Distributional Effects of WTO Agricultural Reforms in Rich and Poor Countries*

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"Trade theory is about whose hand is in whose pocket and trade policy is about who should take it out." Finger (1980)

1. INTRODUCTION

This paper is about some well-known hands in well-known pockets but in new combinations and at a level of detail that has not previously been possible. For the first time it considers the trade-offs in global agricultural trade reform between farmers in rich and poor countries making use of farm-level and household-level data. It delves further into the distributional consequences of reform than previous research and in doing so lays bare some of the political economy that has made agricultural trade reform so tortured.

A common apology for preserving agricultural support is that it supports low income farmers in the North and that liberalization would benefit only the rich land owners in the South. While these assertions contain a few grains of truth, this paper shows that the net effects are the very

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opposite: it is the wealthiest of rich country farmers who predominantly gain from protection and farm households in poor countries who pay the price.

The Doha Development Agenda (DDA) of the World Trade Organization (WTO), which is in the process of being restarted after its collapse in mid-2006, has an explicit mandate to improve welfare and reduce poverty in developing countries (WTO, 2004). The bulk of the global gains from merchandise trade reform derive from reforms in agriculture (Hertel and Keeney, 2006; Anderson and Martin, 2006), and most of these gains are predicted to accrue to rich countries as they reduce outlays on farm programs and reduce protection for agricultural products. But such reforms also benefit many households in developing countries – particularly those in the farm and rural sectors, which comprise a majority of the world's poor – so it would seem that such reforms should be an easy sell to policy makers in rich and poor countries alike. Experience suggests the opposite.

While agricultural reforms in industrial countries are indeed likely to benefit large and diffuse groups of taxpayers and consumers, they will hurt some of the farm sector – with the impact concentrated on some of the most powerful and well-organized interest groups in that sector. By contrast, farmers in developing countries – the potential beneficiaries of reform – have little or no influence in the political process, while their urban counterparts have some interest in maintaining the status quo.

The political economy of trade policy has long recognized the greater effectiveness of concentrated lobbies – see, for example, Winters (1987) or Anderson (1995) and Ordent, et al. (1999) on agriculture – and 70 years ago Schattschneider (1936) recognized that one needs to evaluate such concentration at a fine level of disaggregation. Thus, in this paper we argue that the interesting issue in agricultural reform is not the potential global welfare gains, although these can be substantial (Anderson, Martin and van der Mensbrugghe, 2006), but rather, the medium run (2 – 3 years) *distribution* of the benefits and costs of reform across households in rich and poor countries. Given the ambition of this exercise, we can consider only the United States among rich countries, and 15 developing countries for which we can assemble household survey data on income sources on a relatively uniform basis.

While we are interested in the impacts of agricultural reforms previously deemed possible under the DDA, we also want to advance the policy-making agenda and so devote considerable attention to reforms that are not currently under consideration. Notably, we consider greater-than-Doha liberalization by developed and developing countries, which turns out to be pro-poor – and some compensation mechanisms which might reduce rich country opposition to agricultural trade reforms. There is a tendency at present to doubt that the WTO could ever deliver the sorts of reforms we discuss here. The immediate prospects are not auspicious, but we do not entirely despair for the longer run. Moreover, we believe that if developing countries can not collectively persuade developed countries to reform agriculture in the context of the WTO, they certainly will not be able to do so in the context of bilateral negotiations for regional trade arrangements such as are currently absorbing so much effort around the world.

This analysis contains four key steps: the specification of a plausible DDA agreement including the translation of these into cuts in actual agricultural support; calculating the impacts of such reforms on global trade, prices and production; tracing these global impacts back to different classes of farm households within the US; and tracing them back to households in our focus developing countries. The combination of these steps into a holistic framework represents a significant contribution of this work, which brings together data and modeling components to conduct global scale analysis.[1]

1.1. DDA Specification

There have been many studies of WTO trade reforms in the context of the DDA, but few of these bear close relationship to the actual negotiations undertaken in Geneva or to actual trade barriers in the world at the time the DDA will be implemented. In contrast, recent studies based mostly on the GTAP 6 database, recognize the significance of trade preferences for developing countries' exports (Bchir et al., 2005; Bouët, et al., 2004) and also that the DDA will be implemented in a world in where China has acceded to the WTO and the EU has been enlarged.[2] This is the approach taken here. We build on two recent World Bank projects which begin with tariff line data and specify agricultural market access scenarios based on detailed analysis of tiered formula cuts in current levels of tariff bindings (Anderson and Martin, 2006; Hertel and Winters, 2006). In cases where post-reform bindings fall below currently applied tariff levels, liberalization is predicted to occur. If this is not the case, no actual liberalization occurs despite the reduction in tariff bindings. This detailed analysis is particularly critical for analyzing developing countries, where bound tariffs are high and reductions in these bindings are modest due to special and differential treatment (Jean, et al., 2006). Similar detail is necessary for prospective reductions in domestic support (Jensen and Zobbe, 2006).

Given a set of plausible liberalizations, we need to translate these into a set of changes in prices, outputs, inputs, etc. around the world. Since reforms are widespread sectorally and geographically, this requires a global, multi-sectoral, general equilibrium approach as epitomized in global computable general equilibrium (CGE) models. Many such models have been used to analyze trade reforms, each emphasizing different features according to the authors' purpose. Box 1 offers a brief introduction to the essential features of CGE analysis.

[Insert Box 1 here]

[1] We also offer modest methodological advances on the previous literature in two of the four steps.
[2] Studies dated prior to 2004 typically miss these features.

1.2. Distributional Impacts for US Farm Households

US farm household data are taken from the Agricultural Resource Management Survey (ARMS) (USDA-ERS, 2005). This comprehensive survey of US farm households is conducted over a sample of around 15,000 households using economic and geographic sampling frames. These data distinguish farm households' places in the wealth distribution, commodity sources of farm income, and detailed information on off-farm income so that changes in total income and welfare can be calculated in the wake of agricultural reforms. Keeney (2005) uses these data to analyze the distributional consequences of stylized WTO scenarios, representing the only previous analysis of US farm household impacts of a Doha agreement. The ARMS data have served as the source for other disaggregate analyses (most notably Hanson and Somwaru's (2003) work on the WTO acceptability of counter-cyclical payments) but in these cases the distributional character has been focused on farm structure rather than the welfare focus of Keeney (2005), and global reforms have not been considered.

1.3. Distributional Impacts for Poor Country Households

Winters (2002) and Winters et al. (2004) provide an analytical framework and evidence on tracing the effects of trade policy through to individual households and poverty. Hertel and Reimer (2005) develop this framework in the context of CGE modeling. We believe that the impact of trade reform on individual households will vary widely depending on their sector of primary employment, their endowments, and their consumption patterns. Therefore for each of our 15 focus developing countries we utilize household survey data to divide households into seven classes (strata) according to their principal income source and estimate factor-specific poverty elasticities for each country and stratum combination. These elasticities are incorporated directly into our global CGE model and embody information about the shape of income distribution and income sources in the neighborhood of the poverty line. When combined with estimates of consumption behavior at the poverty line, those estimates allow for accurate assessments of how poverty headcounts will likely change in the wake of WTO trade reforms. Drawing on the results for the 15 developing countries in our sample, we seek to arrive at some general conclusions about the poverty impacts of trade policy reforms in rich and poor countries.

The remainder of the paper is organized as follows. We proceed with discussion of the unique analytical framework created for this study's analysis of the distributional impacts of WTO reforms in both rich and poor countries. Following that, we outline the policy scenarios to be applied in this framework. The results section begins with discussion of changes in macroeconomic indicators for trade, prices, and national welfare as well as changes in US farm household welfare and change in developing country poverty focusing on the impacts of agricultural reforms undertaken in rich countries. We extend this analysis to global reforms and non-agricultural sectors, separately identifying the contributions of these reforms to the poverty headcount results. The concluding section summarizes our findings and offers policy recommendations.

2. ANALYTICAL FRAMEWORK

Figure 1 provides an overview of the analytical framework used in this paper. The boxed items in the top rows represent inputs to the framework, and the double boxes at the bottom of the Figure represent outputs of particular relevance to this study. The other entries represent intermediate steps in the analysis. As can be seen, we begin with three fundamental sources of data: household survey data from the US, household survey data from the 15 focus countries, and the GTAP data base. Agricultural earnings data in the latter two sources are reconciled, as the GTAP data are notoriously weak when it comes to the estimation of returns to self-employed labor in the farm sector (see Annex III for details). The reconciled survey data are used to compute the poverty elasticities discussed in Box 2, while the revised GTAP data are used to specify agricultural technology in the global CGE model. Other inputs to the global modeling exercise include: farm income sources by farm type for the US, the poverty headcounts, by region, for $1/day and $2/day, the estimated parameters for our consumer demand system, estimates of farm factor supply and demand elasticities from the OECD, as well as the trade reform scenarios (see Table 6). These inputs are combined with a modified version of the GTAP CGE model of the global economy.

With this overview in mind, a bit more needs to be said about the aspects of this analytical framework that are key to our analysis. Our starting point is the GTAP version 6.1 data base (Dimaranan, 2006). Virtually all contemporary analyses of the Doha Development Agenda start at this same point. Data availability is easily the most limiting resource for global analysis and GTAP version 6 represents the only data base covering global economic activities with bilateral trade and protection data that reflects tariff preferences. This also permits us to draw on the carefully constructed Doha reform scenarios developed and utilized in the recent books by Anderson and Martin (2006), and Hertel and Winters (2006).[3] These scenarios also involve a pre-experiment in which key trade policies are updated to 2005, and it is from that new benchmark that the trade liberalization experiments proceed.

Our modifications to the standard GTAP model focus on features that enhance analysis of agricultural reforms and simulation of distributional impacts. We retain the simplistic yet empirically robust assumptions of constant returns to scale and perfect competition typically

[3] These tariff cutting scenarios are now available on the GTAP web site to those wishing to replicate this work. For purposes of this paper, we have used scenarios S0 (pre-simulation with China's WTO accession, EU enlargement, etc.) and S8: the central Doha scenario used in the Hertel-Winters volume.

featured in agricultural trade studies.[4] Our modifications are aimed at permitting us to shed new light on the distributional consequences of WTO reforms – focusing particularly on the seemingly intractable problem of agriculture liberalization in the industrial countries. We turn now to these modifications.

2.1. Factor Markets>

Since the work of T.W. Schultz (1945), economists have recognized the importance of off-farm factor mobility in determining farm incomes. Significant wage differentials between farm and non-farm employment persist in the United States and other high income economies (Gardner, 1992; Kilkenny, 1993). The limitations of agricultural labor markets have also been prominently featured in the development economics literature, as an explanation for the very low level of agricultural supply response (de Janvry *et al*., 1991). The common CGE assumption of perfect mobility of labor and capital from agriculture to non-agriculture forcing wages to equalize at each point in time for farm and non-farm workers, with comparable skills, is at odds with historical observation.

Effectively modeling the complex processes leading to limited farm/non-farm, rural/urban mobility for the full range of countries in our model would be a lifetime project. Instead, we specify a constant elasticity of transformation function which "transforms" farm-labor into non-farm labor and vice-versa. This transformation function permits wages to diverge between the farm and non-farm sectors, a key driver in our distributional analysis. With segmented labor markets, the impact of reduced subsidies to agriculture in the rich economies will not be shared equally between the farm and non-farm labor forces. Similarly, the benefits from higher farm prices in developing countries following rich country reforms will not be shared as widely with non-farm households in the presence of factor market segmentation.

Much of the reasoning behind differing agricultural and non-agricultural labor rewards similarly applies to returns to agricultural investment. Therefore, we also introduce a constant elasticity of transformation function governing capital movements between agriculture and non-agriculture, with full capital mobility (a unique rental rate on capital) only applying across uses within these two broad sectors.

The extent of burden shifting between farm and non-farm labor and capital will depend on the size of the associated factor supply elasticities. In order to calibrate these key parameters, we draw on the OECD's (2001) parameterization of agricultural factor markets which derive from comprehensive econometric reviews for the EU (Salhofer, 2001) and for North America (Abler,

[4] Francois et al. (2004) introduce monopolistic competition in the manufacturing sector into their analysis of WTO reforms. The resulting variety and scale effects generally boost the gains to rich countries and dampen the gains to poor countries from rich country reforms. However, the predominance of variety gains and losses in this framework can be questioned, and this feature also makes their model less stable; given our focus on agricultural reforms, we have chosen to exclude this feature from our analysis.

2001) as well as a modeling panel's assumptions for the Japanese economy. These elasticities are intended to represent medium term adjustment possibilities (i.e., 2 – 3 years). Thus we gear our analysis around medium term outcomes from trade reform. (This is appropriate, since our CGE model does not take into account the impact of trade reforms on investment, productivity and economic growth.)

We assume a constant aggregate level of land, labor, and capital employment reflecting the belief that the aggregate supply of factors is unaffected by trade policy. This is not the 'full employment' assumption sometimes derided by advocates of structuralist models of development; rather it assumes that aggregate employment is determined by factors such as labor market norms and regulation that are largely independent of trade policy in the long run. Absent sufficient detail on these employment drivers, we look to wage changes to clear farm and non-farm labor markets in each country.[5]

2.2. Rich Country Farm Household Impacts

The potential for adverse impacts on rich country farm household incomes has received far less attention than the distributional impacts in poor countries, yet it represents a key component of the political economy of WTO trade reform. A primary factor in determining the impact of agricultural reforms on farm household welfare in rich countries is the share of their income that currently comes from the farm sector. If farm income is only 10% of total household income, then a 10% drop in farm income translates into just a 1% drop in overall household income (for constant non-farm income). Recent OECD (2003) statistics report the on and off-farm income split for farm households in numerous member countries – see Annex Table A.6.1. Farm income provides only 8% of the total income of US farm households and 10% and 12% in Canada and Japan respectively. In Europe the share is larger, in 60%-70% range.

In the global CGE model, we model a representative farm household for each region and explicitly track the allocation of its labor and capital between the farm and non-farm sectors (recall the factor supply elasticities above) and the allocation of its land across agricultural uses. As returns in agriculture fall when subsidies are removed, farm households reallocate some farm-owned resources to the non-farm sector as well adjusting the output composition to changes in relative land returns. Total farm household income in the model is then determined as the sum of returns on their endowments employed in agriculture, plus the returns on those employed in non-agriculture.

While the average farm household's welfare change is an important component in assessing WTO outcomes for any given country, greater detail on the distribution around this average is required to develop insight into the political economy of agricultural reform. This requires more

[5] This market clearing assumption means that our model does not generate the large changes in competitiveness that Polaski finds when real wages become misaligned.

disaggregate data. We have obtained these data for the US, and we use a "micro-simulation" approach in which the general equilibrium changes in product and factor prices are combined with disaggregated household data to evaluate the welfare impact on different groups of farm households in this country. These different groups are defined first by their product specialization and then by their place in the wealth distribution of similarly specialized producers. The households and their initial income sourcing are benchmarked using the ARMS annual survey data of the United States farm household population for 2004. The ARMS survey data has no longitudinal component. Hill (1996) argues that in such cases wealth provides a suitable substitute for multi-period averages necessary to accurately gauge the income position of farm households. Accordingly, we group households by wealth decile.

Table 1 identifies the disaggregate US farm households of our study. They represent income specialized households in four highly protected sub-sectors: dairy, cotton, rice and sugar, and a residual category of non-specialized farm households. The specialization criterion is that at least 1/3 of farm revenue be derived from rice, cotton, or dairy (to be specialized in those products), and 1/5 of farm revenue from sugar (to be specialized in sugar). The second line of delineation among households distinguishes eleven intervals in the wealth distribution of each specialization group. The farm income share for the specialized groups ranges from 0.22 to 0.92 with larger dependencies for wealthier farms. The residual category "Other", is by far the largest in the population and mirrors the aggregate distribution of US farm households. Its low farm income shares contrast sharply with those of the specialized farms.

The choice of dairy, sugar, rice, and cotton as focus households is driven by the level of support and protection these products enjoy in the US: about 50% of total producer revenue for US milk, sugar and rice is attributable to farm programs (OECD 2002) while government programs provide about 35% of revenue for cotton producers (Sumner, 2005). Other products like maize and oilseeds receive less support in the US (25%) as do livestock products (less than 5 %). In addition, maize, oilseed, and livestock producers in the US tend to be much more product-diversified in farm revenue. Thus, the focus of our analysis is squarely on those households specialized in highly protected products. In particular, we believe that high levels of support foster income specialization and specialization enhances interest group formation and lobbying around a specific agricultural product. Our results will provide insight into this dynamic that disfavors policy reforms in the most needed areas.

2.3. Poverty Assessment

There are many dimensions through which rich country reforms affect developing countries. Here we focus on the poverty headcount – that is, the proportion of the population that falls below the poverty line. This is the most widely cited figure in the literature, and, by considering two different poverty criteria ($1/day and $2/day), we explore the sensitivity of our findings to the choice of poverty line. We do this for 15 focus countries for which we have been able to assemble comparable household survey data. These countries are listed in Table 2 and together they span the continents of Africa, Asia and Latin America. In the aggregate, they account for nearly 1 billion people, and more than 400 million poor (measured at the $2/day poverty line; 150 million poor when evaluated at the $1/day poverty line). While they are not a random sample, they do span a wide range of per capita income levels as well as differing degrees of industrialization. Therefore, as we will see, the location and earnings patterns of the poor in these 15 countries vary greatly.

There are many alternative approaches to estimating the poverty impacts of trade reforms (Annex II). The analytical approach used here builds on that of Hertel et al. (2004), which employs a sequential, macro-micro modeling strategy in which results from the global model are passed on to a series of micro-simulation models. In this paper we summarize the key characteristics of these micro-simulation models using *highly disaggregated* poverty elasticities – describing the impact of a change in various components of earnings on poverty within a given population group, or stratum. This permits us to present and analyze our results for all 15 focus countries in a compact and easy to understand manner while maintaining the diversity of poverty outcomes under global trade reform.

A key finding in the work of Hertel et al. (2004) is the importance of stratifying households by their primary source of income. Unlike some of the rich countries (and particularly the US, as discussed above), farm households in developing countries often rely on the farm enterprise for virtually all of their income and are likely to be highly diversified in the products grown on the farm. Furthermore, the share of national poverty concentrated in these agriculture-specialized households is quite high in the poorest countries in our sample – between one-quarter and one-half of the $1/day headcount in Chile, Colombia, Indonesia, Malawi, Mozambique and Zambia. On the other hand, this share is relatively small in Mexico, Peru and Thailand, where a much smaller proportion of the households are engaged in farming, as well as Vietnam, where rural households are more likely to have substantial off-farm income.

Not only are farm households in the poorest countries more likely to be specialized in farming, these specialized farm households also tend to be poorer, on average, than the rest of the population. This point is evident from Figure 2 which plots the poverty headcount in the entire population (horizontal axis) against the poverty rate in the agriculture-specialized group (vertical axis). With the exception of Peru, Mexico and Venezuela, which lie slightly below the 45 degree-line, it is clear that agriculture specialized households have a higher poverty rate – indeed, in the case of Brazil, this is about six times the national poverty rate. The implication of this pattern of farm income specialization is that the poorest households in the poorest countries are more concentrated on agriculture and therefore more likely to benefit from producer price increases engendered by multilateral trade reforms.

We follow Hertel et al. (2004) in identifying five household groups that rely almost exclusively (95% or more) on one source of income: agricultural self employment, non-agricultural self-employment, rural wage labor, urban wage labor, or transfer payments. The remaining households are grouped into rural and urban diversified strata, leading to seven total strata. Table 2 reports the share of the total national poverty headcount ($1/day) arising in each stratum, for each of our 15 focus countries. Agriculture specialized households and rural diversified households tend to dominate the poverty headcount, although exceptions are Colombia, Venezuela and Peru, where self-employed, non-agriculture households contain a large share of the poor.

The change in the national poverty rate is calculated from the changes in the poverty headcount in each stratum. The latter depend on the density of the income distribution in the neighborhood of the poverty line. This can be usefully captured by the stratum-specific poverty elasticities which have been computed numerically based on the cumulative income distribution taken from the household survey data for each of the focus countries (Box 2). These are reported in Table 3, and they answer the question: If incomes in a given stratum rise by 1%, what percentage reduction in the poverty headcount will be achieved? They range from a low of 0.0006 in the self-employed agriculture stratum in Zambia, where nearly all of the population is well below the poverty line, to a high of 3.63 in the urban diversified stratum of Brazil, where the population density at the poverty line is quite high.

[Insert Box #2 here]

However, all income sources are not equally important for households in poverty. In most cases these households own few assets, and have few skills, so their primary endowment is unskilled labor. Increased returns to capital in the wake of trade reforms will do little to reduce poverty. However, a rise in the unskilled wage will make a great deal of difference. This fact is captured in our work by disaggregating the poverty elasticities by income source, as shown in Table 4 for the case of Peru. These elasticities measure the percentage change in stratum poverty headcount, in response to a 1% increase in returns to different types of household endowments.

So, for example, from the first entry in row 2 of Table 4, we see that a 1% increase in unskilled wages in Peruvian agriculture reduces the $1/day poverty headcount in the agriculture stratum by 1.41%. It also contributes to poverty reductions in the diversified households. Indeed, the elasticity is slightly higher for urban diversified households than for rural diversified ones, indicating that these households earn a non-negligible share of their income from agriculture self-employment, despite their urban status in the survey. Labor income is also dominant in the other strata, although in the case of non-agriculture, it is non-agricultural, self-employed labor, and in other cases it is wage labor. Note also that the non-agriculture and wage-labor specialized households receive income from both skilled and unskilled labor.

Returning to the agriculture stratum poverty elasticities in the first column of Table 4, we see that, in addition to unskilled labor, there are also small elasticities for land, agriculture capital and transfers. If returns to all of these income sources were to rise by 1%, then stratum income would rise by 1% for all households, including the households at the poverty line. Therefore, the elasticities in Table 4 sum (column-wise) to the same figure displayed in Table 3 for this particular stratum.

As noted in Table 2, in addition to the agriculture stratum, the rural diversified stratum is a very important repository for the poor in most of our focus countries. For this reason, it is interesting to examine the poverty elasticities for this particular stratum across the full range of focus countries. These are reported in Table 5. To facilitate comparison across countries, we have normalized these elasticities, by dividing by their total (e.g., 1.05 for the rural diversified households in Peru, as taken from the last column of Table 3). So the elements in each row of Table 5 represent the contribution of each endowment to the total poverty elasticity for the rural diversified stratum in a given country. Clearly the composition of the aggregate poverty elasticity for the rural diversified stratum varies considerably across countries–further evidence of the great variety of developing countries included in our sample.

As expected, unskilled earnings are generally dominant in the rural diversified households' earnings profile, with the type of earnings depending on the sector in which the labor is employed. Land rents are generally unimportant for the poor, excepting in the case of the Philippines, and, to a lesser degree, Uganda. Skilled labor also plays a small role in earnings at the poverty line in these countries, and hence contributes little to the poverty elasticities. Agriculture and non-agriculture capital plays a more important role in some countries – most notably non-agriculture capital in Vietnam, where it accounts for 55% of the poverty elasticity for the rural diversified households. Transfer payments are quite significant at the poverty line in the wealthier countries – most notably Brazil, Chile and Thailand, where they account for more than a third of the total poverty elasticity for the rural diversified households.

The ten different income sources in Table 5 must be mapped to factor earnings in the general equilibrium model. For example, agricultural labor and capital receive the corresponding farm factor returns from the general equilibrium model, as do non-agricultural labor and capital. Wage labor reported in the survey presents a problem, since we don't know how much of this is employed in agriculture vs. non-agriculture activities. For this reason, we simply assign to it the economy-wide average wage – a blend of the farm and non-farm wages. Finally, transfer payments are indexed by the growth rate in net national income (Annex V offers elaboration on this choice).

Of course our evaluation of household welfare depends not only on earnings, but also on what happens to consumer prices. With food prices likely to rise in the wake of rich country agricultural reforms, and with the poorest households potentially spending the bulk of their income on food, this could have adverse consequences for poverty. Therefore, we turn next to our treatment of consumer preferences.

2.4. Household Preferences and Welfare

Given the emphasis in this paper on household welfare – in both rich and poor countries – it is important that we pay close attention to the specification of household preferences and the resulting pattern of demands across the income spectrum. The approach used here follows closely that of Hertel et al. (2004) insofar as we begin with an econometrically estimated, international, cross-section demand system, which is then systematically adjusted to reproduce national per capita demands. These national preferences are then used to predict demands across the income spectrum within each country; in particular they are used to assess the impact of consumer price changes on households at the poverty line in our 15 focus countries. In the US, the national demand system is used to evaluate welfare for each of the farm household groups discussed above.

The demand system chosen for this task must be flexible enough to explain the broad pattern of consumption in Malawi, on the one hand, and the United States on the other. Accordingly, we follow Hertel et al.(2004) in using a demand system – nick-named AIDADS -- which features highly non-linear Engel curves and has been shown to perform very well in out-of-sample predictions of per capita international demand behavior (Cranfield et al., 2003; see Annex IV for a detailed discussion). For our purposes, the key feature is that the chosen demand system allocates two-thirds of its parameters to predicting behavior at extremely low income levels, which is what we need to predict the consumption impacts on the poor. Estimation of this demand system for this paper is undertaken using the 80-country, per capita consumption data set offered by GTAP, version 6.1, and it is subsequently nationally calibrated to reproduce observed demands in each country; the resulting parameters are reported in Annex IV.

The best way to understand the implications the estimated demand system is to view the results for a particular country. Figure 3 plots the predicted household budget shares for Peru, across the income spectrum. These show how the pattern of consumer expenditures are predicted to vary from the subsistence level (origin of horizontal axis), where expenditures on food and clothing are dominant (budget share of nearly 60%), to the national per capita expenditure level where the household budget is more diversified (the horizontal axis reports the natural logarithm of consumption expenditure, per capita, and extends only to the national average income level). Vertical lines denote the $1/day, $2/day and national per capita expenditure levels. Note that at $1/day poverty line, 49% of the budget is devoted to food, with the bulk of this spent on crops. The initial levels of utility at the two poverty lines are each fixed, and the estimated demand system is used to determine the change in the cost of attaining this exogenous poverty level of utility when prices and demands change following trade liberalization.

3. POLICY SCENARIOS

Our attention in this paper is on the distributional impacts of WTO reforms in agriculture. Since such reforms are most contentious in the rich countries, we focus initially on impacts from liberalizing agricultural policies in the rich countries alone. The OECD produces annual estimates of the producer support estimate for its member countries. Rice is far and away the most protected commodity by this measure; on average OECD rice producers receive 80%+ of their revenue as a result of some policy intervention. Both sugar and milk producers in the OECD receive over 40% of their revenue from some combination of market intervention and direct government support, while other grains and oilseeds lie below that level.

Across countries, the producer support for OECD member countries varies widely ranging from a low value of 1% of producer revenue in New Zealand to a high value of 69% of producer revenue in Switzerland (Annex Table A.6.2). For the OECD in aggregate, transfers to producers account for 31% of revenues. Producer support in the EU is near the OECD-wide average. In Western Europe and East Asia producer support is considerably above the OECD average, while that in North America and Central and Eastern Europe is somewhat below. Australia and New Zealand provide minimal support to producers through agricultural policies.

The OECD producer support estimate is a combined measure of all support to producers capturing the transfer of treasury monies paid to farmers as well as the transfers from commodity sales at prices supported above world market levels. Thus this subsidy measure can be broadly decomposed into market price support (i.e. border policies) and farm policy transfers including output and input subsidies, area- and livestock headage-based payments, and the various payments tied to land use, farm income, and historical payments. The relative importance of these differs across countries but in most instances the division between market price and other support is roughly equal. The primary exception is in East Asia (Japan and Korea) where producer support is provided nearly entirely as market price support.

The WTO separates support policies into three groups, with separate negotiating modalities for each of them. Translating from the OECD producer support measure to the WTO's aggregate measure of support framework is not straightforward. The market price support component captures both the market access and export subsidy pillars of the WTO agricultural negotiations. The remaining portion of the OECD measure poses a significant challenge for quantifications in the context of the WTO domestic support negotiations, as these are differentiated according to "traffic light" designations (amber, blue, and green boxes) that intend to characterize the level of distortion created by a particular policy implementation. This complexity of moving from the OECD's comprehensive domestic support data base to the WTO domestic support framework is the reason we draw on the published study by Jensen and Zobbe (2006) for our Doha agricultural scenarios. These authors consider in detail not only the WTO designations of support, but also the associated binding overhang versus actual support levels that we can not evaluate by looking at the OECD producer support estimates in isolation.

The Doha scenario considered in this paper derives from the so-called July 2004 Framework Agreement (WTO, 2004) as embodied in the core scenario from the Hertel and Winters volume (2006) and is summarized, along with the other policy scenarios considered in this paper, in Table 6. The first column of this table highlights the implications for cuts in support in the rich countries' agricultural sectors – the main focus of this paper. This Doha scenario assumes that industrial countries with domestic support in excess of 20% of production cut their bound commitments by 75%, while others cut by 60%. However, even with these ambitious reductions, the gap between bindings and applied policies, as well as the inclusion of market price support concepts mean that effectively only five WTO members would be required to reduce actual support, based on 2001 notifications: Australia, EU, Iceland, Norway, and US (Jensen and Zobbe, 2006). Export subsidies are the one area where bold cuts (full elimination) are on the table, and we assume this outcome in our Doha scenario. When it comes to developing countries (see column three) domestic subsidy bindings are cut by 4%. In this case, Jensen and Zobbe (2006) estimate that only Thailand's subsidies would be affected.

Agricultural tariffs in the rich countries are reduced using a tiered formula, with marginal cuts changing at 15 and 90% initial bound tariff rates. The marginal cuts are 45% on the first 15 percentage points of the tariff, 70% for the range between 15 and 90%, and 75% on the remainder.[6] For developing countries, the inflection points are placed at 20, 60 and 120% bound tariff levels in agriculture, with marginal cuts of 35, 40, 50 and 60%, respectively.

Of course, cross-sector trade-offs are at the heart of the WTO negotiations, so we also consider the impact of non-agricultural elements of a prospective Doha Development Agenda on both rich and poor countries. Given the importance of non-agricultural income to farm households in many of the rich countries, this also could have a direct bearing on farm household welfare. In the case of poverty impacts in developing countries, improved access to rich country manufactures markets, as well as access to the markets of other developing countries can have an important impact on the demand for unskilled labor, and hence poverty rates.

Following Hertel and Winters (2006), we focus the attention of our non-agricultural shocks on market access (see column 3 of Table 6), since barriers to services trade and investment remain difficult to quantify and these parts of the WTO negotiations appear unlikely to yield significant changes in the near term. Specifically, non-agriculture tariffs are subjected to proportional cuts of 50% for developed and 33% for developing countries. The Least Developed Countries are not required to cut tariffs under this central scenario (see Anderson and Martin, 2006). As a consequence of these relatively ambitious tariff cuts in both farm, and non-farm

[6] For example, a tariff of, say, 100% is cut by 66.95%: = [15%*0.45 + (90-15)%*0.70 + (100-90)%*0.75]. By applying the cuts at the margin we avoid the discontinuities implied by the July Framework.

trade, average world-wide tariffs for all merchandise trade drop from 4.7% in the baseline to 3.2%.

In order to establish a benchmark set of liberalization results from which to make comparisons, we begin by examining the distributional consequences of the complete elimination of rich country support for agriculture. We then consider the portion of this impact that would be delivered under the particular Doha scenario discussed above. After this, we add, in turn to non-agricultural reforms in the rich countries, and liberalization in the developing countries (both agricultural and non-agricultural).

Finally, we consider the likely scenario that governments in rich regions will opt to compensate adversely affected farm households through WTO green-box means. These green-box payments are tied to land use, not output, and are designed to be neutral across farm products (i.e. the subsidy is not contingent of a specific use of the land). As such they generate minimal distortions in world markets and so are in line with WTO guidelines as their primary effect is simply the transfer of income from taxpayers (including farmers) to farmers.

Throughout our analysis, we employ a macroeconomic closure which fixes the ratios of government spending, tax revenue, net national savings, and the trade balance, all relative to net national income. This closure facilitates linking the aggregate and disaggregate welfare impacts of trade reform (see the Annex 5 for an extended discussion of our closure assumptions and their implications).

4. RESULTS

4.1. Agricultural Liberalization by the Rich Economies

Before discussing the farm household impacts, we consider briefly the macro-economic impacts of these policies. Complete liberalization of rich country farm policies generates some very large trade volume increases for rice, sugar and beef products where border protection is dominant, whereas world trade in coarse grains and cotton actually falls, as rich country subsidies are eliminated and exports are reduced. Under the Doha scenario, which emphasizes trade volume-reducing export subsidy elimination, as opposed to trade volume-increasing tariff reductions, the global trade volumes for wheat and dairy products also fall. Details are available in Annex Table A.6.3.

We begin our discussion of model results by looking at the national macro-economic impacts of the reforms. These are reported in Table 7 using the two key national indicators of the percentage change in the regional terms of trade (ToT; an index of export prices, relative to import prices), and the percentage change in real aggregate consumption (national welfare derived from the private consumption of goods and services). For this first table of model results we report mean (in bold) as well as upper and lower bounds from a 95 % confidence interval for each result. This allows us to evaluate whether a particular result is significantly different from zero (we note the cases where they are not with a hash mark: #) as well as evaluate when confidence intervals for two scenarios overlap (meaning we can not say with 95 % confidence that one scenario produces a different result than another)[7]. These sensitivity results refer to the robustness of results to the uncertainty inherent in our estimated trade, factor demand and supply elasticities, as these are the crucial parameters in our model. They have been generated using the Gaussian Quadrature method of numerical integration. This procedure shares many properties with the common Monte Carlo simulation sensitivity process of drawing from a set of parameter distributions, but is considerably more efficient due to the intelligent selection of evaluation points.[8]

Turning to the results reported in Table 7, we first note from these results that agricultural liberalization is good for the rich countries (welfare rises). Furthermore, these changes are statistically significant from zero (no # marks next to them). The fact that reform of this highly distorted sector will benefit the rich countries should come as little surprise, and it is well-established in the literature (Anderson, Martin and van der Mensbrugghe, 2006; Francois et al., 2005; Dimaranan, Hertel and Keeney, 2004). The roadblock to agricultural reform has to do with the concentration of losses among key interest groups – a point to which we will turn shortly. Note also that the Doha reforms capture a significant share of total gains available to Europe under full agricultural reform, and a little under half in other rich countries. In fact, for Europe we can not even establish with 95% certainty that the welfare gains from Doha reform will be lower than those from full reforms based on the confidence interval bounds (i.e., they overlap)

A somewhat more controversial point has to do with the impact of rich country agricultural reforms on the developing countries. Here, the key mechanism for transmission of economic welfare is through the terms of trade (ToT). If a country is a net importer of food products and the world price of food products rises, then the ToT might be expected to deteriorate. This is the case of Bangladesh, for example, which, according to Table 7, experiences a 0.60% ToT deterioration under Rich-Agr-Full Liberalization, and a 0.25% ToT decline under the Rich-Agr-Doha scenario – both of which are statistically significant. This is primarily due to higher prices for cotton, wheat and oilseeds. With a deteriorating ToT, Bangladesh can afford fewer imports for a given amount of exports and real consumption is expected to decline. On the other hand, Brazil, with a 5.48% ToT appreciation, can now consume more imports, or export less and consume more domestic production, so its welfare rises.

[7] In subsequent tables of results we only note when a result can not be distinguished from zero with 95 % confidence.

[8] Because of the quadrature-based intelligent selection of evaluation points, our model results needs to be well-approximated by a third-order polynomial. Arndt (1996) has tested and developed the procedure for the GTAP model finding that a third-order polynomial does provide a good approximation to GTAP model results and that GQ results are quite consistent with those generated from Monte Carlo simulations. Our particular implementation of Gaussian Quadrature (GQ) also requires that we assume parameter distributions are symmetric and that parameters are independently distributed.

Of course, the story is a bit more complex for two reasons. First of all, in a world of differentiated products, there is no single "world price" for a good. Even a commodity like rice is differentiated and many different prices can co-exist in the world market at one point in time. So it can matter whether you source your rice from a country whose price is rising, for example due to the elimination of an export subsidy. This is the case with dairy imports into Venezuela from the EU and US. Venezuela also suffers from higher import prices for manufactures from Brazil, since the latter country experiences a real appreciation. In short, Venezuela is an example of a country that experiences ToT and consumption losses due to its specific pattern of imports. (A full decomposition of the ToT results is available in Annex Table A.6.5.) Overall, we find that the ToT deteriorate in 8 of the 15 focus countries in the case of full agricultural reform in the rich countries, with the number being somewhat larger (10 of 15) in the case of the Doha reforms. The latter result follows from the greater emphasis of Doha on export subsidies as opposed to market access.

The second complication to the simple "ToT drive welfare" story described above arises due to the presence of domestic tax and subsidy distortions. Note in particular, that in the case of the Philippines (Rich-Agr-Full) and Peru (Rich-Agr-Doha), the ToT improve, but welfare falls. This stems from fact that all three countries have domestic tax policies that favor agriculture, relative to industry. Therefore an expansion of agriculture at the expense of industry has an adverse effect on economic efficiency and overall welfare. However, neither the ToT change for Philippines (Rich-Agr-Full) nor the welfare change for Peru (Rich-Agr-Doha) are statistically significant in light of our parametric sensitivity analysis.

Now let us turn to the distributional results of rich country agricultural reforms. Table 8 reports the percentage change in real on-farm income and off-farm household income, as well as the implied change in real household income for the aggregate farm household in each of the rich economies. From the on-farm income results, it is clear why there is so much opposition to these reforms. The average decline in Japan is 16% under the Doha scenario and 28% under the Full Liberalization scenario and 6% and 13% respectively in the EU. On-farm income losses in the US are much smaller – indeed they are not distinct from zero under the Doha scenario, while Canadian and Australia/New Zealand producers see gains in real on-farm income.

However, as noted above, farm households in many of these countries are quite diversified in their earnings. If we factor in the change in real, off-farm income, which tends to rise (albeit modestly, since there are no reforms outside of agriculture), the total impact on real farm household income is considerably moderated. Indeed, in Japan, the losses drop by a full order of magnitude – from -15.5% to just -1.4% under the Doha scenario. In the US, the losses become negligible, even under full liberalization. The dampening factor is less prevalent in Europe, where the role of off-farm income is smaller than in Japan and US.

Given the very modest aggregate farm household losses in the US, the question arises: Why is the farm-based opposition to reform so strong in that country? This becomes quite clear when we delve more deeply into the US impacts. Table 9 reports the welfare impacts on representative households in each of the 11 wealth classes across the five US producer groups. It is clear that under the Rich-Agr-Full-Lib scenario, the losses to the richest and likely most influential, producer groups are very large – nearly 20% of income in the case of the wealthiest rice producers. The wealthiest sugar producers are also hard-hit, as are cotton producers across the board.

One surprising thing about the results in Table 9 is the impact on rice producers under the Doha scenario. Here, they switch from being the biggest losers to the biggest gainers (based on this particular 5-way producer grouping). To further investigate this result we have performed a decomposition (using the methodology of Harrison, Horridge and Pearson, 1999) that separately identifies the partial impact of US rice reforms, US non-rice reforms, Japanese rice reforms, and the residual category of all other agricultural reforms on US Farm Household welfare. Results (available in annex Table A.6.6) show that the US agricultural reforms contribute negatively to rice producer welfare. The initial level of support for rice production is very high and even the modest reduction of the Doha scenario would generate an average real income loss of -4.5% for rice producers if applied in isolation. Other US agricultural reforms have a lesser impact (-2% average income change) since rice households lose support on any other crops they might produce and non-rice reforms lower returns to labor and capital in agriculture. Therefore, the positive Doha welfare impact derives from non-US policy reforms.

The US rice producer gains under Rich-Agr reforms are dominated by the gains owing to increased access to the lucrative Japanese market. Cuts in Japanese rice protection increase average USA rice producer welfare by 8%, with the average contribution of other countries liberalizing adding an additional 1%. So US producers gain under Rich country reforms, following the Doha Agenda, since their cuts in domestic support are modest (28%), while the improvement in market access to Japan is substantial. Of course, Japanese negotiators will strive to have rice treated as a sensitive product, thereby limiting the increase in market access, and this will obviously limit the final gains under any agreement.[9] A further qualification of these results is that they show a very large standard deviation. This is because they are extremely sensitive to the size of the substitution elasticity between rice sourced from different countries – and this has itself been estimated with a fairly large standard deviation (Table A.1.1). Therefore, it is hardly surprising that the US rice household welfare gains under Doha, are not significantly different from zero at the 95% confidence level.

Given the very large amount of household wealth tied up in agriculture, it is also important to consider the impact of these trade reforms on the wealth position of farm households in the

[9] Anderson and Martin (2005) provide a systematic analysis of the case in which sensitive and special commodities are exempted from steep tariff cuts, facing instead a modest 15% cut in bound rates (the Doha scenario considered in this paper). In the case where just 2% of industrial country tariff lines and 4% of developing country tariff lines in agriculture are exempted, the overall average tariff cuts are greatly reduced. Furthermore, Anderson, Martin and van der Mensbrugghe (2005) find that such exemptions erase any potential for poverty reduction under our Doha scenario.

US – again by the 11 wealth categories. These results are reported in Table 10 for the three most severely affected household groups: rice, sugar and cotton producers. This table decomposes the total change in household wealth (final column) into its component parts for under the Rich-Agr-Full scenario. The first three columns of Table 10 deal with the asset side of farm wealth, giving the share of land in farm assets, and the percentage change in farm asset value associated with farm land and farm capital (they are share-weighted so that the sum of these two entries gives the percentage change in farm assets). We see that farm households differ considerably in the share of land in their farm asset portfolio which typically increases with wealth class. Therefore, the contribution of farmland losses to the total change in farm asset values also tends to rise with wealth. Thus, for the 95 – 100 wealth percentile of rice households, the total decline in farm asset values is – (23.96 + 1.44) = -25.40%. Since these households are also somewhat leveraged (10% debt to asset ratio – see column 4 in Table 10), and since the cost of servicing the farm debt declines very little, the decline in farm wealth (-28.25%) is larger than the decline in asset values.

The final three columns detailing the Rich-Agr-Full scenario concern changes in *total* household wealth. In order to move from the change in farm wealth to total household wealth, we need to know the share of farm wealth in total household wealth, as well as the change in non-farm wealth. These are reported in the columns preceding the change in total household wealth. Note that the changes in non-farm wealth are small, since the scenarios here consider only agricultural liberalization. When we look at the farm share in total wealth, we see that it tends to be quite high – and is often highest for the wealthiest households. Thus, the detrimental impact on land rents from the reductions in support carry through as the dominant component of aggregate household wealth change with larger effects on wealthier households.

Comparing these wealth results from Rich-Agr-Full to those in Table 9 for household income, we see that the relatively greater importance of agricultural assets in household wealth, as compared to the share of farm income in household income, coupled with non-negligible debt/asset ratios, leads to a magnification of the losses in wealth, relative to the income losses. While rice, cotton and sugar households stand to lose a substantial percentage of their income under the full liberalization scenario, they lose an even larger percentage of their wealth.

Having considered the impact of rich country agricultural reforms on farm households in the rich economies, we now turn to the impact of these reforms on the poorest farm households in some of the poorest countries in the world. As noted previously, we do this via a set of disaggregated poverty elasticities -- each of which relates to one of the income sources for the poor. We focus our analysis on the Rich-Agr-Full-Lib results, subsequently comparing these to the Doha impacts.

Table 11 reports the change in cost-of-living deflated factor returns, by country under the \$1/day poverty line assumption. With the exception of Uganda, which is the only focus country to experience a real depreciation in the face of rich country agricultural liberalization,[10] these returns rise for all agricultural factors in all regions – a simple consequence of the higher world prices for farm products. The biggest increases are in land prices (the least mobile factor of production) – with very substantial increases (from 15 – 39%) in Brazil, Mexico, Peru and Thailand. This is followed by unskilled agricultural labor and capital. Note that the poverty-deflated earnings fall for nonagricultural labor and capital in most countries. This will translate into higher poverty rates for the self-employed, non-agriculture households. However, the economy-wide average wage for unskilled labor rises in Brazil, Chile, Malawi, Peru, Philippines, Thailand and Vietnam, so that modest poverty reductions in the wage-labor households are expected. The final column of Table 11 shows that transfers, which are assumed to be indexed by net national income, generally do not rise fast enough to offset the higher cost of living at the poverty line. So we expect poverty in the transfer strata to rise.

Table 12 reports the consequent changes in $1/day poverty, by stratum. As expected, poverty rates in the agriculture stratum fall in all countries, excepting Uganda. Due to its relatively higher poverty elasticities, the largest percentage reductions in poverty are in Thailand. However, there are also double-digit percentage reductions in poverty among the self-employed agricultural households in Brazil, Chile, and Peru. Clearly the same reforms that reduce the incomes of the richest farm households in the US, and other developed countries boost those of the poorest farm households in some of the poorest countries in the world. Obversely, the very policies that assist the richest farmers in the rich countries create poverty among poor country farm households. The diversified household strata (both urban and rural) also show substantial poverty reductions in a number of cases – particularly Brazil, Chile and Thailand. On the other hand, higher food prices consistently push more of the non-agriculture, self-employed and the transfer dependent households into poverty.

Figure 4 offers a useful summary of the differential impact of rich country agricultural liberalization on different types of poor households in developing countries. The vertical axis in reports the "sign consistency" of poverty impacts across the 15 focus countries. This is computed as the ratio of the average to the average absolute value of the poverty change. When this reform lowers poverty for a given stratum in all countries, its sign consistency reaches its minimum value of -1.0. On the other hand, when it raises poverty in all countries, this measure reaches its maximum value of 1.0. From the figure it is clear that the impact on poverty amongst agriculture specialized households is consistently favorable (i.e. a reduction). On the other hand, poverty amongst non-agriculture self-employed households consistently rises in the wake of rich country agriculture reforms. On balance, the rural and urban wage dependent and diversified households also tend to experience poverty reduction, while transfer dependent households show consistent poverty increases across this sample of countries.

[10] In the case of Uganda, the impact of preference erosion in the EU market is particularly severe.

The other important piece of information summarized in Figure 4 is the average absolute value of the poverty changes for each stratum. This is captured by the relative areas of each shaded rectangle, with the associated value recorded as well. Thus, the average absolute value of the poverty changes for the agriculture stratum is 5.1%. This is considerably larger than the next largest entries: 1.5% and 1.7% for the rural and urban diverse poverty changes, respectively. Overall, Figure 4 gives a picture of relatively broad-based poverty reduction, with some important exceptions in the case of self-employed non-farm, and transfer-dependent households.

The net effect of Rich-Agr-Lib on the national poverty headcount is reported in the first set of columns in Table 13. National poverty at the $1/day level falls in 10 of the 15 countries, with small percentage increases in Mozambique (unskilled wages fall), Uganda (factor prices fall), Venezuela (high share of poor in the non-agriculture stratum), Vietnam (large poverty elasticity for non-agricultural capital) and Zambia (negligible poverty elasticity in agriculture stratum). The next column of Table 12 converts these percentage changes in national poverty into thousands of people. Here, the reductions in Brazil, Indonesia, Philippines and Thailand are clearly dominant. When we move to the $2/day of Rich-Agr-Lib (next two columns of the table), the national poverty picture is reversed in two cases: Bangladesh (small decrease becomes a small increase) and Vietnam (small insignificant increase becomes a small decrease), so once again poverty falls in 2/3 of the 15 countries. On balance, the largest changes involve poverty reductions, with Brazil, Indonesia, Philippines and Thailand standing out.

We can contrast these outcomes with those that would be achieved under the prospective Doha reforms (Rich-Agr-Doha reforms only), and this is done in the final four columns of Table 13. More modest rises in agriculture earnings and lesser increases in the unskilled wage rate (adjusted for the cost of living at the poverty line) means that now poverty rises (albeit slightly) in more than half the countries (8 of 15) in the case of $1/day poverty. Clearly even the ambitious Doha Development Agenda under examination here is less poverty friendly than would be a proportionately scaled back version of full liberalization in rich country agriculture. The latter would presumably show poverty reduction in all the same countries – just to a lesser degree. Yet the Doha scenario results in fewer countries showing poverty reductions than under the full liberalization of Rich Agriculture.

4.2. Global Liberalization Scenarios

We now turn to a set of liberalization scenarios that involve tariff cuts in both agriculture and non-agriculture sectors and in both the rich and the poor countries. Developing country agricultural tariffs are quite high, so abolishing them increases world agricultural trade volumes relative to Rich-only liberalization. Reforming them on Doha terms, however, makes little difference because the large binding overhangs and modest cuts in developing country bound tariffs (no cuts for LDCs) translate into little additional market access. Adding tariff cuts in manufactures on the other hand leads to significant increases in manufacturing trade under both full and Doha scenarios and for both developed and developing countries (see Annex table A.6.3 for detailed results).

Table 14 reports the aggregate welfare and terms of trade impacts of these global reforms. Comparing Rich agriculture (Table 7) with Global reforms (Table 14); the most striking change in the rich countries is the improvement in the terms of trade for Japan, which benefits from manufacturing tariff cuts. On the other hand, the Canadian terms of trade deteriorate more as a result of preference erosion in the US manufactures market. However, despite the terms of trade loss, Canadian welfare rises by more under global full liberalization than under Rich-Agr-Lib alone.

Turning to the focus countries, we see very different terms of trade and welfare impacts than those stemming from Rich-Agr reforms only. The terms of trade for these developing countries fall in about the same number of cases (9 of 15), due to the expansion of poor country exports in the wake of own and other developing country tariff cuts and the erosion of preferences in manufacturing. However, welfare only falls for six of these countries, with efficiency gains dominating the ToT losses in the other three cases (Philippines, Vietnam and Zambia). In contrast, under Global Doha, there are fewer ToT losses, but also fewer (and smaller) welfare gains. These mixed aggregate welfare effects for developing countries from global trade reforms are quite comparable to those reported in other studies of the aggregate impacts of global trade reforms on developing countries (Francois et al., Anderson and Martin, Hertel and Winters, Bouet et al., 2006).

The changes in real farm income under global reforms are dominated by the Rich-Agr reforms previously discussed. Liberalizing rich country non-agricultural merchandise trade is slightly beneficial to the farm households – by lowering the price of non-agricultural goods, but tariffs on most of these products are already quite low and so the impact is minimal. On the other hand, trade reforms in the poor countries as a group tend to be slightly adverse for the welfare of rich country farm households. This is due to a complex set of factors, including the tendency for tariff cuts to encourage labor and capital to shift back to the food and agriculture sector, as well as the impact of increased demand on the general price level in rich countries. But these effects are very small, relative to the primary impact of the Rich-Agr policies themselves.

Given these results for the average farm household in the rich countries, it is hardly surprising that the impacts of global reforms on individual US farm households are quite similar to that reported previously in the Rich-Agr reform scenario (Table A.6.8). Welfare for the wealthiest farm households is driven first and foremost by their own national policies, with the largest international interactions occurring among the world's richest (and largest) markets – as in the case of US-Japan rice trade.

However, when it comes to the poverty impacts of global trade reform, agricultural policies in the rich countries are only part of the story – trade policies in the developing countries themselves assume much greater prominence. Figure 5 uses the sign consistency and average absolute value measures developed in Figure 4 to summarize the national poverty impacts of the different types of trade policy reform. Specifically, we decompose the impact of global trade reform into its constituent parts: Rich-Agr, Poor-Agr, Rich-Nagr, and Poor-Nagr, using the numerical technique of Harrison, Horridge, and Pearson (1999). As noted previously, Rich-Agr reforms contribute to poverty reduction in the majority of countries (negative sign consistency). The large average absolute value of these poverty impacts (1.1%) is also the largest of any of these policies. This is followed in importance by agricultural trade reforms in the poor countries (AAV = 0.87%), which show an equally consistent pattern of poverty reduction. The average impact of non-agriculture reforms rich countries is of lesser magnitude, although generally poverty-reducing, whereas the non-agriculture tariff cuts in the poor countries are poverty-increasing, on balance, in our 15 country sample. (Individual country results are reported in Annex Table A.6.9.)

The final rectangle in Figure 5 reports the sign consistency and average absolute value of the national poverty changes under the Doha scenario. This should be compared to the Global result at the beginning of the figure. Here, we see that, not only does the Doha scenario have a smaller average absolute value than global full liberalization (hardly surprising), the Doha scenario is also less poverty friendly than the global liberalization scenario, with a sign consistency of less than -0.5. (Individual country results are reported in Annex Table A.6.10.) Hertel and Ivanic (2006) emphasize that qualitatively less favorable impact of Doha on poverty is due to the heavy weight given to export subsidy elimination (which raises import prices for food), while the developing countries make only mild cuts to their applied tariffs under the Doha scenario and the least developed countries are not required to cut tariffs at all.

4.3. Compensation for Rich Country Farmers

The farm household welfare impacts in rich countries are dominated by liberalization of the agricultural pillars. Inclusion of agriculture and developing country reforms do little to make-up the lost income as the scope of reforms is broadened. With this in mind we consider a final scenario that asks what compensation would be required to hold aggregate farm income unchanged under the global full liberalization experiment.[11] This requires solving for an endogenous green-box subsidy to land in the following rich regions where aggregate farm income declines: Japan (-28.4%), Europe (-11.5%), and the US (-3.7%). The choice of aggregate farm income as a compensation target reflects the expectation that the policy process will continue to focus on this readily available measure to gauge the well-being of the farm population. In an alternative compensation simulation we investigate the cost savings generated

[11] We are not asserting that compensation for OECD farmers is justified, nor even necessary to achieve the reforms, although a case for the latter could certainly be made.

in these three countries by compensating on the basis of aggregate farm household income (inclusive of off-farm income).

Farm income compensation at the level of a representative farm household in each of these countries leads to sizable increases in WTO green-box outlays in each country. In Japan, agricultural land is subject to net taxation initially, and compensation requires an increase in expenditure to produce net subsidization at the level of $9.1 billion in land-based payments. Both the EU and US have significant land-based payments initially and the compensation scheme here indicates that the EU would need a 63% increase over that initial level at a cost of $11.8 billion. For the US, the percentage increase is smaller at 27.4%, coming at a cost of $3.3 billion.

As discussed previously, the use of farm income as a welfare indicator for the population of farm households in wealthy countries is incomplete and in this case would lead to considerable over-compensation in welfare terms. Using the full farm household welfare criterion as opposed to solely farm income, we find that Japanese and US policy-makers need only compensate these farmers with $6.3 billion and $2.4 billion dollars, nearly a 1/3 reduction. The reduction in the European Union is much smaller (only $300 million less than when compensating based on losses in farm income alone). This follows directly from the small share of income obtained from non-farm activities by farm households in the European Union as well as the less favorable developments in off-farm wages.

5. CONCLUSIONS

This paper has sought to identify the impacts of WTO reforms on farm households in rich and poor countries. It has done so via innovative use of newly available household survey data that identify the income sources and degree of earnings specialization of households. This proves to be a critical factor in assessing the household welfare impacts of trade reforms. In the rich countries, we focus our attention on the United States, where survey data permit us to assess the impacts of trade reforms by wealth decile and commodity specialization. In the poor countries, we analyze changes in the poverty headcount – among both farm and non-farm households.

Our findings highlight the fact that, in the medium run (2 – 3 years), wealthy farmers are the main beneficiaries of current trade policies aimed at protecting agriculture in the rich countries. Furthermore, these benefits tend to be concentrated in a few products that receive very high levels of support presently. In the United States, rice stands out – followed by cotton, sugar and dairy. When we look at aggregate farm household welfare in the United States, it is little affected by agricultural trade policy reforms. This is because many of the farm products receive little or no support and improved market access in other countries benefits export-oriented producers. Indeed, this is why the average farm household in Australia, Canada and New

Zealand is expected to gain from rich country agricultural trade reforms. A second reason why the average farm household in the US is not more severely affected by trade policy reform stems from the degree of earnings diversification in that country. On average, only 8% of farm household income in the US is derived from farming. This income diversification is also critical in Japan where just 12% of farm income is obtained from on-farm earnings. As a consequence, while Doha trade reforms cause on-farm incomes to drop by 16% in Japan, the average farm household impact is just 1.4%.

The finding of generally modest medium run impacts on the average farm household stands in sharp contrast to the strong opposition from agricultural lobbies in the rich countries. This opposition can be better understood when we use our household survey data for the US to show that the degree of earnings diversification diminishes for the wealthiest farms in the highly protected commodities, and this provides them with strong incentives to prevent the very substantial drop in household welfare that can be expected under trade reform. Furthermore, since these households have most of their assets tied up in agriculture, the percentage drop in household wealth is even greater than the income decline. Consequently, some compensation mechanism may prove necessary to solve the political impasse currently plaguing the Doha talks. We explore one such mechanism by which payments are aimed at neutralizing the loss in average on-farm income for each commodity group. This program would introduce around $25 billion of new agricultural subsidies into global agriculture from the three countries where farm income declines (Japan, EU, and US) and would undoubtedly make the Doha scenario much more palatable to the farm lobbies.

In the poorest countries, we find that, with one minor exception, rich country agriculture reforms benefit low-income farm households. Regardless of the poverty line considered, the poverty headcount in this part of the developing world falls. However, the impact on non-farm population groups is mixed. In those countries where agriculture makes up a large share of the unskilled labor force, rich country reforms tend to increase the demand for labor sufficiently to benefit unskilled workers throughout the economy. But self-employed households in the non-agricultural economy, as well as those dependent on transfer payments, systematically lose. Therefore the national poverty outcome inevitably depends on the relative weights of these different groups in the national poverty picture. Since a large share of the poor reside in agriculture, national poverty falls in 2/3 of the focus countries in the wake of rich country agricultural liberalization.

Reviving the DDA in the WTO offers one way – we would argue almost certainly the only way – of starting to reap these benefits in the near term. The WTO could reform the privileges of the richest farmers of the North for the sake of the poor farmers in the South. And, if policy makers were really serious about poverty reduction, they would push for more poor country farm and food tariff cuts, as these products loom large in the household budgets of the poor. Giving the latter access to food at world market prices (adjusted for marketing margins) is a sure way to reduce poverty. Yet this is precisely the component that is mostly omitted under the current Doha proposals. Indeed, global trade liberalization is the policy configuration with the most favorable poverty outcomes across the fifteenth 15 developing countries examined in this study.

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Box 1 Computable General Equilibrium Modeling

General equilibrium, which dates back to Leon Walras (1834-1910), is one of the crowning intellectual achievements of economics. It recognizes that there are many markets and that they interact in complex ways so that loosely speaking, everything depends on everything else. Demand for any one good depends on the prices of all other goods and on income. Income, in turn, depends on wages, profits, and rents, which depend on technology, factor supplies and production, the last of which, in its turn, depends on sales (i.e., demand). Prices depend on wages and profits and vice versa.

To make such an insight useful, economists have to be able to simplify it sufficiently to derive predictions and conclusions. Theorists typically do this by slashing the dimensionality, say to just two goods, two factors and two countries, and often focusing on just a few parts of the system. An alternative approach is to keep the complex structure but to simplify the characterization of economic behavior and solve the whole system numerically rather than algebraically. This is the approach of Computable General Equilibrium (CGE) modeling.

CGE models specify all their economic relationships in mathematical terms and put them together in a form that allows the model to predict the change in variables such as prices, output and economic welfare resulting from a change in economic policies, given information about technology (the inputs required to produce a unit of output), policies and consumer preferences. They do this by seeking prices at which supply equals demand in every market—goods, factors, foreign exchange. One of the great strengths of CGE models is that they impose consistency of one's view of the world, e.g., that all exports are imported by another country, that the sum of sectors' employment does not exceed the labor force, or that all consumption be covered by production or imports. This consistency can often generate empirical insights that might otherwise be overlooked in complex policy analysis – such as the fact that import protection gives rise to an implicit tax on exports.

The mathematical relationships assumed are generally rather simple, and although 'many' markets are recognized, they still have to be very aggregated—particularly for global economic analysis. For example, the global CGE model used in this paper has 31 sectors, so, for example, 'transport and communications services' appear as a single industry. In principle all the relationships in a model could be estimated from detailed data on the economy over many years. In practice, however, their number and parameterization generally outweigh the data available. In the model used for this paper, only the most important relationships have been econometrically estimated. These include the international trade elasticities (Hertel et al., 2005), the agricultural factor supply and demand elasticities (OECD, 2001), and consumer preferences (estimated specially for this paper, based on the methods outlined in Cranfield et al., and Reimer and Hertel). The remaining economic relationships are based on literature reviews, with a healthy dose of theory and

Box 2. Estimating Poverty Impacts in the Focus Countries

The unifying theme of our results is that different households are affected differently by trade reforms. Thus how we derive and treat differences among households is central to the analysis. The most consistent approach embeds household behavior fully within the national CGE model, but this is computationally burdensome (Rutherford, Tarr and Shepotylo, 2006) and would add significant complexity to an already complex global analysis. A popular simplification involves solving a national CGE model and combining the resulting changes in commodity prices, factor prices and possibly quantities and employments with household data on earnings and expenditures to estimate a (first-order) approximation of the welfare effects on households. Chen and Ravallion (2004) apply this to 80,000 households to estimate the poverty effects of Chinese accession to the WTO. Hertel and Winters (2006) is conceptually similar in its estimates of the poverty implications of the Doha Round, but with up to three levels of modeling: a global multi-country CGE model to calculate the effects of the Round on each country's prices of imports and export demand; more detailed national CGE models for twelve country case studies to estimate the effects of these on local prices etc, and, in the cases where the national models do not embed households directly, household modules to calculate the first order welfare approximations by household.

A further simplification is again to solve a CGE model with a single representative consumer, but now to consider the effects of a shock only on a few summary statistics such as average incomes, unskilled wages and food prices. Then, applying 'poverty elasticities' to these statistics allows one to estimate the implied change in poverty. (The poverty elasticity relates the proportionate change in poverty to the proportionate change in *per capita* GDP – see, for example, Ravallion (1997)). This is the approach in Cline (2004), and Anderson et al. (2006) among others. These studies differ *inter alia* in the base poverty levels to which they apply the elasticities.

For purposes of this paper, we adopt a hybrid of the alternatives. For a global model of the size we have used to explore the DDA, it is not computationally feasible to embed households or even many representative household groups into the CGE model. And neither do we have the requisite data on factor earnings by household for the majority of developing countries. However, we believe that the impact of trade reform on individual households will vary widely depending on their primary sector of employment, their endowments, as well as their consumption patterns. Therefore we reject the single poverty elasticity approach. Instead we utilize the factor earnings and income distribution data for our 15 target developing countries, where this has been obtained and processed in a uniform manner, and we estimate country-stratum-factor price-poverty line specific poverty elasticities. These elasticities embody information about the shape of the income distribution as well as the

Table 1. US Farm Income Shares by Household Type and Wealth Group

Wealth Group	Rice	Sugar	Cotton	Dairy	Other
10-%ile	0.39	0.22	0.67	0.56	-0.01
20-%ile	0.39	0.22	0.67	0.47	0.03
30-%ile	0.58	0.22	0.75	0.72	0.01
40-%ile	0.58	0.78	0.64	0.48	-0.01
50-%ile	0.84	0.78	0.82	0.59	0.07
60-%ile	0.55	0.78	0.59	0.57	0.07
70-%ile	0.76	0.31	0.64	0.71	0.11
80-%ile	0.80	0.31	0.63	0.61	0.12
90-%ile	0.75	0.66	0.83	0.81	0.20
95-%ile	0.74	0.91	0.68	0.83	0.21
100-%ile	0.74	0.91	0.91	0.92	0.41

Source: 2004 USDA-ERS ARMS.

Table 2. Stratum Contributions to the $1/day Poverty Population in each Country

Country	Strata							
	Agr.	N-Agr.	Urb. Lab.	Rur. Lab.	Trans.	Urb. Div.	Rur. Div.	Total
Bangladesh	0.15	0.13	0.04	0.22	0.03	0.07	0.37	1.00
Brazil	0.14	0.09	0.24	0.15	0.32	0.04	0.03	1.00
Chile	0.26	0.01	0.09	0.09	0.28	0.15	0.12	1.00
Colombia	0.28	0.43	0.03	0.04	0.12	0.05	0.04	1.00
Indonesia	0.42	0.12	0.02	0.07	0.04	0.06	0.28	1.00
Malawi	0.54	0.11	0.00	0.03	0.07	0.01	0.25	1.00
Mexico	0.05	0.06	0.05	0.12	0.28	0.14	0.29	1.00
Mozambique	0.41	0.13	0.01	0.05	0.14	0.06	0.19	1.00
Peru	0.07	0.35	0.01	0.02	0.22	0.11	0.23	1.00
Philippines	0.12	0.06	0.03	0.05	0.03	0.23	0.49	1.00
Thailand	0.06	0.02	0.00	0.06	0.11	0.07	0.68	1.00
Uganda	0.10	0.04	0.00	0.03	0.02	0.07	0.75	1.00
Venezuela	0.08	0.24	0.17	0.10	0.28	0.08	0.05	1.00
Vietnam	0.04	0.11	0.00	0.00	0.05	0.10	0.70	1.00
Zambia	0.34	0.23	0.10	0.07	0.07	0.09	0.11	1.00

Source: Household surveys for each country.
Notes: Column headings are specializations for each household: Agr. = agricultural, N-Agr. = non-agricultural, Urb. Lab. = urban labor, Rur. Lab. = Rural labor, Trans. = Transfer, Urb. Div. = urban diversified, Rur. Div. = rural diversified.

Table 3. Elasticity of Poverty Headcount ($1/day) with Respect to Total Income

	Strata						
Country	Agr.	N-Agr.	Urb. Lab.	Rur. Lab.	Trans.	Urb. Div.	Rur. Div.
Bangladesh	1.64	2.02	1.58	0.63	0.56	1.74	1.09
Brazil	0.75	1.28	1.94	2.19	0.34	3.63	2.69
Chile	1.90	2.24	2.06	1.55	2.45	2.29	2.60
Colombia	0.79	0.60	1.73	1.72	0.93	1.14	1.00
Indonesia	2.35	2.14	2.38	2.89	1.17	2.58	2.87
Malawi	0.49	0.30	2.26	1.97	0.43	1.04	0.76
Mexico	1.73	1.90	3.33	2.08	2.28	1.63	1.80
Mozambique	0.28	0.94	0.97	0.76	0.48	1.58	0.99
Peru	1.50	1.32	2.37	1.73	0.44	1.09	1.05
Philippines	2.25	1.96	2.98	2.44	1.69	2.42	1.98
Thailand	2.30	2.42	2.98	2.45	2.78	2.42	2.59
Uganda	0.28	0.40	1.71	0.34	0.01	0.36	0.21
Venezuela	0.69	1.16	2.57	2.17	0.01	1.72	1.53
Vietnam	0.48	1.12	2.81	8.98	0.84	0.86	1.01
Zambia	0.00	0.64	2.28	0.91	0.45	1.29	0.37

Source: Authors' calculations, based on household survey data.
Notes: Column headings are specializations for each household: Agr. = agricultural, N-Agr. = non-agricultural, Urb. Lab. = urban labor, Rur. Lab. = Rural labor, Trans. = Transfer, Urb. Div. = urban diversified, Rur. Div. = rural diversified.

Table 4. Poverty Elasticities, by Stratum and Income Source, $1/day: Peru

Factor	Agr.	N-Agr.	Urb. Lab.	Rur. Lab.	Trans.	Urb. Div.	Rur. Div.
Land	0.04	0.00	0.00	0.00	0.00	0.01	0.03
Ag. Unskilled Labor	1.41	0.00	0.00	0.00	0.00	0.25	0.21
Ag. Skilled Labor	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Non-Ag. Unskilled Labor	0.00	1.08	0.00	0.01	0.00	0.31	0.32
Non-Ag Skilled Labor	0.00	0.14	0.00	0.00	0.00	0.05	0.07
Wage Labor Unskilled	0.00	0.00	2.19	1.58	0.00	0.21	0.13
Wage Labor Skilled	0.00	0.00	0.16	0.12	0.00	0.01	0.00
Agricultural Capital	0.05	0.00	0.00	0.00	0.00	0.01	0.03
Non-agricultural Capital	0.00	0.09	0.00	0.00	0.00	0.05	0.12
Transfers	0.01	0.01	0.02	0.02	0.44	0.18	0.15
Total	1.50	1.32	2.37	1.73	0.44	1.09	1.05

Source: Authors' calculations based on household survey data.
Notes: Column headings are specializations for each household: Agr. = agricultural, N-Agr. = non-agricultural, Urb. Lab. = urban labor, Rur. Lab. = Rural labor, Trans. = Transfer, Urb. Div. = urban diversified, Rur. Div. = rural diversified.

Table 5. Poverty Elasticities for Rural Diversified Stratum, $1/day

Country	Land	Ag. Unskilled Labor	Ag. Skilled Labor	Non-Ag. Unskilled Labor	Non-Ag Skilled Labor	Wage Labor Unskilled	Wage Labor Skilled	Agr. Capital	Non-agricultural Capital	Trans.	Total
Bangladesh	0.01	0.18	0.00	0.20	0.00	0.43	0.04	0.01	0.03	0.10	1.00
Brazil	0.00	0.10	0.04	0.12	0.00	0.32	0.01	0.01	0.00	0.41	1.00
Chile	0.05	0.16	0.00	0.02	0.00	0.35	0.00	0.07	0.00	0.35	1.00
Colombia	0.00	0.22	0.00	0.30	0.00	0.22	0.02	0.00	0.02	0.21	1.00
Indonesia	0.06	0.32	0.00	0.20	0.00	0.26	0.00	0.04	0.08	0.04	1.00
Malawi	0.03	0.38	0.00	0.07	0.00	0.08	0.00	0.06	0.11	0.27	1.00
Mexico	0.01	0.14	0.00	0.06	0.00	0.48	0.00	0.01	0.01	0.30	1.00
Mozambique	0.01	0.43	0.00	0.07	0.00	0.07	0.00	0.02	0.20	0.20	1.00
Peru	0.02	0.20	0.00	0.30	0.07	0.13	0.00	0.03	0.11	0.14	1.00
Philippines	0.22	0.00	0.02	0.14	0.01	0.30	0.01	0.12	0.08	0.11	1.00
Thailand	0.04	0.21	0.03	0.03	0.01	0.24	0.07	0.02	0.02	0.35	1.00
Uganda	0.14	0.15	0.00	0.06	0.00	0.09	0.06	0.26	0.14	0.10	1.00
Venezuela	0.00	0.10	0.00	0.32	0.01	0.28	0.04	0.00	0.00	0.26	1.00
Vietnam	0.01	0.09	0.00	0.14	0.00	0.00	0.00	0.00	0.55	0.21	1.00
Zambia	0.01	0.03	0.00	0.20	0.00	0.43	0.05	0.03	0.13	0.12	1.00

Source: Authors' calculations based on household survey data.
Notes: Column headings are earnings sources: Trans. = transfers.

Table 6. Overview of Scenarios

	Rich Agriculture		Global (All countries and merchandise)	
Instrument	Doha	Full	Doha	Full
Agr. Tariffs Rich	-45 %, -70 %, -75 %[c]	-100 %	-45 %, -70%, -75 %	-100 %
Agr. Tariffs Poor (Non-LDC[a])	n.a.	n.a.	-35%, -40%, -50%, -60%[d]	-100 %
Agr. Export Subsidies	-100 %	-100 %	-100 %	-100 %
Amber Box Subsidies[b]	-75 % Group 1 -60 % Group 2	-100 %	-75 % Group 1 -60 % Group 2	-100 %
Non-Agr. Tariffs Rich	n.a.	n.a.	-50%	-100 %
Non-Agr. Tariffs Poor (Non-LDC[a])	n.a.	n.a.	-33 %	-100 %
Green Box Subsidies	n.a.	n.a.	n.a.	n.a.

[a]Least developed countries are not required to make any tariff reductions under Doha scenarios.
[b]Group 1 countries have amber box subsidies accounting for more than 20% of producer revenue. Group 2 countries have support less than 20% of producer revenue. A third grouping exists for developing countries where 40% reductions are required, but adequate data on amber box subsidies is available to model this.
[c]These three percentage cuts are applied in a tiered formula whereby higher portions of the tariff are more deeply cut. Tiers are defined over the tariff rate and the reductions increase at 15% and then 90%.
[d]These four percentage cuts are applied in a tiered formula whereby higher potions of the tariff are more deeply cut. Tiers are defined over the tariff rate and the reductions increase at 20%, 60%, and 120%.

Table 7. Welfare and Terms of Trade Results

	Full			Doha			Full			Doha		
	ToT Lower	ToT Mean	ToT Upper	ToT Lower	ToT Mean	ToT Upper	Welf. Lower	Welf. Mean	Welf. Upper	Welf. Lower	Welf. Mean	Welf. Upper
Rich Countries												
Aust. and New Zlnd.	2.21	**2.80**	3.39	0.92	**1.10**	1.28	0.58	**0.72**	0.86	0.22	**0.26**	0.30
Japan	-1.47	**-1.25**	-1.03	-0.47	**-0.39**	-0.31	0.50	**0.95**	1.40	0.23	**0.47**	0.71
Canada	-0.11	**-0.07**	-0.03	-0.04	**-0.02**#	0.00	0.23	**0.27**	0.31	0.08	**0.10**	0.12
US	0.29	**0.35**	0.41	0.12	**0.14**	0.16	0.02	**0.02**	0.02	0.01	**0.01**	0.01
Europe FTA	-0.40	**-0.30**	-0.20	-0.10	**-0.06**	-0.02	0.12	**0.22**	0.32	0.12	**0.18**	0.24
Focus Countries												
Bangladesh	-0.80	**-0.60**	-0.40	-0.25	**-0.21**	-0.17	-0.36	**-0.28**	-0.20	-0.12	**-0.10**	-0.08
Brazil	3.31	**5.27**	7.23	0.82	**1.94**	3.06	0.41	**0.72**	1.03	0.08	**0.26**	0.44
Chile	0.55	**0.77**	0.99	0.13	**0.15**	0.17	0.09	**0.15**	0.21	-0.01	**0.01**#	0.03
Colombia	1.06	**1.26**	1.46	0.52	**0.60**	0.68	-0.04	**0.00**#	0.04	-0.01	**0.01**#	0.03
Indonesia	-0.27	**-0.23**	-0.19	-0.12	**-0.10**	-0.08	-0.30	**-0.26**	-0.22	-0.09	**-0.09**	-0.09
Malawi	1.94	**2.55**	3.16	-0.23	**0.12**#	0.47	1.41	**1.82**	2.23	-0.10	**0.17**#	0.44
Mexico	-0.38	**-0.14**#	0.10	-0.13	**-0.11**	-0.09	-0.30	**-0.24**	-0.18	-0.08	**-0.08**	-0.08
Mozambique	-0.50	**-0.40**	-0.30	-0.17	**-0.15**	-0.13	-0.65	**-0.53**	-0.41	-0.16	**-0.14**	-0.12
Peru	1.70	**3.25**	4.80	0.05	**0.15**	0.25	0.22	**0.53**	0.84	-0.03	**-0.01**#	0.01
Philippines	-0.07	**0.01**#	0.09	-0.10	**-0.08**	-0.06	-0.25	**-0.21**	-0.17	-0.11	**-0.11**	-0.11
Tanzania	-0.31	**-0.02**#	0.27	-0.35	**-0.23**	-0.11	-0.17	**-0.09**	-0.01	-0.10	**-0.08**	-0.06
Thailand	0.64	**1.11**	1.58	0.17	**0.23**	0.29	0.42	**0.71**	1.00	0.11	**0.15**	0.19
Uganda	-1.04	**-0.59**	-0.14	-0.81	**-0.65**	-0.49	-0.33	**-0.23**	-0.13	-0.23	**-0.19**	-0.15
Venezuela	-0.47	**-0.41**	-0.35	-0.25	**-0.23**	-0.21	-0.13	**-0.11**	-0.09	-0.06	**-0.06**	-0.06
Vietnam	0.07	**0.27**	0.47	-0.14	**-0.12**	-0.10	-0.09	**0.07**#	0.23	-0.20	**-0.18**	-0.16
Zambia	-0.26	**-0.18**	-0.10	-0.05	**-0.01**#	0.03	-0.24	**-0.20**	-0.16	-0.05	**-0.05**	-0.05

Source: Authors' simulations.

Result can *not* be distinguished from zero change at the 95% confidence level.

Note: Model results at mean values differ from model results evaluated at the point estimate due to non-linearity of the model.

Table 8. Percentage Change in Farm Income for Rich Regions by Source (On/Off-Farm)

	Rich Region Doha Ag. Reforms			Rich Region Ag. Full Reform		
Region	On-farm	Off-farm	Total	On-farm	Off-farm	Total
Australia and New Zealand	7.3	-0.0#	4.4	17.3	-0.0#	10.5
Japan	-15.5	0.6	-1.4	-28.2	1.2	-2.5
Canada	3.5	0.0	0.4	6.3	0.1	0.7
US	-0.3#	0.0#	-0.0#	-4.4	0.1	-0.3
EU and Other Europe	-5.8	0.3	-3.5	-12.7	0.5	-7.7

Source: Authors' simulations.
Result can *not* be distinguished from zero change at the 95% confidence level.

Table 9. Disaggregate US Farm Household Income Impacts of Ag. Reforms

Income	Rice Hhld.		Sugar Hhld.		Cotton Hhld.		Dairy Hhld.		Other Hhld.	
Group	Doha	Full	Doha	Full	Doha	Full	Doha	Full	Doha	Full
10%ile	1.36#	-5.08	-0.12#	-0.97	-2.09	-8.31	-0.30#	-2.44	0.02	0.08
20%ile	1.37#	-5.11	-0.12#	-0.97	-2.09	-8.31	-0.30#	-2.00	-0.03	-0.12
30%ile	1.89#	-6.55	-0.34#	-2.64	-1.63	-7.03	-0.43#	-2.94	0.00#	0.00#
40%ile	1.89#	-6.57	-0.87	-4.80	-2.13	-8.14	-0.32#	-2.11	0.01	0.08
50%ile	6.32#	-16.63	-0.87	-4.80	-1.60	-7.64	-0.41#	-2.56	-0.08	-0.35
60%ile	1.63#	-7.68	-0.87	-4.80	-1.18	-5.00	-0.44#	-2.74	-0.08	-0.34
70%ile	4.64#	-14.92	-0.37	-1.98	-1.47	-6.66	-0.66	-3.74	-0.17	-0.70
80%ile	5.53#	-17.08	-0.37	-1.98	-1.15	-5.13	-0.47	-2.92	-0.18	-0.78
90%ile	5.60#	-17.79	-0.65	-3.73	-1.81	-8.94	-0.71	-4.26	-0.31	-1.31
95%ile	5.33#	-18.91	-1.33	-6.49	-1.61	-6.77	-0.46#	-3.56	-0.30	-1.31
100%ile	5.31#	-18.83	-1.33	-6.49	-3.53	-12.68	-0.50#	-4.04	-0.56	-2.39

Source: Authors' simulations.
Result can *not* be distinguished from zero change at the 95% confidence level.

Table 10. Disaggregate US Farm Household Wealth Impacts of Ag Reforms

	Farm Assets Land Shr.	Farm Assets Land.	Farm Assets Capital	Farm Wealth Debt/ Asset	Farm Wealth Value	NFarm Wealth Value	HHLD Wealth Farm Shr.	HHLD Wealth Value
RICE								
10%ile	0.27	-10.93	-2.88	0.19	-17.13	-0.07	0.72	-12.38
20%ile	0.27	-10.93	-2.88	0.19	-17.13	-0.07	0.72	-12.38
30%ile	0.17	-5.98	-3.30	0.07	-9.99	0.01	0.72	-7.15
40%ile	0.17	-5.98	-3.30	0.07	-9.99	0.01	0.72	-7.15
50%ile	0.34	-17.27	-2.60	0.19	-24.42	0.00	0.63	-15.40
60%ile	0.27	-10.20	-2.88	0.21	-16.59	-0.03	0.74	-12.29
70%ile	0.43	-17.22	-2.27	0.18	-23.78	-0.02	0.80	-18.95
80%ile	0.46	-19.14	-2.15	0.15	-25.01	-0.37	0.91	-22.85
90%ile	0.50	-21.73	-1.98	0.14	-27.71	0.01	0.69	-19.07
95%ile	0.64	-23.96	-1.44	0.10	-28.25	-0.03	0.91	-25.59
100%ile	0.64	-23.96	-1.44	0.10	-28.25	-0.03	0.91	-25.59
SUGAR								
10%ile	0.30	-1.17	-2.77	0.19	-4.91	-0.06	0.88	-4.34
20%ile	0.30	-1.17	-2.77	0.19	-4.91	-0.06	0.88	-4.34
30%ile	0.30	-1.17	-2.77	0.19	-4.91	-0.06	0.88	-4.34
40%ile	0.40	-3.07	-2.37	0.28	-7.63	-0.01	0.84	-6.42
50%ile	0.40	-3.07	-2.37	0.28	-7.63	-0.01	0.84	-6.42
60%ile	0.40	-3.07	-2.37	0.28	-7.63	-0.01	0.84	-6.42
70%ile	0.52	-3.56	-1.92	0.21	-6.95	-0.01	0.89	-6.19
80%ile	0.52	-3.56	-1.92	0.21	-6.95	-0.01	0.89	-6.19
90%ile	0.48	-2.93	-2.05	0.11	-5.64	0.00	0.83	-4.69
95%ile	0.52	-4.65	-1.91	0.16	-7.85	0.00	0.89	-7.02
100%ile	0.52	-4.65	-1.91	0.16	-7.85	0.00	0.89	-7.02
COTTON								
10%ile	0.60	-10.39	-1.60	0.10	-13.30	-0.18	0.96	-12.83
20%ile	0.60	-10.39	-1.60	0.10	-13.30	-0.18	0.96	-12.83
30%ile	0.44	-6.51	-2.21	0.12	-9.87	-0.01	0.84	-8.29
40%ile	0.60	-10.58	-1.59	0.08	-13.23	-0.02	0.88	-11.66
50%ile	0.36	-5.92	-2.53	0.14	-9.89	-0.02	0.76	-7.55
60%ile	0.49	-5.49	-2.02	0.08	-8.17	0.01	0.69	-5.62
70%ile	0.39	-6.93	-2.41	0.20	-11.67	0.01	0.76	-8.89
80%ile	0.45	-5.38	-2.20	0.07	-8.14	0.02	0.29	-2.31
90%ile	0.49	-7.82	-2.03	0.15	-11.68	0.00	0.74	-8.60
95%ile	0.63	-7.62	-1.45	0.11	-10.17	-0.02	0.89	-9.04
100%ile	0.91	-13.66	-0.38	0.02	-14.31	-0.28	0.98	-14.02

Source: Authors' simulations.
Notes: First column is land share in farm assets and second two columns are share weighted value changes in farm land and capital assets. Farm debt to asset ratio is computed from the USDA-ERS ARMS database for each household type and is used for calculating the percentage change in household wealth change from farming (sixth column). The next to last column provides the share of farm wealth in the total household wealth (from the same ERS database) and is used to share weight farm and non-farm wealth changes to the total in the final column.

Table 11. Percentage Change in Cost of Living Adjusted Factor Returns: $1/day Poverty

Country	Land	AgUnskl	AgSkl	NagUnskl	NagSkl	WgUnskl	WgSkl	AgCap	NagCap	Transfer
Bangladesh	1.64	0.77	0.57	-0.38	-0.46	-0.06[#]	-0.46	0.53	-0.55	-0.33
Brazil	39.28	16.06	14.73	-1.68	-1.99	0.46	-1.82	14.63	-2.31	-0.69
Chile	12.55	6.13	5.44	-0.96	-1.19	0.12	-1.18	5.42	-1.29	-0.72
Colombia	9.75	4.41	3.74	-1.70	-1.84	-0.58	-1.84	3.68	-2.19	-1.13
Indonesia	2.56	1.22	0.81	-0.75	-0.95	-0.12	-0.94	0.82	-0.94	-0.57
Malawi	1.78	1.37	1.13	0.78	0.53	1.02	0.54	1.22	0.61	1.35
Mexico	16.73[#]	4.82	4.13	-1.20	-1.50	-0.18[#]	-1.50	4.13	-1.60	-1.11
Mozambique	1.38	0.51	0.31	-0.61	-0.65	-0.26	-0.64	0.32[#]	-0.72	-0.46
Peru	14.61	7.90	6.34	-1.53	-1.88	1.30	-1.61	6.19	-2.05	-0.71
Philippines	2.20	1.07	0.65	-0.79	-0.90	-0.03[#]	-0.86	0.54	-1.16	-0.57
Thailand	22.67	10.93	8.28	-1.66	-2.70	2.41	-2.42	7.83	-3.27	-1.27
Uganda	-0.14[#]	-0.16	-0.19	-0.15	-0.22	-0.16	-0.22	-0.18	-0.21	-0.19
Venezuela	2.02	0.90	0.78	-0.39	-0.43	-0.20	-0.43	0.79	-0.45	-0.33
Vietnam	4.23	2.03	1.61	-0.66	-0.86	-0.04[#]	-0.86	1.68	-0.76	-0.32
Zambia	1.56	0.75	0.60	-0.32	-0.38	-0.07	-0.38	0.59	-0.54	-0.21

Source: Authors' simulations.
[#] Result can *not* be distinguished from zero change at the 95% confidence level.
Note: All earnings have been deflated by the country-specific cost of living at the poverty line.

Table 12. Percentage Change in the Poverty Headcount ($1/day) across Developing Country Stratums, when Rich Countries undertake Full Agricultural Reform

Country	Agr.	N-Agr.	Urb. Lab.	Rur. Lab.	Trans.	Urb. Div.	Rur. Div.
Bangladesh	-1.27	0.78	0.09#	0.05	0.18	-0.05#	0.02#
Brazil	-10.45	2.21	-0.57#	-0.79	0.23	-7.10	-4.81
Chile	-12.53	2.24	-0.22#	-0.14#	1.78	-4.65	-4.25
Colombia	-3.37	1.04	1.04	1.03	1.06	0.13#	0.01#
Indonesia	-2.86	1.62	0.45	0.46	0.66	-0.56	-0.80
Malawi	-0.67	-0.22	-2.10	-1.88	-0.57	-1.20	-0.92
Mexico	-7.83	2.35	0.77	0.37#	2.57	-0.29#	-0.52#
Mozambique	-0.15	0.62	0.25	0.20	0.22	0.21	0.06#
Peru	-10.83	2.14	-2.53	-1.82	0.32	-1.61	-1.32
Philippines	-3.52	1.68	0.22#	0.15#	0.97	-0.55	-0.54
Thailand	-22.04	4.35	-6.68	-5.49	3.43	-7.69	-7.90
Uganda	0.05	0.07	0.34	0.06	0.00	0.06	0.04
Venezuela	-0.61	0.45	0.54	0.46	0.00	0.37	0.31
Vietnam	-0.99	0.78	0.13#	1.87	0.26	-0.64	0.36
Zambia	0.00	0.26	0.40	0.12	0.09	0.19	0.06

Source: Authors' simulations.

Result can *not* be distinguished from zero change at the 95% confidence level.

Notes: Column headings are specializations for each household: Agr. = agricultural, N-Agr. = non-agricultural, Urb. Lab. = urban labor, Rur. Lab. = Rural labor, Trans. = Transfer, Urb. Div. = urban diversified, Rur. Div. = rural diversified.

Table 13. National Poverty Impacts due to Rich Country Liberalization of Agriculture: Full versus Doha Reform

	Rich Agriculture Full Reform				Rich Agriculture Doha Reform			
	$1/day		$2/day		$1/day		$2/day	
Country	%	1000s	%	1000s	%	1000s	%	1000s
Bangladesh	-0.06#	-27#	0.06	62	0.00#	0#	0.02	21
Brazil	-1.88	-431	-2.61	-958	-0.73	-167	-0.96	-352
Chile	-3.99	-12	-2.48	-35	-0.99	-3	-0.57	-8
Colombia	-0.29	-12	-0.67	-59	-0.17	-7	-0.46	-40
Indonesia	-1.18	-177	-0.20	-210	-0.13	-20	0.00#	0#
Malawi	-0.72	-31	-0.32	-25	0.41	17	0.15	12
Mexico	0.34	32	-0.10	-25	0.15	14	0.03	7
Mozambique	0.09	5	0.06	8	0.05	3	0.02	3
Peru	-0.43	-19	-1.71	-157	0.04	2	-0.18	-17
Philippines	-0.66	-75	-0.41	-143	0.03#	3#	0.00#	0#
Thailand	-7.10	-84	-4.15	-806	-1.43	-17	-0.83	-161
Uganda	0.04	7	1.12	220	0.04	7	1.58	310
Venezuela	0.24	8	0.18	13	0.11	4	0.09	6
Vietnam	0.25	4	-0.24	-62	0.14	2	0.12	31
Zambia	0.13	8	0.03	2	0.03	2	0.01	1

Source: Authors' simulations.

Result can *not* be distinguished from zero change at the 95% confidence level.

Table 14. Macroeconomic Impacts of Liberalization: Global Scenarios

	Global (All countries and merchandise)			
	Full		Doha	
	ToT	Welfare	ToT	Welfare
Rich Countries				
Aust. and New Zlnd.	2.30	0.76	1.09	0.28
Japan	0.28	1.29	0.04	0.54
Canada	-0.64	0.39	-0.23	0.06
US	0.29	0.06	0.01	0.01
Europe FTA	-0.12	0.42	-0.12	0.20
Focus Countries				
Bangladesh	-5.66	-0.65	-0.04	-0.04
Brazil	3.72	0.67	2.03	0.31
Chile	0.58	0.32	0.18	0.01
Colombia	-1.52	-0.54	0.33	-0.07
Indonesia	1.11	0.51	0.23	0.07
Malawi	3.56	3.83	0.34	0.32
Mexico	-2.02	-0.20	-0.43	-0.12
Mozambique	0.00	1.19	-0.13	-0.08
Peru	0.66	0.60	0.11	-0.02
Philippines	-0.33	0.49	0.12	0.12
Tanzania	-2.05	-0.66	-0.29	-0.08
Thailand	1.50	2.08	0.54	0.51
Uganda	-0.99	-0.32	-0.64	-0.18
Venezuela	-2.19	-0.26	-0.68	-0.03
Vietnam	-1.25	5.73	-0.85	-1.17
Zambia	-0.46	0.28	0.04	-0.03

Source: Authors' simulations.
Notes: No sensitivity analysis is conducted for global scenarios.

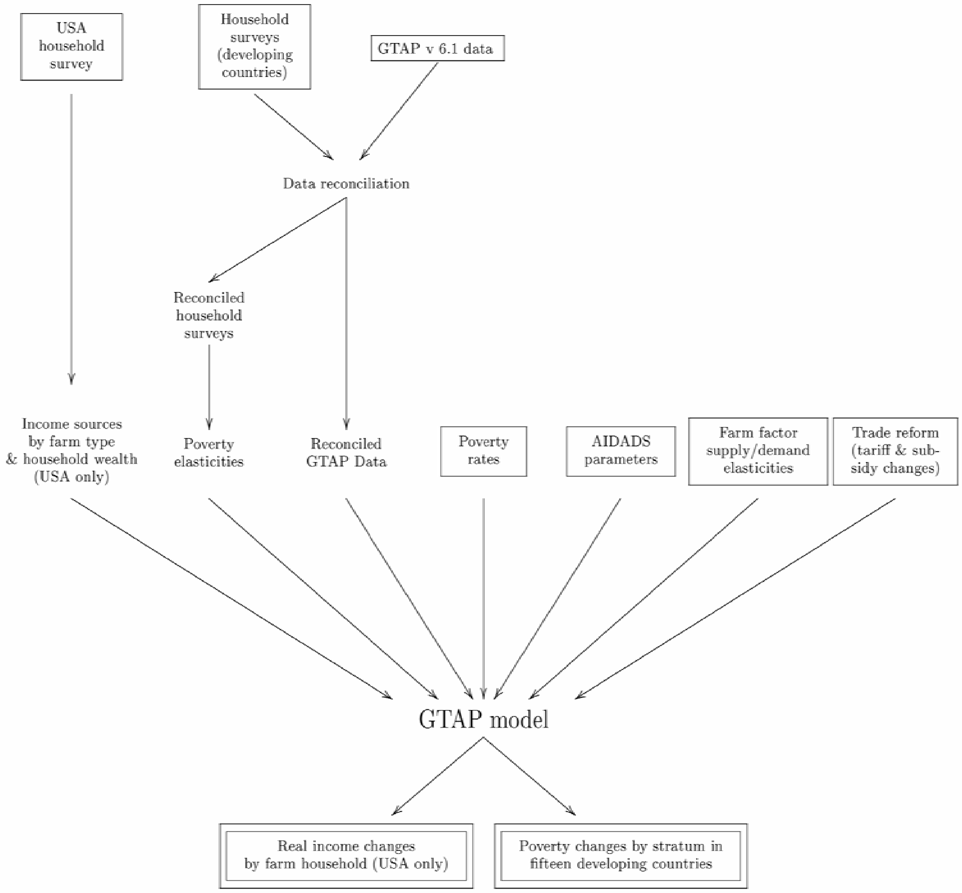
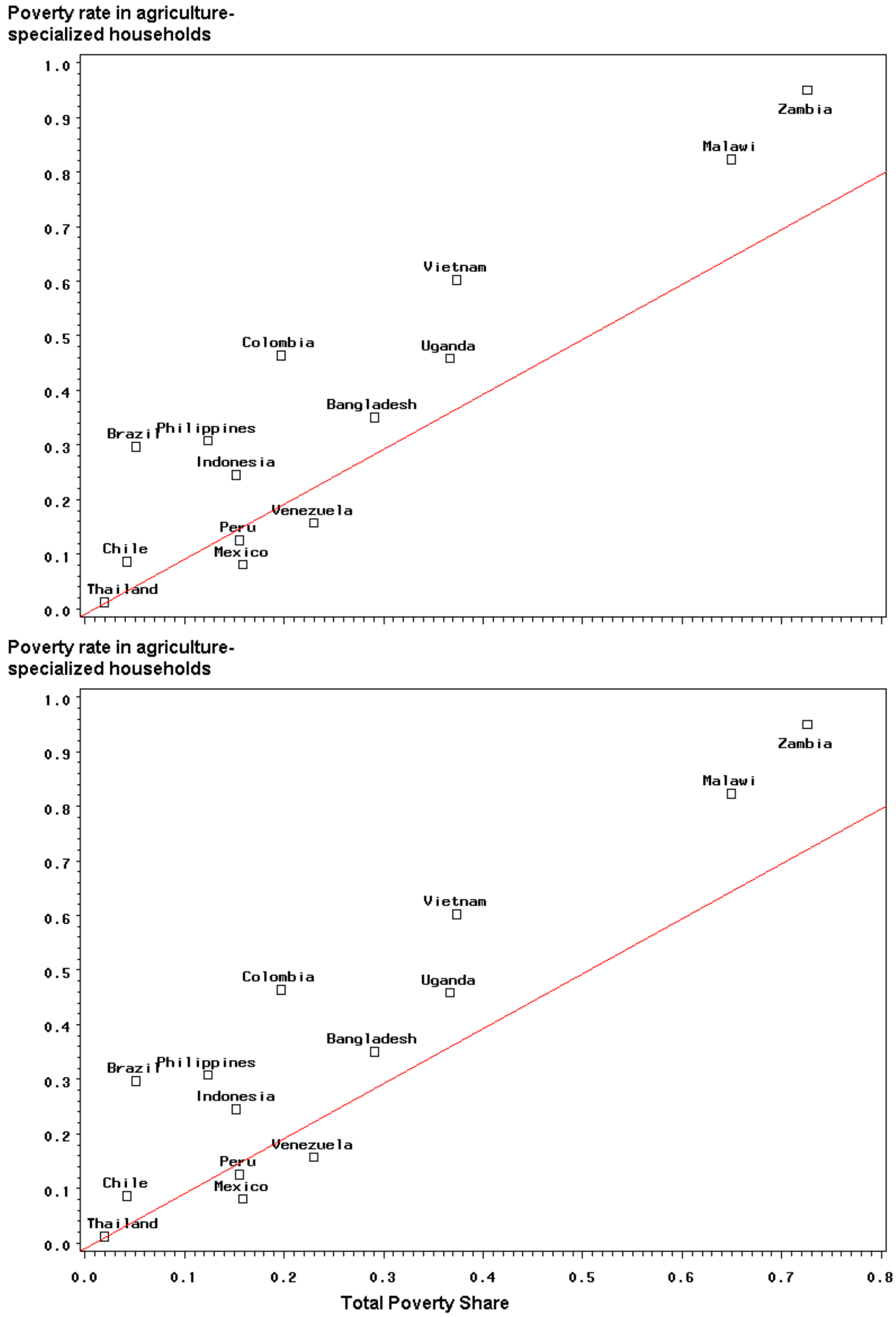
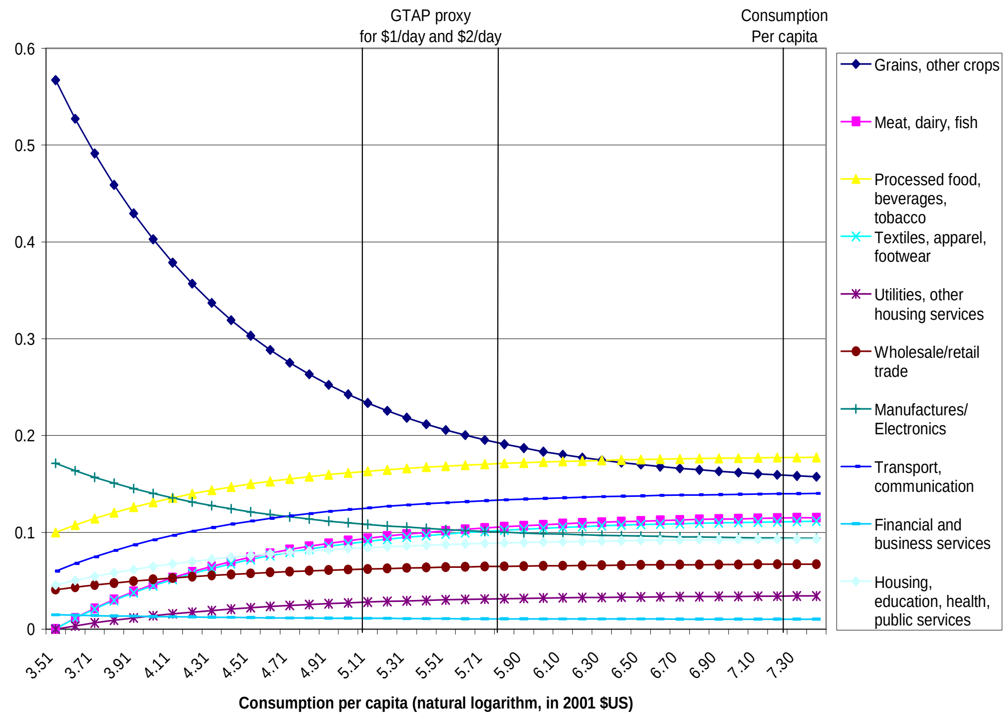


Figure 1. Overview of the Analytical Framework



Source: Authors calculations.

Figure 2. Total poverty rate versus poverty rate among agricultural specialized households (line denotes locus of points with equal poverty rates)



Source: Authors' calculations.

Figure 3. Estimated budget shares across the income spectrum in Peru

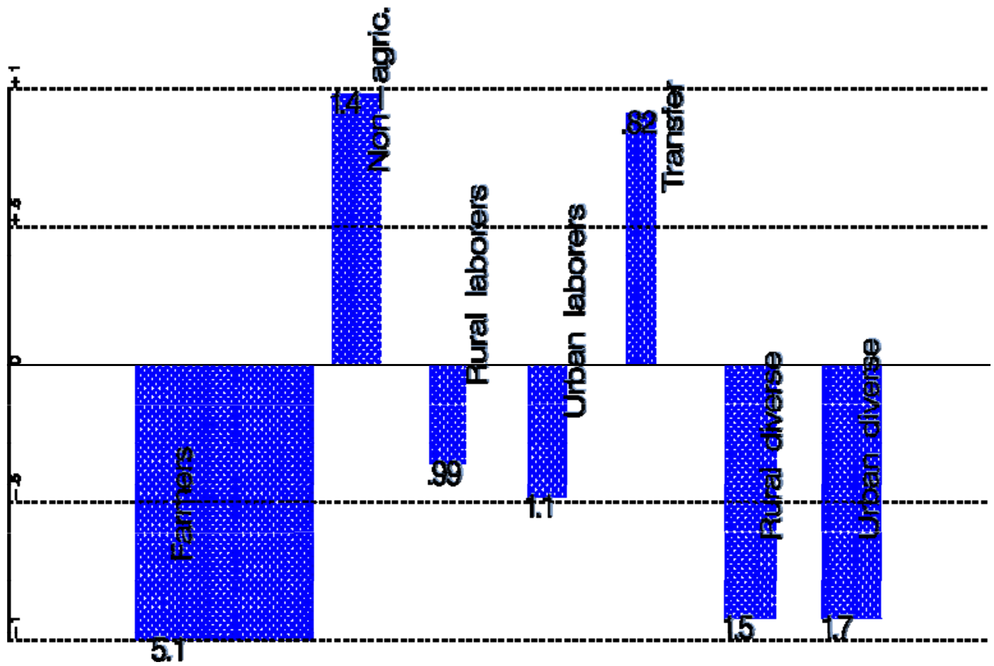


Figure 4. Sign consistency (y-axis) and average absolute value (area of rectangle) of percentage poverty changes, by stratum, 15 focus countries: Rich-Agr-Full scenario

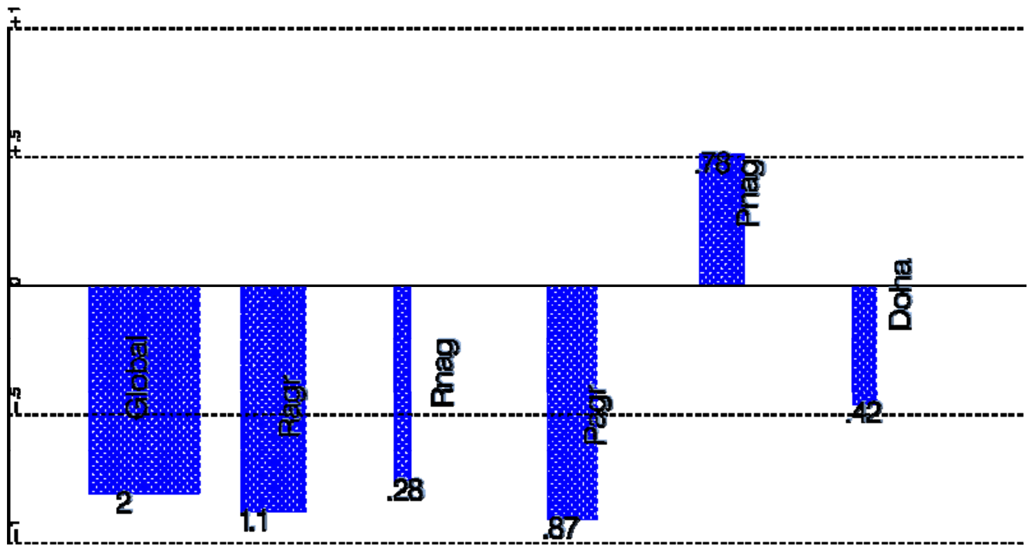


Figure 5. Sign Consistency (y-axis) and Average Absolute Value (area of rectangle) of percentage national poverty changes, by policy scenario, 15 focus countries