CHAPTER THREE: Approaches to Modeling Commodity Markets

3.1 Introduction

Two main types of models are used in quantitative policy analysis: *time series projection models* and *market equilibrium models*. *Time series projection models* attempt to forecast the future through the extrapolation of historical data. These models put more emphasis on the statistical behavior of historical data rather than on the economic theory behind behavioral equations. On the other hand *Market equilibrium models* contain the reaction of economic agents to changes in input and output prices as well as other structural supply and demand shifters. The main objective of these models is to determine the equilibrium prices and quantities in a particular market. The reaction of economic agents is typically derived from certain behavioral assumptions, namely: cost minimization or profit maximization on the production side, and utility maximization, given a certain budget constraint, on the consumption side. This modeling method also uses many structural assumptions, such as constant returns to scale technology, homothetic consumer preferences, and perfectly competitive markets. Equilibrium models are developed for short, medium, or long term, depending on the modeler's degree of interest in the reallocation of production factors.

This chapter reviews relevant literature on modeling approaches to the analysis and control of economic systems and structure of commodity markets.

3.2 Partial Equilibrium and Economy-Wide Approaches

In quantitative policy analysis models, national economies can be represented as *single market models*, a selected set of multi-markets or multi-sector systems, or as *economy equilibrium wide models*, for a more complete representation of national economies. Partial equilibrium models consider a particular market or sector, for example agriculture, as closed and without linkages to the rest of the economy, meaning that the agricultural sector is affected by the rest of the economy but it has

no direct effect on the said economy. The effects of the rest of the world and the local economy on the sector are treated as exogenous. These models can be single or multi-commodity market systems, with the second capturing the interrelationships among the various commodity markets included. Partial equilibrium models develop behavioral equations, which represent the responses of economic agents making supply and demand decisions. These models are mainly applied to detailed policy analysis of specific products. *Economy-wide models* on the other hand, give a complete representation of a national economy, together with trade relations with other economies capturing the effects of international trade on the economy in question. These models are typically specified as: macro-econometric, multi-sector or applied general equilibrium models. (Dervis 1984, Sadoulet and de Janvry 1995)

3.3 Dynamic Versus Comparative Static Analysis Approaches

Quantitative policy analysis models are constructed to deal with changes over time in two ways, as dynamic or comparative static models. Dynamic models provide for an adjustment process over time, through the inclusion of inter-temporal transmission variables as part of the model structure. On the other hand comparative static models compare different but not necessarily related equilibrium points, given different assumptions on the state of exogenous data and policy variables at that point with no reference to the time path between equilibrium points.

Dynamic adjustments over time can be included in equilibrium models in several ways, but usually in a recursive sequential manner such that equilibrium is attained at each time period as adjustment moves over time. In such recursive models policy changes can have lasting effects, on for example production, growth, or consumption.

Comparative static models are used to generate projections in some future time by constructing an artificial future dataset given certain assumptions. This dataset is constructed based on assumptions about changes in the exogenous variables and parameters determining how the state of the world will look like in the future. These

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models are then solved for equilibrium, which is referred to as the baseline solution to which the outcome of various policy experiments are then compared.

In most commodity market models certain assumptions regarding the commodity traded are made. One such assumption is that all goods are perfect substitutes for each other both domestically and internationally, and are thus homogeneous. Another assumption is that the number of suppliers and buyers is large enough for the market to be considered nearly perfectly competitive. These assumptions greatly simplify trade modeling making it "non-spatial", however they impose the limitation that only trade among industries is possible and not within the same industry.

Trade and domestic economic policies are important elements in formulating quantitative policy analysis models as they distort both domestic and international prices. There are two ways of including policy instruments in a model. The first is to include the price mechanism directly in the model and the second is to use a price transmission relationship capturing the policy intervention. Tariffs and quantitative restrictions on trade are the two policy instruments most commonly modeled.

3.4 Partial Equilibrium Trade Models

Over the past decade, several partial equilibrium trade models have been developed. To name a few: AGLINK, European Simulation Model (ESIM), FAO World Model, Food and Agricultural Policy Research Institute (FAPRI), General Agricultural Policy Simulation (GAPsi), MISS, Static World Policy Simulation (SWOPSIM), and World Agricultural Trade Simulation Modeling System (WATSIM). These models not only differ from each other in model design but also in the commodities modeled and the number of countries included in the model. These models also differ with respect to regional emphasis, for example FAPRI focuses on the US, including, however, linkages to other countries, the ESIM model on Eastern Europe, MISS on the US-EU interactions and GAPsi focuses on the EU. The AGLINK, FAO World Model, FAPRI, and GAPsi are all dynamic recursive models. The AGLINK, FAO World Model, and WATSIM all endogenously model land allocation as, while

AGLINK, ESIM, GAPsi, MISS, and WATSIM explicitly model quantitative policies; the SWOPSIM model however includes bilateral trade using the Armington assumptions. The number of countries and regions included in these models ranges from 147 countries and 1 region in the FAO World Model to 1 country and 3 regions in the MISS model. The number of sectors, or products, varies from 13 in the FAO World Model and GAPsi to 29 in the WATSIM model. (Van Tongeren *et al* 2001)

The models listed above cover only farm products or agriculturally related processed goods. The results that are therefore obtained from a general equilibrium model will differ significantly from the partial equilibrium results if agricultural trade policies cause significant price shifts in other sectors. This is the case in developing countries, and countries in transition, as the share of agriculture in the general economic activity is quite high (Van Tongeren *et al* 2001).

From the previous section it is evident that many partial equilibrium trade models have been estimated at the global level. The few case studies found in the African literature are reviewed below.

Townsend and Thirtle (1997) studied the supply response of small-scale producers in Zimbabwe. The sample period used was 1975-1990, a period in which the government set the maize producer price, and announced it after planting. The variables included to explain maize production were the number of marketing depots in the communal sector, the volume of loans to communal farmers, the increased land through resettlement programs, the population of the communal areas, research and extension expenditures and the amount of rainfall. An error correction model for communal maize production was estimated and the relative price of maize and the number of loans was found to be significant. Townsend and Thirtle reported and own price elasticities of 0.78 and 1.01 in the short and long run respectively.

Foster and Mwanaumo (1995) estimated the dynamic supply response of maize in Zambia using a second-order rational distributed lag model. The sample period was

1971 to 1990. The short run own price and fertilizer price elasticities are reported as 0.54 and −0.48 respectively. The corresponding long run elasticities are 1.57 and −1.44.

Van Zyl (1990) analyzed various economic aspects of the South African maize market. In this study, both supply and demand for maize was studied for the period 1960-1988 using stepwise regression. Van Zyl estimated, at the mean, a price elasticity of supply of 0.136, while own price elasticities of demand for maize by the animal sector was between −1.84 and −2.20 while the human consumption elasticity was estimated as −0.15.

Poonyth , Hassan , and BenBelhassen (2001) studied the acreage response to risk of the maize and wheat sectors in South Africa. Using Generalized Least Squares (GLS) and time series data from 1970 to 1998, they determined that maize and wheat producers in South Africa are risk averse with price risks being an important factor influencing a farmers decision in allocating area to maize.

This study focuses on modeling one commodity, namely maize, in a region and therefore models regional trade in a single commodity. The modeling system and the approach used will be discussed in the following chapter.