## Appendix 1: Model and Database

We use the single-country, International Food Policy Research Institute (IFPRI) standard computable general equilibrium model (CGE), which explicitly describes the wholesale and retail transaction services that link production to sales and create a price wedge between producer and purchaser prices.[11] Production is described by a constant elasticity of substitution (CES) value-added production function with Leontief intermediate technology. Consumer demand is a described by a Cobb-Douglas utility function. Three factors of production—labor, capital, and land—are fully mobile within the country and fixed in aggregate supply. India is linked to the rest of the world through trade flows that are described by Armington import demand and constant elasticity of transformation (CET) export supply functions. The model's macroeconomic closure was chosen to realistically represent the Indian economy. Investment is savings driven, with private savings changing as household incomes change, given fixed private savings rates. Public savings (the fiscal deficit/surplus) adjust with changes in tax revenues and subsidy and transfer payments, given fixed real government expenditures and fixed tax and subsidy rates.[12] We assume a flexible exchange rate that adjusts to maintain a fixed current account balance. The consumer price index is used as numeraire. The model is implemented in the General Algebraic Modeling System (GAMS) software documented in Rosenthal (2007).

[11]The model is fully documented in Löfgren et al., 2002.

[12]For a detailed discussion of the implications of model macroclosure rules, see Löfgren (2002) and Robinson (1991). The use of the CET function contributes to the limited response of export supply to changes in import tariffs. The use of Armington import demand functions constrains the import demand response to tariff elimination. The import response in the model to tariff reform may still be overstated in cases where domestic prices are below tariff-adjusted world prices and tariffs are not the binding constraint on imports.

The database for the model is the Global Trade Analysis Project (GTAP) Version 6 with a base year of 2001. We use the data-download program developed by McDonald and Thierfelder (2004) to organize the GTAP data for India and its world trade flows into a 23-sector Social Accounting Matrix (SAM) that is compatible with the IFPRI standard CGE model. We develop a model database with 30 sectors, of which 12 are crop and livestock sectors in primary agriculture. Seven sectors encompass processed foods, beverages, and tobacco. The five remaining commodity sectors are natural resources, textiles, apparel, and light and heavy manufacturing. There are two trade services sectors: (1) the wholesale and retail trade services required for domestic and export sales of domestically produced agriculture and food, and (2) all other trade services in the economy. Armington and export supply elasticities have a value of 2; the factor substitution elasticities have a value of 0.8. Households' Cobb-Douglas utility functions imply, for each good, a unitary income elasticity, a negative own-price demand elasticity of one and zero cross-price demand elasticities.

For this analysis, the GTAP SAM for India was extended in three ways: (1) commodity disaggregation, (2) trade services sector disaggregation, and (3) household disaggregation. We disaggregated three of the agricultural and processed food sectors in the GTAP database to support a more detailed analysis of several important Indian commodities: (1) corn was separated from GTAP "other grain" to create corn and other grain, (2) pulses were separated from GTAP "fruits and vegetables" to create fruits and vegetables and pulses, and (3) GTAP "oils and fats" were separated into oils and fats and oilmeals.

To disaggregate the subsectors, activity columns were added to the SAM to describe subsectors' intermediate inputs, factor demands, and taxes. Commodity columns were added to describe subsectors' domestic produc-

tion, imports, and commodity taxes. Corresponding activity rows and commodity rows were also added. The activity rows report the sale of total domestic production of the subsectors to the commodity accounts. The commodity rows report intermediate and final demand for each new subsector. The newly disaggregated rows and columns of the SAM sum to the original rows and columns. Data used for the agricultural sector disaggregation are drawn from multiple USDA data sources.

The trade services sector in the SAM is disaggregated into (1) trade services used in wholesale and retail sales of domestically produced food and agricultural commodities to domestic and export markets, and (2) all other trade services. The objective of the disaggregation of the agricultural and food trade services sector is to create a link between total expenditures by firms and final demand (households, government, investment, and exports) on trade services reported in the GTAP database and the commodity composition of those wholesale and retail trade services. As a first step in creating this link, we create control totals for aggregate domestic and export agricultural marketing expenditures by assuming that the trade services required for all domestically consumed goods are of equal proportion and that those provided for exports are of equal proportion. The control total for trade services used for domestic sales of agricultural and food goods is then assumed to equal the share of these goods in aggregate domestic expenditure multiplied by total domestic trade service expenditure in the economy. The control total for marketing expenditures on exports of agricultural and food goods is assumed to equal the budget share of these goods in total export sales multiplied by total export trade service expenditure. Next, to capture variation in marketing costs across agricultural and food commodities, we estimate trade margin costs for each commodity by applying to the domestic and export control totals the trade and marketing margins based on farm-retail price spread data and data from various studies of Indian commodity markets. Finally, the trade service margins for domestic and export sales are uniformly scaled so that the sums of trade service expenditures are equal to the control totals for domestic and export trade service expenditures and meet the constraint that, for any production activity or agent, agricultural trade expenditures cannot exceed total trade expenditures by commodity reported in the GTAP data. For sectors in which base exports are a negligible share of production, trade and marketing costs on export sales are assumed to be zero.

The category “other trade services” becomes a residual of the trade service sector in the GTAP data. It is defined as total trade service expenditures minus trade services produced and consumed in marketing domestic production of agricultural and food goods.

We follow Arndt et al. (1999) in restructuring the India SAM to include one production activity row and one activity column to describe the production and sale of margin services used for agricultural and food products. The activity column account reports the production technology as a proportion of, and identical to, the production of trade services in the original SAM. One commodity row account and one commodity column account is added to the SAM to describe the supply of and demand for margin services used for agricultural and food products. The commodity column account describes the supply of margin services, which are only produced domestically. The commodity row account describes the intermediate input demand

for the margin service in the production of margin services and the allocation of margin services for marketing domestic sales and exports. Two trade margin accounts (a column and row for each) are added to the SAM—one for domestic sales and one for export sales. The trade margin row accounts report demand for trade margin services for the sale of agricultural and food products in the domestic market and as exports. These margins are demanded by each agricultural and food commodity, in their column accounts, so that the value of each agricultural and food commodity purchase reported in the SAM now includes its trade margin on the domestic variety. Nonfood and nonagricultural commodity purchases are reported net of marketing costs.

Expenditures by firms, households, government, investment, and exports are adjusted so that expenditures on food and agricultural commodities are reported in purchaser prices that include the wholesale and retail trade and marketing costs. These trade service expenditures, now embedded in commodity prices, are then subtracted from each agent's total expenditures on trade margin services.

Finally, we extend the India SAM by disaggregating the single household into 10 representative households. Household income and expenditure data are from the 2003/04 India SAM developed by Saluja and Yadav (2006). Using 1999-2000 data from the National Sample Survey Organization (Government of India, Ministry of Statistics and Programme Implementation, 2001), Saluja and Yadav disaggregated 10 household types that characterize 5 income and expenditure classes each for rural and urban households: abject poverty, poverty, middle income, upper income, and high income. The middle household classes have national average per capita expenditures in urban and rural areas. Saluja and Yadav draw data on sources of factor income by household type from Pradhan and Roy (2003).

The 73-sector data in the Saluja and Yadav SAM are aggregated into the sectors of the GTAP India SAM, and the household income and expenditure shares of the 10 household types are then applied to disaggregate the single household in the GTAP SAM. Because the Saluja and Yadav SAM includes only labor and capital, whereas the model used here also includes land, we assume that land income has the same distribution as capital income in the Saluja and Yadav database. Furthermore, we assume that land returns accrue only to rural households.

## Appendix 2: Sector Aggregation From GTAP Database: Mapping GTAP Sata Into the India SAM

| No. | Sector name | GTAP sector |
|---|---|---|
| 1 | Rice | pdr pcr |
| 2 | Wheat | wht |
| 3 | Corn | gro |
| 4 | Oth grain | gro |
| 5 | Pulses | v_f |
| 6 | Frt/veg. | v_f |
| 7 | Oilseeds | osd |
| 8 | Sugar | c_b sgr |
| 9 | Fibers | pfb |
| 10 | Crops nec | ocr |
| 11 | Beef | ctl |
| 12 | Poultry/hog | oap wol |
| 13 | Nat. Resource | frs fsh coa oil gas omn p_c crp nmm |
| 14 | Beef/mutton | cmt |
| 15 | Poultry/pork | omt |
| 16 | Oilmeals | vol |
| 17 | Fats oils | vol |
| 18 | Dairy prods | rmk mil |
| 19 | Foods nec | ofd |
| 20 | Bev tobac | b_t |
| 21 | Textiles | tex |
| 22 | Apparel | wap |
| 23 | Light mfg. | lea lum ppp |
| 24 | Heavy mfg. | i_s nfm fmp mvh otn ele ome omf |
| 25 | Agric trade services | trd |
| 26 | Food trade services | trd |
| 27 | Othr trade services | trd |
| 28 | Ag. Transp. | otp wtp atp |
| 29 | Oth transp. | otp wtp atp |
| 30 | Oth services | ely gdt wtr cns cmn ofi isr obs ros osg dwe |

Source: ERS model.

## Appendix 3: Scenario Results for Impacts of Agricultural Marketing Efficiency, Input Subsidy, and Tariff Reform Scenarios in India

| Variable | 50 % increase in total factor productivity in agricultural & food marketing | Elimination of agricultural subsidies | Elimination of agricultural tariffs |
|---|---|---|---|
| | Percent change from base | | |
| **Aggregate impacts:** | | | |
| Real GDP | 1.0 | 0.1 | 0.3 |
| Real household consumption | 1.4 | -1.3 | 1.2 |
| Real investment demand | 0.4 | 4.2 | -2.2 |
| Government revenue | 1.0 | 7.4 | -2.3 |
| Producer price index | 0.4 | -0.4 | 1.0 |
| Land rents | 5.6 | -5.0 | -0.1 |
| Wages | 1.6 | -1.4 | 1.3 |
| Capital rents | 0.1 | -0.5 | 1.2 |
| Agricultural exports | 3.9 | 3.9 | -2.7 |
| Agricultural imports | -0.9 | -36.4 | 21.4 |
| Exchange rate - rupees/$ | 0.7 | -0.6 | 2.4 |
| **Consumer price impacts:** | | | |
| Rice | -0.8 | 5.4 | 0.9 |
| Wheat | -0.5 | 8.7 | 0.8 |
| Corn | -0.2 | 1.1 | 0.6 |
| Fruit & veg. | -1.0 | 0.9 | -1.3 |
| Oils & fats | -2.1 | -0.6 | -21.0 |
| Sugar | -1.8 | -2.2 | 0.8 |
| Fibers | -0.1 | 1.5 | 0.3 |
| Poultry & pork | 0.6 | -0.7 | -34.7 |
| Dairy | -0.7 | -2.2 | 0.3 |
| Food, nec | -4.0 | -0.9 | -1.1 |
| **Producer price impacts:** | | | |
| Rice | 1.2 | 5.8 | 0.9 |
| Wheat | 1.8 | 9.5 | 0.8 |
| Corn | 2.2 | 1.4 | 0.6 |
| Fruit & veg. | 2.3 | 1.3 | 0.6 |
| Oils & fats | 0.4 | -0.4 | -0.7 |
| Sugar | 1.0 | -2.3 | 0.8 |
| Fibers | 2.4 | 2.1 | 0.7 |
| Poultry & pork | 2.7 | -0.8 | -5.5 |
| Dairy | 1.9 | -2.3 | 0.3 |
| Food, nec | -0.1 | -0.9 | 0.5 |

continued—

## Appendix 3: Scenario Results for Impacts of Agricultural Marketing Efficiency, Input Subsidy, and Tariff Reform Scenarios in India—continued

| Variable | 50 % increase in total factor productivity in agricultural & food marketing | Elimination of agricultural subsidies | Elimination of agricultural tariffs |
|---|---|---|---|
| | Percent change from base | | |
| **Real household consumption (welfare) impacts by household type:** | | | |
| Rural: Abject poverty (R1) | 2.0 | -2.6 | 1.7 |
| Rural: Poor (R2) | 1.9 | -2.3 | 1.7 |
| Rural: Middle income (R3) | 1.8 | -1.9 | 1.5 |
| Rural: Upper mid. income (R4) | 1.7 | -1.6 | 1.3 |
| Rural: High income (R5) | 1.4 | -1.2 | 0.9 |
| Urban: Abject poverty (U1) | 1.4 | -1.8 | 1.7 |
| Urban: Poor (U2) | 1.3 | -1.4 | 1.6 |
| Urban: Middle income (U3) | 1.2 | -0.9 | 1.4 |
| Urban: Upper mid. income (U4) | 0.9 | -0.5 | 1.0 |
| Urban: High income (U5) | 0.8 | -0.8 | 1.0 |
| Source: ERS model results. | | | |