Osservatorio sulle Politiche Agricole dell'UE

INEA

Working Paper n.11

THE COMMON AGRICULTURAL POLICY IN MULTISECTORAL MODELS

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September 2001

Istituto Nazionale di Economia Agraria

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This paper will appear as *La Politica Agricola Comune nei modelli multisettoriali* in: Giovanni Anania, edt., *Valutare gli effetti della Politica agricola Comune. Lo "stato dell'arte" dei modelli per l'analisi quantitativa degli effetti delle politiche agricole dell'Unione Europea*, Edizioni Scientifiche Italiane, 2001, pp. 181 – 252.

Abstract

The paper reviews the multisectoral models used in the last 10 years to analyse the effects of the Common Agricultural Policy. It begins with a presentation of the theoretical structure of computable general equilibrium models, including both single-region and multi-region models. In this respect, the paper deals with the questions of disaggregation of commodities, households, regions and factors of production, as well as the issues of parameter specification and model closure. The paper then turns to the problems of modelling policies which are included in the present CAP. Firstly, there is the issue of the linkages between institutional and market prices. Secondly, there is the issue of decoupled or semi-decoupled direct payments. Thirdly, there are those related to monitoring the effects of the implementation of Uruguay Round Agreement commitments. Fourthly, there are the questions on the modelling of different policy instruments either related to the use of output, or input. The paper closes with an appraisal of the state of the art and recommends directions for future research, data needs and modelling efforts on the CAP.

Giovanni Anania, Filippo Arfini, Piero Conforti, Fabrizio De Filippis, Pierluigi Londero and Paolo Sckokai provided useful comments which helped improve a first draft of the paper. Conclusions and remaining errors are, as usual, the author's alone. Research financially supported by the Italian National Institute of Agricultural Economics (INEA). *[E-mail: luca.salvatici@uniroma1.it]*

1. Introduction

This chapter examines "multisectoral" models. The term "multisectoral" is used to denote all the models that cover more than one sector of the entire economy. Consequently, aggregate macroeconomic models covering all economic sectors but not characterising any productive sector in particular will not be reviewed, nor will multiproduct, multimarket microeconomic models that do not represent the economy in its entirety. Since their introduction, multisectoral models have been used to analyse agricultural policies[1]. A large literature on multisectoral analyses of agricultural policies and rural development in both industrialised and developing countries is currently available. Two recent texts (Hertel, 1999 and Gohin et al. 1999) review the advantages and current limitations of general equilibrium analyses applied to the agricultural sector.
The models reviewed here have been selected using the same criteria followed in earlier chapters. Within the broad spectrum of multisectoral models, specific attention will be devoted to those studies which, over the last ten years, have sought to represent at least some of the instruments of the Common Agricultural Policy (CAP). Although this decision was dictated by the need to rationalise the amount of literature reviewed, it has significant methodological implications in this case, because numerous other approaches that are employed extensively, particularly outside of the agricultural economics debate, will not be considered. Among these special mention should be made of "structuralist models", which are used extensively in the literature on economic development, "financial models", and "specialised models", which incorporate uncertainty and dynamics[2].
In order to situate the models reviewed here within the literature on multisectoral models, this chapter will discuss, in particular, the different theoretical approaches used in various models (section 2). The following two sections give a brief description of each model considered. A distinction is drawn between models which relate to a *single country* or region (section 3), and *multicountry (regional)* models (section 4). The advantages and limitations in the modelling of the CAP are analysed in section 5, which compares the approaches used in each model with respect to four categories of intervention in the agricultural sector: direct price support, trade policies, measures to limit production and, finally, partially de-coupled support. Section 6 sets out our conclusions and underscores, on one hand, the theoretical and practical difficulties encountered in constructing and applying this type of model, and on the other, the merits and limitations of a general equilibrium approach in analysing agricultural policies.

2. THE STRUCTURE OF APPLIED MULTISECTORAL MODELS

Multisectoral models have a long history in economic analysis: in fact, they appeared right at the dawn of economic policy in the XVIII century: Quesnay's *Tableau Economique* dating back to 1758 is one example. However, an actual applied multisectoral model has only been available since the 1930's (Leontief,1936). After the Second World War, the need to plan and analyse economic policy, along with the advent of computer technology, fostered the development of applied multisectoral models. In the early 1960s two works which may be considered milestones in the empirical development of multisectoral models were published: the first presented the social accounting matrix (SAM), developed by the *Cambridge Growth Project* (1962-74), and the other presented the first empirical general equilibrium model with endogenous prices (Johansen,1960).
Finally, the 1970s saw the introduction of "modern" applied multisectoral models (both single and multi -country): linear models based on SAMs, computable general equilibrium models (CGE) and applied general equilibrium models (AGE). Originally, the difference between the CGE and AGE models consisted of the fact that the former attempted to combine Walras with Keynes, in other

[1] See, for example, agricultural policy experiments in the seminal model of Adelman and Robinson (1978).
[2] For bibliographic references on these types of models see Hertel (1999).

words, traditional *microeconomic* theory of general equilibrium with Keynesian *macroeconomic* theory, whilst the latter were “pure” neoclassical models. Nowadays, both terms CGE and AGE tend to be used interchangeably, although, as we shall see subsequently, there are quite a few differences - not only at the theoretical level - between models which adhere strictly to the theory of general economic equilibrium and those which are less orthodox and more pragmatic. For this reason, the terms CGE and AGE will be used in their original meaning in this presentation.

The broad category of multisectoral models may be subdivided according to various criteria: their spatial dimension (regional, national, global,), their temporal dimension (static, dynamic), their theoretical and formal structure, their degree of aggregation (of sectors or households), their sectoral focus, and so forth. For the purposes of a comparative analysis, it is more appropriate to start by examining the theoretical foundations of such models, using a formal approach. From this perspective one important distinction needs to be made, on the one hand, between Leontief-based and SAM-based models, which are generally Keynesian and linear, and CGE /AGE models, on the other, which are generally Walrasian *and* non-linear. Midway between these two major groups can be placed linear programming multisectoral models, which share the formal (linear) structure of the former and the theoretical structure (optimisation) of the latter group.

2.1. Linear Models

2.1.1. Leontief-type models

Leontief-type models have a long tradition in Italy, even in the agricultural economics sector[3]. Therefore, there is no need to describe the fundamental principles of this family of models, or the input-output tables on which they are based. We would like, however, to discuss a few relevant issues.

First of all, it is important to recall that, according to many scholars, Leontief models are the “ancestors” of CGE/AGE models. For instance, Balderston (1975) states that “Leontief was probably the first to apply a modified system of Walrasian general equilibrium to a particular country at a particular time” (pg. 70) and that “the input-output model is a simplification of the Walrasian system from which it is derived” (pg. 75).

Another relevant aspect in terms of subsequent sections, is the difference between a Leontief closed model and a Leontief open model. The adjective closed/open does not refer to the absence/presence of foreign trade, but rather to the complete endogeneity/exogeneity of final demand (consumption, investment, government spending, exports)[4]. In Leontief’s original closed model, final demand is completely endogenous, while, in the subsequent open model, final demand is completely exogenous. Consequently, the closed model is more similar to the Walras model, while the open model is closer to the Keynesian model - where, however, a large part of consumption is endogenous. It should be remembered that in the closed model, which consists of a system of homogeneous linear equations where the number of equations equals the number of unknowns, a non trivial solution is obtained only by exogenously establishing the value of one of the unknowns, i.e. from the total level of one of the commodities produced or from labour. In this way the model becomes standardised for the variable which is established exogenously[5].

The open model is normally employed for empirical applications, which also include agricultural policy, owing to this model’s greater practical rather than theoretical relevance and the smaller amount of data required (Pasinetti,1975). Consequently, virtually all the input-output tables developed worldwide are based on the open model. However, this practical advantage of the model is partly offset by the disadvantage that no interrelationships between income generation (value

[3]Among the first studies, we would like to mention those by Cesaretti and de Stefano (1974),and Fabiani and Manfredi (1981), Bernini Carri (1981), Chang Ting Fa (1981).Other contributions are analysed in De Muro (1993).

[4]In this presentation we are referring to the model on quantities and not the model on prices.

[5]As a result, the solutions of this model will provide the relative composition of production, but not the absolute production level or “scale” of the system. The same sort of problem arises in the Walras models where, as we will see, the price of a good is selected as the numeraire.

added formation) and income allocation (consumer expenditure), can be established, unlike in the closed model.
As we shall see in subsequent sections, the question of the closed/open nature of models will be debated throughout this presentation, albeit in more complex terms.

2.1.2. Linear Models based on SAMs

SAMs are a simple and effective method to demonstrate the fundamental economic principle that for every income there is a corresponding outlay or expenditure (Pyatt,1988). A SAM, or an input-output table, is not an economic model, but simply a method to represent a model, therefore, every model may be designed by a SAM. To a certain extent, a SAM may be considered an expansion or a generalisation of Leontief's input-output table, in other words, an input-output table characterised by a higher degree of *closure*. While the productive system in that case receives the main focus of attention, a SAM allows for a much broader perspective. An input-output table describes, in brief, the relationships which exist: a) between productive activities; b) between productive activities and what we call "primary factors"; c) between productive activities and final demand; d) between productive activities and the rest of the world. The basic flaw of this method, as we have already pointed out, is that it fails to describe the direct linkages between production factors and final demand, thereby making it impossible to study the manner in which income from production factors is allocated.
The first natural extension of an input-output table, therefore, would be the construction of an account in order to record flows from production factors and to agents of expenditure, i.e. economic and social institutions. This requires the creation of a series of accounts registered in the name of institutional agents present in the economic system: households, enterprises, the public sector (see Table 2.1). Such accounts would record as input any income generated by each institution, in other words, payments received from production factors and productive activities, including those derived from other institutions; and, would record as outputs the manner in which such income is spent e.g. consumption, savings, payments of taxes, etc. This procedure would generate a series of accounts which would be much more comprehensive and detailed than just the one account simply consisting of an input-output table. Accounting principles would remain unchanged, while attention would no longer be exclusively focussed on production, but would also take into account other components of an economic system. A SAM, therefore, is a general economic model of interdependence in the broadest sense of the word. Analytically speaking it is a square block matrix (and "sparse", since many blocks are made up of zeros), which provides a method for re-organising appropriately disaggregated national income accounts.
Another advantage of a SAM is its flexibility: the number and type of accounts (i.e. blocks) that can be opened depends solely on the nature of the economic system to be analysed, and the goals of the researcher. If, for instance, we are looking at the economy of a developing country which is primarily agricultural, then it would be appropriate to have the household sector broken down into urban and rural, in order to study the differences in income formation and participation in productive activities. Furthermore, rural households could be disaggregated on the basis of land ownership: owners, tenants, farmhands, etc.; or, the size of farms. If we wish to examine labour market issues, accounts of production factors may be disaggregated on the basis of manpower categories: factory workers, office workers, technicians, professionals, self-employed and so forth, depending on the level of "human capital". In other words, a SAM lends itself to a host of different configurations, and, naturally, a higher degree of sectoral disaggregation will require and generate a greater quantity of data .
The construction of a SAM is a rather complex task. Even today, there are not many social accounting matrices available, and most of them have been constructed by international organisations (International Labour Office, World Bank, OECD) for developing countries. Very few industrialised countries have developed a SAM. One of the first to do so was the United Kingdom, with the *Growth Project* initiative led by Richard Stone in the 1960s in the *Department of Applied Economics in Cambridge* (1962-74). Italy does not have, as yet, its own official social

accounting matrix, only an unpublished quasi-SAM, developed and used by the ISTAT (National Statistics Office) for balancing national accounts, as well as a few other SAMs which individual researchers have estimated and used.

The difficulty in constructing such matrixes is that the data required is difficult to procure and accounts are difficult to balance. One needs to have access to a great deal of data, but the real problem is that this type of data is not systematically collected by national statistics bodies, or else, the data is derived from a heterogeneous source (e.g. national accounts, household budgets, business surveys). As a result, it is often necessary either to conduct *ad-hoc* statistical surveys, based on the limited data that is available in national accounts, or, to collect heterogeneous data. This approach, however, has its disadvantages, in that the accounts are rarely balanced upon completion, i.e. in the matrix the totals per line do not match the relevant totals per column, due to errors either in procurement or estimation. In the end it is almost always necessary to reconcile and balance the accounts.

The most immediate use of a SAM would consist of an analysis of the impact of exogenous variables by calculating multipliers. This requires the construction of a linear Leontief - type model based on a SAM. Unlike the open Leontief model, however, a higher degree of closure is obtained with a SAM- based model. In fact, the accounts of households and businesses are normally considered to be endogenous; the only accounts considered alternatively or simultaneously to be exogenous are public sector accounts, the rest of the world as well as capital accounts. Once a decision has been made on which of these three accounts are exogenous then the "closure rule" of a SAM- based model is established. An account for the rest of the world is generally considered to be exogenous, and the same often applies to a public sector account. This decision simply means that exports and government spending are deemed to be exogenous variables, while imports and taxes depend, in a residual manner, on income. Somewhat more tricky is the question of a capital account: whenever it is considered to be exogenous, the model will look more Keynesian, because savings correspond to the level of investment which is determined exogenously; if, however, the account is considered to be endogenous, then the model becomes neoclassical since it implicitly assumes there is a market which balances investment demand with savings supply by means of interest rates. In view of the fact that it is precisely this choice, more than any other, that characterises the model from the theoretical standpoint and significantly influences the results that are obtained, it is undoubtedly a crucial aspect of a SAM- based model's closure rule.

In such models, the calculation of multipliers is virtually identical to the calculation used to derive Leontief's inverse matrix, except that in this case the multiplier matrix obtained is closed with respect to income distribution and consumption, and describes the circular flow of income in the economy. By breaking down the multiplier matrix appropriately, four additional components may be obtained, each one will describe: 1. the initial impact; 2. the net contribution of multiplier effects of direct internal flows to accounts (e.g. inter-industry flows); 3. the net contribution of open circuit effects among accounts; 4. the net contribution of circular closed circuit effects among accounts (e.g. from productive activities to factors and then on to institutions, and back again to productive activities). To further clarify the significance of these four components, let us consider an exogenous variation of demand, for instance, a rise in foreign demand for agricultural products. The first multiplier component will simply indicate how much agricultural production needs to grow in order to meet this demand, this growth will obviously match the rise in demand exactly. The second component will measure how much production has risen in all other industries, directly and indirectly, since the initial increase in agricultural production. The sum of the first two components corresponds to the traditional input-output multiplier. The third component will measure the increase in factor income (capital, labour,...) and income of agents (households, government,...) resulting from the earlier increase in production in various sectors; this income variation is defined as "open circuit effects" because it has to do with the impact of one account (production in this case) on all other accounts (factors, agents...) of a SAM. Finally, the fourth multiplier component will measure, how much production will rise in all industries as a result of a

rise in the income of agents; this production variation is defined as “closed circuit effects” because it indicates the *feed-back* which the initial impact on an account has generated as a result of interaction with other accounts once it returns back to itself.
In this way, multipliers calculated by a SAM may be used to study the extent to which an impulse given to a component in the system will spread and reach all other components; hence their utility as an analytical tool for studying the economic interdependence between different parts in the system.

Table 2.1. Example of a social accounting matrix

Expenditures / *Receipts*	*Activities*	*Factors*	*Households*	*Enterprises*	*Government*	*Capital account*	*Rest of world*	*Total*
Activities	Intermediate inputs		Household consumption		Government consumption	Investment	Exports	Total demand
Factors	Value added							Factor income
Households		Wages	Transfers	Distributed profits	Transfers		Foreign remittances	Household income
Enterprises		Gross profits			Transfers		Profits received from abroad	Enterprise income
Government	Indirect taxes		Direct taxes	Enterprise taxes				Government receipts
Capital account			Household savings	Retained earnings	Government savings		Net capital inflow	Total saving
Rest of world	Imports	Factor incomes to abroad	Imports	Profits distributed abroad		Asset purchases from abroad		Payments to abroad
Total	Gross output	Value added	Household expenditure	Enterprise expenditure	Government expenditure	Total investment	Foreign exchange inflow	

2.2. General Equilibrium Model

2.2.1. Different Approaches

Notwithstanding their common Walrasian roots, general equilibrium models are a fairly diverse group, as we have already mentioned above. Schubert (1993) makes a distinction between five different approaches: the Johansen approach, the Harberger-Scarf-Shoven-Whalley (HSSW) approach, the structuralist approach (to which several World Bank researchers have contributed), the Jorgenson econometric approach and the Ginsburgh-Waelbroeck and Manne approach.
The empirical development of Walrasian general equilibrium models began with Johansen’s model (1960) for the Norwegian economy. Johansen linearised the general equilibrium model in logarithms, and, in this way, he managed to reach a solution through a simple matrix inversion which provided growth rates for the endogenous variables. One important aspect of this model is that it gave rise to a procedure which is now adopted by the majority of CGEs: the value of parameters is obtained by a method currently called “calibration” (see section 2.2.3 below) and hence, the model is entirely deterministic. One of the most interesting extensions of Johansen’s model was the subsequent ORANI model for the Australian economy (Dixon et al.,1977).
The HSSW approach is derived from the tradition of welfare economics and is generally applied to public finance problems. It is essentially based on Scarf’s algorithm (1967) which calculates the

equilibrium of a Walrasian model numerically, as well as on Shoven's and Whalley's demonstration (1973) of the existence of a general equilibrium with taxes, and the publication of an algorithm which makes it possible to attain this equilibrium. The HSSW models are strictly based on Walrasian theory. They exclude any *ad-hoc* specification (i.e. unrelated to the "standard" theory of general equilibrium) that tends to make the model closer to reality, but which, according to these authors, would have the disadvantage of obscuring the interpretation of results. Johansen, on the contrary, while not departing from the neoclassical paradigm, conceived his own model as an approximation of the "true" unknown model of the economy, and this involved the addition of specifications incompatible with Walrasian theory (for example, the assumption of intersectoral wage differentials, even though for only one type of employment).

The first important structuralist model was developed by Adelman and Robinson (1978) for South Korea, and was mainly designed to study income distribution issues. It is in this work that the term "computable general equilibrium" was used for the first time. Even Adelman's and Robinson's model, like Johansen's, departs from a strictly Walrasian framework, although in a different direction: this model incorporates inflation and certain rigidities in goods and labour markets.

Structuralist CGE models were designed mainly by the World Bank, and, while maintaining a Walrasian approach, they often incorporate assumptions originating outside the neoclassical tradition. Since these models have been mostly conceived for developing countries, their authors generally justify such "contaminations" by claiming that the rigidities and distortions found in these countries cannot be dealt with by the Walrasian model without modifications to reflect the anomalies. These departures from Walras vary among different authors: some limit themselves to modifications of a more microeconomic nature (e.g. price rigidity in certain markets), others go further and introduce changes in the macroeconomic structure of the model (investment as an autonomous component of final demand).

According to Robinson (1989), three types of structuralist models may be distinguished. Firstly, those that remain within the structure of the traditional neoclassical model, but specify limited elasticities of substitution in several important relationships. This type of model may be defined as "elasticity structuralist". A second type of model – which may be defined as "microstructuralist" – is based on the assumption that several markets are not functioning properly or are even absent. The assumption, therefore, is that restrictions to factor mobility, rigid prices, rationing, and neoclassical imbalances exist in one or more important markets. "Macrostructuralist" models are the third type, these focus on the issue of how to attain equilibrium among different macroaggregates, in particular, savings and investment, exports and imports, and government spending and revenue.

Jorgenson, together with various co-authors, has distanced himself from the traditional approach, by constructing AGE models that are calculated econometrically and are not calibrated. Econometric calculation is theoretically more satisfactory than calibration, but it also raises many questions. First of all, an average size CGE/AGE model includes a huge number of parameters that need to be calculated, which grow quickly with the number of sectors and households treated; an extremely high number of observations are required in order to estimate all the parameters of the model at the same time. Secondly, simultaneous calculation of a CGE/AGE model requires the use of sophisticated econometric techniques; an alternative may be separate estimation for each of the model's sub-systems (e.g. a block for production, a block for demand), yet it may still not be possible to include all equilibrium conditions in the model.

The approach of Ginsburgh-Walbroeck and Manne is derived from linear programming planning models used in the 1960s and 1970s. The main characteristic of this approach is its representation of models in the Negishi format (or methodology), instead of the usual Arrow-Debreu format (which uses optimisation problems for consumers and enterprises)[6]. In a simplified example of a single producer and a single consumer, the model would have the following form:

[6] For a discussion of the various general equilibrium model forms see Gunning and Keyzer (1995).

C= consumption, X= production and H= initial resources, with C and X belonging to the convex sets of consumption and production possibilities respectively. Preference is represented by the concave function U(C). The question is how can an allocation of resources be found to resolve the problem of mathematical programming:

$$\begin{cases} \text{Max } U(C) \\ C - X - H \leq 0 \end{cases}$$

The solution to this problem (C*, X*) is compatible with a competing equilibrium. Associated prices, p*, are obtained in the form of dual variables. This approach has received less attention from economists than the HSSW approach. The main reason is that it is based on an equivalence between the solution of the planner's optimisation problem and the equilibrium solution for a decentralised market economy. This type of equivalence only exists when an economy is in a first- best situation, and therefore, the models constructed according to this approach are not entirely realistic, since they do not allow for any distortions, for example fiscal distortions, to be introduced, and the range of problems which these models can address is limited. However, it is necessary to point out that such an approach is methodologically more advanced than the HSSW one in terms of the modelling of dynamic behaviours. Moreover, dynamic multisectoral programming models have been widely developed since the early 1970s[7], whereas the first dynamic models based on the HSSW tradition only appeared a decade later (Fullerton et al., 1981, 1983).

2.2.2. The basic structure of a CGE model

Since it is not possible to describe the structure of each one of the different models mentioned in the previous section, we shall undertake a brief review of the structure of one model which may be deemed to be sufficiently representative of the entire family, to the extent that it is a compromise between a purely Walrasian model and another model which seeks to identify the characteristics of a real economy. Our goal is not to describe a standard model, since such a model is difficult to define and may not even exist, but rather, to describe a model which gives us the opportunity to discuss the salient features of CGE/AGE models.

Table 2.1 sets out the equations of a simplified version of a stylised model for an open economy, which also includes the public sector[8]. This model is not written in an Arrow-Debreu format, nor in a Negishi format, but, like most applications, is written in a "CGE" format, i.e. it contains explicit (Marshallian) functions of consumer demand and inputs. In the table, variables with a tilde denote nominal magnitudes, whereas those with a bar are exogenous. The superscripts d, m, e, x and q refer to domestic welfare, imports, exports, output and composite welfare respectively (D, M, E, X and Q). The superscripts D and S refer to demand and supply. The apexes L and K refer to labour and capital. The superscripts P and G refer to the private and the public sectors. A dot denotes the multiplication. The model examines just one sector producing only one good (X), this good is then transformed into an export good (E) and into a good for the domestic market (D). Equation (1) represents the production function, which uses labour, intermediate input and capital, and generally assumes a CES (constant elasticity of substitution) form, nested at two levels. Equation (2) represents the function of output transformation into different goods for export and the domestic market; usually this is a function with constant elasticity transformation (CET). In a multisectoral model, goods from the same domestic sector and from foreign markets are assumed to be of different quality or tradable composition. The CET function enables the composition of sectoral production for domestic and foreign markets to be modified.

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[7]See Manne's Review (1974).

[8]The model is described in detail in Dervis,de Melo and Robinson (1982,ch.6,7).

Table 2.1. An example of a CGE model

Real flows	*Nominal flows*
(1) $X(L^{\mathrm{D}}, V^{\mathrm{D}}, K^{\mathrm{D}})$ production	(16) $\tilde{Y}^L = W \cdot L^{\mathrm{S}} \cdot (1 - \overline{T}^L)$ labour income
(2) $X(E, D^{\mathrm{S}})$ export transformation	(17) $\tilde{Y}^K = R \cdot \overline{K}^{\mathrm{S}} \cdot (1 - \overline{T}^K)$ capital income
(3) $Q^{\mathrm{D}}(M, D^{\mathrm{D}})$ import aggregation	(18) $\tilde{Y}^G = \overline{T}^L \cdot W \cdot L^{\mathrm{S}} + \overline{T}^K \cdot R \cdot \overline{K}^{\mathrm{S}}$ government income
(4) $M / D^{\mathrm{D}} = f_1(P^m, P^d)$ import demand	(19) $\tilde{C}(\tilde{Y}^L, \tilde{Y}^K)$ consumption function
(5) $E / D^{\mathrm{S}} = f_2(P^e, P^d)$ export supply	(20) $\tilde{S}^P = \tilde{Y}^L + \tilde{Y}^K - \tilde{C}$ private saving
(6) $C^{\mathrm{D}}(P^q, \tilde{C})$ consumption demand	(21) $\tilde{M} = \overline{P}^{\$m} \cdot M$ dollar imports
(7) $Z^{\mathrm{D}}(P^q, \tilde{Z})$ investment demand	(22) $\tilde{E} = \overline{P}^{\$e} \cdot E$ dollar exports
(8) $V^{\mathrm{D}}(R, W, P^q, P^x)$ intermediate demand	
	Price equations
(9) $Q^{\mathrm{D}} = C^{\mathrm{D}} + Z^{\mathrm{D}} + V^{\mathrm{D}} + \overline{G}^{\mathrm{D}}$ total demand	(23) $P^m = r \cdot \overline{P}^{\$m}$ import price
(10) $L^{\mathrm{S}}(W, P^q)$ labour supply	(24) $P^e = r \cdot \overline{P}^{\$e}$ export price
(11) $L^{\mathrm{D}}(R, W, P^q, P^x)$ labour demand	(25) $P^q(P^m, P^d)$ composite price
(12) $K^{\mathrm{D}}(R, W, P^q, P^x)$ capital demand	(26) $P^x(P^e, P^d)$ output price
Real system constraints	*Nominal system constraints*
(13) $D^{\mathrm{D}} - D^{\mathrm{S}} = 0$ product market	(27) $\tilde{S}^P + \tilde{S}^G + r \cdot \overline{B} - \tilde{Z} = 0$ savings - investment
(14) $L^{\mathrm{D}} - L^{\mathrm{S}} = 0$ labour market	(28) $\tilde{Y}^G - P^q \cdot \overline{G}^{\mathrm{D}} - \tilde{S}^G = 0$ government balance
(15) $K^{\mathrm{D}} - \overline{K}^{\mathrm{S}} = 0$ capital market	(29) $\tilde{M} - \tilde{E} = \overline{B}$ balance of trade
	(30) $f_3(P^d, P^m, P^e, W) = \overline{P}$ numeraire

Table 2.1 (continues)

Accountingidentities

(31) $P^x \cdot X = P^e \cdot E + P^d \cdot D^S$ value of output = value of sales

(32) $P^q \cdot Q^D = P^m \cdot M + P^d \cdot D^D$ value of composite goods = absorption

(33) $P^x \cdot X = W \cdot L^D + R \cdot K^D + P^q \cdot V^D$ value of sales = value of inputs

(34) $P^q \cdot C^D = \tilde{C}$ consuption demand = expenditure

(35) $P^q \cdot Z^D = \tilde{Z}$ investment demand = expenditure

Endogenous variables	*Endogenous variables (cont.)*
X = aggregate output	$\tilde{M}$ = dollar value of imports
D^S = supply of domestic output	$\tilde{E}$ = dollar value of exports
D^D = demand for domestic output	P^m = domestic price of imports
E = exports	P^e = domestic price of exports
M = imports	P^x = price of aggregate output
Q^D = composite good demand	P^d = price of domestic sales
V^D = intermediate demand	P^q = price of composite good
L^S = labour supply	W = wage of labour
L^D = labour demand	R = rental rate of capital
K^D = capital demand	r = exchange rate
C^D = real consumption	$\tilde{Y}^G$ = government income
Z^D = real investment	$\tilde{S}^P$ = private savings
$\tilde{Y}^L$ = nominal income	$\tilde{S}^G$ = goverment savings
$\tilde{Y}^K$ = capital income	$\tilde{C}$ = nominal consumption
	$\tilde{Z}$ = nominal investment

Exogenous variables

$\overline{G}^D$ = real government demand	$\overline{B}$ = balance of trade (in dollars)
$\overline{K}^S$ = aggregate capital supply	$\overline{P}^{\$m}$ = world price of imports
T^L = tax rate on labour income	$\overline{P}^{\$e}$ = world price of exports
$\overline{T}^K$ = tax rate on capital income	$\overline{P}$ = numeraire price index

Source: Robinson, 1989.

On the import side, domestic goods sold in the domestic market are assumed to be imperfect substitutes of imports (the Armington assumption). Intermediate and end consumers want a composite commodity, which consists of a CES aggregation of domestic and imported goods. Equation (3) represents the import aggregation CES function, often at two levels. Given equations (2) and (3), and traditional assumptions on maximising profits and minimising costs, the relative levels of exports and imports desirable are, therefore, functions of domestic and foreign prices.

These functions are represented by equations (4) and (5). Equations (25) and (26) define the price of the two composite goods, X and Q, and correspond to the cost functions duals for equations (2) and (3). The homogeneity of CES and CET functions ensures that the accounting identities of equations (31) and (32) are met.

Equations (8), (11) and (12) are the respective demand functions for intermediate goods, labour and capital, based on the best conditions for maximising profit and minimising costs. In many models, intermediate demand is assumed to be given by fixed input-output coefficients, in this case, equation (8) is only a function of output.

Unlike the orthodox theory of trade where all goods are tradable and all tradable goods are perfect substitutes, the model specification described here assigns a significant degree of autonomy to the domestic pricing system. There are some seven prices associated with a single sector: P^x, P^q, P^d, P^m, P^e, $P^{\$m}$ and $P^{\$e}$. The model follows the traditional "small country" assumption, i.e. that world export and import prices are exogenous. It should be stressed, however, that trade policies which incorporate a "wedge" between global prices and domestic and import prices, will be less effective than in a traditional trade model.

Our model, unlike a pure Walras model, presents some additional system constraints for the trade balance, (equation 29), and government accounts (equation 28). Furthermore, another cost, the exchange rate, acts as a variable to ensure equilibrium in the trade balance. Since the model represents no assets and the level of the trade balance in equation (27) is exogenous, the exchange rate will adjust to ensure that flows remain in equilibrium. This balancing mechanism functions through changes in the real exchange rate, which in this model is the ratio between the price of a non tradable domestic good, D, and the prices of tradable goods, E and M. Equation (30) defines the numeraire.

According to traditional neoclassical theory, investment is assumed to be determined by savings; aggregate consumption is given by equation (19), public sector savings are determined residually in equation (28),and equation (27) serves to determine aggregate investment. Accounting identities {equations (31) - (35)} are derived from behavioural equations and ensure that the model complies with the Walras Law; the sum of the nominal values of equations (13) - (15) and (27) - (29) is equal to zero.

In conclusion, there are 29 endogenous variables and 30 equations in the model. The equations, however, are functionally dependent and represent 29 independent equations.

2.2.3. *Methodological Aspects*

Specifications

The principal specifications of an AGE/CGE model involve the selection of the functional forms, in view of the crucial role they play in terms of final results, and the choice of the level of disaggregation.

The two main requirements when selecting the functional forms to specify production and utility functions are they must:

a) be compatible with the theoretical approach;

b) be manageable from the analytical standpoint.

The conditions required to ensure compatibility with the theoretical approach are the following:

1) utility functions must be such that the demand functions derived are not negative, continuous and homogeneous of zero degree with respect to prices;

2) production functions must present constant returns to scale. This condition applies to a pure Walras framework; if imperfect competition and increasing returns to scale are introduced, then this condition is no longer applicable.

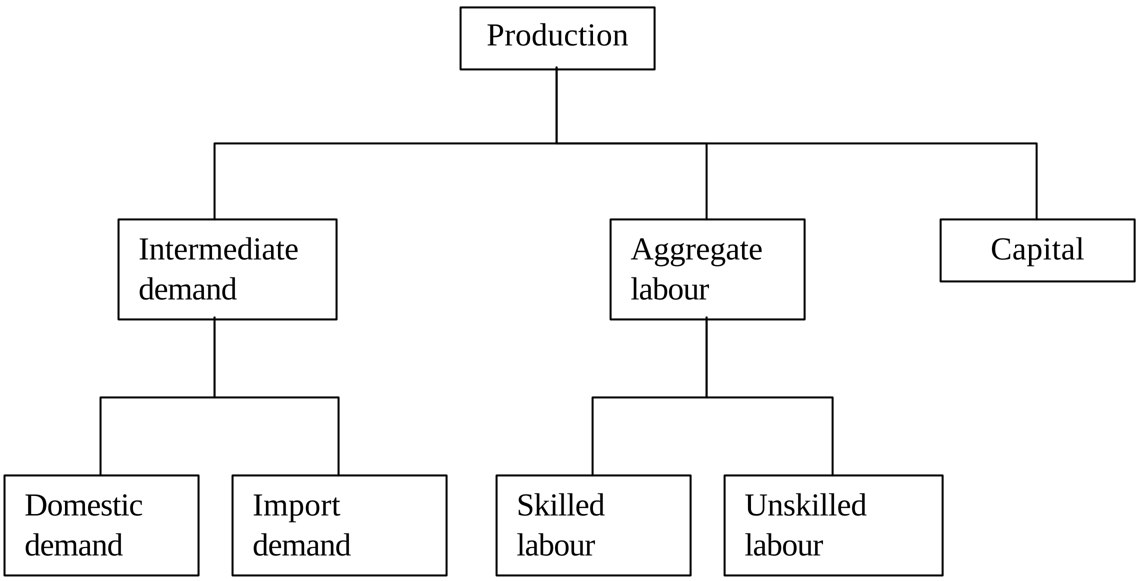
Analytical manageability is the criteria which usually determines the selection of one of the following functional forms: *Cobb-Douglas*, CES, LES (*Linear Expenditure System*), CRESH (*Constant Ratios of Elasticities of Substitution, Homothetic*), *translog*. The decision on which of these to select will depend on how sophisticated the description of the substitution phenomena in the model needs to be, and how the elasticities are used. For a description of the advantages and disadvantages of the various functional forms mentioned above, see Taylor (1990) and Schubert (1993).

Specifications of functions in the AGE/CGE models make extensive use of nested production and utility functions, as we have already seen in the previous section. Figure 2.1 gives an example of a nested production function. The lower part combines intermediate goods of different geographical origin, on the one side, and different labour skills on the other. The upper part combines composite intermediate goods, aggregate labour and capital. In this way, the production structure is broken down into a number of cascade decisions which allow a wide range of possible substitutions to be made.

The selection of level of disaggregation is not an easy one to make. It is generally reached through a compromise between the desire to have a model with as much detail as possible to ensure the best results, on the one hand, and limitations connected with the quantity of information available, the cost of constructing a very large model and the risk that the understanding of the principal mechanisms may be obscured by too much detail, on the other.

One recent approach to this problem is to use the same data at different levels of aggregation: for instance, during the first stage one may construct a model with a high level of aggregation; subsequently, one may introduce a higher level of disaggregation depending on the specific questions considered. A solution of this type, known as “flexible aggregation”, was proposed by Reinert and Roland-Holst (1997) and Bloningen et al. (1997): these researchers started with a very high level of sectoral disaggregation (487), and, subsequently – depending on applications – began to aggregate sectors of no interest.

Figure 2.1. Nested production function



Calibration

The procedure AGE/CGE modellers normally use (with the exception of Jorgenson and his collaborators) to estimate some of the parameters required is a deterministic one called "calibration". It consists of three stages. Stage one involves the construction of a database that is consistent for all the variables contained in the model, with respect to a base year; in other words, a SAM will be needed.

The second stage consists of the actual calibration of the unknown parameters of the model. Once the database – which has to establish the benchmark equilibrium for the economy has been constructed – a "reverse" solution of the model will need to be introduced in order to determine the values of the parameters that are compatible with the exogenous variables and the endogenous variables of the base year, in other words, those parameter values which will make it possible, once the model has been made to function "correctly", to find the initial database, i.e. the equilibrium attained. It is not always possible to find a single set of parameter values to meet this criterion. If that is the case, then it will become necessary to impose the value of certain parameters and leave the model to do a "reverse turn" in order to calculate the value of the remaining parameters.

Finally, the third stage of calibration requires a verification to ensure that the SAM associated parameters determine a position of equilibrium within the economy once simulations are undertaken. At any rate, in view of the fact that the benchmark period is normally represented by one observation (reference year), it is worth noting that calibration procedures do not generally make it possible to evaluate the "statistical robustness" of the results obtained.

2.2.4. Closure Rules

As in the case of SAM based linear models, CGE/AGE models also require the selection of a "closure rule". In the case of general equilibrium models, as we have seen above, this will require a decision on which variable needs to be adjusted in order to obtain equivalence *ex post* of any macroeconomic function considered to be important, mostly between investment and savings. The problem was initially raised in more general terms by Sen (1963), and has been addressed in at least four different ways in the CGE/AGE literature through:

- Keynesian closure, which permits the existence of unemployment. Equilibrium is ensured by the presence of unemployment, which is the adjustment variable. Labour demand, therefore, becomes endogenous. Some structuralists adopt a variant of Keynesian closure: enterprises are on their labour demand curve and nominal wages are fixed, the macroeconomic variable that is adjusted is the general price level;
- Kaldorian closure, which assumes that factors are not paid for according to their marginal productivity (therefore, equivalence between marginal labour productivity and real wages does not apply) and equilibrium is achieved through a re-distribution of income which influences the savings rate;
- Johansen closure, which attributes a decisive role to investment, to which savings are adjusted; similarly consumption is determined by sales. This specification has also been adopted, (in addition to Johansen), by Adelman and Robinson in their model for South Korea (1978);
- neoclassical closure, which attributes a propulsive role to savings; investment varies to ensure equivalence *ex post*. In one of the variants, investment and savings are both endogenous and equilibrium is ensured by the adjustment of an additional variable, the interest rate (Fisherian closure): in this way, a capital market is often implicitly introduced.

The type of closure rule chosen is important because it greatly influences the functioning of the model. As Targetti Lenti (1989) has observed: " the choice of one rule over another, as well as the numeraire, is linked to specific behavioural assumptions of the agents in the system, and ultimately influences the configuration of equilibrium values including functional and personal income distribution". Some authors have shown, through simulation with AGE/CGE models, that the

results that are obtained are not only heavily dependent on the type of closure rule chosen, but in some cases, may even be in conflict with each other[9].
With respect to the general equilibrium models used to analyse agricultural policies, the neoclassical closure rule is the choice most frequently found in the literature. It is interesting to note, though, that the reasons for its selection are seldom discussed at all.

3. National and Regional Models

3.1. Presentation of Models

Models that focus on one country or region are discussed in the following section.
In addition, our review also includes three other models which do not analyse the CAP:

- the CGE USDA/ERS model, a milestone in agricultural policy modelling within a general equilibrium framework, which presents some interesting methodolgical features;
- the WAGEM (*Wageningen Applied General Equilibrium Model*, Komen and Peerlings, 1999) model, which provides useful information on linkages between agriculture and environmental policies;
- a CGE model of the UK (McDonald and Roberts, 1998), which analyses the impact of BSE on the British economy.

The nine "one country" or "one region" models we identified in the literature[10] may be broken into two groups: linear models (Leontief or SAM-based) and CGE/AGE models. The first group consists of four models, two based on input-output tables (Leat and Chambers, 1991, Serrao, 1998) and two based on a SAM (Roberts,1994, Roberts and Russel, 1996). The second group consists of five models:

- the two most important models are the MEGAAF (*Modèle d'équilibre général de l'agriculture et de l'agro-alimentaire français*, Gohin et al., 1998,1999a, 1999b) and the CGE USDA/ERS (Kilkenny, 1991a, 1991b, Kilkenny and Robinson, 1990, Robinson et al., 1990);
- the other three refer to Hungary (Banse and Tangeman,1998), Holland (Komen and Peerlings,1998) and the United Kingdom (McDonald and Roberts,1998).

3.2. Linear Models

While the four linear models discussed here share the same theoretical basis, they are, in fact, substantially different. Three of these models apply to Great Britain: which is a clear indication of how widespread they are in that country.
The first model was constructed by Leat and Chambers (1991) and relates to the Grampian region of North-East Scotland. It is a traditional Leontief model, with a focus on the agro-industrial sector. As a matter of fact, it includes nine agricultural sectors, eight agro-industrial sectors, and just one sector for the rest of the economy in the region. This model was constructed for a variety of reasons, one of which was to evaluate the implications of applying set aside schemes to the grain sector and levying milk quotas on the dairy farming sector. Naturally, the assessment may be made by calculating multipliers of output, income and occupation.
There are two interesting aspects to Leat and Chalmers work. Firstly, in order to construct the model, the authors had to estimate the input-output matrix for the Grampian region; this required the use of data from the *Farm Accountancy Data Network* of Scotland (the European equivalent of the Italian RICA). Secondly, in addition to calculating the traditional multipliers in Leontief's open model (in the literature called "Type I» multipliers), Leat and Chalmers "closed" the model, making the household sector endogenous (see section 2),and then proceeded to calculate "Type II» multipliers, which, in addition to measuring direct and indirect effects, also measure "induced"

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[9]See the various articles published on this subject in the *Journal of Policy Modelling* (1979).
[10]In addition to these nine models, there are others that have not been included in our review, as the published documentation was either not sufficient or not available. An example are the CGE models for Hungary and Poland developed by Boussard and Christensen (1999).

effects; in other words, effects on economic activities caused by an increase in household spending as a result of a rise in occupational income.

The second study examined is Serrao (1998). It covers four regions in Portugal (Alentejo, Litoral, Alto Alentejo, Central Alentejo, Baixo, Alentejo), and, in fact, consists of not one but three different "vertically integrated" models. The author begins by constructing a Johansen type econometric model of the agricultural sector, to estimate the impact of the CAP Reform (cuts in support, milk quotas, convergence towards world prices, compensatory payments) on agricultural variables. In the second phase, the effects of CAP reform on agricultural production levels are "injected" into an input-output model to estimate their impact on total income and occupation in all four regions. Finally, in the third and last phase, the effects of reform on land use and inputs are employed to calculate a whole series of indicators on the environmental impact. Although Serrao's work is characterized by a variety of interesting analytical tools, it does not present a real multisectoral modelling of agricultural policies. In fact, policies are simulated by the sectoral econometric model and the input-output model is used only to estimate subsequently the indirect effects on income and occupation for the entire regional economy. In view of the issues examined in this chapter, our discussion will be limited to Serrao's input-output model.

This author - like the previous ones for the Grampian region - had to undertake a specific estimation of regional input-output tables in order to construct the relevant models. To secure these estimates, he began with the 1990 national table of 49 sectors and added them to12 sectors, a level of disaggregation for which reliable regional data was available. This 12 sector national table was then converted into regional tables using the GRIT (*Generation of Regional Input-Output Tables*) technique, originally developed by Jensen et al. (1979) and based on relative occupational levels. In the national table including the extended version, however, agriculture is treated as one sector. This kind of configuration does not allow for an adequate analysis of the impact of EC policies on, for instance, milk or grain production. For this reason, Serrao decided to disaggregate the agricultural sector in the input-output tables into eight compartments (cattle-raising, milk production, sheep farming, pig farming, wheat, corn, rice cultivation and a hybrid sector). In order to estimate the input-output coefficients of these eight compartments, he constructed a system of input demand and supply derived from a dual cost function. These coefficients were then used to calculate regional "Type II» multipliers of income and occupation for all four sectors to be examined.

Robert's study (1994) presents some interesting methodological aspects compared to earlier works. This researcher endeavours to estimate the impact of milk quotas on the UK economy using a modified Leontief SAM based model. Since milk quotas are supposed to regulate supply, which is an endogenous variable in the traditional Leontief model, and not final demand, Roberts concludes that the traditional form of the model has to be modified in order to make milk production exogenous. To achieve this, a small number of modifications have to be made to both the demand driven Leontief model, and the supply driven one, so that the effects of *backward linkages* and *forward linkages* of milk quotas on the entire economy can be estimated.

Roberts then proceeds to construct two models. The first is a demand driven Leontief model, where, however, production in a sector is exogenously fixed: this is a model with mixed exogenous variables, in which one of the exogenous variables represents gross milk production and the other *n-1* exogenous variables represent the final demand of the remaining *n-1* sectors. This model is used to estimate the effects of backward linkages, i.e. the impact of cuts to milk production on sectors upstream. The second model, unlike the traditional one, is, conversely, supply driven, and also includes mixed exogenous variables: one of the exogenous variables is still gross milk production, while the other *n-1* exogenous variables represent income that is not transferred to households in the remaining *n-1* sectors. This model is used to estimate the effects of forward linkages, i.e. the impact of cuts in milk production on sectors downstream.

These two models were applied to a SAM for the UK in 1984, which included 86 productive activities, 9 primary factors and 5 categories of households, distinguished according to their income level. The closure rule selected is such that, in addition to milk production, accounts relating to the public sector, capital and the rest of the world would be considered exogenous, as is generally the case. The simulation analysed the effects of cuts in milk production on the entire UK economy, between the base year and 1992.

The contribution of Roberts and Russell (1996), which is based on the same SAM as their earlier work, has the merit of taking full advantage of one of the main comparative benefits that multisectoral models provide. It actually examines the relationship between income distribution and the structure of agricultural production based on disaggregation of the household sector. For this purpose, the authors designed a SAM based Leontief model, which they used to calculate:

- the multiplier matrix of direct, indirect and induced effects on the incomes of each group of households resulting from an injection into exogenous accounts, so that the matrix could identify the relative efficacy of different income support policies;
- the matrix of redistributive effects which measure how the structure of the economic system influences the relative benefits/disadvantages which accrue to different household groups as a result of policy changes.

There are two particularly interesting features in Roberts and Russell's work. Firstly, the multiplier matrix is not calculated by using the mean consumption propensity of households, derived directly from the SAM, but rather by estimating marginal propensities obtained from a different source. This removes the restrictive assumption of equivalence between mean propensities and marginal propensities, used in SAM based Leontief models. Therefore, to use the terms introduced by Pyatt and Round (1979), the multipliers obtained by Roberts and Russell are not "accounting" multipliers, but "fixed price" multipliers.

However, the second and more interesting aspect is that the matrix of redistributive effects identifies those who are relatively more advantaged/disadvantaged as a result of a move from a coupled income support policy to a more decoupled policy. The effects of this policy change are simulated by modelling coupled support as an exogenous injection into production accounts, and more decoupled support as an injection into the factors account or, alternatively, into that of households.

One drawback in both of these works, is the method of disaggregation chosen for the household sector. Although the authors are well aware of the reasons for preferring disaggregation of household sectors based on geographical, social and professional criteria rather than criteria of income size, the data at their disposal led them to divide households into income quintiles. In this way, it is not possible for the model to identify "agricultural" households and, therefore, the analysis is of limited value regarding the consequences of changes in the nature of agricultural policies. This case demonstrates that, in order to secure a correct assessment of the effects of different agricultural policies, it is important not only to disaggregate households, but to make sure that "agricultural" households are disaggregated from those of other sectors. A disaggregation of this kind, however, should seek to resolve the problem of how this category (or categories) of households may be appropriately defined, no small problem given the fact that multiple activities are a commom occurrance.

3.3. General Equilibrium models

All the five models briefly examined in this section refer to national economies. Two of them have been constructed by government agencies: one model is from the *Economic Research Service* of *the United States Department of Agriculture,* the other is the MEGAAF model constructed by the *Départment d'Économie et de Sociologie Rurales* of the *Institut National de la Recherche Agronomique*. The other three models, on the contrary, are of academic origin.

The documentation on the basic version of the USDA/ERS model is contained in the work of Robinson and others (1990), which describes in detail the equations and the way the model is calibrated on a SAM for the United States[11]. The publication also includes the complete list of commands for the computer programme (GAMS - *General Algebraic Modelling System*) used to

[11]This SAM is documented in Hanson and Robinson (1989).

find the solutions. The main purpose of this model is to create a multisectoral scheme to formulate an analysis of the effects of changes in agricultural policies and exogenous *shocks* on the agricultural sector, the rural economy, related non-agricultural sectors, and the rest of the economy. The basic model (Kilkenny and Robinson, 1988) was a starting point for a number of extensions and applications[12], which explore various economic policy issues, mainly related to agricultural trade policies and the effects of alternative national policies.

The model is constructed to analyse, in particular, international trade and is based on the assumption of imperfect substitution between imported goods and domestic goods in the demand function. On the export supply side, we find the same assumption of imperfect transformation between products for the home market and those for export markets, in each sector. These characteristics are typical of many CGE models applied to developing countries to study structural adjustment problems. This is a model with "semi-tradeable" goods and its theoretical foundation is well documented in the literature. It may be considered to be an extension of the Salter-Swan Australian model which incorporates non-marketed goods.

This type of approach to modelling trade flows isolates domestic prices from changes in world prices of substitutes in a realistic way. On the import side, the model is based on the "small country" assumption, that is the United States has no influence on world prices of imported products. On the export side, decreasing world demand functions for certain US agricultural products are assumed. All other exports have fixed world prices.

Each sector produces a composite good which can be either exported or sold on the domestic market. The output for each sector is obtained by a production function which uses primary and intermediate inputs. Sectoral input demand is derived from first class conditions for maximising profits.

Two modelling forms are envisaged for the market of primary factors (labour, capital and land). In the short-run version, capital is assumed to be fixed in each sector; as a result, in the final equilibrium, profit rates will be differentiated on a sectoral basis. In the long- run version, all the factors are mobile and factor prices adjust to equilibrate factor markets at full employment.

In the model, domestic aggregate demand consists of four components: consumption, intermediate demand, the public sector and investment (including variations in stocks). The expenditure functions of households are derived from utility maximisation. Each household pays income taxes to the government and saves part of its income. Intermediate demand is given by fixed input-output coefficients. For the public sector, real aggregate spending for goods and services is exogenous. Variations in stocks per sector are in fixed proportion to domestic output. The model distinguishes fixed investment as regards destination and the demand for investment goods as regards origin. The latter is then translated into investment demand for each destination using a capital composition matrix.

The model includes the most important macroeconomic equilibrium ratios: savings-investments, public deficit and trade balance. The aggregate level of investments is fixed exogenously according to a macroeconomic model, or is determined by savings. Aggregate savings represent the sum of undistributed business profits plus amortisation expenses, households savings, government surplus, and capital account flows from the foreign sector.

In the trade balance equation, the value of world import prices must equal the value of world export prices plus capital account flows from the foreign sector, net reserves, and net foreign financing by the US government. Two alternative mechanisms are provided to obtain equilibrium. In the first, the trade balance is determined exogenously and the real rate of exchange is adjusted to attain equilibrium. In the second, the exchange rate is exogenous and it is assumed that the trade balance is adjusted.

Like most AGE models the solutions provide relative prices only. The GDP deflator is chosen as the numeraire price index. Once the numeraire is chosen, the model provides the solution for all

[12] Of these Kilkenny and Robinson (1990) and Kilkeny (1991a, 1991b) deserve to be mentioned.

factor outputs and relative prices which equilibrate markets of factors and products. The model also provides solutions for the real exchange rate equilibrium value, once the trade balance has been fixed exogenously.

The model is defined only in terms of flows and determines an equilibrium for just one period; there are no *stocks*, money, interest rates, expectations or dynamic relationships.

In the basic version, the US economy is disaggregated into 10 productive activities[13]. There are three primary production factors, three categories of households, and three agents which act as "intermediaries" in the transfer of income from factors to households. As the authors says " the model is very close to a neoclassical Walrasian paradigm".

Another important national model, the MEGAAF model, is also static and, according to its authors, " is derived from the Shoven and Whalley (1984) approach". It is calibrated on data for the year 1990, organised in the form of a SAM for the French economy. This model is documented in detail in Gohin (1998).

The French economy is divided into 30 products and 22 productive activities, 9 of which are agricultural producing 14 different goods, and 6 agri-food activities producing 11 different products. Some activities, therefore, are multi-product. This is the case, for example, with the grain sector which offers six products (soft wheat, barley, corn, oil seeds, protein oil seeds, and other grains).

One of the model's distinctive features is the distinction it makes between two trade zones: the EU and the Rest of the World. This distinction – which enhances the model's value – was made to take into account France's membership of the EU and the fact that its agricultural policy is substantially European.

The UK model constructed by McDonald and Roberts (1998) is based on a 1990 SAM. Like the MEGAAF model, it focuses on the role of agriculture and the agro-industrial system in the national economy: in fact, it covers a total of 19 productive activities, 8 of which are agricultural, 5 food production and one food supply. With respect to the model's structure, the authors followed the USDA model, mentioned-above.

The Banse and Tangeman (1998) model for Hungary is based, on the contrary, on the Adelman and Robinson model (1978) for Korea. Unlike the other ones examined so far, it is a dynamic model. In particular, it has a dynamic recursive structure with a one period temporal delay for the increase of the capital stock. One drawback of this model is the aggregation level: only 9 productive sectors are covered, one of which is the agricultural sector and another the agro-industrial sector. This feature, as the authors themselves acknowledge, seriously limits the possibility of simulating a large number of important agricultural policies. For this reason, Banse and Tangerman use, alongside the general equilibrium model, a partial equilibrium model of agriculture in Hungary. It is necessary to point out, however, that the authors, instead of integrating the two models, simply provide an integrated reading of the results obtained.

The last model examined is the Komen and Peerlings (1998) model for Holland, the WAGEM (*Wageningen Applied General Equilibrium Model*). One of its distinctive features is its focus on problems of an environmental nature; there are still very few AGE/CGE models with an agro-environmental focus. The basic structure is described in a previous work of the two authors (Komen and Peerlings, 1996). The model is based on a 1990 SAM, which enables a very high level of disaggregation: 42 goods and 37 productive activities, many of which are agricultural, food related and agro-industrial. The fundamental characteristics of the WAGEM are fairly traditional, although, conversely, an innovative approach is used for the main polluting emissions relating to input, production and consumption. Indeed, a very detailed matrix of emissions has been added with the same level of disaggregation as the economic model. This enabled the authors to simulate certain Dutch environmental and agricultural policies and to analyse their economic effects on the environment.

[13]Kilkenny (1991a) has developed a version of the model with 30 productive activities.

4. Multiregional models

4.1 Presentation of Models

The models examined in this section have been selected on the basis of the same criteria in the previous section: these models are multisectoral, representing (partly, at least) some aspects of the CAP and have been used over the last ten years. The main difference between the models presented earlier and those examined now is their multiregion rather than one region scope and their generally *global* nature, i.e. they take into consideration the world economic system. 12 models have been selected and, according to their characteristics set out in the database, they may be grouped as follows:

1) Global Models

- GTAP (Hertel,1997) and models that use this database:
- MEGABARE (ABARE, 1996), FARM (Darwin et al., 1995), WTO (Francois et al., 1994), Harrison-Rutherford-Tarr (Harrison et al., 1996).
- RUNS (Burniaux and van der Mensbrugghe, 1991) and models that use this database: Weyerbrock (1998a and 1998b).
- MICHIGAN (Deardorff and Stern,1986).
- Other models: Fehr-Wiegard (Fehr and Wiegard, 1996), Nguyen-Perroni-Wigle (Nguyen and al.,1991), Harrison-Rutherford-Wooten (Harrison et al., 1995).

2) Non-global Models:

- ECAM/CAPMAT (Folmer et al., 1995; Keyzer and Marbis, 1998).

The main characteristic of these models is their all inclusive nature, to the extent that for the most part they cover all sectors and countries. Naturally, the magnitude of the modelling makes a high level of aggregation between products and regions inevitable, even though this aggregation varies considerably from model to model. Described below are the "standard" characteristics of a global multiregional model, therefore, when each individual model is presented we only need to indicate if, and to what extent, it departs from the benchmark.

From the theoretical standpoint, the standard characteristics consist of a *real, static* model with *perfect competition*. A real model implies that no financial activities are present (and hence, no money either): what does count are relative prices and any good or aggregate of goods may be chosen as a *numeraire*. The fact that the model is static implies that the results of *shocks* incorporated into the model will include all the effects of adjustments required to obtain a new equilibrium: in other words, this entails a comparative statics exercise. It is not possible to establish, therefore, the duration of the adjustment period and the adjustment of variables during that period. Finally, the assumption of perfect competition precludes the existence of increasing returns to scale or failure to make full use of endowment of production factors (for example, the presence of unemployment).

The structure of demand and supply is similar in all regions: at the international level differences will manifest themselves through the different structures of the SAMs. The values assumed from behavioural parameters (normally elasticities) are taken from the literature and calibrated to the data of the reference year. The utility function, as well as the functions relating to substitutability between primary factors (land, labour and capital) and intermediate consumption, are of the CES type. Final goods, on the contrary, are produced on the basis of a production function at fixed co-efficients. With respect to the modelling of trade flows between regions -a distinctive feature of multiregional models - the standard solution is to assume a differentiation on the demand side, in the sense that the same goods produced by different countries are not perfect substitutes in the eyes of the consumer (the so-called *Armington assumption*).

In the standard model there is no explicit representation of the public sector as a producer of goods and services: consequently, revenue derived from government policies (for example, duties and taxes) are used to finance public expenditure and any difference between receipts and expenditure is automatically returned to households (the representative consumer). Macroeconomic closure is neoclassical: investment is adjusted to the amount of global savings and the balance of payments is fixed for individual regions[14].

Finally, it is worth noting that access to the model and the database used in its applications, is generally restricted to the institutions or the researchers who have contributed to its development.

4.1.1. Global Models

Models using the GTAP database

1) The *Global Trade Analysis Project* (GTAP) was developed in 1990 as a result of the initiative of T. Hertel at Purdue University, USA. It is much more than a model, since its specific purpose was to reduce the (often prohibitive) research costs associated with the construction of a global AGE model by making available and disseminating[15]:

- a "basic model" and database that are updated periodically;
- GEMPACK *software* (Harrison and Pearson, 1994) to permit the basic model to be used and modified;
- theoretical updates from the worldwide network of researchers using the model.

The GTAP is currently managed by a Consortium of 18 national and international agencies (inter alia, *The Australian Bureau of Agricultural and Resource Economics* -ABARE, *The World Bank, The Economic Research Service* -ERS- of the US Department of Agriculture -USDA, *The World Trade Organization*- WTO, *The United Nations Conference on Trade and Development* -UNCTAD, and *The Organization for Economic Co-operation and Development* -OECD, which are responsible for any developments of the model and associated database.

The most recent version of the database (*Version 4)* dates back to 1995 and includes 45 regions and 50 products (McDougall et al., 1999). The basic model (Hertel, 1997) faithfully follows the general features of the global models referred to above. The model is distinguished by an explicit representation of transportation costs among the various regions and a possible selection of macroeconomic closures in which the balance of payments can be endogenous.

It should be stressed that the model is sufficiently flexible to allow for even a substantial modification to its structure: in this regard, for example, several different applications modelling markets that are not perfectly competitive (based on Francois, 1998a) have already been developed, while a recursive type dynamic version was recently made available (McDougall and Ianchovichina,1998; Ianchovichina and McDougall 2000).

GTAP applications for the European Union are already quite numerous and cover four main areas (Francois,1999):

- multilateral liberalisation, with particular reference to the impacts of the Uruguay Round;
- regional integration, with particular reference to the integration process underway in Asia (*Asia-Pacific Economic Cooperation*) and in Europe (enlargement of the EU);
- environmental policies, with particular reference to the impact of climate changes;
- agricultural policies, with particular reference to the CAP reform process.

Obviously, many overlapping issues can be found among these four areas. For instance, in the case of the CAP along with specific applications designed to model the reforms of the 1990s (Blake et al., 1998; Hubbard, 1995a and 1995b; Salvatici, 1999; Sand, 1998), several studies examine the interaction between the CAP and the process of EU enlargement (Bach and Frandsen,1998; Bach et al., 2000; Frandsen et al., 1998; Frandsen et al., 2000; Herok and Lotze, 2000; Hertel et al, 1997; Jensen et al., 1998; Nielsen,1999) or, evaluate the impact of the Agricultural Agreement of the Uruguay Round (Elbehri et al., 1999; Hertel et al.,1999).

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[14]In a global model, balance of payments may be made *endogenous*, provided that their sum is maintained equal to zero. To achieve this, however, a component in the model has to allow for total savings to be allocated among different regions.

[15]The GTAP has a world wide web site (http://www.agecon.purdue.edu/gtap/) which provides a considerable amount of information on the Project.

2) The MEGABARE model (and the new version currently being developed, the *Global Trade and Environment Model* - GTEM) was designed by ABARE based on the GTAP model (ABARE, 1996). The main difference is its dynamic nature: capital stock is partially adjusted and a demographic module regulates the endogenous trend of the population. This feature makes it particularly suitable for evaluating the environmental impact. In fact, its main applications deal with the policies designed to reduce greenhouse gasses and, in particular, with the implications arising from the implementation of the Kyoto Protocol[16]. This model has also been used to analyse regional or multilateral integration processes (Mai et al., 1996). The model is well documented.
3) The *Future Agricultural Resources Model* (FARM) was developed by ERS-USDA to evaluate the impact of climate change on the global agricultural sector (Darwin et al.,1995). This model includes:

- an environmental component represented by a geographical information system (GIS);
- an economic component represented by an AGE model derived from the GTAP and utilizing its database. The main differences compared to the standard model consist in the inclusion of water as a production factor and the modelling of land use for productive purposes[17].

In line with institutional objectives, the model's main applications are an analysis of changes in the availability of water and soil quality as a result of possible climate changes (Darwin et al., 1994; Darwin, 1999). However, the model also simulates the effects of possible changes in agricultural trade policies (Darwin et al., 1996). It is very well documented.
4) The *World Trade Organization* (WTO) model was developed by J. F. Francois, B. McDonald and H. Nordstrom at the *Economic Research and Analysis* Devision of the WTO. This model's institutional goal was to analyse the results achieved by the final agreement of the Uruguay Round and to provide quantitative support for the activities of the WTO in view of the ongoing round of negotiations. Its applications focus on traditional issues of trade liberalisation, namely, the reduction of trade and non-trade barriers which limit market access. (Francois et al., 1994, 1995, 1996a, 1996b, 1997; Francois and McDonald, 1997).
The model has the same database as the GTAP, but uses different software (GAMS/MPSGE) as well as additional data from the GATT - *Integrated Data Base* (IDB). The basic version is exactly the same as the standard model, but more sophisticated versions that are capable of selecting different types of macroeconomic closure and incorporating assumptions of imperfect competition and increasing returns to scale are also available. This model is well documented.
5) The *Harrison-Rutherford-Tarr* model was designed to simulate the effects of multilateral liberalisation and its applications (Harrison et al., 1996, 1997) have focussed on an analysis of the impact of the Uruguay Round Agreement. It departs from the standard structure to the extent that monopolistic competition is incorporated for markets in non-agricultural sectors. The model uses the GAMS/MPSGE software and the database is *Version 2* of the GTAP, updated by using data on national tariffs from the GATT-IDB.

Models using the RUNS database

1) The *Rural/Urban North/South* RUNS model (Burniaux,1988; Burniaux and van der Mensbrugghe,1991) was developed by J.M. Burniaux at the University of Brussels during the 1980s. During the 1990s this model was used extensively by the OECD to analyse the impact of the CAP on developing countries (Burniaux and Waelbroeck, 1990; Brandao and Martin, 1993) and to quantify the effects of the Uruguay Round (Golden and van der Meansbrugghe, 1992; Goldin, Knudsen and van der Mensbrugghe, 1993). The model is fairly standard (Buchi,1997), even though some of its distinctive characteristics deserve to be mentioned:

[16] A complete list of publications on the subject is available on the World Wide Web of ABARE (http://www.abare.gov.au/).
[17] Following the dissemination of the dynamic version of the GTAP model, the development of a "Dynamic Farm" model was announced.

- Agricultural products are considered to be homogeneous goods as regards international trade. The Armington assumption is applied to all other products, not only on the demand side, but also on the supply side. This means that national producers distinguish between goods for the domestic market and goods intended for export.
- The RUNS model, like the GTAP, allows for a modification of the macroeconomic closure making the balance of payments of individual regions endogenous.
- The model is not static, in that it is recursively dynamic.
- Finally, the principal characteristic of the RUNS model is that, within national economic systems, two very different components are highlighted from the perspective of production factor mobility: the *urban* and the *rural* component.

The model is written in FORTRAN language and, considering its institutional use by OECD, it contains quite extensive documentation.

2) *Weyerbrock*. This model was constructed in an academic environment to analyse the reform of the CAP (Weyerbrock, 1998a) and the effects of EU enlargement (Weyerbrock, 1998b). Its structure follows that of Robinson et al. (1993) and the RUNS model. One important difference compared to the standard is the inclusion of a real exchange rate (defined in terms of the price of "semi-tradeable" domestic products) which allows for trade balances to be made endogenous while equivalence between savings and investment is maintained for each individual region. The model is written in GAMS and is adequately documented.

Michigan Model of World Production and Trade

This model was developed at the University of Michigan (Deardorff and Stern; 1986) in the second half of the 1970s by a group of economists which includes D. Brown, A. V. Deardorff, and R. M. Stern. Its purpose was to analyse the effects of trade liberalisation policies and, consequently, this model has been mainly applied to multilateral (Tokyo Round and Uruguay Round: Brown et al.,1995b; Deardorff, 1996), as well as regional agreements (NAFTA and EU enlargement: Brown, 1995a). The main difference between this model and the standard is the assumption of imperfect competition for the manufacturing sector and the introduction of the Armington assumption on the supply side as well (similar to the approach followed in the RUNS model for non-agricultural products). Although the documentation provided is not comprehensive (for example, it is not clear what type of software is used), this model is amply documented in terms of its analytical structure and the availability of data[18].

Other models

The models of *Fehr-Wiegard, Nguyen-Perroni-Wigle* and *Harrison-Rutherford-Wooton* share some common characteristics, in particular, their academic origin and the fact that, despite their *global* nature, they use smaller databanks than the models described in previous sections. Their applications focus on agricultural policy reform , particularly, the liberalisation effects of the Uruguay Round (Nguyen et al.). The Nguyen - Perroni - Wiegle and Harrison - Rutherford - Wooton models use GAMS software, while the Fehr - Wiegard model is written in FORTRAN. All the models provide good documentation. Indeed, some of them (Harrison et al. 1995; Nguyen et al.) also provide access to the date used.

4.1.2 Non Global Models

The *European Community Agricultural Model* (ECAM) is the only example in this review of a non-global multiregional model. It was developed in the latter half of the 1980s by the Centre for World Food Studies in Amsterdam, the Central Planning Bureau and the Agricultural Economics Research Institute in the Hague. This model is currently extending the geographical scope, though for the time being the results obtained by the model are extended to a larger number of countries through an accounting module, known as, the Common Agricultural Policy Modelling and Accounting Tool (CAPMAT).

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[18]See the World -Wide Web sit :http://www.spp.umich.edu/rsie/model.

The agricultural sector is the focus, and closure may be considered to be only 'partially' in general equilibrium. In fact, although the model establishes several functional linkages between agricultural and non-agricultural sectors (the processing of agricultural products and the use of certain inputs, for example), several variables change according to exogenous trends (for example, the allocation of land between agricultural and other sectors or the prices of non-agricultural products).

In view of the greater detail involved in the modelling of the agricultural sector, it is not surprising that applications have focussed on the most significant reforms of the CAP introduced during the 1990s (MacSharry Reform and Agenda 2000: Bettendorf e Merbis, 1998; Folmer et al., 995; Keyzer e Merbis, 1998), as well as on multilateral agreements (Uruguay Round: Folmer et al., 1993; van Tongeren et al., 2000[19]). ECAM is written in FORTRAN, while the CAPMAT accounting module uses GAMS. The model is documented in great detail.

4.2 A Comparative Analysis of Models

4.2.1 Theoretical Structure

Supply and Demand Modelling

The standard approach is closely followed by most models: the main differences have to do with the number of nests included in the CES function before a Leontief production function can be attained (with fixed coeffecients) for the more aggregated level. The only exception is the Nguyen-Perroni-Wigle model, which includes a CES type function at an aggregated level as well as the ECAM/CAPMAT model, which can provide a much more detailed modelling of agricultural production. The latter, in fact uses a non-linear mathematical programming module which is able to attribute variations in the supply of crops to both changes in the yields and in the number of hectares under cultivation, and to also distinguish between livestock feed that is either purchased or produced on site. In both cases, the impact of current decisions on quantities produced will only appear the following season.

On the demand side, in addition to differences in the number of "nests" considered in the modelling of consumption patterns, even greater variations are found in terms of the number of functional forms, although the CES is the most common choice. At times, modelling choices are more 'restrictive' than in the standard model, since a Cobb - Douglas utility function is adopted (Michigan; GTAP at the aggregated level); or a *linear expenditure system* (ECAM/CAPMAT at the disaggregated level) or, an *extended linear expenditure system* (RUNS for agricultural commodities) is used. Conversely, other researchers undertake a modelling of demand in such a way as to enable greater "flexibility" in the values of parameters: an AIDS model is present in the ECAM/CAPMAT model (at the aggregated level) and Weyerbrock model, while private consumption is represented by means of a CDE (*Constant Difference of Elasticities*) functional form in the GTAP model.

Homogeneity of products and market forms

One important issue facing multiregional models is the question of how products traded between countries should be differentiated. The simplest approach, obviously, is to assume that the origin of products is irrelevant and that products are by all means homogenous. This approach, however, tends to produce "extreme" results to the extent that every country specializes in certain products and it may not be possible for a country to have import as well as export flows within the same sector. (Hertel et al. 1997)[20].

An assumption of perfect homogeneity between domestic and international products is not surprising in a model like the ECAM/CAPMAT, since regions outside the EU are not included in the modelling. It is necessary to stress, however, that a similar assumption for agricultural products can be found in a global model, such as RUNS. Moreover, this is the only global model which is unable to analyse bilateral trade flows.

[19] This is a particularly interesting study since it provides an example of how different models may be jointly used: in this case the ECAM/CAPMAT and the GTAP.

[20] This result becomes even more unrealistic when the productive structure in the model is less detailed.

Once the assumption of perfect homogeneity is abandoned, the most popular modelling strategy is the *exogenous* differentiation associated with the Armington assumption. Individual models will clearly differ in terms of the methods they use to represent productive technology and consumption choices (functional forms, number of "nests", etc.) but, in general, exogenous differentiation is easier to introduce and is less demanding in terms of data requirements than *endogenous* differentiation. The latter, in fact, presupposes that individual firms have a certain 'clout' in the market, therefore non-competitive market forms[21] also need to be modelled. Endogenous differentiation is chosen (mostly for non-agricultural sectors) by the MICHIGAN model, the WTO model and several GTAP applications which remove the assumption of perfect competition. (Anderson e Francois, 1998; Baldwin e Francois, 1997; Baldwin et al., 1997; Francois, 1998b; Francois e Baldwin, 1999; Francois et al., 1996, 1997)[22].

Time Horizon

The majority of the models examined are *static* and use a comparative static approach to analyse changes in policies. This may be undertaken in two ways: first, by applying changes in policies to the model's reference year (in this case, the question to be answered is: "what would have changed in the past if the new policies had existed?"), or second, by introducing the reforms on a projection of the original databank (in this case, the question to be answered is: "how can the introduction of new policies alter the future projection?"). It is important to note that the *projections* are obtained by varying certain exogenous variables, be they macroeconomic, demographic or technological, (based on forecasts that are either *ad-hoc* or obtained by using dynamic *models*) and it will not be possible to know - due to the static nature of the model - how these variables will evolve (particularly, those pertaining to stocks): the new equilibrium that is determined is *counterfactual* rather than *predictive*.

The dynamic models reviewed here (the MEGABARE, RUNS, ECAM/CAPMAT and the dynamic GTAP model) all have a *recursive* structure. On the contrary, there are no examples of *intertemporal* dynamic models and, as will be seen in the following section, this affects the way a number of important agricultural policy instruments (i.e. public sector stocks) are handled.

4.2.2 Databanks and Parameters

Statistical Sources

As described in the previous section, owing to its comprehensive nature and accessibility the GTAP databank is also used extensively for different applications than those envisaged by the model. The first version of the GTAP databank contained the same 15 intersectoral matrices of the SALTER Project developed by the Australian Industry Commission. The original version was then updated and extended to include additional countries and products until the completion of the current *Version* 4 (McDougall et al. 1998)[23].

The intersectoral tables are generally provided by participants of the "GTAP network" located in different countries. The tables have a standard format (Huff et al. 1996), but are highly differentiated both in terms of the reference year selected (ranging from 1983-1994), and the sectoral structure. With respect to temporal consistency, all the tables are updated to 1995 (the reference year of *Version 4*) using the FIT programme (James and McDougall, 1993) which allows the values of the tables to change on the basis of a series of exogenous data (usually macroeconomic variables). With respect to *sectoral* consistency, tables that are too synthetic are disaggregated by using the tables of regions with an as similar as possible productive structure as a benchmark, or, the database of the FAO (*Supply Utilization Accounts -SUA*), in the case of

[21] A monopolistic competition market would need to be modelled due to consumers "love for variety" (Dixit and Stiglitz,1977; Krugman,1979,1980), in the presence of fixed costs so that *economies of scale* may be achieved.

[22] Some examples of exogenous differentiation and non-competitive market forms exist in the literature, e.g. in Harrison et al. (1997) and Hertel et al. (1997).

[23] Version 5 is near completion and should contain, in addition to other innovations, complete disaggregation of EU member countries.

agricultural products. Finally, the source of macroeconomic data (GNP and its components) is obtained from the “Analytical Databank for Economic Development” set up by the World Bank.
As regards the two other large-scale global models - RUNS and MICHIGAN - the databank of the former mostly consists of intersectoral tables for the base year 1985, built by the *Development Centre of the O.E.C.D.* Once again, further disaggregation of the agricultural sector is made possible by using data from the FAO (SUA and *Production Yearbook*). The intersectoral tables in the Michigan model are drawn from national sources and, therefore, have been updated at different times: 1990 is the base year of the model. The main source for other data is UN statistics.
Information on data used by the global models developed in academic circles is less detailed, since it is contained in articles published in journals, where references to other documentation is not always readily accessible. Generally, these models prefer to update national and international tables by using macroeconomic data and data on trade flows provided by various international organizations (WTO, International Monetary Fund, the United Nations Organizations, etc.). The reference years are somewhat outdated, however, ranging from 1974-85 for the Harrison-Rutherford-Wooton model, 1982 for the Nguyen-Perroni-Wigle model and 1987 for the Fehr-Wiegard model.
In global models two categories of data are particularly important: data relating to customs' protection on the one hand, and bilateral trade flows on the other. With respect to the latter, it is evident that there may be significant discrepancies between the imports and exports declared by individual regions. The GTAP databank manages to procure consistent data by using the COMTRADE databank provided by the UN Statistics Office, as well as an *ad hoc* methodology to determine the reliability of the data provided by each exporting and importing country (McDougall et al., 1998). The RUNS model uses the CHELEM (CEPII, 1998) data base, while data reconciliation is a routine function of the RAS programme. No information is available on the procedure followed by the MICHIGAN model, nor by the other smaller models, although the lower level of regional disaggregation of the latter tends to “offset” the inconsistencies found in the data of individual countries. Furthermore, these models clearly need to use either aggregated data for regions comprising more than one country, or the data from a single country deemed to be “representative” of a larger region or another country where no national intersectional tables are available.
In the case of customs policies, the data sources used are substantially the same for all models considered. In the case of non-agricultural sectors, the main source of data is from the GATT-IDB, including the TRAINS databank of the UNCTAD. For the primary sector, the main reference is the Producer Subsidy Equivalent (PSE) estimates provided by the OECD and the USDA.
Data sources tend, of course, to be more “eurocentric” in models which distinguish various regions within the EU, and the ECAM/CAPMAT model. In general, intersectoral matrices are provided by EUROSTAT and use CAP data provided by the FEOGA . Due to the greater detail required in the modelling of the agricultural sector in the ECAM/CAPMAT model, data from FADN, SUA (the FAO) and the SPEL databank are used. The benchmark period for the model's calibration ranges from 1982 to 1990.

Disaggregation

As shown in Table 4.1, the level of disaggregation varies considerably from model to model in terms of the number of regions and products.

Table 4.1 - Regional and Sectoral Disaggregation

Models	Regions	Products/Sectors
ECAM/CAPMAT	13 states (UE) + 1 region (Belgium-Luxembourg)	27 agro-food products + 2 other sectors
RUNS	13 states + 9 regions (incl. UE-12)	15 agro-food products + 5 other sectors
Weyerbrock	4 regions (incl. UE-12) + 2 states	8 agro-food products + 5 other sectors
MICHIGAN	34 states (incl. Italy) + 1 region (ROW)	2 agro-food products + 26 other sectors + 1 natural resource

GTAP	31 states + 14 regions (incl. EU-15)	20 agro-food products + 24 other sectors + 6 natural resource
Fehr, Wiegard	7 states (incl. Italy) + 4 regions (incl. UE-12)	2 agro-food products + 5 other sectors
Nguyen, Perroni, Wigle	3 states + 7 regions (incl. EU-12)	1 agro-food products + 6 other sectors + 2 natural resource
Harrison, Rutherford, Wooton	10 UE countries (incl. Italy) + 1 region (ROW)	2 agro-food products + 3 other sectors + 1 natural resource

Regional disaggregation ranges from a maximum of 45 “commercial areas” in the GTAP[24] databank, to a minimum of 10 in the Nguyen-Perroni-Wigle study. All the global models naturally include a residual region: the *rest of the world* (ROW).There is also a highly diverse level of disaggregation within the European Union area: ranging from one region for the RUNS and the Nguyen-Perroni-Wigle models to 13 countries (plus the Belgium- Luxemburg region) in the ECAM/CAPMAT models.

Huge differences also exist in terms of sectoral disaggregation: ranging from 50 sectors in the GTAP[25] database, to 6 in the study by Harrison et al. (1995). Within this highly diverse framework, the amount of attention devoted to the primary sector in a broad sense (including natural resources) also differs considerably. At one end, in fact, some models focus almost exclusively on the agricultural sector, the ECAM/CAPMAT is one example which covers 20 basic and 7 processed agricultural products. Other models cover no more than 2 or 3 products, either because of the limited level of overall disaggregation (e.g., the “academic” models), or the focus they place on other sectors of the economy (e.g. the MICHIGAN model).

A more uniform approach is followed in the case of production factors. Practically all the models include *land, labour and capital*, but in certain cases these categories are disaggregated even further:

- the RUNS model makes a distinction between *urban* and *rural* labour and capital;
- the GTAP model makes a distinction between *skilled* and *unskilled labour*, and *natural* and *generic capital;*
- the FARM model introduces *water* as a factor and makes a distinction between 6 different types of land quality.

The assumptions made with respect to the degree of factor mobility are also quite similar in the different models. Land and water are always considered to be specific to the agricultural sector (and are, therefore, characterized by *intrasectoral mobility*), and the same applies to labour and capital in the RUNS model. International mobility is generally absent, with the exception of capital mobility in some models, such as the Fehr-Wiegard, RUNS and GTAP models. In the Runs and GTAP models this characteristic allows for macroeconomic closure with endogenous adjustments of the trade balance .

Lastly, with respect to the differentiation of households and/or farms, most of the models do not undertake any disaggregation, since they assume that only one agent is representative of the entire economic system. The only exception to this is the RUNS model which makes a distinction between an “urban” and a “rural” household.

Such restrictive disaggregation in the representation of agents has important consequences. On the one hand, without any differentiation of households these models cannot possibly be used to analyse certain important issues, such as the redistributive impact of changes in policies. On the other, the lack of differentiation of farms directly affects the modelling of agricultural policies, since it is not possible to represent policies of a voluntary nature explicitly, as will be seen later (see Section 5).

[24]It should be recalled that most GTAP applications do not use the maximum disaggregation allowed by the databank: no more than 10 regions may be included if a personal computer is used.

[25]For regions mentioned in the previous note, applications in the GTAP model rarely exceed 10 sectors.

With respect to the disaggregation of agents by the various models, representation of the public sector is of particular importance in order to formulate a policy analysis. In the standard model no public sector economy is envisaged. This type of assumption can be found in many of the models reviewed here (ECAM/CAPMAT; MICHIGAN; Nguyen-Perroni-Wigle; Harrison-Rutherford-Wooton). Some of these (Harrison et al.; ECAM/CAPMAT) include at least an explicit national accounts constraint to allow for a comparison between the cost of policies and tax and tariff receipts. In others, tax and tariff revenue, net of expenditure on the implementation of policies, are automatically (and at no cost) attributed to the "representative consumer": in this way a national accounts constraint is incorporated in the more general macroeconomic closure.

Models that do provide a representation of a public sector economy (i.e. RUNS; Weyerbrock; Fehr-Wiegard; GTAP) are based on an assumption that an economic agent (the state) exists and that it utilises resources to produce "public sector goods". The supply of these goods, and therefore the amount of goods purchased on the market by the public sector, is usually exogenous: with the sole exception of the GTAP model where public sector consumption falls under the utility function of the representative agent.

It should be stressed that the behaviour of the public agent is represented in a completely different manner to that of the private agent: policy-makers' decisions, in fact, are not the result of optimizing behaviours generated within the models. The exogenous nature of public sector decisions, in particular, in terms of policy-making, is definitely consistent with the *positive* nature of these models which are frequently used to simulate the impact of policy changes. On the other hand, the exogeneous nature of policy-makers' behaviour makes the adjustment process extremely *asymmetrical* : whenever any external *shock* is introduced, for instance, the models discussed here allow for adjustments in all markets, but do not allow for any "response" on the part of governments.

Parameters

The determination of parameters is traditionally the "weak point" of AGE models (Hertel, 1999). This view is confirmed by the models reviewed here, to the extent that *behavioural parameters* (elasticity of substitution between goods and between factors, degree of factor mobility, elasticity of demand in respect of income and prices) are generally drawn from the literature or other models: with the exception of the ECAM/CAPMAT model which econometrically estimates the parameters of the behavioural functions it utilises[26].

Whatever the source of the parameters, a *calibration* phase will be required in order to verify the model's ability to reproduce the data observed in the reference period (see section 2.2.3). Although a greater and more systematic use of *sensitivity analysis* would be a more appropriate response to the criticism levelled at calibration procedures (Hertel,1999), this type of analysis is certainly not frequently found in the literature reviewed here, or the results are not reported (with the exception of Harrison et al., 1997; and Hubbard, 1995b). Another way to enhance confidence in the reliability of the model might well be to conduct the calibration over a certain number of years instead of on one observation alone: this procedure was followed by Harrison et al. (1995) and the ECAM/CAPMAT model.

5. Modelling Agricultural Policy

In this section we undertake a comparison of the different representations of CAP instruments provided by the various models described in the previous section. Our purpose is not to compare the results of simulations or to evaluate the theoretical exactness of the different modelling, but rather to assess the extent to which the various models are able to represent agricultural policy instruments in a *realistic* fashion.

[26]Some "partial" exceptions exist, in the sense that only some parameters are estimated, the elasticity of water supply in the FARM model is an example.

This theoretical comparison will be based on an *explicit* modelling, this means that any representation of policy meets two fundamental requirements: first, the exogenous variables correspond to those actually established by policy-makers and second, the ways these variables influence the model are able to reproduce the mechanisms used to implement these policies. However, we shall see that, because of the simplified assumptions chosen for the behavioural representation of economic agents, and the aggregation required, the models in question are often obliged to adopt an *implicit* representation, or a representation which "translates" a particular instrument of agricultural policy by modifying some of the variables in a model. Obviously, the accuracy of this kind of representation will vary depending on the structural characteristics of each model's level of disaggregation.

In view of the fact that the literature under consideration refers to the 1990s, it comes as no surprise that the agricultural policy experiments undertaken by the various models focus , on one hand, on the reforms introduced over the last ten years - the MacSharry Reform of 1992 and Agenda 2000 of 1999 - and, on the other, on the constraints resulting from developments in the area of trade relations - the Uruguay Round Agricultural Agreement (URAA) as well as EU enlargement prospects. The following review will consist of four parts each corresponding to the four categories of agricultural policy instruments of particular importance under the CAP:

- coupled support policies;
- trade policies;
- supply management policies (quantitative production constraints);
- partially decoupled support policies.

This type of break-down is quite similar to the one followed in previous chapters, with the exception of a section on *voluntary policies*. The latter is not included simply because the literature examined contains no applications modelling this type of instrument. Moreover, to the extent that farms are assumed to be all the same and their behaviour is ascribed to decisions made by a single representative farm, it is clearly not possible for these models to generate any *endogenous* rate of participation in policies that are voluntary based.

5.1 Direct Price Support

Under this category we examine all the policies which have a direct impact on prices that farmers receive for the sale of products as well as the purchase of production factors. Despite the fact that *guaranteed minimum price* policies have become increasingly less important over the '90s, the ability to represent this type of intervention is still an important component of models that seek to undertake an assessment of the CAP.

Among the models considered here, "linear" models (Leat and Chalmers, 1991; Roberts, 1994; Roberts and Russell, 1996) are, indeed, the only ones which fail to deal with pricing policies, since this type of model does not even provide for any direct relationship between pricing and quantities (see 2.1). The one exception is the model by Serrao (1998) which, although linear, is utilised to estimate the effects of changes in market policies on income and factor utilization. In this case, however, the impact on production output, which is calculated by an econometric model, is used to represent any *shocks* introduced into the model.

It is well known that, guaranteed minimum price policies may be pursued either through *deficiency payments* or *market price support*. This latter mechanism is the one that poses most modelling problems, since the actual policy does not stipulate the price that producers must receive, but only a *minimum threshold* below which the market price should not drop.

As a matter of fact, if we consider price trends in an important area such as the grain sector, we realise that the EU market price fluctuates between the two extreme institutional prices (*intervention* and *threshold*), and tends to coincide with one or the other depending on the market situation. The problem that arises, therefore, is how the linkage between *institutional* prices (i.e. the "intervention price" and the "threshold price") and the market price should be modelled. This is generally solved by assuming that the market price eventually coincides with the guaranteed price and, consequently, that any change in the latter will be fully passed on to the market price.

In fact, the market price tends to coincide with the intervention price only under particular market conditions (for instance, when domestic supply largely exceeds domestic demand). Consequently, by making the assumption that a unitary elasticity of transmission always exists between the market price and the intervention price, most of the studies referred to here overestimate the impact of price cuts resulting from the reforms introduced in 1992 and 1999.

In this respect, two recent studies which have followed a less restrictive assumption deserve to be mentioned. For instance, in order to allow for the determination of a market price (P) which is higher than the intervention price (PI), Gohin et al. (1999b) incorporate a pair of constraints of the following kind in the MEGAAF model:

(5.1) $$\begin{array}{l} P \geq PI \\ S(P - PI) = 0 \end{array},$$

where S represents the amount of export subsidies. In this case, a domestic price that is higher than the intervention price may be observed if exports do not need to be subsidised. This mechanism, however, is somewhat “rigid”, on account of the fact that only a small export subsidy will make the market and intervention prices coincide. More promising seems to be the approach followed by van Meijl and van Tongeren (2000) which modifies the standard GTAP model along the lines of Surry (1992) and Von Lampe (1999), by assuming that the market price (P) represents a weighed average between the intervention price (PI) and the threshold price (PS):

(5.2) $P = \alpha PI + (1 - \alpha)PS$.

The introduction of parameter a, determined according to a logistic function which represents oversupply in the market, makes P vary *endogenously* and coincides with the two extremes only in the event of serious imbalances on the demand or supply side[27].

In many cases, the only way to prevent the market price from falling below a certain level is through customs policies (variable levies and export restitutions). This is a considerable over-simplification, since, in point of fact, European policy-makers have another instrument (which they frequently use) at their disposal: public stockpiling. Only a few models include this component of guaranteed minimum price policies. Weyerbrock has adopted the simplest solution: public sector purchases are not modelled as an additional component of demand, but rather as an exogenous *shock* which makes the supply curve shift so as to secure market equilibrium. This is a typical example of how implicit modelling is often necessary: the introduction of an *ad hoc* variation (shifting the supply curve) definitely makes the model’s results more realistic, in that the effects on the domestic market of public sector purchase flows in a given period may be represented; but it is equally true that in reality no political decision will correspond to the *shock* introduced into the model, and, in fact, no answers can be provided by the model regarding the management of the build up of stocks [28].

McDonald and Roberts (1998), Fehr and Wiegard (1996), and Harrison et al. (1995) represent public stocks as an additional component of demand. In the first case, the UK’s government purchase of beef products from the meat industry had the purpose of offsetting the adverse effects of the BSE crisis. In the other two cases, stockpiling by the government is necessary to maintain a certain price level in the domestic market. In the Fehr-Wiegard model, the quantity stockpiled is determined exogenously, and once the price is set, the amount of subsidised exports is determined endogenously; in the Harrison et al. (1995) model the government decides to export a pre-determined percentage, and then purchases the amount which exceeds domestic demand. In both cases the problem of the management of stocks is resolved in a rather simplistic manner, by implicitly assuming that the amounts purchased and not exported are immediately destroyed.

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[27]For example, a coinciding of market prices and guaranteed minimum prices ($\alpha = 1 \Rightarrow P = PI$), quite commonly found in the literature examined, would only occur in the event of major surpluses.

[28]Failure to consider the costs (and receipts) associated with the management and disposal of stocks makes the assessment of the impact of stocks on the community budget unrealistic.

The most detailed representation of public sector stocks is undoubtedly provided by in the RUNS and ECAM/CAPMAT models, which explicitly represent stock trends and associated management costs. This management, however, is also exogenous to the model, to the extent that it forms part of the assumptions that are made in order to determine the benchmark scenario. Moreover, any adequate representation of stockpiling policies in the models ought to include not only *variations*, but also the *levels* of stocks and, hence, should be based on dynamic optimization models.
In view of the fact that many of the models discussed here fail to represent public sector stocks at all, while others, as mentioned above, do so in a very simplified manner, one is left to wonder about the consequences of such decisions. The impossibility to stock products, for instance, may have an impact on either international markets or government accounts.
The first case concerns models which do not provide for government demand: here, in fact, given a certain domestic price level, any supply exceeding domestic demand will have to be exported by resorting to subsidization. In this event, exports could be overestimated and this could lead to an excessive drop in world prices, at least in the short term. On the other hand, in the event of a binding obligation to reduce export subsidies under the URAA, cuts in domestic prices to ensure compliance with the international agreements would be overestimated. One could respond to this critique by saying that ever increasing stocks are clearly unsustainable. Consequently, this would apply only to the *short run* (which is not the time-frame of the analyses undertaken by these models), since in the *long run* amounts purchased by the government will still have to be placed on the market.
In the case where public sector demand is incorporated without any provision for stockpiling (hence, products purchased by the government but not exported will be destroyed), the impact on world markets will be lessened, but higher public sector costs will be incurred, due to the fact that the government relinquishes proceeds from abroad for the quantities purchased (but not exported). This alternative may seem paradoxical at first, but it could be much more realistic once the constraints on export subsidies introduced by the URAA are taken into account (see section 5.2)[29].
In addition to guaranteed minimum price policies, the CAP also provides for a range of other coupled subsidies. These seem to pose fewer problems in their representation, as they may be easily incorporated in models in the form of differences between consumption prices and market prices, in the case of production subsidies, or as differences between market prices and consumer prices, in the case of subsidies connected to the use of production factors. In both cases, price differentials may obviously be fixed exogenously on the basis of the level of subsidies (or taxes) determined by *policy-makers*. However, the modelling for these intervention mechanisms is not completely *explicit* either, since an aggregation between products or between forms of subsidies will still be required. The degree of realism of the operation of single Common Market Organizations (CMO) varies from model to model depending on the level of sectoral and policy aggregation.
It goes without saying that sectoral disaggregation has to correspond to specific agricultural policy decisions: any lack of correspondence between these two elements, in fact, makes the *ad valorem* subsidy difficult to calculate (since it will be applied at an "average" price for the entire aggregate), along with the effects on the amount offered. In fact, the model will record an overall variation in supply for the entire sector the subsidy applies to, and not just for the product actually subsidised.
With respect to the aggregation of different policies, almost all the models decide to apply one type of subsidy which ought to be "equivalent" to the various intervention instruments actually adopted. In fact, with the exception of the ECAM/CAPMAT models - which calculate the subsidy explicitly and directly on the basis of the relevant item of expenditure contained in the FEOGA and the MEGAAF accounts. The MEGAAF being a national model provides a greater amount of detail,

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[29] If constraints on subsidised exported quantities (or on expenditure for such subsidies) were more stringent than market access constraints (or in terms of bound tariffs), a government with no particular budget problems could guarantee the domestic price by "consuming" (or destroying) any excess supply.

all other models use the *Producer Subsidy Equivalents* (PSEs) calculated by the OECD[30] and the USDA. In these models the value of the production subsidy is determined as the difference between total PSE and its market component (measured, in turn, as the difference between domestic prices and world prices). This means that the "equivalent production subsidy" consists of a series of very different instruments, ranging from cuts to input costs (for example, cuts in capital costs, insurance premiums or fertilizer prices) to the provision of free services (such as agricultural extension and phytosanitary monitoring) to farms. Moreover, the weight of each intervention within the ambit of the equivalent subsidy is proportionate to the budget cost of the intervention. This is the same as claiming that every euro spent on the agricultural sector, regardless of the instrument of intervention, will produce the same impact on production decisions: an assumption that is clearly nowhere near the actual reality.

The second observation has to do with the way the PSE is used to model the constraints introduced by the URAA with respect to domestic support. Developed countries, as we know, have undertaken to reduce the "aggregate measure of support" (AMS) based on the average for 1986 - 88 by at least 20%. Models seeking to introduce this type of constraint generally choose to introduce a 20% cut in subsidies coupled to production (Anderson et al., 1999; Harrison et al., 1997). A percentage cut in a subsidy is a *shock* that can be easily implemented, but there is ample reason to question the accuracy of this kind of representation of this aspect of the URAA.

In the first place, the model would need to include the same initial support set out in the Uruguay Round Agreement. This is never the case, either because the models do not necessarily use a reference year corresponding to the average for the 1986 - 88 two-year period, or because the methods used to calculate the PSE are not the exact same methods used to calculate the AMS (Anania, 1996).

More generally, the fact that no distinction is made between the *introduction* of an overall constraint and the *modelling* of the reforms required to achieve it, is open to criticism. For instance, simulations are based on the assumption that the cuts in the subsidy will occur uniformly across all the agricultural commodities covered by the model, although this is a far more restrictive requirement than the Agreement stipulates (as a matter of fact, a 20% cut could also be obtained by a complete elimination of the support guaranteed to a *single* commodity). As regards this, the percentage selected for the subsidy cut is equally hard to defend: a 20% subsidy cut, in fact, may well result in a much higher reduction in the value of the support, as in all likelihood it will also be accompanied by a reduction in quantities produced.

5.2 Trade Policies

As far as imports are concerned, we find fundamentally different approaches being applied to tariff and non-tariff barriers. With respect to the former, in general, an *ad valorem* duty can easily be incorporated to create a differential between the domestic market price and the world price.

Actually, there are also specific duties, that is taxes proportional to import volumes rather than values[31]. However, these duties are ascribed to an *ad valorem* equivalent, since the flow of imports can rarely be ascribed to a common unit of physical measurement at the aggregation level adopted in the models reviewed. Naturally, this poses problems, as the *ad valorem* duties used can never really be completely "equivalent" to the specific ones they represent[32].

An additional problem of equivalence arises in the case of product aggregation, as the same *average* duty has to be applied to all the products included in the same sector (e.g. "grains", "crops" or, even, " agriculture"). The need to use equivalent duties (in terms of policy instruments and/or product aggregation) is a recurrent methodological problem that remains unresolved in the literature on AGE models (Bach and Martin, 2001).

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33 The OECD recently modified the procedure for calculating the support indicator by introducing the *Producer Support Estimate* (OECD,1999).

[31]While an ad valorem duty is expressed as a percentage (e.g.5%), a specific duty is expressed as a value of the levy per unit imported (e.g. 50 Euros per quintal).

[32]On the question of the determination of the "equivalent duty" see Vousden (1990, chapter three).

Non-tariff barriers require a completely different approach: in the case of duties, the difference between the domestic market price and the world price is, in fact, established *exogenously*, while in the case of other measures of protection, the duty is determined *endogenously* and the exogenous variable changes according to the type of barrier to be modelled. In the case of variable levies which, as stressed in the previous section, are always associated with the modelling of guaranteed minimum price policies[33], the exogenous variable is represented by the import price (called the *threshold price*). In this respect, it is worth mentioning certain distinctive features:

- In the ECAM/CAPMAT model, the modelling is by definition simpler, since it is not a global model and the world price is completely exogenous.
- The same applies to the MEGAAF model, although in this case two types of imports are distinguished for each product: *differentiated* imports based on the country of origin according to the Armington assumption and *undifferentiated* imports, which are perfectly interchangeable with the domestic product.
- In the RUNS model, the assumption is that the government uses trade policy to avoid excessive divergences between the trend of agricultural prices (ΔPr) and the trend of prices in other sectors (ΔPu)[34]. Therefore, an equation regulates the transmission of variations in international prices (ΔPw) to the domestic market:

  (5.3) $\Delta \text{Pr} = a\Delta \text{Pu} + (1 - a)\Delta Pw$.

  Depending on how parameter a is fixed, either an *ad valorem* duty effect (*a = 0*, i.e. a complete transmission of variations in the world price) will be obtained, or the terms of trade between agriculture and other sectors will be maintained (*a = 1*, i.e. a complete isolation of the domestic market).

Import quotas are another important non-tariff barrier. Generally speaking, when the quota is binding, all the models reviewed are potentially able to determine the duty equivalent to a specific quantity of imports endogenously. In many practical applications, however, problems arise as a result of sectoral aggregation. In fact, if the product subject to a quota represents only part of the sector modelled, a "mean equivalent" duty will have to be calculated for the entire sector and used as an exogenous variable instead of the real quota.

Finally, the approach followed by the models under review in the case of another significant category of non-tariff barriers, the so-called *technical barriers*, is somewhat approximative. The effects produced by this type of barrier, in fact, are usually represented by introducing equivalent duties drawn from the literature or calculated outside the model. In addition, an attempt is made to take account of these barriers in a "qualitative" manner, by introducing *ad hoc* assumptions in the simulation scenarios (the MICHIGAN model, for instance, decreases the extent of liberalisation in some sectors and not others). In both instances we are clearly a long way from a satisfactory solution, from both the theoretical and empirical standpoint.

Turning now to trade policies regulating exports, there is, once again, a close link between pricing policies and trade policies. As a result, the two models which do not represent guaranteed minimum price policies (MICHIGAN and Nguyen-Perroni-Wigle), do not cover export subsidies either (moreover, these kinds of subsidy are difficult to model due to the very limited disaggregation of the agricultural sector: see section 4.1.). The other models include a system of variable restitutions representing the instrument that has to be used to guarantee a price level on the domestic market. This component represents the exogenous variable, although in models which include public sector stocks, decisions on exported quantities also play a role. Once again the ECAM/CAPMAT model is an exception. Here restitution payments still reflect the (expected) trend of the world price and the (exogenous) management of stocks, since the world price is exogenous.

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[33]The only two cases which use only ad valorem duties (the Michigan and Nguyen-Perroni-Wigle models) give no representation of guaranteed minimum price policies.

[34]As shown in section 4, the RUNS model distinguishes between a rural sector (comprising the agricultural sector) and an urban sector (comprising all other sectors).

It should be stressed that Version 4 of the GTAP databank also follows the same approach in measuring non-tariff barriers on the export side, in other words, it calculates an "equivalent" subsidy corresponding to the difference between the domestic price and the world price. As a consequence, any differences between duties and subsidies for the same sector are ascribed to a "composition" effect, since the same product could be included with different shares among imports and exports.

With respect to the specific approaches chosen to model the reforms implemented in recent years, it is well known that important policy changes have resulted from the commitments made within the URAA. Following the reforms designed to increase market access, the EU has undertaken the task of transforming ("tariffication") all non-tariff barriers into equivalent duties (specific or *ad valorem*).

This should have put an end to the use of instruments like variable levies, which are still applied in such an important area as the grain sector (Anania, 1996). One interesting question to be considered is how were the constraints arising from the URAA in the area of tariffs – "binding" [35] and the 36% average reduction in duties – incorporated in the models under consideration. The modelling approaches chosen to represent these commitments are open to criticism, for a number of similar reasons to those made in connection with the compulsory reduction of domestic support (see section 5.1).

Firstly, models using either *effective* (equivalent) or *bound* duties, usually overestimate the liberalising effects of the URAA: the reason is that in the former case the tariffication commitment appears to be more binding than in reality; while in the latter case there is an overestimation of the initial protection. For this reason, some studies modelling the effects of the Uruguay Round (Francois et al., 1995) do not even provide for any reductions in duties on agricultural products. Undoubtedly, a more convincing approach is followed by models which use the real tariffs *applied* in all cases where they are lower than *bound* tariffs (Hertel et al., 1997a; Weyerbrock, 1998a).

Moreover, even the compulsory tariff cut along with other components of the URAA, is expressed at aggregate level (average reduction of 36% with the only additional constraint of a minimum 15% reduction). However the "tariff schedules" deposited at the WTO are highly disaggregated (over 1,700 agricultural commodities for the EU). In view of the fact that the EU - although to a lesser extent than other countries - (Anania,1996; Bureau et al., 2000), has used this mechanism to distribute tariff cuts in a "strategic" manner, the common assumption of a uniform 36% reduction adopted in the literature is undoubtedly more restrictive than the terms of the Agreement.

In an attempt to limit the effects of "dirty tariffication", the URAA requires states to guarantee the same level of trade flows in existence prior to the Agreement and to introduce *minimum import quotas* which should account for 5% of domestic consumption by the year 2001. The Agreement does not stipulate the obligation to import a quantity equal to the minimum import quota, it merely states that imports within the quota will be subject to a duty equal to 32% of the duty levied on (any) additional imports (Anania, 1996). Tariff quotas are a particularly difficult instrument to model [36]. In fact, only models using the GTAP databank have attempted to model them.

One example is the WTO model, which determines duties endogenously for agricultural commodities to obtain a level of imports which does not fall below the highest value of import levels in the base year and the minimum access quota. Accordingly, import levels are fixed, to the extent that any additional imports are subject to what is (assumed to be) a prohibitive duty. This implies that only some of the characteristics of the URAA, and not even accurately, are captured by the model.

Another example relating to tariff quotas is the modifications to the GTAP model suggested by Veenendaal (1998) and applied by Elbehri et al. (1999). Using the approach for modelling

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[35] Since countries have undertaken not to increase duties above the levels set out in the Schedules attached to the URAA, these levels are called "bound".

[36] This type of instrument is not easy to analyse in AGE models, in that it introduces discontinuity in functions, making the convergence of the model's algorithm solution more difficult.

inequality constraints proposed by Bach and Pearson (1996), Veenendaal represents in explicit form all the constraints required to model tariff quotas both multilateral (minimum access quotas) and bilateral (preferential agreements), but does not provide any empirical application. Elbehri et al. (1999) concentrate on multilateral quotas and compare liberalisation scenarios affecting either the level of *extra-quota* duties or the volumes of quotas benefiting from lower duties.

With respect to export policies, the URAA provides for no less than a 36% cut in the expenditure on export subsidies and a cut of 21 % in the volume of subsidised exports. Consequently, two non-equivalent constraints are brought into effect[37] and like tariff quotas, they are not easy to handle in the models under examination. Nevertheless, in modelling this part of the Agreement export subsidies are simply reduced in many cases by 36%. This solution ignores the equality constraint, and does not take into account correctly the expenditure constraint.

A few more recent studies have attempted to make the modelling more consistent with the terms of the Agreement. In particular, Blake et al. (1998) and Bach and Frandsen (1998) have endeavoured to model both constraints, by making the export subsidy rate endogenous. Three possible cases emerge from their analysis:

- compliance with the expenditure constraint is sufficient to ensure compliance with the constraint on quantities;
- compliance with the expenditure constraint is not sufficient to ensure compliance with the quantity constraint: in this case the additional constraint to reduce exported quantities by 21% is triggered;
- by attempting to reduce quantities an elimination of the subsidy occurs: in this case the constraints no longer exist, because exports are no longer *subsidised* .

A similar approach is followed by Weyerbrock (1998a), although the model's closure differs in terms of endogenous policy instruments. Weyerbrock, as a matter of fact, uses two instruments to secure compliance with constraints: the minimum price intervention level and the rate of compulsory set aside.

Lastly, it is important to address the ability of models to represent preferential policies and/or regional integration policies. This is unquestionably influenced by how the model is structured in terms of its representation of international trade. In the case of *non-spatial* models, for instance, only those which consider agricultural commodities as *non-homogeneous* goods are in a position to represent the implementation of discriminatory and selective trade policies. Consequently, models like the ECAM/CAPMAT and the RUNS are unable to simulate these policies.

At any rate, a modelling of specific scenarios relating to regional integration or preferential access needs to represent a differentiated structure of trade flows based on the country of origin (at least for non-spatial models), but this alone is not enough. Models must also provide accurate disaggregation of both the countries and products involved. In this regard, the models using the GTAP databank which comprises a large number of regions and sectors are undoubtedly better placed. At the other end of the spectrum is the Harrison-Rutherford-Wooton model which, while introducing an Armington type product differentiation assumption, is not in a position to provide answers regarding scenarios of EU enlargement or trade concessions to specific countries, because apart from the 10 EU countries covered, it only includes one other residual region .

5.3 Quantitative Production Constraints

Quantitative constraints on the supply side may apply either to quantities produced or production factors. Both types are found in the CAP, where extensive use has been made of these kinds of instruments to limit the productive potential of sectors particularly affected by problems of surpluses. The most salient examples are dairy farming, through the levying of milk quotas, and to grain production, where land is subject to a mechanism of set aside.[38]

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[37] For an analysis of the implications deriving from compliance with both constraints simultaneously, refer to Anania (1996).

[38] In fact the "compulsory" set aside of land should be modelled as a voluntary measure, since this obligation only applies to those who choose to benefit from the compensatory payments. Since the unprofitability of such payments can

It is important to make clear that quantitative production constraints are not analysed by models that cannot adequately disaggregate products in the agricultural sector (MICHIGAN; Fehr-Wiegard; Nguyen-Perroni-Wigle; Harrison-Rutherford-Wooton). In these models, in fact, products subject to constraints are incorporated in much larger aggregates, thus any attempt to model specific policies can not be undertaken.

Models with a greater degree of disaggregation follow the standard approach of the MEGAAF model where milk quotas are modelled along the lines of Hertel and Tsigas (1991), as a fourth primary production factor to ensure compliance with the zero profit condition that applies to the milk sector. The "price" of the quota reflects the restricted right to produce milk, and the income derived from the quota simply represents the price of the quota multiplied by the value added. Milk supply is exogenously constrained by the quota level and the quota price is determined by the zero profit condition, since the value added is fully distributed to the four primary inputs (capital, labour, land and quota duties).

A similar approach is followed by some GTAP applications (Jensen et al., 1998; Nielsen, 1999), and by Weyerbrock (1998a,1998b), where the quota rent is endogenized by placing an *ad valorem* tax on production: thus allowing for quantities produced to be established exogenously. It should be stressed, however, that it is necessary to make sure that a *maximum* (and not a *minimum)* production quota is being modelled, by never allowing the *tax* to change (algebraic) sign and become transformed into a production *subsidy*. This type of problem does not arise in the ECAM/CAPMAT model, since the quotas on milk and sugar production are expressly incorporated as *non-equivalent* constraints. In this way Lagrange multipliers associated with such constraints represent the *shadow prices* of the "production quotas" factor of production set out by agricultural policy.

The impact of quotas are also studied in *input-output* models. In the study of Leat and Chalmers (1991), the authors, having *prior* knowledge of the impact of quotas on milk production levels during the period under consideration, employed traditional occupation "type I» and "type II» multipliers (see section 3.1) to calculate job losses in the agricultural and non-agricultural sectors.

The study of Roberts (1994) resorts to two less elementary techniques. First, instead of using completely *demand-driven* traditional multipliers, which work on the assumption that the demand for milk has dropped to allow for quotas to be simulated, they try to modify the Leontief modelling for the milk production sector, by making production exogenous and autonomous final demand endogenous (public sector consumption, investments, exports). In this way it is possible to calculate multipliers with "mixed" exogenous variables and therefore incorporate a constraint on production correctly (see 3.1).

The second technique used by Roberts is to construct a *supply-driven* version of the Leontief model and calculate the relevant multipliers. The latter, unlike the former, captures what is known as "downstream linkage effects", which are particularly relevant in the case of milk quotas. In fact, it is legitimate to assume that downstream transformation activities in the milk chain are also affected to some extent by the levying of quotas.

With respect to constraints applied to the use of inputs, the most significant example under the CAP is the compulsory set aside of a certain percentage of the agricultural land used to grow grain. In view of the many different approaches used by models analysing this type of intervention, a few simple graphs representing market equilibrium in the grain sector for the production factor "*land*" will better explain these differences.

Once again, the ECAM/CAPMAT model provides the most accurate representation. Not only does it explicitly include the constraint on the quantity of land used, but it also takes account of the effects of such practices on yield (known as the "*slippage*" effect). A graphic representation is provided in Figure 5.1, where the compulsory set aside (*qs*) is calculated as a percentage of the new quantity of equilibrium (*q*'*) attained by shifting the demand curve of the land factor from *D* to

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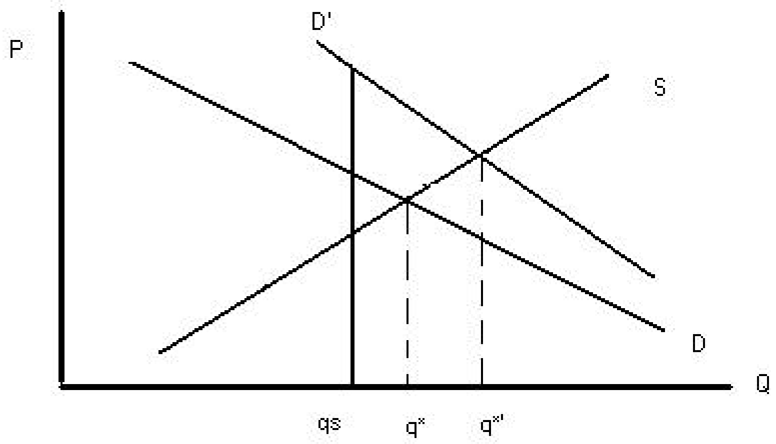
hardly be assumed, the simplification whereby this type of policy is considered to be a valid constraint for all producers appears acceptable.

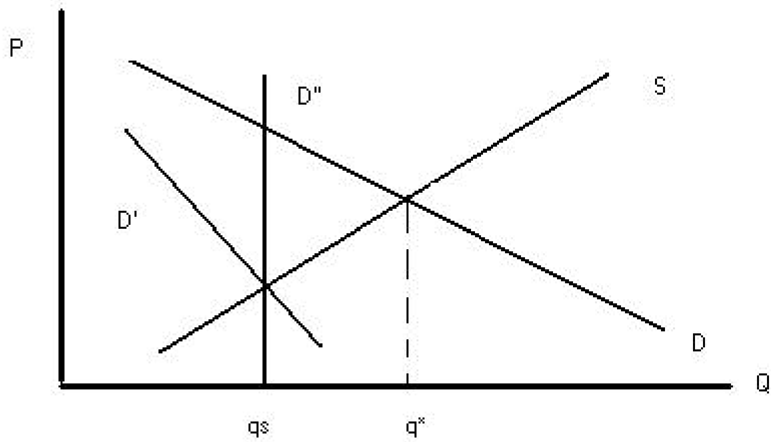
D'. Therefore, when the demand curve comes close to the compulsory set aside, it becomes completely rigid, although this effect is calculated on a higher curve than the original one since productivity rises as a result of *slippage*.

Figure 5.1 - The modelling of set aside in the ECAM/CAPMAT model



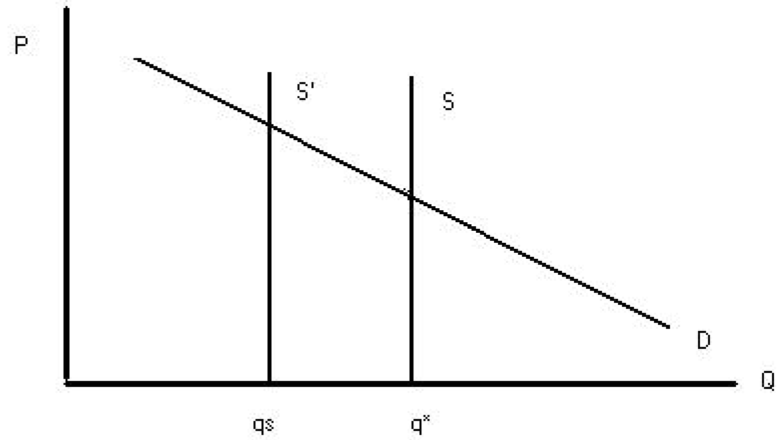
Other applications such as those in the GTAP (Frandsen et al., 1997) and Weyerbrock (1998a and 1998b), have also chosen to model compulsory set aside as a constraint on demand (Figure5.2).

Figure 5.2 - The modelling of set aside based on demand shifts



There is a substantial difference, however, between the two approaches. While the Weyerbrock model assumes that land utilisation is equal to *qs* (i.e. a certain percentage of the quantity of original equilibrium), and hence that demand is perfectly rigid at that level (*D''*); Frandsen et al. (1997) model the same compulsory set aside by reducing land productivity by exactly the same percentage as the compulsory set aside. In Figure 5.2 this corresponds to a rotation of the demand curve from *D* to *D'*. However, the *slippage* effect is not taken into account in either case.
Finally, other authors prefer (Blake et al., 1998 in the GTAP model, and also the MEGAAF model) to model compulsory set aside as a supply constraint rather than a demand constraint (Figure 5.3).

Figure 5.3 - The modelling of set aside based on supply shifts



In this case a new supply curve (*S'*), perfectly rigid at the level corresponding to qs, replaces the original supply curve (*S*). Note that the S curve is also perfectly rigid, because of the assumption that the quantity of land growing grain is fixed. Since Blake et al. (1998) distinguish between different grains, the application of a uniform rate of set aside for each grain is more restrictive than the actual policy, where an aggregate percentage of set aside is applied to all grains.
Lastly, it should be stressed that the percentage of area *to be set aside* does not match the percentage *actually set aside*, since the latter fluctuates as a result of exemptions granted to *small producers*. Although no model has the ability to distinguish between small and large producers, the ECAM/CAPMAT model is the only one which considers this element by introducing an (exogenous) assessment of the percentage of land actually set aside in individual EU countries.

5.4 Partially Decoupled Support Policies

This type of intervention has played an important role in the CAP as a result of the introduction of *compensatory payments* in 1992. However, since these payments only benefit certain sectors and are linked to particular production factors, it is not surprising that they are only represented by models with a certain degree of disaggregation of the agricultural sector: ECAM/CAPMAT, GTAP, Weyerbrock and MEGAAF.
The ECAM/CAPMAT model, which provides a much more detailed representation of supply than others, is best placed to incorporate payments per hectare or per head of cattle. Through its disaggregation of the EU region, it can apply different "average" payments for each country. As a matter of fact, since agricultural production is represented by the product of a factor (land or cattle) for the corresponding yield, compensatory payments will have an influence on decisions regarding the allocation of factors, but not on the yield: thus the partially decoupled nature of such payments will be reproduced.
Furthermore, compensatory payments linked to *historical* quantities (for both hectares and cattle) are also included in the modelling, by establishing total available expenditure and reducing unitary payments whenever reference values are exceeded.
In the GTAP model, the transformation of direct payments into subsidies for production factors is made difficult by the level of aggregation. Therefore, direct payments were introduced -in the case of grains - as an input subsidy equivalent based on a percentage value of the land factor (Frandsen et al., 1997; Bach and Frandsen, 1998; 2000; Jensen et al., 1998; Herok and Lotze,2000;Lotze and Herok, 1997; Salvatici, 1999), or a percentage of the value added for grains (van Meijl and van Tongeren, 2000). In the case of cattle, conversely, payments per head were considered -at least in part - to be subsidies to production factor *capital* (Jensen et al., 1998; van Meijl and van Tongeren, 2000), or to be subsidies coupled to quantities produced (Salvatici,1999). It should be stressed that some studies (e.g. Jensen et al., 1998) attempt to link the amount of subsidy to overall budget expenditure, thus modelling an important feature of the 1992 reform.

The Weyerbrock and MEGAAF models make the assumption that payments per hectare can be translated into a rise in income for the land production factor (rent). These payments have no chance of influencing production decisions, as they are linked to the use of a factor that is assumed fixed, and therefore these payments are completely decoupled.

In the same models, payments per head of cattle are represented as transfers to rural household income. Since there is no uncertainty in the model and, both investment amounts and labour supply are pre-determined exogenously, the increase in household income has no allocative consequence and, as a result, these payments too are completely decoupled (Gohin et al., 1999b)[39].

Finally, worthy of mention is the study of Roberts and Russell (1996), although it does not explicitly model decoupled policies, it does attempt, nonetheless, to assess the effects of such policies on income distribution among households moving from coupled agricultural income support to decoupled support. This feature is assessed by modelling coupled support as an exogenous injection into production accounts, and decoupled support as an exogenous injection into factor accounts and household accounts. It should be stressed, however, that its failure to distinguish between agricultural and non-agricultural households, greatly reduces the value of the results obtained.

6. CONCLUSIONS

Although it is not easy to draw conclusions on such a large body of literature, it is possible to attempt to take stock of the state of the art and identify what appears to be the main priorities on the agenda for future research.

Since a general economic equilibrium analysis evidently entails greater constraints and higher costs than other approaches, the first question that needs to be addressed is what type of problem can these models address in their analyses of agricultural policies. In responding to this question it is important to bear in mind that no single multisectoral model can be applied to all problems: it is preferable to think in terms of different methodologies which may be more or less suited (or adaptable) to the specific issues in question.

With respect to the agricultural policy instruments analysed in section 5, one important effect of direct price support policies is to generate an increase (or prevent a decrease) in the amount of production factors used, thereby distorting the allocation of resources and reducing the overall efficiency of the economic system. Although a general equilibrium approach is, in theory, the most satisfactory instrument to assess the impact of policies on the allocation of resources, no assessment can do without an accurate modelling of intervention mechanisms. The agricultural policy instruments adopted within the CAP, in fact, are so complex that they can hardly be represented by models unable to distinguish which products and factors are subject to intervention.

On the other hand, any multisectoral model no matter how well designed to analyse the agricultural sector, cannot easily avoid operating at an aggregate level when it comes to determining policies. Consequently, it is extremely important that models dispose of *policy indicators* which are able to represent in an exact manner the "equivalent" features of a specific intervention mechanism (customs duty, subsidy, quota). Such indicators are not always readily available and, as we have already seen, the solution most frequently adopted is to use existing indicators (PSE, simple or weighed tariff, etc.) , without any discussion (or maybe even awareness) of the implications of this decision. The quality and quantity of indicators available and actually utilised is something which needs to be improved in the future.

Above and beyond the problem of a model's level of disaggregation, the representation of market policies is another open issue awaiting a more satisfactory solution. First of all, there should be more extensive modelling of the link between *market prices and institutional prices*: the current

[39] A similar solution is adopted by Blake et al. (1998) where compensatory payments are deemed comparable to agricultural household income transfers, even though they had introduce them as income increases for sector specific factors (e.g. land), since the GTAP model does not allow for agricultural households to be distinguished from other households.

approach whereby both levels are considered to coincide (with a uniform elasticity of transmission) is too simplistic an assumption in many cases. More accurate representation of public sector intervention in the market is, moreover, difficult to imagine without adequate modelling of stockpiling policies: progress on this front, however, will largely depend on the availability of models with an adequate dynamic structure.

Furthermore, the models reviewed here do not always place sufficient emphasis on the fiscal implications or consequences of CAP reform on the EU budget. Although this is certainly true of AGE/CGE models which have a more sectoral orientation compared to models geared towards analysis of fiscal policies (Shoven and Whalley, 1984), it is quite astonishing that this is also the case with the CAP, considering that this policy absorbs almost half of the EU budget. It would be desirable for such models to give explicit consideration to the implications of budget constraints and, for those models with adequate regional disaggregation, to undertake more detailed modelling of transfers between EU and national accounts.

With respect to the modelling of trade policies and the constraints deriving from multilateral agreements, in our opinion, the AGE/CGE models, in particular, the global ones, are an essential instrument for appropriate representation of liberalisation processes. Here, too, however, certain aspects need to be further refined and investigated. Firstly, there is the difficulty of adequately modelling instruments and constraints which function in a “discontinuous” manner, for instance, tariff quotas - where the duty will switch from one level to another when a certain quantity of imports is reached- or multilateral commitments - whose binding nature may vary in the light of prevailing market conditions.

More generally, the fact that the commitments governments undertake are more *results* oriented (as in the case of cuts in domestic support or in the amount of subsidised exports), rather than geared towards specific intervention *instruments* (as in the case of a cut in duties) makes modelling particularly difficult, since the same result may be obtained by a combination of different policy interventions. Another important consideration is that any change introduced in order to comply with an international commitment, may render compliance with other existing constraints more or less difficult (consider, for instance, the effects of the constraint on subsidised exports on the possible continuation of a guaranteed minimum price on the domestic market): the ability of models to take account of all these complex interactions is still unsatisfactory.

As regards (more or less) decoupled policies and new interventions of a structural nature designed to promote rural development, a general equilibrium approach would appear to be the most suitable from, at least, two points of view. On one hand, a support partially decoupled from production decisions diminishes the “substitution effects” within the sector, while continuing to produce a whole series of “income-effects” (in distributive terms as well) which cannot be adequately captured by partial models. On the other, structural rural development policies focus on a specific region rather than a specific sector: in this case too, it is important that models provide a representation of the economic system as a whole.

Unfortunately, the results currently provided by models are not entirely satisfactory in terms of the representation of partially decoupled policies and are entirely wanting when it comes to structural policies. Any explicit modelling of partially decoupled payments, should not fail to give detailed representation of production decisions, for example, the extent to which production factors are used and combined. Furthermore, it would also be useful to access models which disaggregate the “household” sector, so that differences in support could be incorporated (for example, allocations to agricultural households in a certain region or below a certain income level). The level of aggregation in most of the models reviewed here is clearly far too high to achieve this. In the case of structural policies, their *voluntary* nature poses the greatest difficulty in modelling terms, and any explicit representation of these policies should not fail to differentiate agricultural producers. The structure of a single region model is more suited to represent this type of differentiation, at least in principle, while global models may find it more difficult to depart from the assumption that there is only one representative agent for each region considered.

Multisectoral models, therefore, are making a considerable effort to analyse agricultural policy problems. The spread of this type of model in the past was mostly impeded by the high cost of data collection and the complexity of calculations. It is worth noting that in recent years both these costs have declined drastically thanks to *technological* innovations as well as *institutional* changes.
On one hand, in fact, the widespread availability of increasingly powerful computers and more manageable software programmes has made it possible to design and undertake complex simulations in a relatively short period of time (at any rate, far shorter than a few years ago). On the other, the development of *networks* (the GTAP, for example) has resulted in a drastic reduction in the cost of access to the information required to formulate a multisectoral analysis. This has been made possible not only by the evident *economies of scale* this type of activity generates (once a model is developed, its productivity is by no means diminished should it be used by many researchers rather than just a few), but also as a result of the provision by "public" institutions of some of the data required for this type of analysis. A good example of this is the *Agricultural Market Access Database* developed recently by a number of national and international institutions now available on line at (http://www.amad.org/files/index.htm).
Although even large scale multisectoral models are, to a certain extent, now easier to obtain and use, there is still the risk of their being used incorrectly. This would happen if they were used to find answers to questions on agricultural policy they were "structurally" unsuited for. If the purpose, on the other hand, is to assess the impact of a multilateral agreement within the WTO, the consequences of an enlargement of the EU, or the implications of preferential agreements with developing countries, then the contribution of global multilateral models, which take account of linkages between agriculture and other sectors as well as the effects of changes in the rest of the economic system on the agricultural sector, will undoubtedly be very valuable.
However, this type of model – due to the level of sectoral aggregation and the fact that the same format is applied to different countries – is not equipped to respond to specific queries relating to intervention policies that apply to a specific product. This is particularly true when there is an attempt to model in detail "complex" instruments like the allocation of partially decoupled payments, the introduction of voluntary policies or the imposition of constraints on production.
It is necessary to clarify, however, that the above-mentioned limitations of *global* multisectoral models do not necessarily apply to multisectoral models with a much more limited scope. Multisectoral models 'targeted" for specific countries/regions or groups of countries/regions may attain, at least in principle, a sufficient level of detail to represent a large variety of intervention mechanisms. This does not mean that multisectoral models may (or should) be used to find a solution to any issue of agricultural policy. However, European agricultural economists have so far tended to underestimate their true potential. In our opinion, multisectoral models which focus on a certain sector or a specific region can indeed provide valuable results to those seeking solution to market problems, in a production chain , for example, or issues of rural development in specific areas.

References

ABARE
1996 *The MEGABARE model: interim documentation*, Australian Bureau of Agriculture and Resource Economics, Canberra.

Adelman, I.; Robinson, S.
1978 *Income Distribution Policies in Developing Countries*, Stanford, Calif.: Stanford University Press.

Anania, G.

1996 *L'agricoltura nell'Accordo conclusivo dell'Uruguay Round*, in Anania, G.; De Filippis, F. (eds.) "L'Accordo GATT in agricoltura e l'Unione Europea", Franco Angeli, Milano.

Anderson, K.; Francois, J.F.
1998 *Commercial Links Between estern Europe and East Asia: Retrospect and Prospect*, in Drysdale, P.; Vines, D. (eds.), "A Shared Global Agenda? Europe, East Asia and APEC and the ASEM Process", Cambridge University Press, Cambridge.

Anderson K.; Erwidodo; Ingco M.
1999 *Integrating Agriculture into the WTO: the Next Phase*, paper presented at the Conference "Developing Countries Interests in a Millennium Round", World Bank/WTO, Ginevra. Settembre.

Armington, P.
1969 *A theory of demand for products distinguished by place of production*, in IMF Staff Papers, n. 16.

Bach, C. F.; Frandsen, S. E.
1998 *European Integration and the Common Agricultural Policy*, in Danish Institute of Agricultural and Fisheries Economics Working Paper, n. 1/98, Copenhagen.

Bach, C. F.; Frandsen, S. E.; Jensen, H. G.
2000 *Agricultural and Economy-Wide Effects of European Enlargement: Modelling the Common Agricultural Policy*, in Journal of Agricultural Economics, Vol. 51 n. 2.

Bach, C. F.; Martin, W.
1999 *Would the Right Tariff Aggregator Please Stand Up?*, paper presented at the IATRC annual meeting, New Orleans USA.

Bach, C.; Pearson, K.
1996 *Implementing Quotas in GTAP using GMPACK or How to Linearize an inequality*, in Global Trade Analysis Project Technical Paper, n. 4.

Balderston, J. B.
1975 "I modelli di equilibrio economico generale", in C. D'Adda e L. Filippini (eds.), *Interdipendenze industriali e politica economica*, Il Mulino, Bologna

Baldwin, R.E.; Francois, J.
1997 *Preferential Trade Liberalization in the North Atlantic*, in CEPR Discussion Paper, n. 1611.

Baldwin, R.; Francois, J.F.; Portes, R.
1997 *The costs and benefits of Eastern Enlargement: the impact on the EU and 1997*, in Economic Policy, n. 24.

Banse, M.; Tangermann, S.
1998 *Agricultural Implication of Hungary's Accession to the EU – Partial versus General Equilibrium Effects*, in Brockmeier, M., Francois, J. F., Hertel, T. W. and Schmitz, P. M. (eds.), "Economic Transition and the Greening of Policies: Modeling New Challenges for Agriculture and Agribusiness in Europe", Kiel: Wissenschaftsverlag Vauk Kiel KG.

Beaumais, O.; Schubert, K.
1999 *La modélisation en équilibre général calculable*, in Economie Rurale, n. 25.

Bernini Carri, C.
1981 *Le funzioni di produzione aggregate del sistema agroalimentare Cee: un'analisi comparata delle matrici input-output,* in Rivista di Economia Agraria, n. 2.

Bettendorf, L.; Merbis, M.
1998 *Implications for net positions of the agricultural reform in Agenda 2000*, in Central Planning Bureau Report, n. 98/2, The Hague.

Blake, A.T.; Rayner, A.J.; Reed, G.V.
1998 *A CGE Analysis of Agricultural Liberalisation: the Uruguay Round and the CAP Reform,* paper presented at the First Annual Conference on Global Trade Analysis, Purdue USA.

Bloningen, B. A.; Flynn J. E.; Reinert, K. A.
1997 *Sector-Focused General Equilibrium Modeling*, in Francois, J. F. e K. A. Reinert (eds.), "Applied Methods for Trade Policy Analysis. A Handbook", Cambridge University Press, Cambridge.

Borges, A.M.;
1986 *Applied General Equilibrium Models: an assessment of their usefulness for policy analysis*, OECD Economic Studies, n. 7.

Boussard, J.-M.; Christensen,
1999 *Risk and Development in Poland and Hungary: An Application of CGE Models Under Different Agricultural Market Systems*, paper presented at the DIAL/PARADI Conference on "CGE Modeling in Developing Economies", Parigi.

Brandao, A.S.; Martin, W.J.
1993 *Implications of Agricultural Trade Liberalization for the Developing Countries*, in Agricultural Economics, n. 8.

Brown, D. K., et al.
1995a *Computational Analysis of Goods and Services Liberalization in the Uruguay Round*, in School of Public Policy Discussion Paper, n. 379, University of Michigan

Brown, D. K., et al.
1995b *An Economic Assessment of the Integration of Czechoslovakia, Hungary, and Poland into the European Union*, in School of Public Policy Discussion Paper, n. 380, University of Michigan.

Büchi, G.
1997 *Metodologie per la valutazione degli effetti delle politiche di liberalizzazione dei mercati agricoli: considerazioni sull'uso del modello RUNS*, in Chang Ting Fa, M.; Piccinini, C.L.; Vidrigh, M. (eds.) "Economia dell'agroindustria. Problematiche teoriche e applicative", Forum Editrice Universitaria, Udine.

Bureau, J.-C.; Fulponi, L.; Salvatici, L.
2000 *Comparing EU and US Trade Liberalisation under the Uruguay Round Agreement on Agriculture*, in European Review of Agricultural Economics, 27, 3.

Burniaux, J.M.

1988 *Effetti intersettoriali della liberalizzazione della PAC,* in Tarditi, S.; Thomson, K.J.; Pievani, P.; Croci-Angelini, E. (eds.) "Liberalizzazione del commercio agricolo e Comunità Europea", Quaderni della Rivista di Economia Agraria - INEA, Il Mulino, Bologna.

Burniaux, J. M.; van der Mensbrugghe, D.
1991 *Trade policies in a Global Context. Technical Specification of the Rural/Urban-North/South (RUNS) Applied General Equilibrium Model*, OECD Development Centre, Parigi.

Burniaux, J.M.; Waelbroeck, J.
1990 *The Common Agricultural Policy of the European Community and the World Economy: A General Equilibrium nalysis*, in Bergman, L.; Jorgenson, D.; Zalai, E. (eds.) "General Equilibrium Modeling and Economic Policy Analysis", Basil Blackwell, Oxford.

Cambridge Department of Applied Economics,
1962-1974 *A Programme for Growth*, Vols. I to XI, Chapman and Hall, London.

CEPII
1988 *CHELEM-Banque de Données du CEPII*, in Centre d'Etudes et d'Information Internationales document de travail, n. 88-14

Cesaretti, G.P.; de Stefano, F.
1974 *Interdipendenze settoriali e agricoltura: nuovi spunti di politica agraria*, in Rivista di Economia Agraria, n.1.

Chang Ting Fa, M.
1981 *L'ipotesi Agribusiness: una verifica sulle matrici intersettoriali dell'economia italiana 1965-1973*, in Rivista di Economia Agraria, n.2.

Darwin, R.F.
1999 *A FARMer's View of the Ricardian Approach to Measuring Effects of Climatic Change in Agriculture*, in Climatic Change, n. 41(3/4).

Darwin, R.F.; Tsigas, M.E.; Lewandrowski, J.; Raneses, A.
1994 *Shifting Uses for Natural Resources in a Changing Climate*, in World Resources Review, n. 6 (4).

Darwin, R. F.; Tsigas, M. E.; Lewandrowski, J.; Raneses, A.
1995 *World Agriculture and Climate Change: Economic Adaptations*, in ERS-USDA Agricultural Economic Report, n. 703.

Darwin, R. F.; Tsigas, M. E.; Lewandrowski, J.; Raneses, A.
1996 *Land use and cover in ecological economics*, in Ecological Economics, n. 17.

Deardorff, A. V.; Stern, R. M.
1986 *The Michigan Model of World Production and Trade*, MIT Press, Cambridge Massachussets.

Deardorff, A. V.
1996 *Some Economic Effects of the Free Trade Agreement Between Tunisia and the European Union*, in School of Public Policy Discussion Paper, n. 385, University of Michigan.

De Muro, P.

1993 *Analisi input-output e sistema agroindustriale: alcuni recenti contributi italiani*, in “La Questione Agraria”, n. 49.

Dervis, K; de Melo, J.; Robinson, S.
1982 *General equilibrium models for development policy*, The World Bank, Washington, D.C.

Dixit, A.K.; Stiglitz, J.E.
1977 *Monopolistic competition and optimum product diversity*, in "American Economic Review", n. 72.

Dixon, P. B.; Parmenter, B.; Ryland, G.; Sutton J.
1977 *ORANI, A General Equilibrium Model of the AustralianeEconomy*, vol. 2, Canberra: Government Publishing Service.

Elbehri, A.; Ingco, M.; Hertel, T.; Pearson, K.
1999 *Agriculture and WTO 2000: Quantitative Assessment of Multilateral Liberalization of Agricultural Policies*, paper presented at the Conference “Agriculture and The New trade Agenda in the WTO 2000 Negotiations”, World Bank/WTO, Ginevra.

Elbehri, A.; Pearson, K.
1999 *Implementig Bilateral Tariff rate Quotas in GTAP using GEMPACK*, in Global Trade Analysis Project Technical Paper n.18.

Evans, D.; Goldin, I.; van der Mensbrugghe, D.
1992 *Trade reform and the small country assumption*, in Goldin, I.; Winters, L.A. (eds.) “Open economies: structural adjustment and agriculture”, Cambridge University Press, Cambridge.

Fabiani, G.; Manfredi, F.
1976 *Agricoltura comunitaria e interdipendenze settoriali*, in Rivista di Economia Agraria, n.3.

Fehr, H.; Wiegard, W.
1996 *A CGE Examination of Worldwide Agricultural Liberalisation Policies: Model Structure and Preliminary Results*, in Fossati, A. (ed.) "Economic modelling under the applied general equilibrium approach", Ashgate, Aldershot U.K.

Folmer, C.
1992 *ECAM data input 1983/1992*, Central Planning Bureau Report, n. IV/92/11, The Hague.

Folmer, C.; et al.
1989 *Modelling alternative Common Agricultural Policies*, in Bauer, S.; Henrichsmayer, W. (eds.) “Agricultural Sector Modelling”, Vauk, Kiel.

Folmer, C.; et al.
1991 *A demand system for marketed and non-marketed feed in the EC-9*, mimeo, Central Planning Bureau, The Hague.

Folmer, C. et al.
1993 *CAP-reform and the EC-US GATT compromise: compatible or not?*, Central Planning Bureau Working Paper, n. 49, The Hague.

Folmer, C. et al.

1994 *CAP reform and its differential impact on member states*, in European Economy. Reports and Studies, n. 5.

Folmer, C.; Keyzer, M.A.; Merbis, M.D.; Stolwijk, H.J.J; Veenendaal, P.J.J.
1995 *The Common Agricultural Policy beyond MacSharry Reform*, North-Holland, Amsterdam.

Francois, J.F.
1998a *Scale Economies and Imperfect Competition in the GTAP Model*, in Global Trade Analysis Project Technical Paper, n. 14.

Francois, J.F.
1998b *Scale Economies, Imperfect Competition, and the Eastern Expansion of the EU,* in in Brockmeier, M; Francois, J.F.; Hertel, T.W.; Schmitz, P. (eds.) "Economic transition and the greening of policies", Wissenschaftsverlag Vauk, Kiel.

Francois, J.F.
1999 *GTAP Applications Survey: An overview with particular emphasis on the European Union*, in FAIR6 CT 98-4148 Interim report, n. 2.

Francois, J.F.; Baldwin, R.E.
1999 *Is It Time for a TRAMP: Quantitative perspectives on trans-Atlantic liberalizaiton*, in Mayer, O.G.; Scharrer, H. (eds.) "Transatlantic Relations in a Global Economy", HWWA, Hamburg.

Francois, J.; McDonald, B.
1997 *The multilateral trade agenda: Uruguay Round implementation and beyond*, in CEPR Discussion Paper, n. 1533.

Francois, J.F.; McDonald, B.; Nordstrom, H.
1994 *The Uruguay Round: A Global General Equilibrium Assessment*, in CEPR Discussion paper n.1067

Francois, J.F.; McDonald, B.; Nordstrom, H.
1995 *Assessing the Uruguay Round*, in World Bank Discussion Papers, n. 307.

Francois, J.F.; McDonald, B.; Nordstrom, H.
1996a *A User's Guide to The Uruguay Round Assessments*, in CEPR Discussion Paper, n. 1410.

Francois, J.F.; McDonald, B.; Nordstrom, H.
1996b *The Uruguay Round: A Numerically-Based Qualitative Assessment*, in Martin, W.; Winters, L.A. (eds.) "The Uruguay Round and the DevelopingCountries", Cambridge University Press, Cambridge.

Francois, J.F.; McDonald, B.; Nordstrom, H.
1997 *The Uruguay Round: A Global General Equilibrium Assessment*, Robertson, D. (ed.) "East Asian trade after theUruguay Round", Cambridge University Press, Cambridge.

Francois, J. F.; Reinert, K.A. (eds.)
1997 *Applied Methods for Trade Policy Analysis*, Cambridge University Press, Cambridge.

Frandsen, S.E.; Bach, C.F.; Stephensen, P.

1998 *European Integration and the Common Agricultural Policy: A CGE Multi RegionalAnalysis*, in Brockmeier, M; Francois, J.F.; Hertel, T.W.; Schmitz, P. (eds.) “Economic transition and the greening of policies”, Wissenschaftsverlag Vauk, Kiel.

Frandsen, S.E.; Jensen, H.G.; Vanzetti, D.M.
2000 *Expanding 'Fortress Europe' Implications ofEuropean Enlargement for Non-MemberRegions*, The World Economy, vol. 23 n. 3.

Fullerton, D.; King, A.; Shoven, J. B.; Whalley, J.
1981 *Corporate Tax Integration in the United States: A General Equilibrium Approach*, in “American Economic Review”, n° 71, p. 677-691.

Fullerton D.; Shoven, J. B.; Whalley, J.
1983 *Replacing the US Income Tax with Progressive Consumption Tax: A Sequenced General Equilibrium Approach*, in “Journal of Public Economics”, n° 20, p. 3-23.

Gohin A.
1998 *Modélisation du complexe agro-alimentaire français dans un cadre d’équilibre géneral*, Document de travail MEGAAF n°6, Équipe PAM, Unité INRA-ESR, Rennes.

Gohin, A.; Guyomard, H.; Le Mouel, C.
1999a *L’analyse des politiques agricoles: l’apport de l’équilibre général calculable*, in “Economie Rurale”, 25: 4-10.

Gohin, A.; Guyomard, H.; Le Mouël, C.
1999b *Tariff protection reduction and Common Agricultural Policy reform: Implications of changes in methods of import demand modelling in a computable general equilibrium framework,* paper presented at the Second Annual Conference on Global Trade Analysis, Assens Denmark.

Gohin, A.; Guyomard, H.; Le Mouël, C.
1999c *Interpretazione economica, vantaggi e limiti del principio di disaccoppiamento*, in La Questione Agraria, n. 75.

Goldin, I.; van der Mensbrugghe, D.
1992 *Trade Liberalisation: What’s at Stake?*, in OECD Policy Brief, n. 5.

Goldin, I.; Knudsen, O.; van der Mensbrugghe, D.
1993 *Trade Liberalisation: Global Economic Implications*, OECD – World Bank, Washington D.C..

Gunning, J. W.; Keyzer, M. A.
1995 “Applied General Equilibrium Models for Policy Analysis”, in in J. Behrman e T. N. Srinivasan (eds.), *Handbook of development economics*, Volume III, North Holland, Amsterdam.

Hanson, K.A.; Robinson, S.
1989 *Data, Linkages, and Models: U.S. National Income and Product accounts in the Framework of a Social Accounting Matrix*, Agriculture and Rural Economy Division, ERS, USDA, Staff Report No. AGES 89-5.

Harrison, G.W.; Rutherford, T.F.; Tarr, D.
1996 *Quantifying the Uruguay Round*, in Martin, W.; Winters, A. (eds.) “The Uruguay Round and the Developing Countries”, Cambridge University Press, Cambridge.

Harrison, G.W.; Rutherford, T.F.; Tarr, D.
1997 *Quantifying the Uruguay Round*, in Economic Journal, n. 107.

Harrison, G.W.; Rutheford, T.F.; Wooton, I.
1995 *Liberalizing Agriculture in the European Union*, in Journal of Policy Modeling, n. 17(3).

Harrison, W.J.; Pearson, K.R.
1996 *Computing Solutions for Large General Equilibrium Models Using GEMPACK*, in Computational Economics, n. 9(2).

Herok, C.A.; Lotze, H.
2000 *Implications of an EU Eastern Enlargement Under a New Common Agricultural Policy*, in “Journal of Policy Modeling”, 22 (6).

Hertel, T.W. (ed.)
1997 *Global Trade Analysis: Modelling and Applications*, Cambridge University Press, Cambridge.

Hertel, T.W.
1999 *Applied General Equilibrium Analysis of Agricultural and Resource Policies*, in Staff Paper Dept. of Agricultural Economics, Purdue University, n. 99-2.

Hertel, T.W.; Anderson, K.; Francois, J. F.; Hoekman, B.; Martin, W.
1999 *Agriculture ans Non-agricultural iberalization in the Millennium Round*, paper presented at the Conference “The Conference on Agriculture and The New trade Agenda in the WTO 2000 Negotiations”, World Bank/WTO,Ginevra.

Hertel, T.W.; Brockmeier,M.; Swaminathan, P.
1997a *Sectoral and economy-wide analysis of integrating Central and Eastern EuropeanCountries into the EU: implications of alternative strategies*, in European Review of Agricultural Economics, n. 24.

Hertel, T. W.; Ianchovichina, E.; MacDonald, B.
1997a *Multi-Region General Equilibrium Modeling*, in Francois, J. F.; Reinert, K.A. (eds.) Applied Methods for Trade Policy Analysis, Cambridge University Press, Cambridge.

Hertel, T. W.; Tsigas, M.E.
1991 *General equilibrium analysis of supply control in US agriculture*, in European Review of Agricultural Economics, n. 18.

Hubbard, L.J.
1995a *CGE Modelling of the CAP: Trade Elasticities, Structural Effects and Welfare*, Department of Agricultural Economics and Food Marketing The University of Newcastle Discussion Paper, n. 4/95.

Hubbard, L.J.
1995b *General Equilibrium Analysis of the Common Agricultural Policy Using the GTAP Model*, in Oxford Agrarian Studies, n. 23(2).

Huff, K.; McDougall, R.; Walmsley, T. L.
1996 *Contributing Input-Output Tables to the GTAP Data Base*, in GTAP Technical Paper, n. 1.

Ianchovichina, E. I.; McDougall, R. A.
2000 *Structure of Dynamic GTAP*, in GTAP Technical Paper n.17.

International Agricultural Trade Research Consortium
1994 *The Uruguay Round Agreement on Agriculture: An Evaluation*, in IATRC Commissioned Paper, n. 9.

James, M.; McDougall, R.
1993 *FIT: An Input-Output Data Update Facility for SALTER*, SALTER Working Paper, n. 17.

Jensen, H.G.; Frandsen, S.E.; Bach, C.F.
1998 *Agricultural and Economic-Wide Effects ofEuropean Enlargement: Modelling theCommon Agriculture Policy*, Danish Institute of Agricultural and Fisheries Economics Working Paper, n. 11/98.

Johansen, L.
1960 *A Multi-Sectoral Study of Economic Growth*, Amsterdam, North-Holland.

Keyzer, M.A.; Merbis, M.D.
1998 *Impact analyses of the Agenda 2000 proposals for CAP reform*, in "CAP Reform Proposals", European Commission - DG VI, Bruxelles.

Kilkenny, M.
1991a *Computable General Equilibrium Modeling of Agricultural Policies: Documentation of the 30-Sector FPGE GAMS Model of the United States*, Staff Report No. AGES 9125, USDA, ERS, June.

Kilkenny, M.
1991b *Nonfarm Prospects Under Agricultural Liberalization*, in “The Journal of Agricultural Economics Research”, Vol. 43, No. 3, Summer.

Kilkenny, M. ; Robinson, S.
1988 *Modelling the removal of production incentive distortions in the US agricultural sector*, XX International Conference of Agricultural Economists, Buenos Aires, Argentina, 27 agosto-1 settembre.

Kilkenny, M.; Robinson, S.

1990 *Computable General Equilibrium Analysis of Agricultural Liberalization: Factor Mobility and Macro Closure*, in “Journal of Policy Modeling”, 12(3):527-556.

Komen, M. H.; Peerlings, J. H. M.

1996 *WAGEM: an applied general equilibrium model for agricultural and environmental policy analysis*, in “Wageningen Economic Papers”, n. 1996-4, Wageningen Agricultural University, Wageningen, The Netherlands.

Komen, M. H.; Peerlings, J. H. M.

1998 *Environmental Indicators in an AGE framework – Effects of the Dutch 1996 energy tax on agriculture,* in Brockmeier, M; Francois, J.F.; Hertel, T.W.; Schmitz, P. (eds.) “Economic transition and the greening of policies”, Wissenschaftsverlag Vauk, Kiel.

Komen, M. H.; Peerlings, J. H. M.

1999 *Environmental Policy Analysis in Agriculture: Applied General Equilibrium Models*, paper presented at the IX EAAE Congress, Varsavia, 1999.

Krugman, P.
1979 *Increasing returns, monopolistic competition and international trade*, in "Journal of International Economics", n. 9.

Krugman, P.
1980 *Scale economies, product differentiation, and the pattern of trade*, in American Economic Review, n. 70.

Leat, P.M.K.; Chalmers, N.
1991 *Analysing agricultural adjustment in Grampian using an input-output model of the agricultural and food complex*, in Midmore, P. (ed.), “Input-Output Models in the Agricultural Sector”, Avebury, Aldershot.

Leontief, W.
1936 *Quantitative input-output relations in the economic system of the United States*, in “The Review of Economics and Statistics”, XVIII, 3.

Liapis, P.; Tsigas, M.E.
1998 CEEC (Central and Eastern EuropeanCountries) Accession to the European Union: A General Equilibrium Analysis, in Economic Research Service, U.S. Department of Agriculture Agricultural Economics Report, n. 771.

Lotze, H. and Herok, C.
1997 *A New directions in the Common Agricultural Policy: Effects of land and labor Subsidies in a General Equilibrium Model,* Humboldt University of Berlin, mimeo.

Mai, Y.H.; Woffenden, K.; Hanslow, K.; Vanzetti, D.
1996 *APEC Trade Liberalization. Implications for the European Union*, paper presentato al Congresso dell’EAAE, Edinburgo, 1996.

Manne, A. S.
1974 *Muli-Sectoral Models for Development Planning: A Survey,* in “Journal of Development Economics”, 1: 43-69.

McDonald, S.; Roberts, D.
1998 *The Economy-Wide Effects of the BSE Crisis: A CGE Analisys,* in “Journal of Agricultural Economics”, n. 49(3).

McDougall, R.; Elbehri, A.; Truong, T.P. (eds.)
1998 *Global trade, assisance and protection: The GTAP 4 database*, Center for Global Trade Analysis, Purdue University West Lafayette.

McDougall, R.; Ianchovichina, E.
1998 *Incorporating Dynamics and International Capital Mobility into the GTAP Model*, in Brockmeier, M; Francois, J.F.; Hertel, T.W.; Schmitz, P. (eds.) “Economic transition and the greening of policies”, Wissenschaftsverlag Vauk, Kiel.

Nguyen, T.T.; Perroni, C.; Wigle R.M.
1991 *The value of a Uruguay Round Success*, in The World Economy, n. 14(4).

Nguyen, T.T.; Perroni, C.; Wigle R.M.
1993 *An Evaluation of the Draft Final Act of the Uruguay Round*, in The Economic Journal, n. 103.

Nielsen, C.P.
1999 *EU Enlargement and the Common Agricultural Policy: Modeling Issues*, Danish Institute of Agricultural and Fisheries Economics Working Paper, n. 7/1999.

OECD
1999 *Agricultural Policies in OECD Countries. Monitoring and Evaluation 1999*, OECD, Parigi.

Pasinetti, L.
1975 *Lezioni di teoria della produzione*, Il Mulino, Bologna.

Pyatt, G.
1988 *A SAM approach to modeling*, in “Journal of Policy Modeling”, Vol. 10, N° 3, Fall.

Pyatt, G; Round, J. I.
1979 *Accounting and fixed price multipliers in a social accounting framework*, in “Economic Journal”, 89.

Reinert, K. A.; Roland-Holst, D. W.
1997 *Social Accounting Matrices*, in Francois, J. F. e K. A. Reinert (eds.), “Applied Methods for Trade Policy Analysis. A Handbook”, Cambridge University Press, Cambridge.

Roberts, D.
1994 *A Modified Leontief Model for Analysing the Impact of Milk Quotas on the Wider Economy*, in Journal of Agricultural Economics, n. 45(1).

Roberts, D.; Russell, N.
1996 *Income Distribution and the Structure of Production: Insights from a SAM-based Model of UK Agriculture*, in Midmore, P; Harrison-Mayfield, L. (eds.), “Rural Economic Modelling: An Input-Output Approach”, CAB International, Wallingford.

Robinson, S.
1989 *Multisectoral models*, in H. Chenery e T. N. Srinivasan (eds.), “Handbook of development economics”, Volume II, North Holland, Amsterdam.

Robinson, S.; Kilkenny M.; Hanson, K.
1990 *The USDA/ERS Computable General Equilibrium (CGE) Model of the United States*, Agriculture and Rural Economy Division, Economic Research Service, U.S. Department of Agriculture, Staff Report No. AGES 9049. Washington, DC.

Robinson, S.; Burfisher, M.E.; Hinojosa-Ojeda, R.; Thierfelder, K.

1993 *Agricultural policies and migration in a US-Mexico free trade area: a computable general equilibrium analysis*, in Journal of Policy Modeling, n.15(5-6).

Salvatici, L.

1999 *Trade Distortion Indexes and CGE Models: The Case of the Common Agricultural Policy*, paper presented at the IATRC Annual Meeting, New Orleans USA.

Sand, R.; Stokstad, G.
1998 *Political preferences, CGE models and conditions for further reductions in agricultural support*, paper presented at the First Annual Conference on Global Trade Analysis, Purdue USA.

Sayan, S.; Tin, E.
1998 *"Green Box" Measures for Agricultural Support: How Decoupled Can They Really Be? An Investigation within SAM and CGE Frameworks*, paper presented at the AAEA Annual Meeting, Salt Lake City, Utah.

Scarf, H. E.
1967 *The Approximation of Fixed Points of a Continuos Mapping*, in "SIAM Journal of Applied Mathematics", n. 15, , p. 1328-1343.

Schubert, K.
1993 *Les modèles d'équilibre général calculable: une revue de la littérature,* in "Revue d'Économie Politique", 103 (6), nov.-déc..

Sen, A. K.

1963 *Neo-classical and neo-Keynesian theories of distribution*, in "Economic Record", 39, pp. 54-64.

Serrão, A.
1998 *Economic and Environmental Impacts of the Post-1992 CAP Reform on Alentejo Economy of Portugal*, paper presented at the AAEA, Salt Lake City, Utah.

Sharma, R.; Konandreas, P.; Greenfield, J.
1996 *An Overview of Assessments of the Impact of the Uruguay Round on Agricultural Prices and Incombe*, in Food-Policy, n. 21(4-5).

Sharma, R.; Konandreas, P.; Greenfield, J.
1997 *Synthesis of results on the impact of the Uruguay Round on the Global and LAC Agriculture*, in Cordeau, J.L.; Valdes, A.; Silva, F. (eds.) "Implementing the Uruguay Round Agreement in Latin America: the Case of Agriculture", Fao and World Bank, Santiago, Cile.

Shoven, J. B.; Whalley, J.
1973 *General Equilibrium with Taxes: A Computation Procedure and an Existence Proof,* in "Review of Economic Studies", n. 40, , p. 475-490.

Shoven, J.B.; Whalley, J.
1984 *Applied General-Equilibrium Models of Taxation and International Trade: An Introduction and Survey*, in Journal of Economic Literature, vol. XXII.

Surry, Y.
1992 *Un Modèle de transmission des prix garantis des céréales dans la Communauté économique européénne*, in Cahiers d'économie et sociologie rurales, n. 22.

Targetti Lenti, R.
1989 *I modelli di equilibrio economico generale calcolabili (CGE) e la metodologia SAM*, in “Giornale degli economisti”, n. 7-8.

Taylor, L.
1990 *Structuralist CGE Models*, in Taylor, L. (ed.) “Socially Relevant Policy Analysis. Structuralist Computable General Equilibrium Models for the Developing World”, The MIT Press, Cambridge, Massachusetts.

Thomson, K. J.

1991 *Modeling theCap*, in Ritson, C.; Harvey, D. (eds.) *The Common Agricultural Policy and the World Economy. Essays in Honour of John Ashton*, CAB International, Wallingford Oxfordshire.

van Meijl, H.; van Tongeren, F.
2000 *The Agenda 2000 CAP reform, world prices and GATT-WTO export constraints*, paper presented at the Third Annual Conference on Global Economic Analysis, Melbourne, Australia, June 27-30.

van Tongeren F.; van Meijl H.; Veenendaal P.

2000 *Global effects of EU Agenda 2000. Implications for the WTO negotiations and developing countries*, Agricultural Economics Research Institute (LEI), report 5.00.05, L'Aia, Paesi Bassi.

Veenendaal, P.J.J.
1998 *EU Agricultural Policy Implementation Using ComplementarityConditions*, paper presented at the First Annual Conference on Global Trade Analysis, Purdue USA.

Von Lampe, M.
1999 *A modelling concept for the long-term projection and simulation of agricultural world market developments – World Agricultural Trade Simulation Model (WATSIM)*, Shaker Verlag, Aachen.

Von Witzke, H.; Kirschke, D.; Lotze, H.; Herok, C.A.
1998 *Going East: EU Enlargement to Central Europe and the Agenda 2000*, paper presented at the *Sixth Joint Conference on Food, Agriculture and the Environment*, Minneapolis, Minnesota.

Vousden, N.
1990 *The Economics of Trade Protection*, Cambridge University Press, Cambridge.

Weyerbrock, S.
1998a *Reform of the European Union's Common Agricultural Policy: How to reach GATT-compatibility?*, in European Economic Review, n. 42.

Weyerbrock, S.
1998b *EU Membership of eastern Euroepan Countries: A General Equilibrium Analysis of the Budgetary and Trade Implications under Alternative Agricultural Policy Scenarios*, paper presented

at the IATRC meeting "Multilateralism and Regionalism: Implications for Agricultural Trade Policy", St. Petersburg USA.

Yang, Y.; Duncan, R.; Lawson, T.
1998 *Trade liberalisation in the EU and APEC: what if the approaches were exchanged?*, in Drysdale, P.; Vines, D. (eds.) "A Shared Global Agenda? Europe, East Asia and APEC and the ASEM Process", Cambridge University Press, Cambridge.