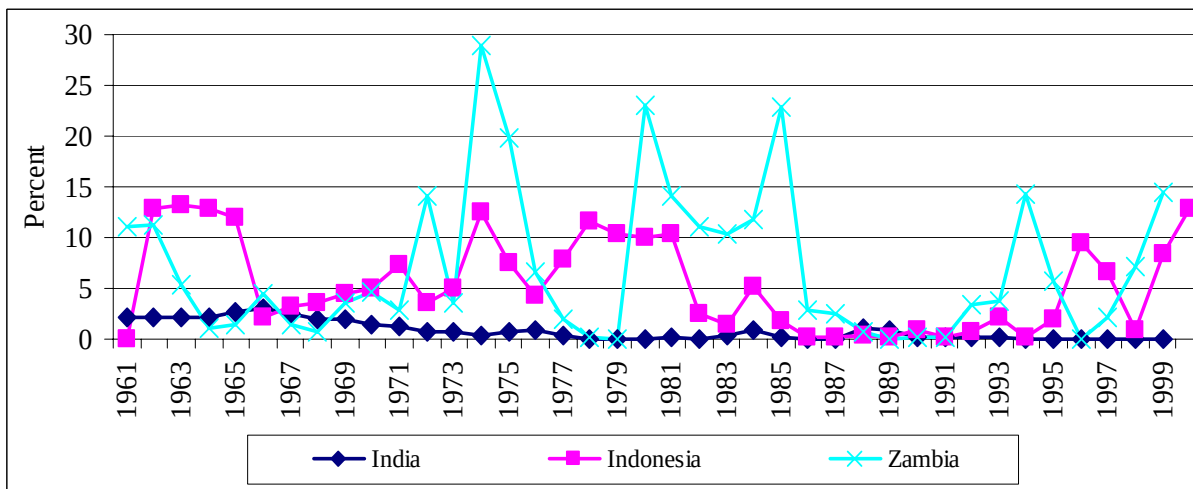


Figure 4. Grain imports as a percentage of total domestic usage (excluding stocks)



IV. Modeling Framework

Because we are interested in both commodity and factor markets, a general equilibrium model is required instead of the earlier, partial-equilibrium approaches of Tyers/Anderson and Vanzetti. Accordingly, we begin with the widely used GTAP model of global trade (Hertel 1997). This general equilibrium model has the advantages of offering global coverage of staple grains production and consumption, along with bilateral trade. By adopting a short run closure in which capital and land are

sector-specific⁶, we are able to target the annual supply volatility outlined in Table 1. We do so using the Gaussian Quadrature approach proposed by DeVuyst and Preckel and implemented for GTAP by Arndt and Arndt and Pearson. The standard GTAP model also has a sufficiently flexible demand system to permit us to calibrate the model to the outside estimates of consumer demand elasticities for grains presented in the final column of Table 1⁷. However, the absence of stock-holding activity and the presence of just one representative household in each region represent fatal deficiencies for this particular research application. This section of the paper outlines how these deficiencies are addressed.

Adding Stock-holding Behavior: In the modified global trade model, stockholding is introduced as an alternative form of investment. Like other investment in the static GTAP model, it is financed by savings. In the standard model closure, these savings could come from anywhere in the world. If the user wishes to force domestic savings, in particular, to finance stock accumulations, then she must do so through the use of a specific closure. In this case the appropriate closure would involve fixing the trade balance and allowing domestic savings to adjust to match the change in investment called for by the stock change.

As is the case for investment determination by the global bank in the standard GTAP model, the equation determining the demand for stocks is *ad hoc*. It is not derived from an explicit optimization problem. This is not possible without moving to an inter-temporal framework, which is too tall an order for the work at hand. Rather, we specify a behavioral relationship between stock accumulation and relative prices that is economically plausible and flexible enough to accommodate the available information on national stockholding behavior. The particular functional relationship that we use is inspired by the work of Dixon and Rimmer (2000) who used it to model the change in sector-specific capital stocks in a dynamic model. We have adapted this approach to the case of grains

⁶ In addition to restricting factor mobility, we set the elasticity of substitution in grains production equal to zero. This permits us to treat grains supplies as pre-determined, with shocks to technology determining output in any given year.

⁷ More specifically, we map disaggregate estimates of these consumer demand elasticities from FAO to GTAP commodities, then we calibrate the CDE demand system in GTAP at the disaggregate level. These parameters are then aggregated to obtain the demand elasticities reported in Table 1.

stockholding. In the following equation, SR represents the ratio of stock changes to grains output, while PR represents the ratio of the grains price, relative to the consumer price index.

$$(1 - PR) = (1/C)[\ln(SR - SR_{\min}) - \ln(SR_{\max} - SR)] \quad (1)$$

In equation (1) $SR_{\max}$ is the maximum change in stocks, relative to output, while $SR_{\min}$ is the minimum change in stocks, relative to grains production. Stock changes in the model will never exceed these extreme values. Totally differentiating this stockholding function and rearranging, we may obtain its slope as follows:

$$\frac{dSR}{dPR} = - \left\{ \frac{1}{C} \left[\frac{1}{SR - SR_{\min}} + \frac{1}{SR_{\max} - SR} \right] \right\}^{-1} \quad (2)$$

From (2) we observe that as the price of grains rises, relative to the CPI, stocks are sold (negative change in SR). On the other hand, if production is exceptionally large in a given year and the relative price of grains falls, stocks will be accumulated ($dSR > 0$). The slope of this stockholding function depends on the parameter C , as well as one's placement on the SR axis. As SR approaches the maximum value, $SR_{\max}$, the price drop must be extremely large to motivate an increase in stocks, relative to output. Similarly, the slope approaches zero as SR approaches its lower bound, $SR_{\min}$. When SR lies halfway in between $SR_{\min}$ and $SR_{\max}$, the slope of this stockholding function is infinite.

This stockholding function interacts with the equilibrium structure of the model through the introduction of stocks demands, $QSTK$, into the market clearing relationship for domestically produced goods:

$$QDS(i, r) = \sum_j QFD(i, j, r) + QPD(i, r) + QPD(i, r) + QGD(i, r) + QSTK(i, r) \quad (3)$$

The most important point about (3) is that the stockholding entity is assumed to buy domestically produced commodities (as apposed to imports, or a composite of the two).

Determining the Impact on Poverty: In order to structure our thinking about the distributional effects of volatile grains supplies, consider the following first-order approximation to the percentage change in the i -th group's compensating variation relative to initial expenditure (cv^i):

$$cv^i = - \left(\sum_f \Omega_f^i w_f - \sum_n \theta_n^i p_n \right), \quad (4)$$

In equations (4), $\sum_f \Omega_f^i w_f$ is the percentage change in income received by group i , with Ω_f^i the share of income from primary factor f , and w_f the return to factor f . If the particular shock in question raises land rents and the poor household owns some land, then it will be better off, *ceteris paribus* ($cv^i < 0$). Likewise, θ_n^i is the i -th group's budget share for good n , and p_n is the percentage change in the price of that good. If the grains supply shock raises the price of food, then, *ceteris paribus*, the household will be made worse off. The degree to which this is the case depends on the relative importance of food in the household's overall consumption basket, as determined by the budget share, θ_n^i . If the overall share-weighted average for consumer prices rises relative to income, then compensation will be required ($cv^i > 0$) in order to hold this household at its initial level of utility.

The problem with the GTAP model, and previous analyses of the problem of grains supply volatility (Tyers and Anderson, Vanzetti) is that they focus only on the *per capita* household. However, any analysis of poverty must ask whether the *marginal* household at the edge of poverty is affected in a similar way. The differential effect of grains supply volatility on the *per capita* versus the *marginal* household may be seen using the decomposition in (5). Here, we introduce per capita changes in income (y) and consumer prices (cpi), as well as differences in expenditure and income shares between the marginal household m and the per capita household:

$$-cv^m = (y - cpi) + \sum_f (\Omega_f^m - \Pi_f) w_f - \sum_n (\theta_n^f - \lambda_n) p_n, \quad (5)$$

where Π_f is the share of primary factor f in the per capita household's income, λ_n is the share of

consumer good n in the average per capita household's budget, $y = \sum_f \Pi_f w_f$, and

$cpi = \sum_n \lambda_n p_n$. From this expression we can readily see that it is differences in factor earnings, and consumption shares that drive the differential effect of a given shock on the marginal, vs. the average household. If land rents rise, but the poor household earns a relatively low share of income from land,

then it will fare less well than the average household. The larger the total of the two right-most terms in (5), the greater the need for disaggregated analysis as opposed to *per capita* analysis when attempting to isolate the impact of trade policy on poverty.

Our approach to characterizing the consumption and factor earnings profiles of households across the income spectrum follows that of Cranfield *et al.* (2000) who investigate the distributional consequences of technical change in agriculture. Rather than disaggregating households in the GTAP model, those authors employ *post-simulation analysis*. This means that any changes in income distribution will not have an effect on the equilibrium prices generated by the model. Since the resulting changes in income distribution are relatively modest, those authors conclude that this approach represents a good compromise between *per capita* analysis and full-blown disaggregation of households in the GTAP model.

On the demand side, Cranfield *et al.* estimate a set of expenditure relationships by quintile for an international cross-section of countries using the ICP database in conjunction with the Deninger and Squire (1996) data on income distribution. Cranfield uses the AIDADS demand system (Rimmer and Powell, 1996), which has been shown to perform particularly well in predicting budget shares for food over wide ranges of income (Cranfield *et al.*, 2001). The estimation approach is such that parameters of the demand system are estimated while simultaneously utilizing data on the distribution of expenditure by quintile to permit recovery of the unobservable distribution of expenditure for each quintile. This requires data typically used in demand system estimation (*i.e.*, prices, per capita quantities and per capita expenditure), which come from the ICP database. Summary measures of the distribution of expenditure (*i.e.* variance, skewness, kurtosis, and quintile information) are also used from the Deninger and Squire data.

In order to permit a sharp focus on grains, the GTAP database is aggregated up to eleven sectors. These production sectors are mapped to the six International Comparisons Program (ICP) consumption categories of Cranfield *et al.* (1998) to permit a determination of spending effects on household welfare. The six ICP goods are (i) staple grains, (ii) livestock products, (iii) other food

products, (iv) other non-durable goods, (v) durable goods, and (vi) services. In order to use the commodity price changes from GTAP, they must be aggregated and adjusted to incorporate the marketing margins necessary to bring them up to the ICP consumer goods categories and prices used in demand system estimation, which is described below. To address this issue, a simple Cobb-Douglas wholesale/retail/trade sector is introduced in the post-simulation analysis. This sector combines GTAP producer goods with GTAP's trade and transport services to produce aggregated consumer price changes consistent with the general equilibrium results. We do not have data on the share of margins services embodied in consumer goods for the four focus countries. Therefore, we simply assume that for manufactures and processed products, the margin is equal to 50 % of the producer price. For farm products that are consumed without further processing, the margin is assumed to be 20 % of the producer price.

On the factor earnings side, in the ideal scenario we would have direct observations on the earnings shares (Ω_f^m) in equation (5). However, there is no comparable international set of estimates on the supply side to aid in the estimation of the factor earnings profile of low-income households. As with the consumption side, we use an indirect approach to estimate this relationship, capitalizing on data on the income distribution data from Deninger and Squire and total factor earnings in each region from the GTAP database for: unskilled labor, skilled labor, capital, and land. Specific functional forms are assumed for the distribution of ownership for each factor. For instance, it is assumed that land ownership changes as a linear function of an individual's relative position in the income spectrum. The values of the parameters of these functions are estimated so as to minimize the sum of squared differences between the given quintile fractions of economy-wide income, and those implied by the factor ownership allocation functions.

The next step in our analysis is to assess the impact of grain production variability on households at the poverty line in the four focus countries. We adopt the World Bank's definition of poverty as applying to households living on less than one dollar per day, where this is measured in

terms of 1985 international dollars. Based on an AIDADS expenditure function estimated for each country (which is used to characterize the consumption and factor earnings profiles of low-income households), we can then compute the poverty level of utility in each case. When a household that was previously below this level of utility rises above it under a given production/trade scenario, it is deemed to have moved out of poverty.

We can also use the AIDADS expenditure function to compute the transfer necessary to lift an impoverished household i out of poverty: $(z - y_i)$. This is a key factor in the computation of the Foster-Greer-Thorbecke (1984) poverty measure:

$$\Phi_{\alpha} = \frac{1}{n} \sum_{i=1}^n \left[\max \left(\frac{z - y_i}{z}, 0 \right) \right]^{\alpha} . \quad (6)$$

The most common values of α considered are $\alpha = 0, 1$ or 2 . Taking the convention that zero to the zero power equals zero, the case of $\alpha = 0$ results in a “head count” measure – the fraction of the population below the poverty level. We calculate the F-G-T measure at $\alpha = 0$ for each of the 28 simulations carried out to replicate variable grains production in each region. We then calculate the standard deviation of this headcount, indicating the frequency with which households move in and out of poverty under alternative trade regimes.

Simulating Supply Uncertainty: With this modeling framework place, we are able to generate distributions of world and domestic prices for consumption commodities, and for factor returns – and through the post-simulation module determine the implications for poverty under alternative trade regimes. The approach to handling uncertain supplies of grains involves use of the Gaussian-Quadrature approach of DeVuyst and Preckel (1997) for generating a set of weights associated with a sample of supplies from the distribution of grains production. To facilitate this procedure we assume that the regional distributions of grain production are independent⁸. Using the Gaussian-Quadrature approach requires that the general-equilibrium model be simulated 28 times for each trade regime. An

alternative procedure such as Monte Carlo would require as many as 1000 simulations for each of the trade regimes (computationally very expensive for a CGE model), and would likely offer little added precision (DeVuyst and Preckel).

V. Model Calibration and Specification of Base Case Trade Policies

It would be most natural to estimate the parameters of the stockholding function given by equation (1). However, for purposes of this paper, we adopt a more modest approach by which we calibrate the parameters based on observed data. First, we set $SR_{\max}$ and $SR_{\min}$ equal to the maximum and minimum observed stock ratios reported in Table 1 for each of the 14 regions in this study. Secondly, we simulate the modified model, using historical variation in supplies of grains for all 14 regions. We then adjust the parameter C in order to replicate observed national price variation.

Of course, the value of the stockholding slope parameter, C , which is compatible with observed price variation, historically depends critically on the price elasticity of demand for grains in each region as well as the trade regime that has been in place historically. Accordingly we have devoted some thought to the specification of these aspects of the model. As noted above, the own-price elasticities of demand for grains in the GTAP model have been recalibrated to disaggregate estimates from the Food and Agriculture Organization of the UN (FAO, 1993). However, the problem of specifying an appropriate trade regime over this historical period is much more difficult. Quite a number of countries have state trading entities that govern grains imports (and in some cases, exports). Until the recent Uruguay Round Agreement on Agriculture (URAA), there were also many non-tariff barriers (NTBs) in place. Quotas were widespread and the European Union maintained a system of variable levies whereby border protection varied endogenously in order to maintain a stable relationship between the market price of imports and domestic prices. The URAA mandated that all

⁸ This assumption is potentially quite important, and we hope to relax it in future work. It is used here because it was determined to be appropriate in previous studies (e.g. Vanzetti 1998), and it greatly facilitates the analysis.

such barriers be converted to tariffs⁹, but the resulting tariff bindings were set sufficiently high in most cases to permit a variety of trade-frustrating measures. In some cases, *de facto* variable levies have been maintained, via weekly adjustment of applied tariffs. In other cases, the NTBs were replaced by tariff rate quotas (TRQs) which permit a limited amount of imports at modest tariff, thereafter charging a prohibitive tariff on “over-quota” imports. Typically the quota level is determined by the country’s minimum access commitment – which is typically specified as a share of total domestic use. Depending on the administration of these quotas, the “fill rate” can vary widely – even for relatively low levels of in-quota tariffs. In short, it is very difficult to ascertain the precise economic impact of these trade regimes.

Because of the difficulty of modeling country-by-country grains trade policies, we have adopted a simple approach that aims to capture their essential economic features. Most of the interventionist trade policies seek to insulate the domestic market from volatile world market prices – and the target is commonly expressed in terms of the ratio of imports to domestic use. This may be done by managing quantities, as in the tariff rate quota case, or managing price, as in the variable levy case. In either case, the effect is the same – namely to frustrate substitution of imports for domestic goods when prices are low – while maintaining imports at the minimum commitment level, even when world prices rise. We model this by “swapping” the ratio of import to domestic prices with a source-generic import levy – in effect creating a variable levy system for the insulating regions.

In order to determine which regions have engaged in this type of insulation historically, we examined the time series data from the FAO on imports/domestic usage. Where this series appears to be very flat, we looked further into the institutions governing staple grains trade: do they have a state trading entity? Are they actively using variable tariffs or tariff rate quotas? This led us to select India, China, the European Union and East Asia (dominated by Japan and Korea) as price insulating regions

⁹ There were a few exemptions, most notably Japan and Korea rice imports, where a minimum access commitment was accepted, in lieu of tariffication.

for calibration purposes. In our policy scenarios, we will explore the implications of relaxing this assumption – and alternatively, expanding the set of regions engaging in this type of managed trade.

VI. Experimental Design

Our goal is to explore the interaction between alternative trade regimes and vulnerability of the poor, in the face of uncertain supplies of staple grains. Towards this end, we consider several different representations of global trade policies. These regimes are necessarily stylized, because we aim for global coverage. Our "base case" is set up to reflect current levels of trade openness, along with price insulation in the four regions noted above. The second scenario is intended to represent a "managed trade" scenario, in which the adherence to minimum access levels spreads to all net importing regions, so that only North America, Australia/New Zealand, and Thailand freely adjust their imports to relating price changes. In contrast, scenario (3) represents "non-managed trade" – in this case there is full price transmission in all regions (no insulating policies). In the final scenario we examine the case of completely liberalized trade, and full price transmission.

VII. Results

We begin by looking at the volatility of domestic staple grains prices under alternative trade regimes. *A priori* it is not clear whether increased exposure to trade will reduce this volatility for countries like India, where domestic production is relatively stable. Indeed, in the absence of a reduction in the volatility of staple grains prices on world markets, one might expect that an increased exposure to trade could actually increase domestic price volatility. However, from the results in Table 2, which reports the standard deviation of staple grains prices for each region under the four trade regimes, we see that managed trade entails the highest price volatility in every region. This is particularly true for Indonesia, Zambia, the Former Soviet Union, and the Middle East / North Africa. Comparing the first and third columns of Table 2, we see that grain prices are less variable in 12 of the 14 regions when no country insulates itself from the rest of the world. In the extreme case, when

countries go to fully liberalized trade, grain prices tend to have less variability than in any other case – China in particular appears to benefit from reduced price variation under the free trade scenario.

Table 2. Standard deviation of staple grain price under alternative trade regimes

	Base case: Managed trade in 4 regions	Managed trade in 11 regions	Non-managed trade at current tariff levels	Fully liberalized global trade
India	12.05	12.25	11.74	11.39
Indonesia	24.68	30.82	24.67	22.27
Thailand	16.00	16.85	14.50	13.53
Zambia	53.89	65.70	53.91	51.46
China	33.77	34.02	24.33	17.66
North America	22.31	23.58	20.80	18.79
Austral. & New Zeal.	19.92	20.65	19.27	17.72
Latin America	18.69	21.86	17.92	16.25
Europe	10.27	10.62	9.94	10.46
Rest of South Asia	12.96	15.35	12.87	12.68
Rest of Asia	12.23	12.25	10.12	10.59
Former Soviet Union	29.42	45.55	29.52	28.57
Mid. East & N.Africa	17.09	41.82	16.66	15.43
Sub-Saharan Africa	8.05	8.60	8.04	8.07

What implications do these trade scenarios have for the movement of households into and out of poverty? We now explore the results of our post-simulation analysis, in which the price distributions from the simulation exercise are plugged into the post-simulation income and expenditure systems for the focus regions. Zambia is omitted from this analysis, since some of the price outcomes violate the subsistence requirements for low-income households. Figure 5 is based on the F-G-T poverty headcount measure calculated for each country under the 28 production outcomes. Each bar in Figure 5 corresponds to the standard deviation, in percentage-point terms, of the number of people in poverty under a different trade regime. Analogous results, in absolute terms, are provided in Table 3. Here, population data from the World Bank (2001) is used to provide a further perspective on the standard deviation of the poverty headcount.

The first point worthy of note in Figure 5 is that the impact of grains volatility on measured poverty is quite small. The standard deviation of the headcount is less than one percent of the population in all three focus countries in Figure 5. This modest impact is due, in part, to the fact that we have only distinguished households by income level, not by geographic location or primary sector of employment. Thus all poor households benefit as agricultural producers when grains prices rise – although they are hurt as consumers of food. This offset is legitimate for rural agricultural households – where the bulk of the poor still reside, but it is not an accurate characterization of the impact on low income urban households. Future work must distinguish these households.

The second point to note about the results in Figure 5 is that the standard deviation of the poverty headcount is highest across all trade regimes for India. However, this is simply a reflection of the higher rate of absolute poverty in that country. Given that the expected value of poverty in the simulations is 49.5, 40.0, and 32.5 percent for India, Indonesia, and Thailand, respectively, poverty is most sensitive in Indonesia, and the least sensitive in Thailand, irrespective of policy scenario.

The third point to note about the results in Figure 5 is the relatively minor variation across alternative trade regimes. Despite the fact that commodity prices are one-fourth more volatile in Indonesia under managed trade, the poverty impacts of managed trade and the base case are virtually identical. On the other hand, the free trade scenario (last column in Table 2) exhibits the lowest commodity price variation in Indonesia, but the highest variation in the poverty headcount. A similar situation arises in the case of India. In Thailand, the rate of vulnerability is positively related to the degree of grain price variation – the free trade and non-managed trade scenarios simultaneously offer the most stability in prices, and the most stability in poverty headcount.

Figure 5. Standard deviation of poverty headcount (percent of population)

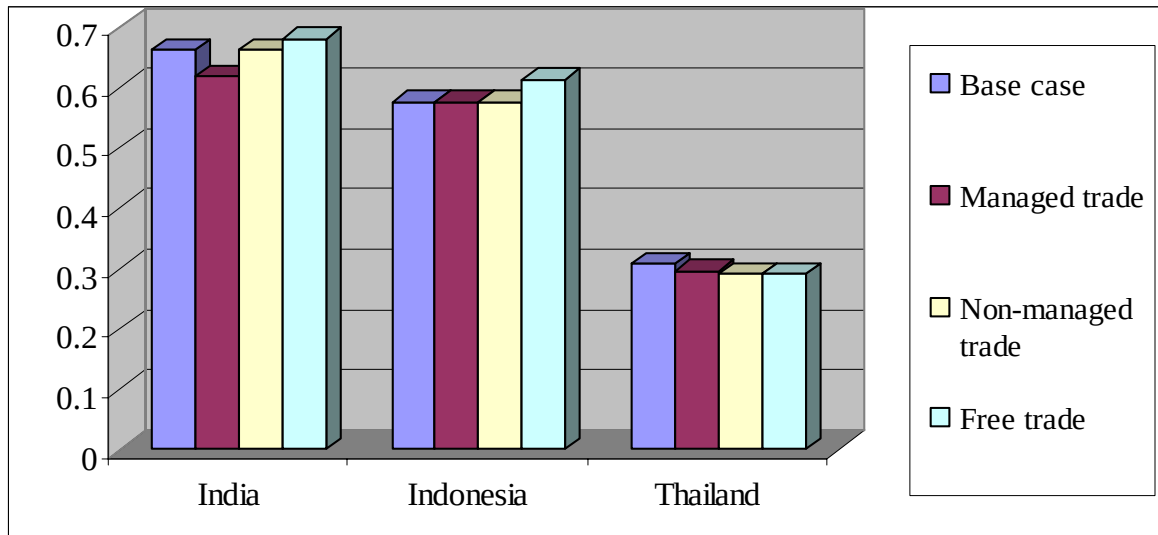


Table 3. Standard deviation of poverty headcount in absolute terms

				Standard deviation of the number in poverty			
	Population ¹⁰	Expected % in poverty	Expected number in poverty	Base case	Managed trade	Non-managed trade	Free trade
India	997,500,000	49.5	493,762,500	3,264,758	3,047,996	3,264,758	3,364,498
Indonesia	207,000,000	40.0	82,800,000	477,508	477,508	477,508	507,730
Thailand	60,200,000	32.5	19,565,000	60,417	58,049	56,758	56,758

VIII. Conclusions and future research directions

This paper introduces a framework has been developed to allow calculation of the rate at which households move into and out of poverty under alternative trade regimes. This framework extends previous multiregion analyses of this issue by taking into account both commodity and factor market effects and by extending the analysis beyond the per capita household. The proposed approach

¹⁰ Population data are from the World Bank, and correspond to the year 1999.

should be viewed as complementary to detailed country case-studies, which offer a definitive assessment for any one country.

Future research will seek to improve on the basic analytical framework in a number of ways. Firstly, we plan to refine our methods for calibrating the stockholding function of observed variation in historical prices and quantities. Use of this new feature of the model is still in its infancy. Secondly, we plan to add an additional dimension to the distributional analysis -- distinguishing households not only by income level, but also by the share of income from agriculture. This should help sort out the differential impact of staple fixed price volatility on urban households. Finally, more work is needed to appropriately characterize grains trade policies currently in use. Together, these efforts should significantly improve the quality of our analysis of this issue.

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