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Walras - A Multi-Sector, Multi-Country Applied General Equilibrium Model for Quantifying the Economy-Wide Effects of Agricultural Policies: A Technical Manual

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No. 84: WALRAS - A MULTI-SECTOR, MULTI-COUNTRY APPLIED GENERAL EQUILIBRIUM MODEL FOR QUANTIFYING THE ECONOMY-WIDE EFFECTS OF AGRICULTURAL POLICIES: A TECHNICAL MANUAL

by

Jean-Marc Burniaux, François Delorme, Ian Lienert and John P. Martin

Growth Studies Division

August 1990

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

This paper presents a technical description of the OECD's multi-sector, multi-country applied general equilibrium model -- the WALRAS model. This model has been developed with the explicit objective of quantifying the economy-wide effects of agricultural policies in OECD countries. The common specification of the model for the major OECD agricultural trading countries/regions (Australia, Canada, EEC, Japan, New Zealand and the United States) is presented in detail. The construction of the benchmark data sets and the calibration of the model are also fully described.

* * *

Ce document de travail présente une description technique du modèle d'équilibre général développé au Département des Affaires Economiques et Statistiques dans le cadre du projet WALRAS. Le but explicite de ce projet est de quantifier les effets macro-économiques des politiques agricoles dans les pays de l'OCDE. Les principaux partenaires commerciaux de l'OCDE en matière agricole (Autralie, Canada, CEE, Japon, Nouvelle Zélande et les Etats Unis) sont représentés à l'aide d'une spécification commune qui est présentée en détail. La construction des données de base et le calibrage du modèle sont également décrits de façon exhaustive.

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I. INTRODUCTION

1. The OECD Economics and Statistics Department has developed an applied general equilibrium model for the major OECD agricultural trading countries/regions -- Australia, Canada, EC, Japan, United States and New Zealand -- with the explicit objective of quantifying the economy-wide effects of agricultural policies in OECD countries. The project is called the World Agricultural LibeRAlisation Study, hereafter referred to as the WALRAS model. The purpose of this paper is to provide a technical documentation of the model.

2. Part of the material in this document was presented in Burniaux et al. (1988) and in the special issue of OECD Economic Studies (No. 13) devoted to modelling the effects of agricultural policies. However, in the light of significant extensions to WALRAS, it was necessary to update the description given in Burniaux et al. (1988). Moreover, the presentation of the model in OECD Economic Studies No. 13 does not provide a complete technical description. This paper aims to fill in these gaps and, as such, represents the technical manual of the WALRAS model.

3. The structure of the paper is as follows. It begins with a non-technical overview of the main blocks in the country/region sub-models together with a description of how world trade flows are modelled in an internationally consistent way. Section III describes the detailed specification of the model. The common framework for the underlying data sets -- relating to 1980 or 1981 -- is outlined in Section IV. Calibration of the model on the benchmark year and its parameterisation are discussed in Section V. Section VI discusses the solution method of the WALRAS model.

II. OVERVIEW OF THE WALRAS MODEL

4. The present version of the model includes six country/region sub-models and a residual aggregate for the Rest of the World (ROW) linked together by a bilateral world trade sub-model. Each country/regional model can be subdivided into five blocks. These are briefly described below. Much more detail together with a full listing of all the equations, functional forms, variables and parameters, is provided in Section III.

A. Production

5. Table 1 lists the thirteen sectors of the production block. Given that the main objective is to quantify the economy-wide effects of agricultural policies rather than their effects on the agricultural sector itself, the sectoral disaggregation of the model was chosen deliberately to highlight the

Table 1

The structure of industries and demand in the WALRAS model

	The thirteen industries		The seventeen demand components (a)
1.	Livestock and livestock products	1.	Bread and cereals
2.	Other agricultural industries	2.	Meat
3.	Other primary industries (b)	3.	Milk, cheese and eggs
4.	Meat products	4.	Other food and non-alcoholic beverages
5.	Dairy products	5.	Alcoholic beverages
6.	Other food products	6.	Tobacco
7.	Beverages	7.	Clothing and footwear
8.	Chemicals	8.	Gross rents, fuel and power
9.	Petroleum & coal products	9.	Household equipment and operation
10.	Other manufacturing industries	10.	Medical care
11.	Construction	11.	Transport and communication
12.	Wholesale & retail trade	12.	Education and recreation
13.	Other private services	13.	Other consumer goods and services
		14.	Gross private fixed investment
		15.	Change in stocks
		16.	Government expenditure (c)
		17.	Exports of goods and services (d)

a) The first thirteen items are components of private consumption.
b) Forestry, fishing, mining and quarrying.
c) Includes government investment.
d) Includes re-exports.

main links between farm activities, food-processing industries and the rest of the economy. Agriculture in WALRAS groups two farm sectors -- livestock and other agriculture (mainly grains) -- which use land as a specific fixed factor; these two sectors are considered separately from the three major food-processing industries -- meat, dairy and other food products. The other eight sectors comprise other primary industries, various manufacturing and service industries.

6. For each sector, a production function describes the technology available to the industry. Given the levels of sectoral demand, producers minimise costs by using optimal quantities of primary factors and intermediate goods (domestic and imported) as a function of their relative after-tax prices. Once the optimal combination of inputs is determined, sectoral output prices are calculated assuming competitive supply conditions in all markets. Since each sector supplies inputs to other sectors, output prices -- which are the cost of inputs for other sectors -- and the choice of the optimal combination of inputs are determined simultaneously for all sectors.

7. Some simplifying assumptions are used in the specification of the sectoral production functions. All non-agricultural sectors are assumed to operate under constant returns to scale, which permits the determination of output prices independently of the level of activity (1). The primary factors of production are assumed to be in fixed supply to the total economy, to be fully employed and partially mobile between sectors. Labour and capital are allocated to each industry according to demand and supply, and are paid a price that equates demand with supply.

8. Land is assumed to be a mobile factor of production between the two agricultural sectors only; it is not modelled as a factor of production in the non-agricultural sectors. This treatment of land implies that the two agricultural sectors are characterised by decreasing returns to capital and labour (2).

9. Another element of simplification is the assumption of fixed intermediate inputs per unit of gross output in all sectors. There are, however, two important elements of flexibility in the choices available to producers:

- i) The optimal combination of capital and labour -- and land in the two agricultural sectors -- is variable and depends on the relative prices of these inputs, assuming substitutability between them;

- ii) For each intermediate input, producers are allowed to buy domestic or imported commodities, depending on relative prices and given the level of product differentiation.

10. Moreover, the model incorporates the assumption that labour and capital are less than perfectly mobile between the two farm sectors and the rest of the economy. At the same time, labour and capital are assumed to be perfectly mobile within the farm and non-farm sectors. This implies that the returns to labour and capital are not equal in all sectors. The reasons for introducing partial factor mobility are three-fold:

i) Historical evidence from OECD countries of persistent discrepancies between farm and non-farm returns to factors;

ii) Econometric evidence in favour of this hypothesis (3); and

iii) The presumption that ageing of the farm labour force would contribute to lower labour mobility over the term of this analysis.

B. Consumption

11. A single representative consumer is assumed to choose between thirteen consumer goods (see Table 1). These consumer goods are different from the outputs of the thirteen sectors of production, and correspond more closely to the standard groups of products which consumers demand. A matrix of fixed coefficients -- a so-called "transition matrix" -- is used to convert goods and services in the production-sector classification into consumer goods and services. Using this matrix, producer prices are translated directly into prices for consumer goods, and the demands for consumer goods can be transformed immediately into demands for producer goods.

12. It is well known that the demand for certain goods -- and in particular for food -- does not increase with income as rapidly as for other goods. For this reason, the model of consumer behaviour incorporates different income elasticities of demand for different goods and services.

13. Consumers are assumed to have the option of importing the commodities they want to buy. Their optimising decisions are thus separated in two stages: first, given their disposable income and the prices of consumer goods, they decide how much they want to save and how much they want to spend on each type of good or service; and second, they decide, for each of these, what proportions to buy domestically or to import, as a function of relative prices.

14. Consumers obtain their income from the returns to supplying primary factors of production and from government transfers. In countries where agricultural production quotas are operative, quota rents add to farm household income. After paying income taxes, consumers spend a proportion of their disposable income on the purchase of goods and services; the remainder is saved. Saving is assumed to take the form of purchases of investment goods; financial intermediation is not incorporated in the model.

C. The role of the government

15. The government collects taxes on incomes, intermediate inputs, outputs, and consumer expenditures, as well as on imports. It also subsidises exports of agriculture and food. All of these taxes and subsidies influence the decisions of economic agents, by changing relative prices and/or by reducing incomes. Tax revenues collected by the government are a function of the level of economic activity and are therefore calculated endogenously. In addition, household income taxes can be adjusted to compensate for the variations in government net budget positions due to changes in agricultural protection.

16. Government expenditure is not constrained to be constant at its benchmark level nor equal to revenues. Once the total level of spending is decided, the government allocates it to transfers, which are exogenous in the model, or to the purchase of goods, services, capital and labour. Non-transfer expenditures are a function of relative prices, obtained from an assumption of optimising behaviour by the government.

D. Foreign trade

17. The world trade block is based on a set of bilateral trade matrices which describe how price and quantity changes in national economies affect world markets, with imports originating in different countries/regions being treated as imperfect substitutes. The use of such a specification -- commonly referred to as the Armington specification (4) -- represents a major departure from the typical Hecksher-Ohlin framework. One drawback, however, with the use of the Armington specification in AGE models is that it often leads to strong terms-of-trade effects following changes in trade policies. In such a framework, welfare losses due to the imposition of tariffs may be compensated for by terms-of-trade gains (5).

18. Imports have already been mentioned above in the context of producer and consumer behaviour. Given composite import prices, calculated as the weighted average of export prices set by the other countries/regions plus tariffs, the decisions to import by producers and consumers are part of their optimising behaviour.

19. While most AGE models treat imports and domestic goods as imperfect substitutes, they often assume that exports and domestically-sold goods are perfect substitutes. This specification of export supply, however, overstates both the links between export and domestic prices and the responsiveness of exports to demand shifts on world markets. Following the approach developed by Dervis et al. (1982) and de Melo and Robinson (1985, 1988), the external closure of WALRAS involves a symmetric assumption of product differentiation for imports and for exports. In each industry, producers are assumed to choose the optimal output-mix between exports and domestic supplies in response to the market-clearing price ratio between domestic and export markets.

20. This specification of export supply -- the so-called "Constant-Elasticity-of-Transformation" (CET) approach -- is often justified on aggregation grounds, i.e. many of the broad sectors used in models such as WALRAS group together industries with widely differing export shares. The wider the product coverage of a given sector, the likelier it is that exported goods will be different from domestically-sold ones. Hence, it seems justified to assume a lower value of the transformation elasticity for large aggregates, which group together a wide variety of different industries, than for sectors with a more homogeneous coverage. In practice, finite transformation elasticities have only been introduced in the two farm sectors and in three large non-farm sectors in WALRAS -- other manufacturing industries, wholesale and retail trade and other private services (see Annex II).

21. Trade flows depend on both country supplies and foreign export demands, with the latter being determined by export prices from one country relative to its competitors' prices. Since goods are nationally differentiated, each

country is assumed to face a downward-sloping demand curve for both its agricultural and industrial exports. Due to the relatively more homogeneous nature of many agricultural products as compared with manufactures, they could be treated as perfect substitutes. However, at the levels of aggregation used in WALRAS, there are considerable inter-country differences between broad categories such as "livestock" or "meat products". The capacity to take account of imperfect substitutability, therefore, seems desirable.

22. As a result, export prices for any commodity may differ from world prices as well as from prices paid on the domestic market, and a country may both export and import goods in a given sector. In this way the model captures the phenomenon of intra-industry trade. This represents a significant departure from the "small-country assumption" of traditional trade theory in which countries can export any amount of a given commodity at a given price and nothing at a higher price.

23. Countries can, in principle, run current-account surpluses or deficits in the model. The counterpart of these imbalances is a net outflow or inflow, respectively, of capital, which is subtracted from or added to the domestic flow of saving (6). To satisfy the world current-account constraint, the counterpart of this net flow in turn has to be reallocated between the other countries/regions. This is done exogenously in WALRAS and no account is taken of net income flows associated with changes in stocks of foreign assets or liabilities.

E. Investment and saving: closing the model

24. To complete the model, an investment equation is specified. Since there are no financial assets in the model, net saving is allocated entirely to investment goods, and thus the specification of investment is greatly simplified. Savings come from three main sources:

i) Private saving, as determined by consumer behaviour;

ii) Public saving, which corresponds to the net budget position; and

iii) Foreign saving, arising from a current-account deficit.

25. It is important to note that all income generated by economic activity is assumed to be distributed to consumers. Therefore, corporate saving is treated as part of household saving and is dealt with in the consumer block. Overall consistency requires making total domestic investment identical to net national saving plus net capital inflows. One possible closure rule would be to allow government and foreign saving to be determined endogenously. A government budget deficit, or a capital outflow as a counterpart of a current-account surplus, represent applications of saving, which reduce the amount available for domestic investment.

26. The closure rule in the WALRAS model can be varied for different simulations. In the standard WALRAS closure, it is assumed that the initial government deficit and base-year foreign trade imbalance do not change. Given a change in agricultural policy, the government's deficit could be expected to change. In the model, the marginal income tax rate is adjusted to restore the

initial government deficit/surplus position. This approximates revenue-neutrality which is considered the appropriate closure to apply to the government sector for long-term simulations. Similarly, it would be unreasonable in the long-run to have a changing foreign balance. In the model, adjustment via real factor prices is the mechanism which restores the initial balance-of-payments position. It is referred to as a "real exchange rate" variation, defined as the weighted average of domestic factor price changes relative to the average world price (7). In the case of exogenous government and foreign trade imbalances, investment is almost entirely savings driven. If these constraints were to be relaxed, changes in the fiscal and external imbalances would be expected to have major effects on the aggregate savings-investment picture.

III. TECHNICAL SPECIFICATION OF THE WALRAS MODEL

A. Price specification

27. Producer supply and consumer demand functions are assumed to be non-negative, continuous and homogeneous of degree zero in all prices, i e doubling all prices (and income) does not change the quantities supplied and demanded. The numeraire price is the price of primary factors in the non-agricultural sector in ROW. As a corollary, this means that only relative prices are relevant in the model. In this way, the benchmark data set may be constructed in value terms and there is no need to specify underlying data in quantity terms.

28. The assumption that all factor prices are normalised on one in every sector is clearly in contradiction with the reality of a dispersion of wage and rental rates for labour and capital services across sectors. However, quantities are adjusted accordingly such that the ratio of factor prices across sectors translates into a ratio of quantities used which differs from the observed physical units. This implies that factors are measured in efficiency units. Since all prices are equal to one, any differences observed in reality correspond to different efficiencies. As a result, changes in factor quantities must be interpreted as changes in efficiency units.

29. In agriculture, there are large distortions in the price mechanism because of tariffs, quantitative restrictions, taxes and subsidies. The relevant prices for obtaining a base-year equilibrium are the market prices at which transactions take place. In the model, it is therefore necessary to distinguish between before- and after-tax prices.

30. The key prices in each country/regional sub-model are the following:

w_a and w_{na} : wage rates in the farm and non-farm sectors, respectively.

r_a and r_{na} : rental rates of capital in the farm and non-farm sectors, respectively.

rm : rental rate of land.

P_i^{wm} : world import price of commodity i, calculated as a weighted average of export prices from the other countries (net of import tariffs).

31 Producer behaviour is represented by "multi-input, multi-output" production functions. Factor and import prices, inclusive of taxes and subsidies, are integral components of equilibrium producer prices (P_i):

$$P_i = f(P) \qquad [1]$$

where P is a shorthand notation for the set of input prices for the thirteen industries in the model. The determination of producer prices is discussed below.

32. The optimum supply mix between domestic and exported goods implies that composite producer prices (P_i) must also satisfy the following dual price function:

$$P_i = f'(P_i^d, P_i^e) \qquad [2]$$

where P_i^d and P_i^e denote producer prices for domestic and export sales, respectively. The specification used for differentiating domestic and world export prices is outlined below.

33. In order to include taxes or subsidies (t_{ji}) and tariffs (τ_j) on intermediate inputs in an ad valorem form, the price definitions are expanded as follows:

$$PT_{ji}^d = P_j^d(1 + t_{ji}^d) \qquad [3]$$

$$PT_{ji}^I = P_i^{wm}(1 + t_{ji}^I)(1 + \tau_j) \qquad [4]$$

34. The conversion of producer prices into consumer prices is straightforward. Each column of the domestic transition matrix (Ξ^d) defines, for each domestic consumer good, the weight that corresponds to each producer good. Thus, the price of each domestic consumer good (including consumption taxes) will be a weighted average of the prices of producer goods, the weights being the column shares from the domestic transition matrix:

$$P_{cg}^d = \sum_i \xi_{gi}^d P_i^d(1 + t_{ci}^d), \quad \text{and} \quad \Xi^d = (\xi_{gi}^d) \qquad [5]$$

where $\sum_i \xi_{gi}^d = 1.$ [6]

Prices for imported consumer goods (gross of tariff rates) can be defined in a similar way:

$$P_{cg}^I = \sum_i \xi_{gi}^I P_i^{wm}(1 + t_{ci}^I)(1 + \tau_i) \quad \text{and} \quad \Xi^I = (\xi_{gi}^I) \qquad [7]$$

where $\sum_{i}^{I} \xi_{gi} = 1.$ [8]

The determination of composite consumer prices is discussed below. World export prices are defined as the producer export price inclusive of any export subsidies·

$$P_i^{we} = P_i^{e}(1 + t_{Ei}) \qquad [9]$$

B. Production structure: intermediate demand and value-added

35. The overall production structure of the model is depicted in Figure 1. A variety of specifications could have been chosen. In the WALRAS model, as with all AGE models, there is a trade-off between tractability and complexity. As a simplification, weak separability is assumed to characterise the relationship between intermediate demand and value added.

36 For intermediate inputs, a Leontief (fixed-coefficients) specification has been adopted. Using the assumption that production prices are normalised on one as described above, total intermediate output of each industry can be obtained from the benchmark data set in value terms. Let each element of the transaction matrix X_{ji} from the input-output tables represent the quantity sold by sector j and purchased by the ith sector, before payment of taxes or receipt of subsidies. The column sums of the transactions table are equal to the quantity of total intermediate inputs of a given sector. The technical coefficients can then be determined immediately:

$a_{ji} = X_{ji}/Q_i$, where Q_i is total gross output of sector i. [10]

$va_i = VA_i/Q_i$, where VA_i is the value added at factor cost in sector i.

It should be noted that the sum of all technical coefficients for the ith sector is not equal to one:

$$\sum_{j=1}^{n} a_{ji} + va_i \neq 1 \qquad [11]$$

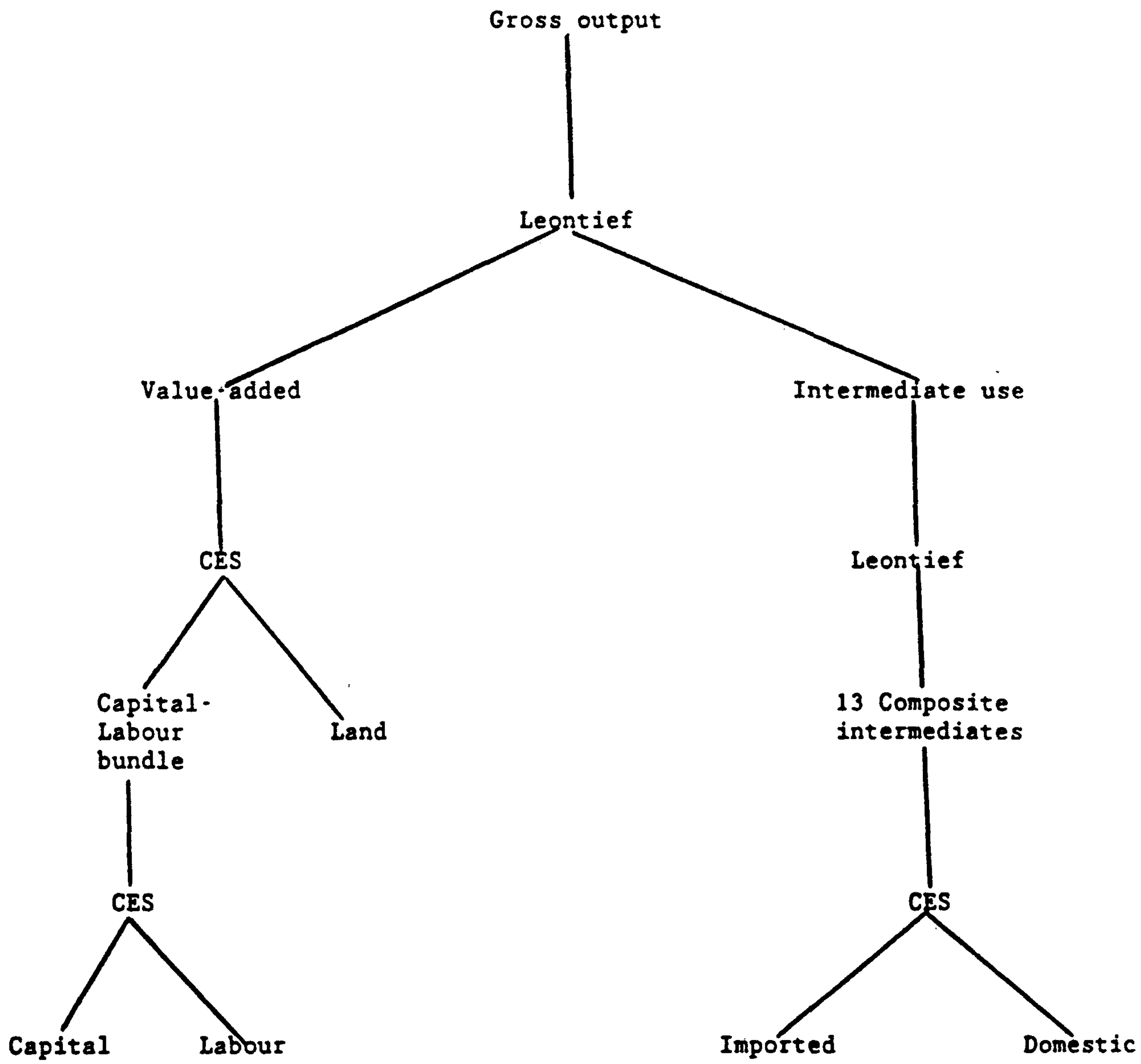
This occurs because total output Q_i is measured by the value of production at market prices (inclusive of taxes and subsidies). Since intermediate and primary factor use, net of taxes and subsidies, are less or more than the market value of the output, the sum of the input-output coefficients is not equal to one.

37. Each of the thirteen industries produces an output Q_i using primary factors of production, according to a neo-classical production function exhibiting constant returns to scale. Each industry also uses intermediate inputs (X_{ji}), which are assumed to be in fixed proportions to gross output. The sum of primary factors across industries constitutes the economy's given factor endowments.

38. Value-added is modelled via a nested CES function; in the outer nest, capital and labour are aggregated to form a capital-labour bundle which is combined with land in the inner nest. There is assumed to be no scope for

Figure 1

THE PRODUCTION STRUCTURE OF THE WALRAS MODEL



substitution possibilities between intermediate inputs since these are specified by a fixed-coefficient system. However, substitution is possible between domestic and foreign intermediate inputs.

39. Thus, technology is characterised by a Leontief system combined with a nested CES production function that generates value-added. The production function for industry i can be written as:

$$Q_i = \min(VA_i/va_i,\ X_{ji}/a_{ji}) = \min[F(G(K_i,\ L_i),\ M_i),\ \sum_j X_{ji}] \quad [12]$$

$$VA_i = \left[\alpha_{Hi}H_i^{(\rho-1)/\rho} + \alpha_{Mi}M_i^{(\rho-1/\rho)} \right]^{\rho/(\rho-1)} \quad [13]$$

$$H_i = \left[\alpha_{Ki}K_i^{(\sigma-1)/\sigma} + \alpha_{Li}L_i^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)} \quad [14]$$

where the α_i are the distribution parameters; and ρ and σ are sector-specific elasticities of substitution.

40 Producers in the model are assumed to minimise their after-tax costs of production; taxes, subsidies and tariffs distort factor input decisions. All kinds of direct and indirect payments to farmers which contribute to support their incomes are modelled as technology-neutral input subsidies. They affect evenly all domestic and imported input and factor prices and are hereafter represented by a price symbol marked by an asterisk. The producer's optimisation problem is formulated in two steps. First, the producer minimises the unit cost of purchasing the capital-labour bundle and land. Formulating the Lagrangian yields:

$$V^* = h_i^*H_i + rm_i^*M_i + e\{[\alpha_{Hi}H_i^{(\rho-1)/\rho} + \alpha_{Mi}M_i^{(\rho-1)/\rho}]^{\rho/(\rho-1)} - 1\} \quad [15]$$

with h_i^* and rm_i^* being the composite capital-labour price (h_i) and the land price rm_i <u>inclusive</u> of the sector-specific input subsidy s_{Qi}:

$$h_i^* = h_i(1-s_{Qi}) \qquad rm_i^* = rm_i(1-s_{Qi}).$$

Deriving the first-order cost-minimisation conditions yields:

$$h_i^*/rm_i^* = \alpha_{Hi}H_i^{(-1/\rho)}/\alpha_{Mi}M_i^{(-1/\rho)} \quad [16]$$

Substituting equation [16] in the unit value-added function gives the optimal technical coefficients for H_i and M_i:

$$a_{Hi} = \alpha_{Hi}^{\rho}\ h_i^{*-\rho}\ [\alpha_{Hi}^{\rho}\ h_i^{*1-\rho} + \alpha_{Mi}^{\rho}\ rm_i^{*1-\rho}]^{\rho/(1-\rho)} \cdot va_i \quad [17]$$

$$a_{Mi} = \alpha_{Mi}^{\rho}\ rm_i^{*-\rho}\ [\alpha_{Hi}^{\rho}\ h_i^{*1-\rho} + \alpha_{Mi}^{\rho}\ rm_i^{*1-\rho}]^{\rho/(1-\rho)} \cdot va_i \quad [18]$$

In the second stage, the producer is assumed to minimise capital and labour costs subject to the value-added sub-function [14]. This yields the optimal capital and labour technical coefficients:

$$a_{Ki} = \alpha_{Ki}^{\sigma}\, r_i^{*-\sigma}\, [\alpha_{Ki}^{\sigma}\, r_i^{*1-\sigma} + \alpha_{Li}^{\sigma}\, w_i^{*1-\sigma}]^{\sigma/(1-\sigma)} \cdot a_{Hi} \qquad [19]$$

$$a_{Li} = \alpha_{Li}^{\sigma}\, w_i^{*-\sigma}\, [\alpha_{Ki}^{\sigma}\, r_i^{*1-\sigma} + \alpha_{Li}^{\sigma}\, w_i^{*1-\sigma}]^{\sigma/(1-\sigma)} \cdot a_{Hi} \qquad [20]$$

All prices are inclusive of the <u>ad valorem</u> input subsidy:

$$\begin{cases} r_i^{*} = r_a\,(1-s_{Qi}) & i = 1,2 \\ \text{or} \quad r_i^{*} = r_{na}\,(1-s_{Qi}) & i = 3,13 \end{cases}$$

$$\begin{cases} w_i^{*} = w_a\,(1-s_{Qi}) & i = 1,2 \\ \text{or} \quad w_i^{*} = w_{na}\,(1-s_{Qi}) & i = 3,13 \end{cases}$$

Given the Leontief specification, intermediate input requirements (a_{ji}) are independent of relative prices. By contrast, the optimal combination of primary factors depends on prices (including taxes and subsidies) since producers minimise their <u>after-tax/subsidy</u> production costs for primary inputs.

41. The final step consists in specifying the substitution possibilities between traded intermediate inputs. Within the fixed requirement, the producer is allowed to choose the optimal composite between domestic and imported intermediate inputs using a CES aggregation function. The complete formulation of intermediate input requirements is then written as:

$$a_{ji} = [\gamma_{ji}^{d}(a_{ji}^{d})^{(\eta-1)/\eta} + \gamma_{ji}^{I}(a_{ji}^{I})^{(\eta-1)/\eta}]^{\eta/(\eta-1)} \qquad [21]$$

$$X_{ji} = a_{ji} Q_i \qquad [22]$$

Cost-minimisation yields the optimal input-output coefficients for domestic and intermediate inputs:

$$a_{ji}^{d} = (\gamma_{ji}^{d})^{\eta}(PT_{ji}^{*d})^{-\eta}[(\gamma_{ji}^{d})^{\eta}(PT_{ji}^{*d})^{1-\eta} + (\gamma_{ji}^{I})^{\eta}(PT_{ji}^{*I})^{1-\eta}]^{\eta/(1-\eta)} \cdot a_{ji} \qquad [23]$$

$$a_{ji}^{I} = (\gamma_{ji}^{I})^{\eta}(PT_{ji}^{*I})^{-\eta}[(\gamma_{ji}^{d})^{\eta}(PT_{ji}^{*d})^{1-\eta} + (\gamma_{ji}^{I})^{\eta}(PT_{ji}^{*I})^{1-\eta}]^{\eta/(1-\eta)} \cdot a_{ji} \qquad [24]$$

and PT_{ji}^{*d}, PT_{ji}^{*I} are input prices defined in [3] and [4] including the sector-specific input subsidies:

$$PT_{ji}^{*d} = PT_{ji}^{d}(1-s_{Qi})$$

$$PT^{*I}_{ji} = PT^{I}_{ji}(1-s_{Qi})$$

42. Once all technical coefficients are known, equilibrium producer prices can be derived from input prices and input demands:

$$P_i = h^*_i a_{hi} + rm^*_i a_{mi} + \sum_j a^d_{ji} PT^{*d}_{ji} + \sum_j a^I_{ji} PT^{*I}_{ji} \qquad [25]$$

where

$$h_i = \left(\alpha^{\sigma}_{Ki} r^{*(1-\sigma)}_i + \alpha^{\sigma}_{Li} w^{*(1-\sigma)}_i\right)^{1/(1-\sigma)} \qquad [26]$$

is the dual of [14] and r^*_i and w^*_i are defined as in [20].

43. Starting with consumer demands for domestic and imported goods obtained from the consumption block described below, these are converted into demands for producer goods using transition matrices. From the definition of the elements of this matrix,

$$PC^d_i = \Xi^d \cdot C^d_g \quad \text{and} \quad PC^I_i = \Xi^I \cdot C^I_g \qquad [27]$$

where PC^d_i and PC^I_i are private domestic and imported consumption matching the thirteen producer-good classification, and C^d_g and C^I_g are vectors of domestic and imported demand for the thirteen consumer goods, respectively. Once the remaining domestic components of final demand (investment, change in stocks, government expenditure and exports) are added to the domestic component of PC_i, the final demand vector (FD_i) can be obtained. Using the inverse of the domestic Leontief matrix, gross output requirements are defined as:

$$Q = [I - A^d]^{-1} (PC^d + INV^d + DSTOC^d + GOV^d + E^d) \qquad [28]$$

and finally, factor demands are obtained from:

$$\begin{bmatrix} K \\ L \\ M \\ IMP^I \end{bmatrix} = [\ D\ ]\ Q \qquad [29]$$

where D is defined as a partitioned matrix incorporating the following variable coefficients:

$$D = \begin{bmatrix} a_{Ki} \\ a_{Li} \\ a_{Mi} \\ a^I_{ji} \end{bmatrix} \qquad [30]$$

Total import demand (IMP_i) for each commodity is finally obtained by adding up intermediate uses (IMP_i^I) and final uses:

$$IMP_i = IMP_i^I + PC_i^I + INV_i^I + DSTOC_i^I + GOV_i^I + E_i^I \qquad [31]$$

44. Turning now to output decisions, producers maximise the value of their supply mix through an optimal allocation of their total supply (Q_i) between domestically sold (D_i^s) and exported products (E_i^s):

$$\text{Max} \quad P_i^d.D_i^s + P_i^e.E_i^s$$

subject to the transformation function:

$$Q_i = \left[\alpha_{Di}\, D_i^{s(\Lambda-1/\Lambda)} + \alpha_{Ei}\, E_i^{s(\Lambda-1/\Lambda)}\right]^{\Lambda/(\Lambda-1)} \qquad [32]$$

where Λ are sector-specific transformation elasticities; α_D and α_E are distribution parameters.

First-order conditions yield the optimal allocation:

$$\frac{E_i^s}{D_i^s} = \left(\frac{\alpha_{Ei}}{\alpha_{Di}}\,\frac{P_i^e}{P_i^d}\right)^{\Lambda} \qquad [33]$$

45. The price of the composite "domestic-exported" good is, of course, equal to its marginal cost, as defined in [25]. Therefore the price wedge between domestic and export markets is such that it satisfies the following dual price function:

$$P_i = \left[\alpha_{Di}^{\Lambda}\, P_i^{d(1-\Lambda)} + \alpha_{Ei}^{\Lambda}\, P_i^{e(1-\Lambda)}\right]^{1/(1-\Lambda)} \qquad [34]$$

Given the market-clearing export price P_i^e and the marginal cost P_i, equation [34] is used to derive the price paid for domestically sold goods (P_i^d).

C. Consumption

46. Consumer demand in each country model is characterised by a single representative consumer. The selection of the appropriate functional form for the utility function is problematic. A Cobb-Douglas specification imposes constant expenditure shares, unit income elasticities, uncompensated own-price elasticities equal to one and zero cross-price elasticities. The CES specification relaxes some of these constraints by assuming a constant but non-unit own-price elasticity. At the same time, however, it maintains the

unit income elasticity restriction and also imposes a constant elasticity of substitution for all goods. The Linear Expenditure System (LES) relaxes the unit income elasticity assumption (8).

47. The specification of consumption adopted in the WALRAS model is illustrated in Figure 2. It is a relatively flexible specification in which the non-unit income elasticity property of the LES approach is combined with a nested CES structure. Incorporating savings leads to the Extended Linear Expenditure System (ELES) being defined over the thirteen consumption goods and savings.

48. The utility function is defined as:

$$U = \sum_{g+1} \theta_{g+1} \ln(C_{g+1} - F_{g+1}) \qquad [35]$$

where g is the number of consumption goods, θ_g is the marginal budget share of commodity g, C_g is the quantity consumed of good g and F_g is the minimum or so-called "subsistence" level of consumption. In equation [34] it is assumed that the good g+1 represents savings, adding the additional restriction (9):

$$F_{g+1} = 0 \qquad [36]$$

49. Commodity demand functions are derived by constrained maximisation of the utility function subject to the budget constraint, defined as the sum of rental income from capital and land, wage income from labour and transfer income from the government minus depreciation, after deduction of personal income taxes:

$$Y = (r_a K_a + r_{na} K_{na} + rmM + w_a L_a + w_{na} L_{na} - DEPR + T_G) \qquad [37]$$

$$YD = (1 - t_y)Y - \mu \qquad [38]$$

with K_a, K_{na}, L_a and L_{na} being the endogenous endowments of labour and capital available for farm and non-farm uses, respectively. μ is the intercept of the linear personal income tax equation. All disposable income is assumed to be spent on consumer goods or saved:

$$YD = \sum_g P_{cg} C_g + SV \qquad [39]$$

50. Personal consumption expenditures are allocated among domestic and imported goods. Foreign and domestic consumer goods are assumed to be imperfect substitutes following Armington (1969), thereby accommodating the phenomenon that a country both imports and exports the same commodity. The Armington commodities can then be aggregated through a CES function as follows:

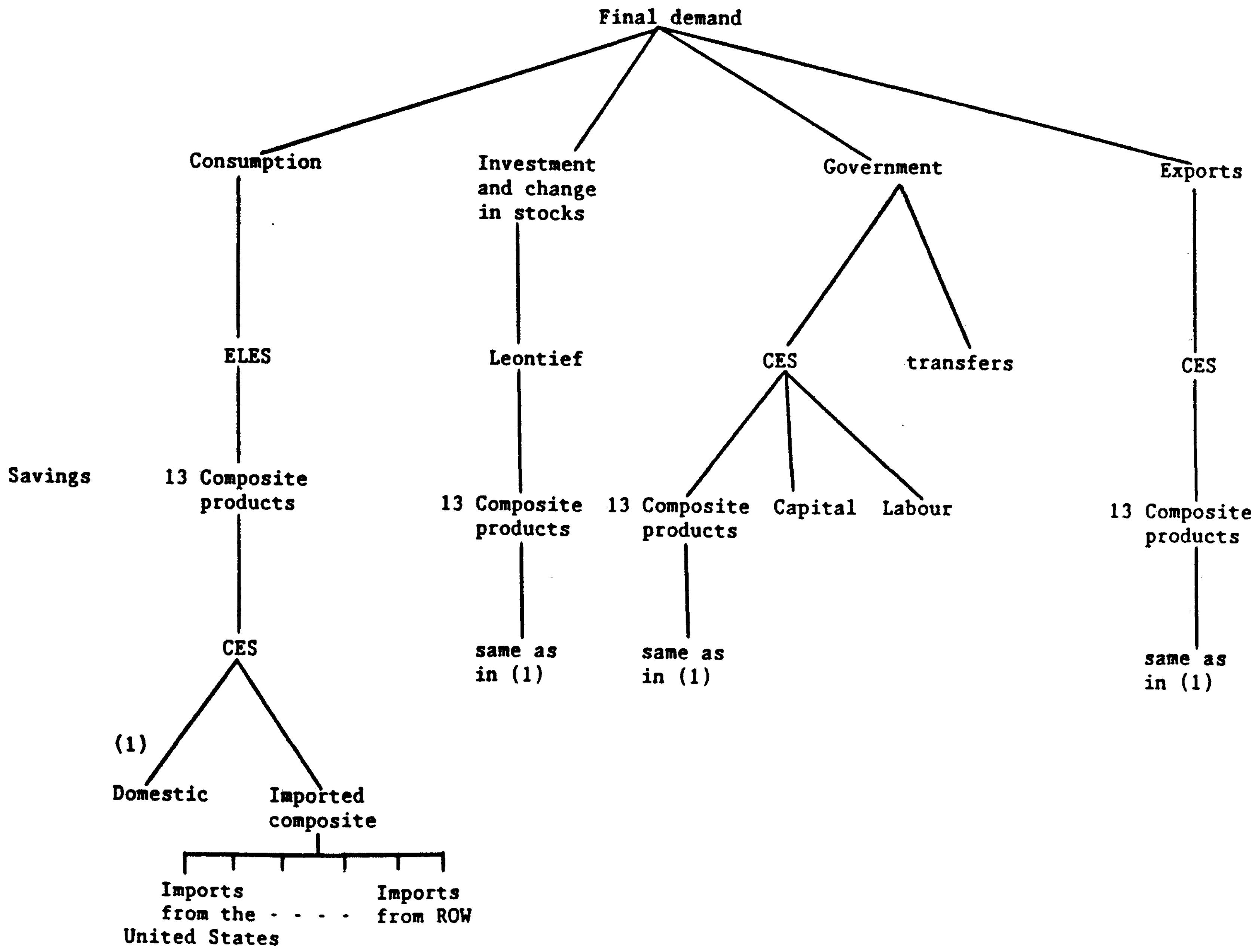
$$C_g = [\omega_g^d C_g^{d\,(\beta-1)/\beta} + \omega_g^I C_g^{I\,(\beta-1)/\beta}]^{\beta/(\beta-1)} \qquad [40]$$

Prices of the composite consumer goods are calculated as the dual of equation [40]:

$$P_{cg} = [(\omega_g^d)^{\beta} (P_{cg}^d)^{(1-\beta)} + (\omega_g^I)^{\beta} (P_{cg}^I)^{(1-\beta)}]^{1/(1-\beta)} \qquad [41]$$

Figure 2

THE FINAL DEMAND STRUCTURE OF THE WALRAS MODEL



51. Consumers determine their optimal demands in two steps. First, they choose a composite consumption bundle by solving their utility function subject to their budget constraint. The resulting optimal demand functions are given by:

$$C_g = F_g + [\theta_g (YD - \sum_h P_{ch} F_h)]/P_{cg} \qquad [42]$$

$$SV = \theta_{g+1}(YD - \sum_h P_{ch}F_h) \qquad [43]$$

where θ_{g+1} represents the marginal propensity to save out of current disposable income. The definitions of the income and own-price (uncompensated) elasticities of demand for domestic consumption goods are given by:

$$\iota_g^d = (\theta_g/P_{cg})\{YD/[F_g + (\theta_g/P_{cg})(YD - P_{ch}F_h)]\} \qquad [44]$$

$$\lambda_g = (F_g/C_g)(1 - \theta_g) - 1 \qquad [45]$$

52 In the second stage, consumers select the optimal mix of domestic-foreign bundles for each composite commodity that minimises the purchasing cost of C_g. Maximising [40] subject to the constraint of a fixed amount of expenditure on the gth domestic-imported composite, $P_{cg}C_g$ (= $P^d_{cg}C^d_g + P^I_{cg}C^I_g$), yields the following optimal conditions:

$$C^I_g/C^d_g = [(\omega^I_g/\omega^d_g)(P^d_{cg}/P^I_{cg})]^{\beta} \qquad [46]$$

53 To solve explicitly for the demand equations for C^d_g and C^I_g, we substitute equation [46] into [40]. This yields:

$$C^d_g = (\omega^d_g)^{\beta} C_g/(P^d_{cg})^{\beta} [(\omega^d_g)^{\beta}(P^d_{cg})^{(1-\beta)} + (\omega^I_g)^{\beta}(P^I_{cg})^{(1-\beta)}] \qquad [47]$$

$$C^I_g = (\omega^I_g)^{\beta} C_g/(P^I_{cg})^{\beta} [(\omega^d_g)^{\beta}(P^d_{cg})^{(1-\beta)} + (\omega^I_g)^{\beta}(P^I_{cg})^{(1-\beta)}] \qquad [48]$$

D. <u>Investment and change in stocks</u>

54. Total private investment is derived residually from savings and the fiscal and external imbalances (See equation [64] below). The distribution of investment by sector is modelled using a fixed-coefficient specification:

$$\Gamma^d_i = INV^d_i/(\sum_i INV^d_i + \sum_i INV^I_i); \qquad \Gamma^I_i = (INV^I_i/\sum_i INV^d_i + \sum_i INV^I_i) \qquad [49]$$

55. A similar specification is used for the sectoral distribution of the change in total stocks (which are assumed to be exogenous):

$$\Omega_i = DSTOC_i/\sum_i DSTOC_i \qquad [50]$$

In equations [49] and [50], the Leontief specification applies to both domestically-produced and imported investment and stockbuilding.

56. The formulation of investment is purely static: there is no link between increased savings today and additional investment in a subsequent time period. These intertemporal features can be very important; in a dynamic model, a policy which has a negative impact on welfare in the current period may yield substantial welfare gains in the long run.

E. <u>Government</u>

57. The government is assumed to use tax and tariff revenues for transfer payments (which are not assumed to be taxed), subsidy expenditures and purchases of primary factors (excluding land). Government expenditures (including public investment) are assumed to be exogenous, but expenditures excluding transfers are derived from a CES government utility function defined over a composite of all non-wage producer goods, capital and labour. The government sector is therefore modelled as if it consisted of an aggregate public sector "consumer".

58. The government utility function is specified as follows:

$$U_G = [\phi_G G^{(\psi-1)/\psi} + \phi_K K_G^{(\psi-1)/\psi} + \phi_L L_G^{(\psi-1)/\psi}]^{\psi/(\psi-1)} \quad [51]$$

Maximisation of this utility function subject to the government budget constraint for non-transfer expenditures

$$Z_G = P_G G + w_{na} L_G + r_{na} K_G \quad [52]$$

yields the following optimal government demands for goods, capital and labour:

$$G = (\phi_G)^{\Psi} Z_G / P_G^{\Psi} \left[\phi_G^{\Psi} P_G^{(1-\Psi)} + \phi_k^{\Psi} r^{(1-\Psi)} + \phi_L^{\Psi} w^{(1-\Psi)} \right] \quad [53]$$

$$K_G = (\phi_K)^{\Psi} Z_G / r_{na}^{\Psi} \left[\phi_G^{\Psi} P_G^{(1-\Psi)} + \phi_K^{\Psi} r^{(1-\Psi)} + \phi_L^{\Psi} w^{(1-\Psi)} \right] \quad [54]$$

$$L_G = (\phi_L)^{\Psi} Z_G / w_{na}^{\Psi} \left[\phi_G^{\Psi} P_G^{(1-\Psi)} + \phi_K^{\Psi} r^{(1-\Psi)} + \phi_L^{\Psi} w^{(1-\Psi)} \right] \quad [55]$$

The allocation of the government demand for production goods (G) follows a fixed-coefficient specification:

$$GOV_i^d = \theta_i^d \cdot G$$

$$GOV_i^I = \theta_i^I \cdot G \quad [56]$$

$$P_G = \sum_i (\theta_i^d P_i^d + \sum_i \theta_i^I P_i^w (1+\tau_i)) + (1+t_{Gi})$$

59. Total government revenue can be expressed as the sum of tariff (τ) and tax (t) revenues net of subsidies, which are expressed as negative tax rates:

$$R_G = \sum_{ij}\sum a^{d}_{ji}\, Q_i\, P^{d}_j\, t^{d}_{ji} + \sum_{ij}\sum a^{I}_{ji}\, Q_i\, P^{wm}_i\, (t^{I}_{ji} + \tau_i + t^{I}_{ji}\tau_i)$$

$$+ \sum_{gi}\sum C^{d}_g\, \xi^{d}_{gi}\, P^{d}_i\, t^{d}_{ci} + \sum_{gi}\sum C^{I}_g\, \xi^{I}_{gi}\, P^{wm}_i\, (t^{I}_{ci} + \tau_i + t^{I}_{ci}\tau_i)$$

$$+ \{\sum_i INV^{d}_i\, P^{d}_i + [\sum_i INV^{I}_i\, P^{wm}_i\, (1 + \tau_i)]\}\, t_{Ii} + \sum_i INV^{I}_i\, P^{wm}_i\, \tau_i$$

$$+ \{\sum_i GOV^{d}_i\, P^{d}_i + [\sum_i GOV^{I}_i\, P^{wm}_i\, (1 + \tau_i)]\}\, t_{Gi} + \sum_i GOV^{I}_i\, P^{wm}_i\, \tau_i$$

$$+ \{\sum_i DSTOC^{d}_i\, P^{d}_i + [\sum_i DSTOC^{I}_i\, P^{wm}_i\, (1 + \tau_i)]\}\, t_{si} + \sum_i DSTOC^{I}_i\, P^{wm}_i\, \tau_i$$

$$+ \sum_i E_i\, P^{e}_i\, t_{Ei} - \sum_i s_{Qi}\, P_i\, Q_i + (\mu + t_y\, Y) \qquad [57]$$

F. Foreign trade

60. Each country has an import demand for all traded goods. Imports are differentiated by country of origin; total import demand by a given country for a given commodity is modelled as a CES composite of imports from all other countries. With the assumption that each country minimises import costs in order to achieve a specific volume of the import aggregate, it solves the following problem:

$$\min \sum_c P^{we}_{ci} \cdot WTR_{icr} \qquad [58]$$

$$\text{subject to } IMP_{ir} = \left[\sum_c sh_{icr} \cdot WTR_{icr}^{\epsilon-1/\epsilon} \right]^{\epsilon/\epsilon-1}$$

where WTR_{icr} is the volume of imports of commodity i by country r which come from country c; P^{we}_{ci}, the world export price by country c as defined in (9); sh_{icr}, the distribution parameters of the world CES import demand functions; ϵ_{ir}, the world trade substitution elasticity; and IMP_{ir}, the demand in country r for imports of the composite good i, as defined by the demand system described in [31]. This gives rise to the following export demands:

$$WTR_{icr} = sh^{\epsilon}_{icr} \left[P^{we}_{ic}/P^{wm}_{ir}\right]^{-\epsilon} \cdot IMP_{ir} \qquad [59]$$

61. P^{wm}_{ir} is the weighted price of the composite import good i in the country of destination r; it is endogenously determined as a weighted average of world export prices by the other countries and enters into the definition of the domestic import price P^{I}_{ir} (see equation [4]). Essentially, equation [59] specifies that country c's share of the import aggregate in country r will increase as country c's world export price P^{we}_{ic} falls relative

to the world composite price. The latter is the dual of the constraint in equation [58]:

$$P_{ir}^{wm} = \left[\sum_c sh_{icr}^{\epsilon} P_{ic}^{we(1-\epsilon)}\right]^{1/1-\epsilon} \qquad [60]$$

62. Finally, the total export demand E_{ic}^{d} for country c is calculated by summing up individual export demands from each of the other countries:

$$E_{ic}^{d} = \sum_r WTR_{icr} \qquad [61]$$

63. The specification for the Rest of the World (ROW) aggregate is restricted to a set of simple import demand functions which express imports as a function of the ratio between the world import prices and the ROW factor prices. Imports from ROW are derived from the world sub-model. Two aggregate factors are identified for the agricultural and non-agricultural sectors, respectively, in ROW. The domestic demand for agricultural commodities in ROW is exogenous and output in agriculture varies only with changes in the net trade positions. Supply of the agricultural factor in ROW is allowed to adjust to the differential in its return between the agricultural and non-agricultural sectors.

G. Factor mobility

64. The migration functions which determine factor flows between the farm and non-farm sectors are based on "migration elasticities" from the IIASA model (IIASA, 1988). Assuming that they provide an estimate of the long-run sensitivity of farm factors to their relative prices, they have been introduced as such in WALRAS by using a reduced-form equation instead of the usual full specification which requires distinguishing between separate income and price effects and the weight of the farm and non-farm sectors in total GDP. The migration assumptions are therefore defined by the following pair of equations:

$$L_a = \bar{L}_a^0 \, (w_a/w_{na})^{\pi L} \text{ and } L_{na} = \bar{L} - L_a \qquad [62]$$

$$K_a = \bar{K}_a^0 \, (r_a/r_{na})^{\pi K} \text{ and } K_{na} = \bar{K} - K_a \qquad [63]$$

with πL and πK being positive migration elasticities for labour and capital, respectively; $\bar{L}$, $\bar{K}$, fixed endownments for total labour and capital; and $\bar{L}_A^0$ and $\bar{K}_A^0$, the initial labour and capital endowments in the farm sector.

H. Closure rule

65. The reconciliation of all sectoral financial balances in any AGE model is known as the "closure rule"; and the way this is specified has a critical bearing on simulation results. In the WALRAS model, various closure rules may be selected. The standard closure relationship is defined as follows:

$$INV^T = SV + \varsigma r\bar{K} + (R_G + (t_y \cdot Y + \mu) - Z_G - T_G) - DSTOC^T - (E^T - IMP^T) \qquad [64]$$

where E^T and IMP^T are total exports and total imports, respectively. Equation [64] states that total private investment is determined residually as the sum of savings, depreciation, change in stocks and the net position of the government and foreign sectors.

I. Equilibrium conditions

66. Once fully specified, the model is solved by using a numerical solution method described in Section VI. The solution algorithm reaches an equilibrium by iterative evaluation of the excess demand system, assuming demands equal supplies -- equations [66] to [68] -- for all factors and each industry meets a zero-profit condition representing the absence of supernormal profits in equation [69]. Once these conditions are satisfied, equations [70] and [71] guarantee the closure of the entire system. Thus, the set of equilibrium prices satisfies the following balances at country/regional and world levels:

a) country/region balances:

$$Q_i = \sum_j X_{ij} + FD_i^d \quad [65]$$

$$r_a \text{ such that } K_a = \sum_i K_i, \; i = 1, 2 \quad [66]$$

$$r_{na} \text{ such that } K_{na} = \sum_i K_i + K_G, \; i = 3, 13$$

$$w_a \text{ such that } L_a = \sum_i L_i, \; i = 1, 2 \quad [67]$$

$$w_{na} \text{ such that } L_a = \sum_i L_i + L_G, \; i = 3, 13$$

$$rm \text{ such that } \bar{M} = \sum_i M_i \quad [68]$$

$$P_i Q_i (1 - s_{Qi}) = \sum_j PT_{ji}^{*d} a_{ji}^{d} Q_i + \sum_j PT_{ji}^{*I} a_{ji}^{I} Q_i + r_i^* K_i + w_i^* L_i + rm_i^* M_i \quad [69]$$

Symbols marked with an asterisk refer to prices inclusive of input subsidies.

b) world trade balances:

-- export demands must equate export supplies:

$$E_{ci}^D = \sum_r WTR_{icr} = E_{ci}^S \quad [70]$$

-- for any given commodity i, the total value of world imports must be equal to the total value of world exports:

$$\sum_r \sum_c P_{ic}^{we} WTR_{icr} = \sum_c P_{ic}^{we} \sum_r WTR_{icr} \quad [71]$$

IV. BENCHMARK DATA SETS

A. Introduction

67. As with all AGE models, constructing the benchmark data set of the WALRAS model involved a major investment in data collection, which needed to be adjusted to ensure consistency and to fit the model's sectoral disaggregation. Input-Output (I-O) tables provided the essential source, supplemented by data from other sources, including OECD National Accounts and Foreign Trade Statistics. Additional information was required to split value added into the returns to each primary factor of production distinguished in the model.

68. The "benchmark" year is 1980 or 1981, depending on the country or region. This choice was governed by the availability of the latest I-O tables for the countries in question. The basic I-O tables were supplied by national statistical agencies together with the corresponding transition matrices linking producer and consumer classifications, the latter being consistent with the National Accounts categories. Full details on the country-specific data sources, together with a description of the various adjustments made to ensure consistency, are presented in Annex V.

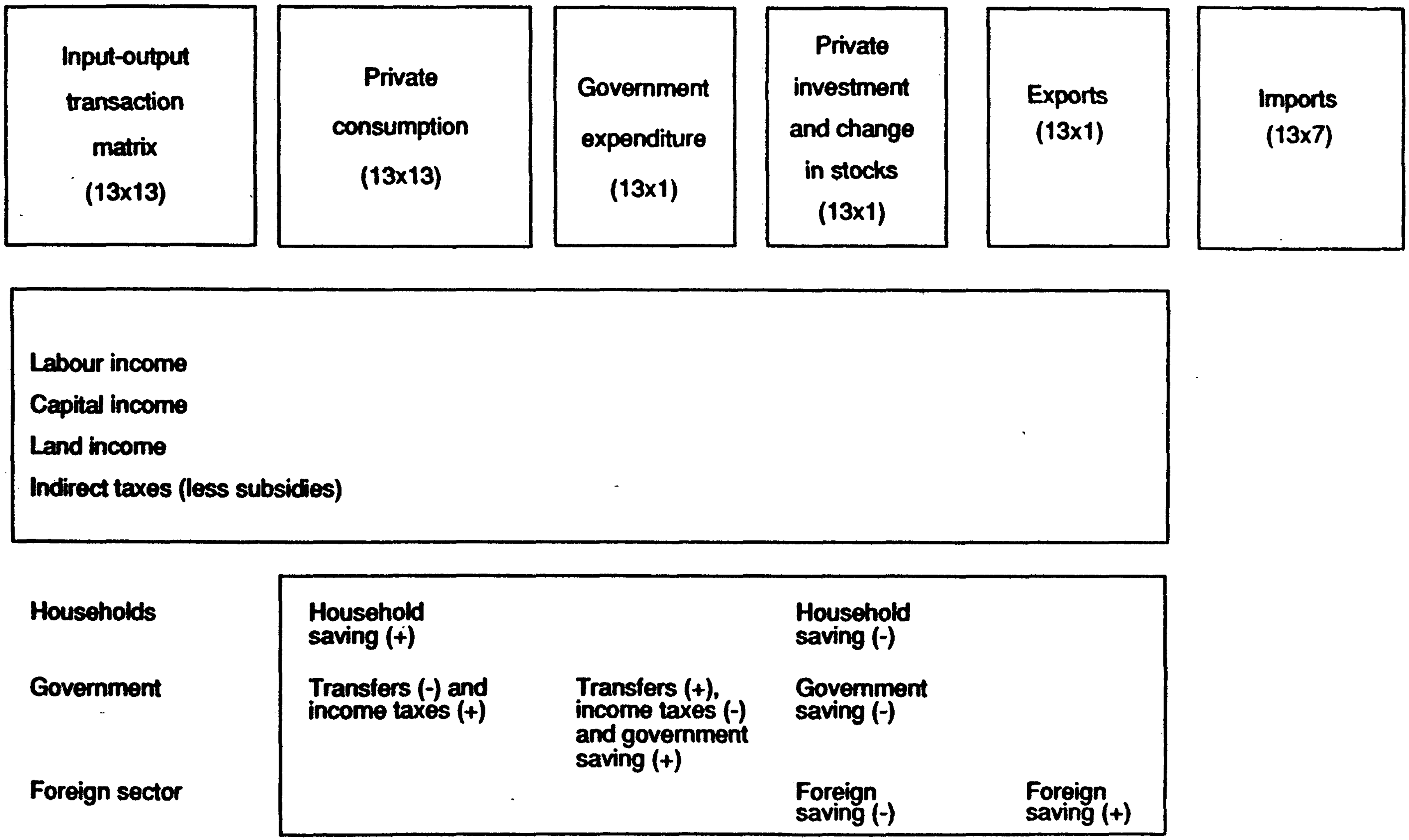
B. The input-output framework

69. The accounting framework underlying the typical AGE model consists of a record of all the commodity transactions occurring in the different markets that comprise the economy. I-O tables, constructed as part of the National Accounts framework, represent the most detailed set of demand and production accounts available. In particular, the I-O tables provide the data for the thirteen industries on the production side as well as for the components of final demand. Disaggregation of the aggregate "food" good into four distinct goods was undertaken using data on private consumption expenditures for 1980 collected as part of the joint OECD/EUROSTAT work on Purchasing Power Parities. The three primary factors -- labour, capital and land -- are also derived from value-added data, as measured in the I-O tables. Finally, the current account balance is defined as exports minus imports; these data are taken direct from the I-O tables and net investment income from non-residents is disregarded in the model.

70. The basic framework for which data are required for all countries is laid out in Figure 3. The two upper panels represent the main data requirements. These are described in the following paragraphs. The last panel presents the necessary flows that close the model. For example, the household account is balanced when net personal income (including transfers but less personal income taxes) is either saved or spent on consumption goods. The same reasoning applies to the government and foreign accounts. The investment account is also in equilibrium when savings from all sources, i.e. private (determined by consumer behaviour), public (a budget deficit in Figure 3) and foreign (a current account deficit in Figure 3), are allocated to the purchase of investment goods. Investment is therefore savings-driven and represents the closure equation of the model. The common adjustments to the data contained in the two upper panels are now described in turn.

Figure 3

Schematic representation of data requirements



C. Intermediate transactions

71. Each national inter-industry set of intermediate demand tables is transformed into a 13 x 13 transaction matrix which shows the amounts of the output of industry i that are used by industry j. For each country, the transaction matrix is split between domestic and imported intermediate inputs.

D. Final demand block

72. In addition to the inter-industry flows, data are required for final demand, split between domestically-produced and imported components. In the WALRAS model, final demand is disaggregated into thirteen private consumption goods, private investment, the change in stocks, government expenditures and exports (See Table 1). The transition matrix, which has 13 producing sectors and 13 private consumption categories, is used to resolve the incompatibility between the different classifications on the production and consumption sides of the model. Each coefficient of the transition matrix represents the amount of each industry's output used in producing each consumer good.

E. Value-added sector

73. Value added at market prices in each industry is split into five components, resulting in a 5 x 13 matrix:

a) Return to labour

This is the sum of employee compensation plus an imputed wage income for the self-employed.

b) Return to capital

This consists of the portion of self-employed income which is imputed to capital, plus the other components of "operating surplus", and the depreciation of fixed capital.

c) Return to land

The initial two-way split of the factors of production is further disaggregated for the two agricultural industries between labour, capital and land. Since land is not assumed to be a primary factor in the non-agricultural sectors, the return to urban land is ignored.

d) Indirect taxes and subsidies

The final two components of value added at market prices are indirect taxes and subsidies.

F. Personal incomes and savings

74. Personal disposable income is defined such that personal consumption plus savings plus government transfers to the household sector equals GDP at

factor cost minus consumption of fixed capital (depreciation) and personal income taxes. The necessary exogenous data for depreciation, general government transfers to households and net lending of general government are taken from the standardised OECD National Accounts. All the other data are from the I-O tables.

G. World trade

75. The bilateral world trade matrices which underpin the world linkage sub-model were constructed from three sources:

i) The WALRAS country I-O tables;

ii) The UN Handbook of International Trade and Development Statistics; and

iii) OECD Statistics of Foreign Trade (Series C).

The figures from the latter two sources were adjusted, using an iterative bilateral adjustment process, to make the world trade matrices consistent with the micro data sets used for the country models.

H. Agricultural policy instruments

76. In order to derive estimates of agricultural policy instruments for use in simulations, the WALRAS model draws on the quantification of agricultural policies provided by the data on Producer/Consumer Subsidy Equivalents (PSEs/CSEs) produced by the OECD Directorate for Food, Agriculture and Fisheries. The PSEs/CSEs are supplemented by additional information on supply controls in certain sectors and countries/regions. To be incorporated in the model, these data have to be translated into a set of wedges between producer and consumer prices. This translation is not straightforward -- see Lienert (1990) for a full description.

V. CALIBRATION AND PARAMETERISATION

77. The equations of the WALRAS model are not estimated econometrically, instead the model is calibrated on the benchmark year, which is taken to be 1980 or 1981, depending on the country/region. The basic assumption underlying the calibration procedure is that the economy is in equilibrium in the base-year. This means that in each country/region prices of all goods and factors of production are such that:

1. Demands (household, industries, investment, government and exports) equal supplies of all commodities;

2. Profits are zero in all industries;

3. All domestic agents have demands which satisfy their budget constraints.

78. Calibration consists of adjusting certain parameters to make the model fit the benchmark data, given the model's behavioural assumptions, its accounting identities and exogenous values for certain key parameters. These latter parameters play a crucial role in determining the simulation results. For WALRAS, the following parameters are exogenous:

-- Elasticities of substitution between labour and capital;

-- Elasticities of substitution between land and the labour-capital bundle in the two farm sectors;

-- Supply elasticities of labour and capital in agriculture relative to their return differentials between farm and non-farm sectors;

-- Elasticities of transformation between domestic output and exports;

-- Price elasticities of imports for intermediate use and for final demand;

-- Price elasticities for export demand;

-- Income elasticities for consumer goods;

-- Marginal tax rates on household incomes;

-- Elasticities of substitution between types of government expenditure;

-- Supply elasticity for agriculture in ROW.

79. The typical procedure in AGE modelling is to search the relevant econometric literature for plausible values for such exogenous parameters. The results of such a literature search for the WALRAS model are described in Burniaux et al. (1988), Section V. The picture is rather mixed. For some parameters, such as the elasticities of substitution between labour and capital or the income elasticities for consumer goods, it was judged that the econometric evidence provided a good guide to the "true" values. For others, notably for the foreign trade elasticities which play a crucial role in the model, the estimates typically found in the econometric literature were judged to be much less satisfactory. Econometric estimates of price elasticities for import and export demands for agricultural and food products were generally lower than for manufactured products, a finding which is contrary to a priori expectations, given the relative homogeneity of agricultural goods, even at the level of aggregation used in WALRAS. In addition, it is extremely difficult to find commodity-specific estimates of price elasticities for import and export demands that match the thirteen WALRAS sectors.

80. Discussion with national experts of the initial simulation results with the single-country models revealed a fairly general consensus that the price elasticities of import and export demand used to calibrate the model in Burniaux et al. (1988) were too low for a long-run analysis. There was also consensus that elasticities for agricultural and food products should be higher than for non-agricultural goods. Faced with this, it was decided to raise the baseline set of foreign trade elasticities significantly.

81. At the same time, one key feature of the previous approach was retained: identical values for all substitution elasticities in production and foreign trade, and the transformation elasticities of export supply are used for all countries/regions. This is not very realistic, but our survey of the econometric literature did not provide much useful guidance on country-specific values. The values of the foreign trade elasticities used in the baseline simulations of the WALRAS model are presented in Table 2 together with the values of other key parameters.

82. For most sectors, the baseline price elasticities for export demands are set at either -10 or -20 and substitution elasticities between imported and domestic goods range from -5 to -7. The larger values are assigned to most agricultural and food products on the grounds that such commodities are closer substitutes than most other manufactured goods or services.

83. Elasticities of this magnitude appear large when compared to time-series estimates for broad aggregates, such as total exports or manufactured exports -- where values of -1 to -2 appear to be the norm. Several observations are, however, relevant for such comparisons. First, the elasticity values needed for an AGE model such as WALRAS are long-run ones. Such elasticities should be relatively high otherwise all countries would have strong incentives to restrict their exports via optimal export taxes -- incentives that are clearly not perceived in reality. Second, there are sound theoretical and econometric reasons why estimates of disaggregate elasticities should be significantly higher than aggregate estimates. Finally, export demand elasticities of similar orders of magnitude are used in other AGE models. One such example is ORANI, the large multi-sector model of the Australian economy (10).

84. In any event, the critical issue is not the magnitude of the foreign trade elasticities *per se*, it is the sensitivity of WALRAS results to the particular choice of parameter values used in the calibration process. The results of extensive sensitivity analysis with some of these key parameters are reported in the paper by van der Mensbrugghe *et al.* (1990).

85. Estimates are needed on the size of the transformation elasticities between domestic output and exports. But there are no econometric studies which provide such estimates. In the absence of any evidence, arbitrary values were assigned to these elasticities for the five sectors in which the CET specification was implemented (see Annex II).

86. Use of the CET specification mitigates the response of exports to changes in relative prices on the world market. Combining export demand and supply equations, one can derive a partial reduced-form elasticity which expresses the export volume change in response to a change in the export subsidy rate (see Annex III). For the sectors in which the CET specification is implemented, these elasticities are typically well below the values of the price elasticities for export demand on world markets.

87. The choice of the labour and capital supply elasticities in agriculture was guided by those in the IIASA model (11). These migration elasticities are "*ex post*" elasticities calculated over the simulation period 1980-2000 with respect to an exogenous change in the agricultural relative to the non-agricultural price. In using these elasticities in WALRAS, account was taken of the fact that they referred to time periods when farmers expected some

Table 2

Parameters values used for baseline simulations

(All countries)

Sector:	Substitution elasticities between: Labour and capital	Substitution elasticities between: Land and the labour/capital Bundle	Price elasticities for export demand	CET elasticities of export supply
Livestock	0.8	0.5	-20	8
Other agriculture	0.8	0.5	-20	8
Other primary industries	0.8	..	-1	..
Meat products	0.9	..	-20	..
Dairy products	0.9	..	-20	..
Other food products	0.9	..	-10	..
Beverages	0.9	..	-10	..
Chemicals	1.1	..	-10	..
Petroleum & coal products	0.9	..	-10	..
Other manufacturing	1.0	..	-10	17
Construction	1.0	..	-0.5	..
Wholesale & retail trade	1.0	..	-10	35
Other private services	1.0	..	-10	15

Elasticity of substitution between types of government expenditure (wage, non-wage and investment)	0.75

Table 2 (continued)

Consumer import (Armington) elasticities

	EC	Canada	Japan	New Zealand	United States	Australia
1. Grains and cereals	6.3	6.5	6.6	6.5	6.0	6.1
2. Meat	6.2	6.2	6.4	6.1	6.1	6.1
3. Milk, cheese and eggs	6.2	6.1	6.1	7.1	6.0	6.1
4. Other food	6.3	7.1	6.2	6.6	6.3	7.0
5. Alcoholic beverages	5.3	5.5	5.2	5.2	5.3	5.7
6. Tobacco	5.6	5.1	5.2	6.2	5.1	5.3
7. Clothing and footwear	5.4	5.8	5.2	5.7	5.5	6.5
8. Gross rents, fuel and power	1.0	1.0	1.0	1.0	1.0	1.0
9. Household equipment and operation	5.4	5.9	5.2	5.6	5.2	6.9
10. Medical care	0.2	0.2	0.0	0.2	0.0	0.2
11. Transport and communication	4.2	5.0	4.2	4.9	4.3	4.5
12. Education and recreation	0.2	0.3	0.2	0.2	0.2	0.2
13. Other consumer goods and services	4.1	4.2	4.1	5.0	4.2	4.3

Partial factor mobility elasticities (a)

	EC	Canada	Japan	New Zealand	United States	Australia
Labour	3.00	2.66	1.06	0.42	2.66	0.42
Capital	2.20	2.76	1.02	2.16	2.76	2.16

a) Elasticities of labour and capital use in the agricultural and non-agricultural sectors with respect to relative factor returns in the two sectors. These estimates are taken from the IIASA model -- *see* Parikh et al. (1986), Table 3.3; for the purposes of WALRAS, the IIASA elasticities are doubled. The elasticities for New Zealand and the United States are assumed to be the same as those reported by IIASA for Australia and Canada.

degree of agricultural protection to continue indefinitely into the future As such, they probably underestimate the response of capital and labour mobility when all agricultural protection is removed. In order to make some adjustment for this, the IIASA elasticities were doubled in the baseline simulations.

88. One can derive analytically a reduced-form elasticity for the agricultural supply response to price changes in each OECD country/region as a function of i) the labour and capital supply elasticities in agriculture; and ii) the level of substitution between the fixed factor -- land -- and the labour/capital bundle. In Annex IV, values for these elasticities are calculated and compared with "ex-post" calculated elasticities from a baseline simulation. Both sets of values suggest that the long-run supply elasticity in agriculture for the OECD area is around two. Accordingly, the supply response in the ROW aggregate has been set at the same level in the baseline simulations, although the sensitivity of the results to this parameter is analysed in the paper by van der Mensbrugghe et al. (1990).

89. Income elasticities are country-specific (Table 3); they are derived from various studies which have been reported in Burniaux et al. (1988). This has been supplemented by an additional literature search needed to document the required elasticities for the four disaggregated food categories introduced in the latest version of the model (12).

VI. MODEL SOLUTION

90. A variety of different iterative solution algorithms can be used to solve AGE models. While some of them, such as Scarf's or Merrill's algorithm, explore the unit simplex of factor prices when searching for the equilibrium solution, others, such as Newton-type methods or Kimbell and Harrison's factor price revision rule, move from the base equilibrium to the solution by adjusting the equilibrium prices according to the excess demands observed at each iteration. The former set of solution methods has the theoretical advantage of guaranteeing convergence but the latter methods are becoming increasingly popular because of their relative simplicity and flexibility. Another class of solution algorithms, which rely on successive linear approximations to the non-linear equilibrium levels -- Johansen-type methods -- are also popular because of the speed of convergence and the ease with which such a method can be preprogrammed on micro-computers (13).

91. In the WALRAS model, a tâtonnement procedure based on the Gauss-Siedel algorithm was chosen for its practical advantages in solving non-linear models. First, the set of equilibrium prices is not constrained to sum to unity so that the prices are less interdependent. Second, the solution path is continuous, making simultaneity problems easy to solve without adding further dimensions to the equilibrium price set, as would be the case with Merrill's algorithm or Newton-type methods.

92. The solution method proceeds in the following order:

i) Each country/region sub-model is solved and excess demand for primary factors are calculated;

Table 3

Income elasticities in the WALRAS model

	Australia	Canada	EC	Japan	New Zealand	United States
<u>Income elasticity of demand for</u>:						
Grains and cereals	0.1	0.0	0.1	0.0	0.0	0.0
Meat	0.3	0.5	0.4	0.7	0.2	0.4
Milk, cheese and eggs	0.2	0.2	0.3	0.7	0.2	0.2
Other food	0.5	0.3	0.5	0.6	0.6	0.3
Alcoholic beverages	0.4	0.5	0.5	0.5	1.1	0.3
Tobacco	0.4	0.5	0.5	0.5	1.1	0.3
Clothing & footwear	0.6	0.6	0.6	0.5	0.7	0.6
Gross rents, fuel and power	1.4	1.1	1.2	1.3	1.3	1.2
Household equipment & operation	1.5	1.4	1.5	1.3	0.9	1.4
Medical use	1.7	0.6	0.6	1.2	1.4	1.1
Transport and communication	1.5	1.3	1.5	1.1	1.2	1.0
Education and recreation	0.8	1.0	1.2	1.1	1.3	1.0
Other consumer goods & services	1.2	1.2	1.4	1.2	1.3	1.4

<u>Source</u>: See Burniaux <u>et al.</u> (1988), Table 3.

ii) The world trade sub-model is solved for bilateral trade flows and derives total export demands for each country/region; and

iii) Factor prices are adjusted in each country/region in order to eliminate excess factor demands.

Then, a new iteration is initiated on the basis of the adjusted factor prices.

93. At the beginning of each iteration, the model first uses the adjusted factor prices in each country/region to solve for the producer prices, given the technical coefficients used in each production sector. Using the transition matrix, producer prices are then converted to consumer good prices. Primary factor prices also determine the income of consumers, under the assumption that all factors are fully employed. Once both consumer incomes and consumer prices are determined, it is possible to calculate the demands for consumer goods, the most important component of final demand.

94. Government spending is fixed exogenously and is allocated to various goods and services as a function of factor and producer prices. Stock changes are also exogenous. Export demands are given by the world trade sub-model. For reasons of simultaneity, the level of investment is calculated by taking for some components of the government budget their corresponding value at the previous iteration as a "proxy" for the current one.

95. When all components of final demand are known, the production sub-model is used to determine total output required to meet demand, and subsequently imports, labour, capital and land demands. Government revenue from all types of taxation can then be computed.

96. With all import demands by each country/region being known, the world trade sub-model can be solved for exports. When the model approaches the equilibrium solution, factor price adjustments between each iteration, as well as the bias from using previous iteration values, become smaller. At equilibrium, factor markets in all country/regions are simultaneously cleared; total values of world imports and exports are strictly balanced and the current accounts of all countries/regions sum to zero.

NOTES

1. The assumptions of constant-returns-to-scale technology and perfect competition have, however, been relaxed in the single-country model for Canada -- referred to as the WALRAS-SE model -- in order to explore what differences this could make to the results. This work is described in Delorme and van der Mensbrugghe (1990).

2. The results of some sensitivity analysis with the Japanese model in which land is used as an input in the non-agricultural sectors, are described in the paper by van der Mensbrugghe et al. (1990).

3. Econometric evidence in support of imperfect mobility of capital and labour between rural and urban sectors is reported in Fischer et al. (1988), p. 129.

4. Armington (1969) was the first to examine the specification of import demand equations when domestic goods and imports are treated as imperfect substitutes.

5. See Brown (1987) for an analysis of the impact of national product differentiation on the magnitude of the terms-of-trade effects.

6. Net factor income from abroad is treated as exogenous in the model.

7. A graphical exposition, highlighting the equilibrating role of the real exchange rate in a one-sector model, is presented in Burniaux et al. (1990).

8. There is a consensus in the theoretical literature that the LES is an overly restrictive demand system (see Deaton and Muellbauer (1980), Section 3.2). Models like translog (Christensen, Jorgenson and Lau (1975) and AIDS (Deaton and Muellbauer (1980a)) are based on flexible functional forms, are more general and impose less a priori restrictions. However, for a number of reasons, these flexible forms are more difficult to implement in an AGE model.

9. In the model, the price of savings is defined as the average consumption price. Hence, myopic expectations are assumed implicitly in the absence of a full dynamic treatment of the consumption-savings decision.

10. See Powell (1985) for a defence of the use of large export demand elasticities in ORANI. Pagan and Shannon (1987) review the Australian debate on the sensitivity of ORANI results to the size of the export demand elasticities. They also point out that the results are equally, if not more, sensitive to variations in the export supply elasticities.

11. See Fischer et al. (1988), p. 129

12. See Dixon et al. (1982), FAO (1986), Hassan and Johnson (1976), Remier and Kulshreshtha (1974), Tryfos and Tryphonopoulos (1973), Hassan and Lu (1974), INSEE (1983), BAE (1985) and Italy (1976).

13. For an exhaustive review of the comparative advantages of different solution methods to AGE models, see Harris (1988).

Annex I

GLOSSARY OF VARIABLES AND PARAMETERS

List of variables

Mnemonic	Description	Main equation number (see Section III)
a^{d}_{ji}	Unit physical requirement of domestic input j used by industry i	[23]
a^{I}_{ji}	Unit physical requirement of imported intermediate input j used by industry i	[24]
a_{Ki}	Unit physical requirements of capital of industry i	[19]
a_{Li}	Unit physical requirements of labour of industry i	[20]
a_{Mi}	Unit physical requirements of land of industry i	[18]
C_{g}	Consumption expenditures on good g	[40]
C^{d}_{g}	Consumption expenditures on domestic good g	[47]
C^{I}_{g}	Consumption expenditures on imported good g	[48]
DEPR	Depreciation of capital stock	[37]
$DSTOC^{d}_{i}$	Change in stocks of expenditure on domestic good i	[28]
$DSTOC^{I}_{i}$	Change in stocks of imported good i	[31]

List of variables

(continued)

Mnemonic	Description	Main equation number (see Section III)
$DSTOC^T$	Value of change in total inventories	[64]
e	Lagrange multiplier	[15]
E_i^S	Export supply of good i	[33]
E_i^d	Export demand of good i	[61]
E_i^I	Export demand for imported good i	[31]
E^T	Total exports valued at world export prices (includes re-exports)	[64]
FD_i^d	Final demand of domestic good i	[65]
G	Government expenditure on production goods	[53]
GOV_i^d	Demand by government for domestic good i	[28]
GOV_i^I	Demand by government for imported good i	[31]
h_i	Price of the capital-labour bundle used by industry i	[26]
H_i	Capital-labour CES bundle used by industry i	[14]
I	Identity matrix	[28]
IMP^T	Total imports valued at world prices	[64]
IMP_{ir}	Total imports of commodity i by country r	[31]

List of variables

(continued)

Mnemonic	Description	Main equation number (see Section III)
IMP_i^I	Imports of commodity i for intermediate uses	[29]
INV_i^d	Demand for domestic investment good i	[28], [49]
INV_i^I	Demand for imported investment good i	[31], [49]
INV^T	Total investment expenditure	[64]
$\bar{K}$	Total capital endowment	[63]
K_a	Supply of capital in farm sectors	[63]
K_{na}	Supply of capital in non-farm sectors	[63]
K_i	Capital input to industry i	[12]
K_G	Government spending on capital	[54]
$\bar{L}$	Total labour endowment	[62]
L_a	Supply of labour in farm sectors	[62]
L_{na}	Supply of labour in non-farm sectors	[62]
L_G	Government spending on labour	[55]
L_i	Labour input to industry i	[12]
M_i	Land input to industry i	[12]
$\bar{M}$	Total land endowment	[68]

List of variables

(continued)

Mnemonic	Description	Main equation number (see Section III)
P_{cg}	Composite consumer price of commodity g	[41]
P_{cg}^{d}	Consumer price of domestic commodity g	[5]
P_{cg}^{I}	Consumer price of imported commodity g	[7]
P_i	Composite producer price of domestic commodity i	[25], [34]
P_i^{d}	Net-of-tax domestic producer price of commodity i	[34]
P_i^{e}	Producer export price of commodity i	[34]
P_i^{we}	World export price of commodity i (inclusive of export subsidies)	[9]
P_i^{wm}	Net-of-tax world import price of industrial good i	[60]
P_G	Composite price of government expenditure on production goods	[56]
PC_i	Total personal consumption of ith industry's output	[30]
PC_i^{d}	Total domestic personal consumption of domestic goods	[30]
PC_i^{I}	Total domestic personal consumption of imported good i	[31]
PT_{ji}^{d}	Gross-of-tax price of domestic intermediate input j used by industry i	[3]
PT_{ji}^{I}	Gross-of-tax price of imported intermediate input j used by industry i	[4]

List of variables

(continued)

Mnemonic	Description	Main equation number (see Section III)
Q_i	Gross output of industry i	[12], [28], [32]
r_i	Price of capital in industry i	[26], [69]
r_a	Aggregate price of capital in farm sectors	[66]
r_{na}	Aggregate price of capital in non-farm sectors	[66]
rm_i	Price of land in industry i	[25], [69]
rm	Aggregate price of land	[68]
R_g	Total revenues of the government	[57]
s_{Qi}	Input subsidy rate for industry i	[15]-[19]
SV	Total personal savings	[39]
t^d_{ci}	Commodity (*ad valorem*) tax rate on domestic consumption good i	[5]
t^I_{ci}	Commodity (*ad valorem*) tax rate on imported consumption good i	[6]
t_{Ei}	Export (*ad valorem*) tax rate	[9]
t_{Gi}	Commodity (*ad valorem*) tax rate on government	[56]
t_{Ii}	Commodity (*ad valorem*) tax rate on investment good i	[57]
t^d_{ji}	*ad valorem* rate of sales tax on domestic intermediate use of input j used by industry i	[3]

List of variables

(continued)

Mnemonic	Description	Main equation number (see Section III)
t^I_{ji}	*ad valorem* rate of sales tax on imported intermediate use of input j used by industry i	[4]
t_{Ii}	Commodity (*ad valorem*) tax rate on inventory good i	[57]
t_y	Marginal income tax rate	[38]
T_g	Lump-sum government transfers	[37]
U	Consumer utility function for consumption and savings	[35]
$\bar{U}_G$	Government utility	[51]
V^*	Lagrangian function	[15]
VA_i	Value added of industry i	[13]
w_i	Wage rate of industry i	[26], [69]
w_a	Aggregate price of labour in farm sectors	[67]
w_{na}	Aggregate price of labour in non-farm sectors	[67]
WTR_{icr}	Volume of imports of commodity i by country r originating from country c	[59]
X_{ji}	Intermediate use of input j by industry i	[22]
Y	Total income of the representative consumer	[37]
YD	Disposable income of the representative consumer	[38]

List of variables

(continued)

Mnemonic	Description	Main equation number (see Section III)
Z_G	Total government expenditure	[52]
τ_i	Tariff rate on commodity i	[4], [7]

List of parameters

Mnemonic	Description	Main equation number (see Section III)
a_{ji}	Unit physical requirement of total intermediate input j used by industry i	[21]
A^{d}	Domestic Leontief matrix of intermediate transactions including taxes	[28]
α_{Di}	Distribution parameter representing the share of domestically sold goods in total output of industry i	[33]
α_{Ei}	Distribution parameter representing the share of exported goods in total output of industry i	[33]
α_{Hi}	Distribution parameter representing the share of capital-labour bundle in value-added function for industry i	[13]
α_{Ki}	Distribution parameter representing capital share in value-added sub-function for industry i	[14]
α_{Li}	Distribution parameter representing labour share in value-added sub-function for industry i	[14]
α_{Mi}	Distribution parameter representing land share in value-added function for industry	[13]
β_g	Elasticity of substitution in Armington CES consumption function of good g	[40]
η_i	Elasticity of substitution between domestic and imported unit physical requirements of intermediate inputs used by industry i	[21]
D	Matrix of technical coefficients for primary and imported inputs	[30]

List of parameters

(continued)

Mnemonic	Description	Main equation number (see Section III)
D_i^S	Domestic supply of good i	[33]
ϵ_i	Elasticity of substitution between exports from different origins on the world market of commodity i	[58]
F_g	Minimum requirements of consumer good g in Klein-Rubin utility function	[35]
ζ	Depreciation rate	[64]
ϕ_G	Distribution parameter for non-wage current expenditure in the government utility function	[51]
ϕ_L	Distribution parameter for labour in the government utility function	[51]
ϕ_K	Distribution parameter for capital in the government utility function	[51]
γ_{ji}^d	Distribution parameter for domestic intermediate input j used by industry i	[21]
γ_{ji}^I	Distribution parameter of imported input j used by industry i	[21]
θ_g	Distribution parameters of commodity g in utility function of the representative consumer	[35]
ι_g^d	Income elasticity of demand for commodity g	[44]
ρ_i	Elasticity of substitution between the capital-labour bundle and land in the CES value-added function of industry i	[13]

List of parameters

(continued)

Mnemonic	Description	Main equation number (see Section III)
sh_{icr}	Distribution parameter representing the share of imports from country c in total imports of commodity i by country r	[60]
σ_i	Elasticity of substitution between capital and labour in industry i	[14]
θ_i^d	Unit physical demand of government on production good i	[56]
θ_i^I	Unit physical demand of government on imported good i	[56]
va_i	Unit physical requirement of total primary factor bundles in industry i	[10]
ω_g^d	Distribution parameter of domestic goods in Armington CES consumption function of good g	[41]
ω_g^I	Distribution parameter of imported goods in Armington CES consumption function of good g	[41]
Ω_i	Unit physical requirement of expenditure on change in stocks on production good i	[50]
λ_g	Own-price (uncompensated) elasticity for commodity g	[45]
Λ	Transformation elasticity between exported and domestically sold goods	[34]
ψ	Elasticity of substitution between expenditure categories in government utility function	[53]-[55]

List of parameters

(continued)

Mnemonic	Description	Main equation number (see Section III)
$\bar{K}_a^0$	Base-year endowment of farm capital	[63]
$\bar{L}_a^0$	Base-year endowment of farm labour	[62]
πK	Migration elasticity for farm capital	[63]
πL	Migration elasticity for farm labour	[62]
μ	Intercept in the linear personal income tax schedule	[38]
Γ_i	Unit physical requirement of investment demand on production good i	[49]
$\Xi^d = (\xi_{gi}^d)$	(i x g) fixed-coefficient transition matrix linking the g consumer-good classification to the i producer-good classification for imported goods.	[6], [27]
$\Xi^i = (\xi_{gi}^I)$	(i x g) transition matrix for imported goods	[7], [27]

Annex II

THE CET SPECIFICATION

When the CET specification is introduced, the response of sectoral output to external shocks can be decomposed into two terms relating to expansion and transformation effects. The former deals with the overall supply elasticity of the sector in question and the latter with the shift in the output-mix within the sector. Output supply with the CET specification can be represented, in percentage change form, by the following four equations:

-- Domestically-absorbed supply (x_d) is a function of total output (x), the price on the domestic market (p_d) and the producer price (p), given a transformation elasticity τ:

$$x_d = x + \tau\ (p_d - p) \qquad [1]$$

-- Export supply has a symmetric specification with p_e being the export market price:

$$x_e = x + \tau\ (p_e - p) \qquad [2]$$

-- The producer price (p) is a weighted average of domestic and export prices:

$$p = (1 - sh_e)\ p_d + sh_e\ p_e \qquad [3]$$

where sh_e = share of exports in total output.

-- The sector supply response to producer price changes (p) depends on the supply elasticity η:

$$x = \eta\ p \qquad [4]$$

The net effect on domestically-absorbed production x_d of an exogenous increase in the price p_e is given by:

$$sh_e\ p_e\ (\eta - \tau) \qquad [5]$$

The positive and negative terms of [5], respectively, define the above-mentioned expansion and transformation effects. For the CET specification to have the same properties as the corresponding disaggregated model, the expansion effect must be outweighed by the transformation effect -- this requires the transformation elasticity (τ) to exceed the supply elasticity (η) in each sector. In a long-term model, such as WALRAS, which does not incorporate any inter-country/region factor mobility, sectoral supply elasticities depend on: a) the share of the sector's value added in total value-added; and b) the degree of factor specificity in each sector.

On the basis of these considerations, sectoral supply elasticities in WALRAS are found to be significantly lower than infinity in the two farm sectors and in the three large non-farm sectors: other manufacturing industries, wholesale and retail trade and other private services.

Annex III

REDUCED-FORM EXPORT ELASTICITIES

1. Combining export demand and supply functions allows us to derive a positive elasticity which relates the percentage change in export volumes by country r (E_r) to a percentage change in its export subsidy rate (τ_r):

$$E_r/\tau_r = [1/\{\epsilon_r.(1-\alpha_r)\} + 1/\{\sigma.(1-\xi_r)\}]^{-1}$$

2. The export response to a change in the subsidy rate depends on i) the level of the price elasticity for export demand on world markets (σ), given the world market share of country r (ξ_r); and ii) on the level of the transformation elasticity between domestic and exported output in country r (ϵ_r), given the export share in total output (α_r). Values for these reduced-form elasticities, calculated on the basis of the base-case values of world substitution elasticities σ and transformation elasticities ϵ_r, are listed in Table A1.

Table A1

Reduced-form export elasticities

	Australia	Canada	EC	Japan	New Zealand	United States
1. Livestock & livestock products	4.4	5.3	5.5	5.7	5.1	5.6
2. Other agricultural industries	4.1	3.9	5.4	5.7	5.2	4.2
3. Other primary industries	3.0	2.9	3.0	3.0	3.0	2.9
4. Meat products	18.1	19.3	13.0	19.9	18.4	16.8
5. Dairy products	19.1	19.4	8.5	19.9	17.6	18.6
6. Other food products	9.7	9.6	8.3	9.8	10.0	8.3
7. Beverages	9.8	9.5	6.4	9.9	10.0	9.7
8. Chemicals	10.0	9.8	6.9	9.2	10.0	9.2
9. Petroleum & coal products	9.9	9.9	8.7	9.9	10.0	9.2
10. Other manufacturing industries	6.0	5.0	5.1	5.5	5.9	5.5
11. Construction	0.5	0.5	0.3	0.5	0.5	0.5
12. Wholesale & retail trade	7.6	7.6	5.4	7.1	7.6	5.9
13. Other private services	5.8	5.8	5.0	5.6	5.8	5.4

Annex IV

AGRICULTURAL SUPPLY ELASTICITIES IN WALRAS

1. We assume a simplified model for agriculture, with one fixed factor and one factor in variable supply according to its price differential between agricultural and non-agricultural uses. The production function implies that intermediate inputs and primary factors are used in fixed proportions whereas some substitution is allowed for between fixed and variable factor uses. Infinite supply of intermediate inputs is assumed. The reduced form of this simplified model yields the following analytical expression for the price elasticity of agricultural supply E^{sa}:

$$E^{sa} = [(\xi_{va}/\mu\ \xi_v) + (\xi_{va}\ \xi_f/\epsilon\ \xi_v)]^{-1}$$

where ξ_{va} is the value-added share in total production;

ξ_v is the variable factor share in agricultural value-added;

ξ_f is the fixed factor share in agricultural value-added;

ϵ is the substitution elasticity between fixed and variable factors; and

μ is the price elasticity of the variable factor supply in agriculture.

2. Table A2 provides a comparison between these analytically-deduced elasticities and those which are calculated "*ex post*" for the aggregate agricultural sector from the baseline simulation.

Table A2

Supply elasticities in the agricultural sector in WALRAS

	Analytical elasticities	"*ex-post*" elasticities
Canada	1.5	2.8
EC	2.2	2.5
Australia	0.7	1.0
Japan	1.4	2.0
New Zealand	1.1	0.5
United States	1.4	1.4
Average	1.7	2.0

Annex V

COUNTRY-SPECIFIC DATA ADJUSTMENTS

1. The correspondence between the thirteen production sectors of the WALRAS model and the classification of industrial sectors in each country's input-output tables is shown in Table A3.

1. Australia

1.1 A brief introduction to the Australian I-O tables

2. In the Australian I-O tables (1), indirect taxes are fully identified: the valuation is at "basic values" instead of at producer prices, as in several other countries. It is also the only country that prepares tables on the basis of both direct and indirect allocation of imports. Nonetheless, some further data adjustments were required for the purposes of creating the WALRAS data set.

3. The Australian I-O structure consists of four quadrants (in some of the other countries the fourth quadrant is absent):

-- a matrix of intermediate usage (Quadrant 1)
-- a matrix of final demand (Quadrant 2)
-- a matrix of primary inputs to production (Quadrant 3)
-- a matrix of primary inputs to final demand (Quadrant 4).

4. At the most detailed level there are 108 industries and about 1500 commodities; the latter are aggregated to 108 commodities for publication. The basic transaction matrix is therefore 108 x 108; the various matrices were aggregated by the Australian Bureau of Statistics to match the sectoral classification of the WALRAS model.

1.2 Adjustments to intermediate transactions

5. The item "sales by final buyers" (P5 of the primary input quadrants) was re-allocated to the sector "other manufacturing".

6. The transactions of government (public administration, defence, health and education -- industries 7101 to 8201 respectively) were removed from the rows and columns of this matrix.

1.3 Adjustments to final demand

7. Government expenditures also include the columns and (negative) rows which were removed from the transaction matrix.

1.4 Adjustments to value added

8. The gross operating surplus had to be split between returns to labour, capital and land. First, the income of unincorporated enterprises was identified using data from the Australian National Accounts (Table 21 of Catalogue No 5204.0, Canberra, 1986). An imputed wage income was calculated

Table A3: Industry aggregation for the WALRAS model

	AGE Aggre-gation	ISIC code (4-digit)	AUSTRALIA I/O, 108-sector, 1980/81	CANADA I/O, 191-sector, 1981	EEC (a) I/O, 59-sector, 1980	JAPAN I/O, 164-sector, 1980	NEW ZEALAND (l) I/O,25-sector, 1981/82	UNITED STATES I/O, 366-sector, 1981
Livestock and livestock products	1	1110-1120	01.01,01.03-01.05	1.1 (b)	010 (c)	0016	1,2 (d)	1.01-1.03
Other agriculture	2	1110-1120	01.02,01.06,02.00	1.2 (b)	010 (c)	0011-0015, 0017-0020	3,4	2.01-2.07,4.00 (e)
Other primary industries	3	1130-2909	03.00-16.00	2-15	010 (c), 030-071, 075 (f)	0211-1990	5-9	3.00,5.00-10.00
Meat products	4	3111	21.01	16,17	310	2011,2012	10-12	14.01
Dairy products	5	3112	21.02	18	330	2020	13-15	14.02-14.06
Other food products	6	3113-3122	21.03-21.08	19-28	350	2030-2092	16-25	14.07-14.20,14.23-14.32
Beverages	7	3131-3134	21.09-21.11	29-32	370	2110-2140	26-28	14.21,14.22
Chemicals	8	3511-3529	27.01-27.07	123-130	170	3111-3192	55-60	27.01-30.00
Petroleum & Coal products	9	3530-3540	27.08	121,122	073	3210,3291	61-62	31.01-31.03
Other Manufacturing Industries	10	3140-3420, 3551-3909	22.01-26.05, 28.01-34.05 (g)	33-120 131-137	110-150, 190-290, 390-510	2200-3000, 3310-3990	29-54, 63-94 (h)	13.01-13.07,15.01-26.08, 32.01-64.12,81 (i)
Construction	11	5000	41.01-41.02	138-146	530	4001-4009	98-101	11.01-12.02
Wholesale & Retail Trade	12	6100-6200	47.01-49.02	164,165	570	6110,6120	102	69.01,69.02
Other Private Services (j)	13	0000,4101-4200, 6310-9600	36.01-37.01, 51.01-93.01	147-163, 166-191 (k)	090,550, 590-930	5110-5300, 6200-9000	95-97, 103-128	65.01-68.03, 70.01-79.03

a) The EEC covers the following eight countries: Denmark, Germany, France, Italy, Netherlands, Portugal, Spain, and United Kingdom.
b) Based on the new Statistics Canada Input-Output L-aggregation level (unpublished).
c) Individual Input-output tables for five European countries (Denmark, Germany, France, Netherlands and United Kingdom) are used to split forestry and fishing (which are classified under "other primary industries") from agriculture (industries 1 plus 2). Then, the European Commission's RICA system is used to split "livestock" and "other agriculture".
d) Isolation of grain, fodder, crop and seed growing from "Agriculture and Livestock Production" is not possible at the 128x128 aggregation level.
e) Services to fishing and forestry, and agriculture, which are not individually disaggregated (even at the 6-digit 537 industry level), are arbitrarily included under "other agriculture".
f) Individual Input-Output tables for five countries are used to isolate "refined petroleum". The latter is re-allocated to "Petroleum and Coal".
g) "Sales to final buyers" (Line P5, Primary inputs to production matrix) is also included here.
h) The item "Second-hand assets", shown as a primary input, is transferred to "Other Manufacturing".
i) For the United States, five Special Industries are identified. The category "Scrap, used and secondhand goods" is allocated to other manufacturing. "Government industry" becomes part of "Compensation of employees". The remaining three industries: "Rest of World industry", "Houshold industry" and "Inventory valuation adjustment" are ignored.
j) See the descriptions of the adjustments to the data-sets for each country, to observe how the government sector was treated.
k) The industries "Office Laboratory and Food operating Services (184-186,188,191), Travel and Advertising (189,190) and Transportation Margin (187) are re-allocated to "Other Private Services".
l) The detailed 128x128 inter-industry tables are only available for 1976-77; only a 25-sector disaggregation is available for 1981-82. The detailed 1976-77 tables were used to disaggregate the 25-sector tables.

for each of the available sectors assuming that proprietors' average wage income is equal to that of employees in the sector. This wage income was added to "compensation of employees". Second, the remaining part of the operating surplus was deemed to be the return to capital, except for the two agricultural sectors, where the initial "capital" income was split between capital and land. Different ratios were used for livestock and non-livestock, on the basis of the capital and land rentals incorporated in the ORANI model (2).

2. Canada

2.1. A brief introduction to the Canadian I-O tables

9. In the Canadian I-O tables (3), the inputs and output of industries are presented in separate tables and classified by commodity. The number of commodities is greater than the number of industries, yielding a rectangular format instead of the traditional square matrices for intermediate transactions.

10. The Canadian I-O structure consists of five main matrices:

- a matrix of the values of outputs (Make matrix V)
- a matrix of the values of intermediate inputs (Use matrix U)
- a matrix of the values of commodity inputs of final demand (Final demand matrix F)
- a matrix of the values of primary inputs of industries (matrix YI)
- a matrix of the values of primary inputs of final demand categories (YF).

At the most detailed level (the L aggregation), there are 191 industries, 595 commodities, 7 primary inputs and 136 final demand categories. Statistics Canada aggregated the data from the 1981 table in line with the sectoral aggregation chosen for the WALRAS model.

2.2. Adjustments to intermediate transactions

11. In order that each element of the 13 x 13 transaction table corresponds to the amount of output of industry j that is used as an intermediate input by industry i, the initially rectangular USE matrix must be multiplied by the normalized Make matrix.

2.3. Adjustments to final demand

12. In the final demand matrix, a negative cell occurs in the "government expenditure" column when government sales exceed total expenditures. An excess supply variable is created to overcome this problem. This item becomes an additional component of final demand in order to preserve the totals.

2.4. Adjustments to value added

i) Split of "net income of unincorporated business"

This item is allocated between labour and capital income using the respective shares of "wages, salaries and supplementary labour income" and "other operating surplus" in the total of these two items.

ii) Split of "other operating surplus" between capital and land in the two agricultural sectors

Data on book values of "land and depletable assets" and other capital were obtained for agriculture from Statistics Canada, Corporation Financial Statistics, Catalogue #61-207, 1981, from which the ratio of land to total fixed assets is calculated. This ratio was then used to split "other operating surplus" between capital and land in each of the two agricultural sectors.

3. EEC

3.1. A brief introduction to the EEC I-O tables

13. I-O tables for 1979-80 have been published by the national statistical offices in eight EEC Member states. There are significant differences between these national tables with respect to their sectoral classifications as well as the treatment of value-added taxes. Since no I-O tables for 1979-80 are available for Belgium, Luxembourg, Ireland and Greece, the EEC aggregate in the model is restricted to only eight Member states: Denmark (DK), France (FR), Germany (DEU), Italy (IT), the Netherlands (NTH), Portugal (POR), Spain (SP) and the United Kingdom (UK).

14. The Statistical Office of the European Communities (EUROSTAT) has harmonized and published the eight available tables using a common sectoral breakdown (4); it also makes available a 44-sector aggregated table (EUR 8), net of value-added taxes, expressed in ECU. This aggregated table was chosen as the appropriate starting point from which to calculate the EEC data set, in spite of the fact that it has several limitations for this purpose:

i) When aggregating the national tables, intra-Community imports and exports should offset one another as they are, in theory, equal. In practice, this is not the case because our EEC aggregate excludes four Member states in addition to other statistical discrepancies. The residual net exports was added to exports to the rest of the world.

ii) The 44-sector breakdown is insufficient for the sectoral specification of the WALRAS model. For example, sector 9 in the WALRAS model (refined petroleum products: NACE.CLIO 140) is aggregated to the R.44 branch 070 and had to be extracted by extrapolating from the national tables for which such a disaggregation is available (DK, FR, IT, NTH, UK). The agricultural sector in the EUROSTAT table includes fisheries and forestry. These activities were separated out and added to sector 3 (other primary industries) by extrapolating from the national tables which provided such a split (DEU, DK, FR, IT, UK). In addition, the agricultural sector had to be split between livestock and other agricultural products. Only the Italian table provides this kind of breakdown. For the other countries, other data sources (see below) had to be used.

iii) The French I-O table compiled by EUROSTAT does not include any breakdown of value-added at market prices into its usual components. Also for some countries, the consumption of fixed capital is not subtracted from the operating surpluses (DK, POR, SP, UK). Adjustments for these factors were made by referring back to the national I-O tables published by the national statistical offices. Where such publications are not available, estimates were made by extrapolating data from the OECD National Accounts.

3.2. The disaggregation of agricultural inputs and outputs

15. This proved to be the most difficult task in setting up the EEC database. Several data sources exist which can possibly provide such a disaggregation; the problem is that they are not consistent with the I-O tables.

16. The output side was disaggregated by using the Supply Utilisation Accounts (SUA) and producer prices published by the Food and Agriculture Organisation (FAO). These databases report for each agricultural product a supply-demand balance including trade, seed and feed uses, processing and industrial uses, food consumption and other uses. However, merging this information into the existing I-O framework raised further difficulties:

i) The allocation between final and intermediate expenditures does not correspond to the I-O table definitions. Consistency was imposed by using an iterative RAS procedure.

ii) The SUA are reported in metric tons. Aggregation over products was carried out using FAO data on producer prices for home-produced goods, f.o.b. prices for exports and c.i.f. prices for imports. These latter prices were derived from the FAO Trade Yearbooks.

iii) The FAO balance sheets refer to a given product level which may not match the product level implied by the I-O table. This gave rise to some discrepancies between trade figures. For example, the I-O output for bovine meat includes live animals for export or slaughter. The corresponding balance sheet, however, is expressed in terms of meat products. This makes little difference so far as domestic output is concerned. But while the I-O trade data refer only to live animals, the balance-sheet trade figures include fresh, chilled and frozen meats, canned and other prepared meats, etc. The solution adopted was to start with the supply-demand balance sheets and then to replace the trade figures by those extracted from the FAO Trade Yearbooks which refer only to the non-transformed products (grains, live animals, fresh fruits, vegetables and milk).

17. The input-side disaggregation of agriculture was based on data from the RICA network which was supplied to the OECD by the EEC Commission (5). These data relate to 1980/81 and cover six Member states (DEU, DK, FR, IT, NTH, UK). They are based on a sample of over 26 000 commercial holdings from a population of almost 2.5 million farms. The total output yielded by extrapolating the average output from the observed sample to the entire population accounts for 69.5 per cent of the actual total output for the six Member states in question. The remaining 30.5 per cent of agricultural output, however, is produced by farms, whose technology differs significantly

from those covered by the RICA sample. Once again, the solution adopted to incorporate these differences was to merge together the information from the RICA database and from the I-O tables using a RAS adjustment.

3.3. Adjustments to intermediate demand

18. In addition to these adjustments, the government sector was extracted from intermediate demand and treated as final consumption. This covers the following NACE-CLIO codes: general public services 91+92A+96A+97A; non-market services of education and research 93A+93B+94A+94B; non-market services of health 95A+95B; and non-market services n.e.c. 96B+97B+99.

3.4. Adjustments to final demand

19. Transition matrices linking the production and consumption classifications are available only for five EEC Member states (DK, DEU, FR, NTH, UK). The row sub-totals for the other three countries were computed by using data from the OECD National Accounts. Consistency between these sub-totals, the aggregated transition matrix and total household consumption from the aggregate I-O table was then achieved by using a RAS adjustment.

3.5. Adjustments to value-added

20. It was necessary to split the net operating surplus into labour and capital remuneration. This was based on the employment figures published in the OECD National Accounts, by imputing to the self-employed the same average wage rate as for employees.

21. As for the two agricultural sub-sectors, the RICA database produces estimates for hired labour, land and capital. Farm net value added is then calculated as the difference between the value of total output and the value of total expenditure including indirect taxes and subsidies. This net profit is finally imputed to land, capital and labour remuneration on the basis of the average returns to capital, land and average paid wages, respectively. These returns are also derived from the RICA database.

4. Japan

4.1. A brief description of the Japanese I-O tables

22. The most detailed I-O tables for 1980 consist of 541 rows and 406 columns. The Administrative Management Agency of the Government of Japan supplied the 164 x 164 tables to the OECD who aggregated them to match the specification of the WALRAS model. The output table, which shows the amount of goods and services produced by the row sectors and sold to the column sectors, was taken as the basis for the aggregation.

23. The inclusion of the item "consumption expenditure outside households", which is part of both value added and final demand in the Japanese I-O tables, represents a slight departure from the standardized I-O tables. These are expenditures which are similar to normal household outlays but are paid for by Japanese firms; they include social expenditures e.g. for sports, leisure activities and medical needs of employees. As a result of including these expenditures, gross domestic product in the I-O tables is 4 per cent higher than GDP as measured in the National Accounts.

24. The valuation of domestic outputs is at producers' market shipment prices. Since this valuation includes certain indirect taxes which increase selling prices, it is not possible to identify fully indirect taxes on commodity outputs. Subsidies are, however, excluded from this valuation.

4.2. Adjustments to intermediate demand

25. Government transactions are removed from the transaction matrix. However, identification of all government activities is not possible at the 164 x 164 level. For the purposes of this exercise, the following government activities are removed:

i) Public administration (industries 8101 and 8102);
ii) Part of Education (industry 8210);
iii) Part of Health and Social Insurance (industry 8250);
iv) Other public services (industry 8290).

4.3. Adjustments to final demand

a) Transition matrix for private consumption

26. The Japanese authorities were unable to provide the required 10-good split of private consumption consistent with the 13-sector industry classification. A breakdown of total private consumption is available from Volume II of the OECD National Accounts and submissions to the OECD Purchasing Power Parity Study for 1980. Data from the annual Japanese household expenditure survey enabled an initial matching of food consumption with individual industry outputs. For the other nine items of household consumption, an initial split by industry was obtained by imposing the pattern observed in the U.S. I-O data. Since many of the individual cells are zero, this procedure yielded a reasonable first allocation of the industrial origin of consumer goods. These manipulations resulted in an initial 13x10 matrix which was inconsistent (row totals did not add to the I-O industrial outputs bought by Japanese consumers in 1980). Consistency was then imposed on the row and column totals by using the iterative RAS procedure.

27. Since most of the expenditures of the "consumption outside households" item are for recreation, this column was allocated to the ninth private consumption category: "recreation, entertainment, education and cultural services".

b) Government expenditure

28. Government expenditures also include the columns and (negative) rows which were removed from the transaction matrix (see above).

4.4. Adjustments to value added

29. Returns to labour are equal to the sum of compensation of employees (which includes bonuses and other supplementary payments), consumption outside households and the operating surplus of private unincorporated enterprises. The latter are taken from Table IV.2 of the Japanese National Accounts, and is only split between agriculture, forestry and fishing on the one hand, and the remaining sectors on the other. In each of these two sub-sectors, the imputed wage income of the self-employed was in excess of the reported gross operating

surplus of unincorporated enterprises. Because of this, the operating surplus of unincorporated enterprises was allocated entirely to labour. The additional allocation to the thirteen WALRAS sectors is on the basis of value added.

30. Remuneration of capital is initially defined as the sum of the remainder of the operating surplus and depreciation of fixed capital. For the two agricultural subsectors, this initial capital income is further split between (final) capital and land remuneration, on the basis of land and non-land assets of farms on 1st April, 1980 (6).

5. New Zealand

5.1 A brief description of the New Zealand I-O tables

31. The New Zealand I-O tables for 1981-82 provide a disaggregation into only 25 industries (7). They are a first step towards publication of more detailed 128 x 128 inter-industry tables which have not yet been completed. Nevertheless, 128 x 128 inter-industry tables are available for 1976-77 and these were used to disaggregate the 25 x 25 tables available for 1981-82. The New Zealand tables do not provide a split of indirect taxes across industries in the transactions and final demand matrices; instead they are identified as a row in the matrix of primary inputs of industries and final demand.

5.2 Adjustments to intermediate transactions

32. In order to arrive at the required aggregation scheme, rows and columns for several industries in the 1981-82 tables were adjusted by assuming that ratios between industries on the more disaggregated 1976-77 basis had not changed. The following industries in the 25 x 25 sector tables required further disaggregation:

a) Industry 1 (agriculture)
b) Industry 5 (food, beverages and tobacco)
c) Industry 9 (chemicals, petroleum, rubber and plastics)
d) Industry 16 (trade, restaurants and hotels)
e) The rows and columns of the government sector (the two industries central and local government) were substracted and added respectively to the "government" column in the final demand sector.

5.3 Adjustments to final demand

a) The 10-good split of private consumption is not available even in the 1976-77 tables. Row totals of the initial breakdown of total consumption were obtained by using information in the submissions to the 1985 OECD Purchasing Power Parity Study and the 1981/82 New Zealand Household Expenditure and Income Surveys. Imports were allocated first. Their row totals enabled the determination of category totals for domestic consumption. Individual cells were filled for most categories using the detailed tables from the above-mentioned sources. For the allocation of wholesale and retail trade output among individual categories, no information is available and it was determined largely as the residual industry;

b) Government investment, which is included in total fixed investment, was reallocated to government expenditure taking National Accounts estimates for 1981/82.

5.4 Adjustments to value added

33. Remuneration of capital is initially defined as the sum of operating surplus and depreciation of capital. Income of the self-employed was subtracted from capital remuneration and added to compensation of employees. The imputed wage income of the self-employed was calculated by multiplying the numbers of self-employed by average compensation of employees. For the two agricultural subsectors the remaining capital income was further split between capital and land using a ratio of 0.5, in line with calculations made by the Directorate for Food, Agriculture and Fisheries.

6. United States

6.1. A brief description of the U.S. I-O tables

34. The most detailed I-O tables for 1981 contain 537 commodities and industries; an 85-sector summary was published in 1987 (8). The 1981 tables are partly based on the detailed tables for 1977, since the former incorporate more information derived from a quinquennial economic census. For the purposes of the WALRAS model database, the U.S. Department of Commerce aggregated the 6-digit industry tables according to the chosen aggregation schemes.

35. The published 1981 tables are incomplete on two counts. First, imports for intermediate and final demand components are not identified. For our purposes the Department of Commerce estimated import flows at the 6-digit level on the assumption that the ratio of total imports to the sum of intermediate and final demand for a given commodity was identical in each 6-digit industry. The import matrices were then re-aggregated to our 13-industry classification. Second, value added is not split into its components; this problem is discussed in Section 6.4 below.

36. The U.S. tables are on a GNP basis, and contain five special industries. For our purposes, three of these industries were eliminated. One of these is "rest of the world industry" (9); its omission changed the I-O data base to a GDP basis, thereby aligning the U.S. model with the accounting base used for the other countries/regions of the WALRAS model.

6.2. Adjustments to intermediate demand

37. A fourth special industry, "scrap", was included under the industry "other manufacturing". The final special industry, "government industry", as well as Federal, State and Local enterprises (industries 78 and 79 in the 85-sector tables) was removed from the intermediate transactions matrix and re-allocated to final demand. This enables the government wage bill to be identified once only, as a component of value added which enters final demand directly.

6.3. Adjustments to final demand

a) Private consumption

38 Eliminating the "rest of world" industry resulted in I-O private consumption being less than the published total for personal consumption spending, since the item "foreign travel and other" was excluded.

b) Government expenditure

39. The columns and rows of the government sectors which were removed from the transactions matrix were added to and subtracted from the final demand column "government expenditure".

c) Change in stocks

40. The removal of the special industry "inventory valuation adjustment" changed the valuation of inventory change to that at book values.

6.4. Creation of a value-added matrix

41. As noted above, the 1981 I-O tables only give total value added in each of the thirteen industries. The Commerce Department's National Income and Product Accounts (NIPA) provide a breakdown of value added (10). For the more important components, there is a relatively detailed sectoral breakdown of each item. Where the sectoral split was inadequate for our purposes, the share of I-O value added in the sector was taken. (This was the case mainly within the two agricultural subsectors and within the food processing industries.) The initial split of value added was as follows:

Value-added component	Basis for sectoral split (National Accounts table numbers)
Compensation of employees	Table 6.4B
Proprietors' income	Tables 1.14 and 6.14B
Rental income of persons	1981 I-O value added
Corporation profits	Table 6.19B
Net interest	Table 6.17B
Capital consumption allowances	Tables 6.15B and 6.24B
Indirect business taxes	The 1977 I-O tables
Subsidies	The 1977 I-O tables
Total GNP (NIPA)	

42. The initial sectoral split was for the 13 industries plus the rest of the world transactions (which are important in corporation profits and net interest). Once these transactions were removed and allowance was made for the other two special industries of the I-O tables which were excluded, the resulting GDP total was very close to that measured in the I-O tables. The remaining discrepancy, which mainly reflects data revisions since the 1981 National Accounts were prepared, was allocated to capital consumption allowances (11). This gave an 8x13 matrix where the row totals (i.e the I-O sectoral split of value added) equalled the column totals (i.e. the adjusted NIPA split of GNP). The RAS procedure was used to ensure that all rows and columns added to their respective totals.

43. The eight rows of the above matrix were then put into their final form as follows:

Return to labour	Compensation of employees Part of Proprietors' income
Return to capital	Part of Proprietors' income Rental income Corporation profits Net interest Capital consumption allowances
Indirect business taxes (less) subsidies	Indirect taxes Subsidies

Proprietors' income was split between labour and capital on the assumption that an average proprietor's wage income is equal to the average income earned by a wage-earner in the sector.

44. Finally, for the two agricultural sub-sectors, the return to capital was further divided between capital and land, on the basis of the share of non-land and land assets of the farm business sector in total tangible assets (12).

NOTES

1. Australian Bureau of Statistics (1987), Australian National Accounts, Input-Output Tables 1979-80 and 1980-81, Canberra, Australia.

2. The correspondence between the two agricultural sectors in the WALRAS model and the eight agricultural industries of the ORANI model was made on the basis of Table 28.1 from Dixon P.B., B.R. Parmeter, J. Sutton and D.P. Vincent (1982), ORANI: A Multisectoral Model of the Australian Economy, North-Holland, Amsterdam.

3. Statistics Canada (1982), The Input-Output Structure of the Canadian Economy, Catalogue No. 15-201 (April).

4. EUROSTAT (1986), National Accounts ESA, Input-Output tables 1980, Luxembourg.

5. Commission of the European Communities (1986), The Farm Accountancy Data Network: Farm Accounts Results 1982/83-1983/84.

6. See Ministry of Agriculture, Forestry and Fisheries (1985), Abstract of Statistics on Agriculture, Forestry and Fisheries, Tokyo, Table 2.(1).g.

7. Department of Statistics (1984), Provisional New Zealand Input-Output Tables 1981-1982, Wellington, (November).

8. See U.S. Department of Commerce (1987), Survey of Current Business, Washington, D.C. (January).

9. The other two industries which were eliminated are "Household industry" and "Inventory valuation adjustment".

10. U.S. Department of Commerce (1986), The National Income and Product Accounts of the United States, 1929-1982, Statistical Tables, Washington, D.C. (September).

11. Due to the incorporation of more recent information, 1981 GNP in the I-O tables is $3.6 billion higher than the total in the NIPA.

12. The data source is the Board of Governors of the Federal Reserve System (1987), Balance Sheets for the U.S. Economy, 1947-86, Distribution of Tangible Assets by Sector, p. 10, Washington, D.C. (May).

BIBLIOGRAPHY

Armington, P. (1969), "A theory of demand for products distinguished by place of production", IMF Staff Papers, 16(1), pp. 159-78.

BAE (1985), "Agricultural policies in the European Community: their origins, nature and effects on production and trade", Policy Monograph No. 2, Bureau of Agricultural Economics, Canberra.

Brown, D.K. (1987), "Tariffs, the terms of trade and natural product differentiation", Journal of Policy Modelling (Autumn), pp. 503-526.

Burniaux, Jean-Marc, François Delorme, Ian Lienert, John P. Martin and Peter Hoeller (1988), "Quantifying the economy-wide effects of agricultural policies: a general equilibrium approach", OECD Department of Economics and Statistics, Working Paper No. 55 (July).

Christensen, L.R., D.W. Jorgenson and L.J. Lau (1975), "Transcendental logarithmic utility functions", American Economic Review, Vol. 65, pp. 367-83.

Deaton, A. and J. Muellbauer (1980), Economics and Consumer Behaviour, Cambridge University Press, Cambridge.

Deaton, A. and J. Muellbauer (1980a), "An almost ideal demand system", American Economic Review, Vol. 70, pp. 312-26.

Delorme, F., and D. van der Mensbrugghe (1989), "Agricultural trade liberalisation under imperfect competition: the Canadian case", OECD Economic Studies, No. 13, pp. 205-236.

de Melo, J. and S. Robinson (1985), "Product differentiation and trade dependence of the domestic price system in computable general equilibrium trade models", (Peeters, T, P. Praet and P. Reding, eds.), International Trade and Exchange Rates in the Late Eighties, North Holland, Amsterdam.

de Melo, J. and S. Robinson (1988), "The treatment of product differentiation and its implications for the foreign trade sector in computable general equilibrium models of small economies", World Bank (March), (mimeo).

Dervis, K., J. de Melo and S. Robinson (1982), General equilibrium models for development policy, A World Bank Research Publication, Cambridge University Press.

Dixon, P.B., B.R. Parmenter, J. Sutton and D.P. Vincent (1982), ORANI: a multisectoral model of the Australian economy, North-Holland, Amsterdam.

Harris, R.G. (1988), "Alternative solution methods in applied general equilibrium analysis", OECD Department of Economics and Statistics, Working Paper No. 53 (April).

Hassan, Z.A. and S.R. Johnson (1976), "Consumer demand for major foods in Canada", Agriculture Canada, Economics Branch Publication No. 76/2, Ottawa (April).

Hassan, Z.A. and W.F. Lu (1974), "Food consumption patterns in Canada", Agriculture Canada, Economics Branch Publication No. 74/8, Ottawa.

IIASA (International Institute for Applied Systems Analysis) (1988): Fischer, G., K. Frohberg, M.A. Keyzer and K.S. Parikh, Linked national models: a tool for international food policy analysis, Kluwer Academic Publishers, Dordrecht.

INSEE (1983), "La consommation des ménages à moyen terme", Archives et Documents, No. 92, France.

Lienert, I. (1989), "Quantifying agricultural policies in the WALRAS model", OECD Economic Studies, No. 13, pp. 103-130.

Martin, J.P., J.M. Burniaux, F. Delorme, I. Lienert and D. van der Mensbrugghe (1989), "Economy-wide effects of agricultural policies in OECD countries", OECD Economic Studies, No. 13, pp. 131-172.

McDougall, R. (1988), "The elasticity of transformation between domestically absorbed and exported products: some issues in applied economic modelling", Industries Assistance Commission, Canberra (mimeo).

McKee, M.J., J.J.C. Visser and P.G. Saunders (1986), "Marginal tax rates on the use of labour and capital in oecd countries", OECD Economic Studies (autumn), pp. 45-101.

Pagan, A.R., and J.H. Shannon (1987), "How reliable are ORANI conclusions?", Economic Record, (March), pp. 33-45.

Parikh, K.S.G., K. Frohberg and O. Gulbrandsen (1986), Towards Free Trade in Agriculture, IIASA, Laxenburg, Austria.

Powell, A.A. (1985), "Short-run applications of ORANI: an IMPACT project perspective", Australian Economic Papers, (June), pp. 37-53.

Remier, E.W. and S.N. Kulshreshtha (1974), "Forecasting livestock production and feed grains demand: an econometric analysis of canadian livestock feed grains sector", Technical Bulletin No. 74-04, Department of Agricultural Economics, University of Saskatchewan, Saskatoon (February).

Tryfos, P. and N. Tryphonopoulos (1973), "Consumer demand for meat in Canada", American Journal of Agricultural Economics (November), pp. 647-652.

van der Mensbrugghe, D., J.P. Martin and J.M. Burniaux (1989), "How robust are WALRAS results?", OECD Economic Studies, No. 13, pp. 173-204.

20.7.90

ECONOMIC AND STATISTICS DEPARTMENT

WORKING PAPERS

In April 1983, the Economics and Statistics Department initiated a new series of economic studies entitled ESD Working Papers.

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   Substitution du capital, de l'énergie et du travail : le bloc de l'offre dans les modèles à moyen terme de l'OCDE (épuisé)

   Patrick Artus

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   Formation des salaires en France : aspects sectoriels (épuisé)

   Patrick Artus

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   Durée de vie utile des actifs fixes (épuisé)

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Flemming Larsen and John Llewellyn

9. Medium-Term Financial Strategy: The Co-ordination of Fiscal Monetary Policy (out of print)
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Peter Hill

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