Appendix 2-1

Description of Methodology

Econometric Approach. In the not too distant past, most gravity models of international trade were estimated using ordinary least squares, and this approach continues to be applied by many researchers. However, the data sets that describe bilateral trade flows usually lack observations for those instances where trade equaled zero or was not reported. This is particularly true at the commodity level, where the proportion of such observations can be rather high. Since this characterization applies to the database used in this chapter, the modified gravity models here are estimated as tobit models, as presented by Green (pp. 727-729):

$$(1) \quad y^*_{it} = \beta' x_{it} + \varepsilon_{it},$$

$$y_{it} = 0 \text{ if } y^* \le 0,$$

$$y_{it} = y^*_{it} \text{ if } y^* > 0,$$

where y^*_{it} is latent measure of trade. The observed, dependent variable (y_{it}) equals the log of U.S. exports to country i in year t, as measured in U.S. dollars.

The number of missing observations in the export data increase as one moves backwards in time through the data set, so the sample is restricted to the 1980-1999 period to ensure that missing observations do not drive the results. In addition, a country's observations are included only if there are at least 10 nonzero observations (out of 14) during 1980-1993 and at least 5 non-zero observations (out of 6) during 1994-99. This evaluation is conducted on a model-by-model basis. Thus, the set of countries included in the model of total agricultural exports is substantially larger than the sets used in the commodity models.

Explanatory Variables. In addition to the intercept, the models in this chapter contain a number of explanatory variables. The log of the importing country's GDP accounts for variations in U.S. exports due to the size of the importing economy. This variable, measured in U.S. dollars, is drawn primarily from the International Monetary Fund's World Economic Outlook Database. GDP data for countries not in this database are from the *Statistical Yearbook of the United Nations*.

Although population estimates are readily available in the World Bank's *World Development Indicators CD-ROM* and the United Nations' *Demographic Yearbook*, the models employed here do not include the log of the importing country's population, a variable that appears in many previous gravity models. This decision is motivated by the fact that the log of population is closely correlated to the log of GDP. According to 1995 data, the correlation coefficient between the two variables is 0.70 for the 127 countries in the sample.

Trade-Agreement Variables. Of primary interest are the explanatory variables that indicate a country's participation in a particular trade agreement (table 2-2). Unlike most previous works, these variables are country-specific in order to address the possibility that the impact of a trade agreement varies among its participants. This possibility is especially strong in the case of NAFTA, which took effect on January 1, 1994, and will complete its implementation phase on January 1, 2008. NAFTA includes three distinct schedules for tariff elimination: a U.S. schedule for Mexican exports, a Canadian schedule for Mexican exports, and a Mexican schedule for U.S. and Canadian exports. Moreover, NAFTA subsumes CFTA and its tariff-elimination schedules for U.S.-Canada trade.

CFTA took effect on January 1, 1989, and its provisions were fully implemented on January 1, 1998. Thus, the first 5 years of NAFTA (1994-98) coincide with the last 5 years of CFTA's tariff-elimination schedule. To distinguish the impact of this latter phase of CFTA's implementation from the agreement's broad influence since 1989, the models include two variables that identify exports to Canada during the CFTA/NAFTA period: CFTA-Canada (1989-1999) and NAFTA-Canada (1994-99).

For Mexico, NAFTA is the extension of a process of unilateral trade reforms that followed the country's accession to the General Agreement on Tariffs and Trade (GATT) in 1986. In the late 1980s and early 1990s, Mexico dramatically reduced its tariffs and opened its economy to foreign direct investment. Import licensing was eliminated for many agricultural products, and tariffs were established well below the 50-percent ceiling established by Mexico's GATT Adhesion Protocol. U.S. exports that benefited from these reforms include beef, pork, sorghum, soybeans, and other oleaginous crops (Rosenzweig Pichardo, 2000). Because Mexico is one of the most important customers for U.S. agricultural products, these reforms may be viewed as a predecessor to NAFTA, somewhat akin to CFTA. For this reason, the models employ two variables to measure trade liberalization's impact on exports to Mexico: Unilateral-Mexico (1989-1999) and NAFTA-Mexico (1994-99). The year 1989 is selected as the beginning of the period covered by Unilateral-Mexico to account for the piecemeal implementation of the reforms over a long period, as well as the fact that key agricultural trade reforms were implemented after 1989.

All four variables listed above are hypothesized to have a positive impact on U.S. agricultural exports, as these measures have provided the United States with substantially freer access to the Canadian and Mexican markets. In contrast, the process of regional integration in South America may have positive or negative effects on U.S. exports. Argentina, Brazil, Paraguay, and Uruguay created MERCOSUR through the Treaty of Asunción, which took effect on November 29, 1991. By progressively eliminating most tariff barriers within the common market, MERCOSUR provides its members with preferential access to each other's markets. Since the United States is not part of MERCOSUR, this process may divert potential U.S. exports from the common market.

However, MERCOSUR also provides for a common external tariff ranging from zero to 20 percent towards non-member countries. In many instances, this tariff is substantially lower than the tariff previously applied by the individual MERCOSUR countries. Thus, its implementation may spur additional U.S. exports to the common market. In addition, Chile and Bolivia became associate members of MERCOSUR in 1996 and 1997, respectively. This means that they share in MERCOSUR's project of internal trade liberalization but do not apply the common external tariff.

To gauge MERCOSUR's impact on U.S. exports, four variables identify exports to particular MERCOSUR countries following the common market's creation: Argentina/1991-99, Brazil/1991-99, Paraguay/1991-99 and Uruguay/1991-99. Four more variables (Argentina/1994-99, Brazil/1994-99, Paraguay/1994-99, and Uruguay/1994-99) indicate exports to these countries during 1994-99. This latter group of variables is intended to capture the additional effect associated with the progressive reduction of tariffs within MERCOSUR, as well as NAFTA's possible influence on U.S. exports to MERCOSUR. Finally, two variables (Bolivia/1997-99 and Chile/1996-99) identify exports to Bolivia and Chile following their becoming associate members of MERCOSUR.

The coefficient for each trade-agreement variable measures the shift in the intercept associated with the observations denoted by that variable. As an example, consider the results for CFTA-Canada in the model of total agricultural exports (table 2-3). The coefficient for this variable

(0.3758) equals the difference between the expected value of the latent trade variable y^*_{it} when CFTA-Canada equals zero and the expected value of y^*_{it} when CFTA-Canada equals one.

Expected Value of the Dependent Variable. Following Green (p. 728), the expected value of the dependent variable (the log of exports to country *i* in year *t*) equals

$$E[y_{it} \mid x_{it}] = \Phi\left(\frac{\beta' x_{it}}{\sigma}\right)(\beta' x_{it} + \sigma\lambda_{it}), \tag{2}$$

where

$$\lambda_{it} = \frac{\phi(\beta' x_{it} / \sigma)}{\Phi(\beta' x_{it} / \sigma)}$$

and σ is the model's scale parameter.

By subtracting the model's coefficient for Unilateral-Mexico (0.4987) from $\beta' x_{it}$ and then substituting this difference for $\beta' x_{it}$ in equation (2), one may calculate the expected value of U.S. agricultural exports to Mexico during 1989-1993 when Unilateral-Mexico is held equal to zero. Similarly, for corresponding exports during 1994-99, one may calculate the expected value when Unilateral-Mexico and NAFTA-Mexico are held to zero by also subtracting the coefficient for NAFTA-Mexico (0.3892) from $\beta' x_{it}$ when re-calculating the equation. This technique provides the basis for a simple simulation of what the value of U.S. agricultural exports to Mexico would have been in the absence of NAFTA and Mexico's unilateral reforms.