Appendix: Model Structure and Data Sources

Model Structure. The model used in this report incorporates the commodity detail of partial equilibrium models while recognizing the aggregate resource constraints that are the focus of general equilibrium models. Because time series data for transition countries are insufficient for the estimation of relationships, the model uses a mathematical programming approach.

In the empirical model, goods and factors are one of four types. Pure final goods are those goods only consumed by consumers. These include: beef, pork, poultry meat, eggs, sugar, butter, cheese, and retail milk. Other goods are used as both a final good and as an intermediate good: potatoes, grain, roots and pulses, the composite other traded good, and the composite nontraded good. Goods that are classified as pure intermediates are: farm milk, cattle, swine, birds, oilseeds, sugarbeets, silage, and forage. Finally, there are the pure factors of production: labor, land, and sector-specific capital.

The model adopts a Ricardo-Viner structure common in trade models (Jones, 1981; Sanyal and Jones, 1982; Paarlberg, 1994). Each country is treated as facing given world prices for tradable goods. Goods are produced by perfectly competitive firms using constant returns to scale technologies. Each industry uses multiple factors of production in variable proportions. Primary factors—land, labor, and capital—are in fixed supply and nontraded. Labor is used by all sectors with an institutionally set wage since these nations had considerable unemployment in the 1994-1996 base period. Thus, the labor market behaves like that described by Brecher (1974). Land is mobile within crop production but is not used in animal agriculture or in agricultural processing. Capital is industry-specific and takes a putty-clay form. Investment in previous periods determines the capital available for production in the current period. The other type of factor consists of intermediates that may or may not be traded (Sanyal and Jones, 1982; Paarlberg, 1995).

Under these assumptions, industries earn zero profits. Let W be a vector of primary factor prices and P_c be a vector of demand prices. Producer prices are given by a vector P_p. The per unit use of primary factors is described by the matrix $A(W, P_c)$. The per unit use of intermediates is described by the matrix $Z(W, P_c)$. Under the constant returns to scale assumption, the per unit factor demands depend on only factor prices. Note that intermediate factor use is also a function of factor prices, so this model allows factor substitution. Thus, the zero profit conditions are:

$$(1)\ A(W, P_c)*W+Z(W, P_c)*P_c = P_p.$$

Nontraded factor markets clear via price, except for labor. Demand for factors is derived from the production activities, denoted by the vector Q. The fixed supplies of these factors are given by the resource endowments (the vector R). This is described by:

$$(2)\ A^T(W, P_c)*Q = R.$$

Goods markets need to clear. There are two sources of demand, as a final good and as an intermediate. Final demand is captured in a demand system. Let C be the vector of final consumption and E be a scalar representing national expenditure. The demand system is:

$$(3)\ C = C(P_c, E).$$

Derived demands are given by $Z(W, P_c)$ *Q which is the per unit use multiplied by the output. The final identity states that demand less output equals imports (M). For nontraded, goods the elements of M are zero:

$$(4)\ M = I* C(P_c, E) +(Z(W, P_c) -I)*Q,$$

where I is an identity matrix.

All goods have price linkages that determine the price for consumption as the producer price less domestic subsidies (S):

$$(5)\ P_c = P_p - S.$$

The elements of the vector S for taxed goods have a negative sign. When there are no taxes or domestic subsidies, the element of S is zero and the producer and consumer price match. Traded goods have additional price linkages that relate the producer price to the world price plus a border intervention. For traded good i these price linkages are:

$$(6)\ P_{pi} = P_{wi} + t_i,$$

where P_{wi} is the world price for good i and t_i is the border intervention for the good. Tariffs represent a positive intervention for imported commodities. Export subsidies also have a positive t_i for exported goods.

The final variable to determine is expenditure on goods (E). Expenditure is defined as the value of returns to primary factors plus net revenues from border intervention plus borrowing from overseas, less savings. Revenue earned in production is allocated ultimately to primary factors W*R. Revenue earned on border interventions is given by t*M, where t is the vector of import tariffs or export subsidies. In the case of an export subsidy on good i, $M_i < 0$, so a loss is incurred. Net borrowing (F) is the negative of the balance of trade. To find expenditure on goods in the current period deferred spending—savings (SV)—must be removed. Thus, expenditure is:

(7) E = W*R + t*M + F - SV.

To determine the impact of changes the system is differentiated and the percent changes are applied to the 1994-1996 base.

Supply Use, Prices. Most of the supply use and price data used are from USDA/Foreign Agriculture Service (USDA/FAS) attaché reports supplemented by national yearbooks. Quantity data for potatoes and pulses that are not normally covered in USDA/FAS reports are from FAO *Production Yearbook and Trade Yearbook,* or national statistical sources. The majority of price data come from USDA/FAS attaché reports. Those reports generally provide sufficient data on prices for grains, oilseeds, sugarbeets, sugar, livestock, and livestock products. Prices for the other commodities are from various sources including national statistics as well as individuals in the country. Three models separate the national supply and use data into peasant/private sectors and commercial/state sectors. The separation of production and consumption relies on using data on farm numbers and average size by type, on crop and animal production allocation, and national per capita consumption to determine household nonmarket use and peasant production (see AEI, 1998 for Romanian dairy information). Once the peasant/private quantity flows are calculated they are subtracted from the national data to determine the commercial/state sector values.

Unit cost shares. Unit cost shares are a critical data input. Sources of cost share information include industry contacts, research institutions, and ministries of agriculture. Unit cost shares for agricultural commodities in commercial Romanian production, except for dairy products, come from budgets developed in the Ministry of Agriculture supplemented by AEI (1996a). Cost shares for hog and poultry production in Romania also use information provided by Luca (1998) and Grant and Gerber (1997). The dairy product cost shares are from a private dairy processor. Cost shares for peasant agriculture are based on survey results (AEI, 1996b). Hungarian cost shares are based on AKII (1997) and Kertesz (1997). For Ukraine and Russia, state sector cost shares are calculated from the World Bank report on Ukraine, with grain and meal shares reflecting information on feed composition from Raskhod. Polish information comes from the agriculture ministry. Another method of deriving cost shares is to use the supply use data from USDA/FAS to calculate unit cost shares for intermediate inputs. In most cases similar results are obtained.

The unit cost shares for physical and human capital are calculated as residuals, and the industry allocation of capital is determined from the cost share. Capital in this formulation consists of physical capital plus the return to management (accounting profits).

The major difference between crops and other production activities concerns the input land. For crops, land is a major input with a payment (rent). Since many of the nations in the study have either a poorly functioning or nonexistent land market, the interpretation of the payment to land in the models must be clarified. The zero profit conditions used to model output behavior are dual conditions to the problem of maximizing national output given the resource (factor) constraints. Consequently, the factor prices are the marginal value of one more unit of the input—shadow prices. The absence of a land market (which is the case in Ukraine) does not imply that the return to land equals zero. That would only occur if land does not represent a binding constraint to national output. If land represents a constraint to expanding output, whether there is or is not a functioning land market, the land has an implicit value and its shadow price is positive. The market rental rate for land may be zero in that case, but the shadow price will be positive and will change as output prices change. Since the shadow return to land is assumed to be common to all crops, the cost shares are calculated using the base yields. The result is that low yields contribute to high cost shares for land, despite the low rent. Intensive crops, like potatoes and sugarbeets, show low land cost shares—2 to 16 percent. Extensive crops, like grain and oil-seeds, show large unit cost allocated to land—30 to 40 percent.

The residual cost share is the allocation to physical and human capital, and indicates profitability of each commodity. Usually subsistence agriculture is more "profitable" than commercial agriculture in that subsistence agriculture has a higher residual. Within animal agriculture, milk and beef production consistently show higher residuals than swine and birds because the feed cost shares are lower. Beyond these broad generalizations, it is difficult to find a pattern to the capital cost shares.

Retail demand elasticities. The retail demand for the model is built using a complete set of elasticities to determine the changes in retail consumption. For Romania, Russia, and Ukraine the elasticities are obtained from ERS estimates.

For Poland and Hungary, the demand elasticities were obtained using a Stone-Geary utility function. Implementation of this system uses food consumption data for each good in the base period, 1994-1996. Most of the numbers come from USDA/FAS. Data for potatoes and roots/pulses come from various sources, including the Food and Agriculture Organization and national statistical yearbooks, and retail consumption is derived from production and trade data along with per capita household consumption estimates. The retail consumption of the nontraded good and the other traded good are obtained when the economy is balanced.

Elasticities of substitution. The model requires values for the elasticities of substitution. Many general equilibrium models assume a nested constant elasticity of substitution production function system with the per unit use of intermediate inputs fixed—a Leontief production function where the elasticities of substitution are zero. This model does not assume the elasticities of substitution are zero, but they need to be low or the processing sector exhibits overly elastic behavior. Given the lack of time series data, estimation of the elasticities is not possible. The approach is to set a pattern where none of the inputs substitute very well, but labor and capital substitute for the bulk commodity better than the other traded and nontraded goods. Accordingly, the elasticities of substitution for labor and capital are set at 0.3 and those for other traded and nontraded goods are set at 0.1. The elasticities of substitution among feed ingredients are found using a pseudodata technique with compound feed rations as described by McKinzie, Paarlberg, and Huerta (1986). These tend to be around 1. Land substitutes for capital in crop production at an elasticity of substitution of 0.3.

Closure. The markets for the other traded good, for the nontraded good, and the macroeconomic accounts are used to close the circular flow of the economy. Closure requires that payments to factors balance, that all goods markets clear via factor price or quantity adjustments, and that external accounts be cleared. This closure starts with the agricultural and agricultural products markets, then moves to the nontraded market, and finally the market for other traded goods.

Gross Domestic Product (GDP) measures the value of all goods and services produced and is the sum of returns to primary factors (IMF). Once the GDP is set, the factor markets are cleared using other national accounts data. The factor use in agriculture and processed agricultural goods is determined. Those figures are subtracted from data on the total labor force and arable area. The nontraded good is assumed not to use land, and labor use is found from employment by sector data. Consequently, the use of labor and land by the other traded good are residuals. Clearing for the capital market is more involved as data for payments to capital are not available. The GDP is reduced by the total wage and land payments, leaving a residual for capital. That value is reduced by the payments to all other sectors to find the value of capital in the other traded good sector.

The national accounts give the output shares by sector, including that devoted to nontraded goods production (CIA a,b; National Trade Data Bank a,b; Trade Mission of Ukraine; U.S. Department of Commerce; U.S. Department of State). This allows calculating the output value and quantity of nontraded goods. Subtracting the value of nontraded goods produced and the value of agricultural and processed agricultural goods produced from GDP gives the value of the other traded good.

Next, the expenditure and external balances are set so that the entire economy is in domestic and external balance. The national accounts give the current account balance at world market prices and the opposite flow is treated as the balance on the capital account. The supply and use data give the trade balance for the agricultural goods. Combined, these figures determine the external balance for the other traded goods, which is added to the value of production to find the value of consumption. National total expenditure is the sum of payments to primary factors, tariff revenues less export subsidy costs, and overseas borrowing (the capital account balance). The level of expenditure on goods and services in the base period is calculated by subtracting the average level of national savings (deferred spending) from total expenditure.