HORTUS
Modelling HORTicultural Use and Supply

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This report describes the economics and data structure of the HORTUS partial equilibrium supply and demand model developed at LEI. HORTUS can be used to simulate the effects of policy changes and exogenous changes in costs, production and consumer trends on the production, trade and consumption patterns of vegetables and fruits in the Netherlands and other European countries. The report demonstrates the use and working of the model by means of two simulations: (1) a general reduction of import tariffs in the EU and (2) a rise in heating gas prices in the Netherlands.

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Preface

This study outlines HORTUS, an applied partial equilibrium model for European horticulture. HORTUS is developed as one of the building stones of the Baseline scenarios developed at LEI. HORTUS enables LEI to make projections of future developments of Dutch and European horticulture. HORTUS may also be used to calculate policy implications of changes in policy variables such as import barriers, energy taxes and so on. Frank Bunte developed the model and constructed the database in co-operation with Michiel van Galen. The study has been guided by Nico de Groot, Andrzej Tabeau and Hans van Meijl. Boudewijn Koole and Marcel Kornelis assisted Frank and Michiel with the data analysis.

Prof. Dr L.C Zachariasse
Director General LEI B.V.

Summary

This study makes a first step in developing an applied partial equilibrium model for European horticulture: HORTUS. The model outlined in this study is made up of three elements:

1. A set of behavioural equations, more specifically:
    - consumer demand for fruits, vegetables and ornamentals;
    - food industry demand for fruits and vegetables;
    - producer demand for intermediary inputs, land, labour and capital;
    - producer supply of fruits, vegetables and ornamentals;
2. A market clearing condition equating demand and supply of fruits, vegetables and ornamentals.
3. A database relating production, trade and consumption of fruits, vegetables and ornamentals. More specifically the database contains:
    - supply balance sheets, in tonnes, relating production, imports, exports, human consumption and other uses for every product and region identified (Table 1);
    - bilateral trade data consistent with aggregate imports and exports from the supply balance sheets;
    - producer and export prices. At this stage, only export prices are used in the model;
    - cost shares of intermediary inputs, labour and capital and land use for every product and region identified.

    Most data are acquired from FAO, WTO/ITC and Eurostat.

HORTUS specifies supply and demand for six fruits, five vegetables and two ornamentals for twenty-seven regions: the EU25, Morocco, Turkey and the Rest of the World. Morocco and Turkey are modelled for illustrative reasons, since trade relations with Mediterranean countries are expected to be an interesting policy area in the near future (Table 1). Further extension of the model with new countries and products is relatively straightforward. Whether such extensions are meaningful depends on future demand for research.

Table 1 Product, country and inputs choice

Vegetables	Fruit	Ornamentals	Countries	Inputs
Cucumbers	Apples	Ornamental flowers	EU-25	Land (area)
Onions	Bananas	Nursery plants	Morocco	Intermediary inputs
Sweet peppers	Citrus		Turkey	Labour
Tomatoes	Grapes		Rest of the World	Capital
Other vegetables	Pears			
	Other fruit			

HORTUS may be used to study the impact of changes in the environment of the horticultural supply on the key economic variables in the supply chain. The environmental (exogenous) variables modelled in HORTUS are given in Table 2 together with the key economic (endogenous) variables. HORTUS may be used to determine the policy implications of changes in environmental variables that may be influenced by public policy and enterprise strategy, e.g. import tariffs, energy taxes.

HORTUS will be used as a building stone of the Baseline scenario framework developed at LEI. The Baseline scenario generates a projection of the future development of Dutch agriculture and horticulture and the impact of major policy and environmental changes on these projections.

HORTUS may be further developed and improved by extending and improving the underlying database and structural model. Underdeveloped in the HORTUS model are the following issues:

- the price structure is weakly developed, since HORTUS only defines export prices. Producer prices, market prices, import prices and consumer prices are not incorporated in the model as yet (see section 3.2). This does not invalidate the model as such, since the model is built on a consistent set of supply balances in tonnes and primarily depends on reasonable estimates of price, income and substitution elasticities;
- in the current version of the model the price, income and substitution elasticities are simply chosen based on literature research and researchers' common sense. Further literature study and empirical research may be used to improve these estimates. This does not invalidate the current model, since sensitivity analyses are relatively straightforward.

The quality of the data may be improved by relating information from the supply balance sheets with information from other sources, notably information on consumer and industrial buying behaviour. The data on ornamentals require thorough investigating. The best way to guarantee the quality of the data required is co-operation within a consortium.

Table 2 Exogenous and endogenous variables

Exogenous variables	Endogenous variables
Prices endowments and intermediary inputs	Product prices on the following levels: production, market, exports, imports and consumption
Population	Production
Income per capita	Bilateral trade
Technological growth	Demand for land endowments and intermediary inputs
Taxes and subsidies on consumption, imports, exports and production	Consumption and industrial use
International transport costs	
Total acreage available for horticulture	

This study also presents the results of two simulations. In the first simulation European import barriers on fruits and vegetables are reduced with 5.5% in%ages of import prices. The simulation shows that trade liberalisation has a large impact on European fruit production and trade. EU fruit production and exports are likely to fall substantially. European vegetable production and exports are relatively sheltered and are likely to benefit from the decline in EU fruit production. In Europe, horticultural land use will shift from tropical fruits to native fruits and vegetables. Export oriented countries such as Spain (bananas and citrus) and France and the Netherlands (apples) face relatively high adjustment costs in terms of shifts in production. Countries whose production depends on export to Europe (Morocco for citrus and tomatoes) are likely to benefit most. The European landscape is also likely to benefit. Horticultural production becomes less labour and capital intensive.

The second simulation elaborates on the effects of a rise in energy costs for Dutch glasshouse horticultural producers. The results indicate that a ten% increase in energy prices could cause significant shifts in production and trade flows. In our partial equilibrium model demand for labour and capital in the effected sectors drops significantly. Due to a substitution effect away from energy intensive crops, glasshouse horticulture would in our short run closure, be more than proportionally affected. Glasshouse vegetables are much more affected than ornamental flowers, because of their energy-intensity. Consumption patterns in the Netherlands and Europe are also likely to respond to changing prices.

1. Introduction

For agriculture, several general and partial equilibrium models have been constructed in the post-war period in order to determine the impact of changes in exogenous variables (e.g. agricultural and trade policy) on agricultural production, consumption and trade. For horticulture, however, there are not many economic models relating the production, consumption and trade of horticultural products to exogenous variables. There are some partial equilibrium models for specific products, such as bananas. However, there are no economic models available, which consider the production and trade of horticultural products in Europe and beyond interdependently. There are several reasons why an economic simulation model for horticultural products might be a useful addition to the agricultural models available. (1) The economic importance of horticultural production and processing grows, especially in the Netherlands. (2) Horticultural production and trade have a major impact on the environment and consequently are subject to environmental policies, e.g. with respect to energy, water and pesticides. Developments in the environment and environmental policies may have major consequences for the division of horticultural production and trade in Europe and beyond. (3) The European Union (EU) is enlarged in 2004 with ten Central and Southern-European countries. Further enlargement and trade liberalisation is foreseen in 2007 and beyond. More in particular, trade liberalisation is foreseen between the EU and the non-EU Mediterranean countries. This might have major consequences for European horticulture, since the Mediterranean is suited for horticultural production, both in Europe, the Middle East and North Africa.

In order to gain insight in the quantitative impact of changes in exogenous variables on horticultural production and trade, we need an empirically validated supply and demand model for horticultural products. This report makes a first step in the construction of such a model. We named the first version of our model HORTUS: HORTicultural Use and Supply. This report accounts for the assumptions made in constructing the model. The account refers to four elements:

- the supply and demand relations used;
- the relation between production, consumption and trade,
- the relation between different price levels in the supply chain; and
- the data employed.

The report ends with a presentation of preliminary results of simulations made on basis of the model and a research agenda.

HORTUS refers to all horticultural products: fruits, vegetables and ornamentals. These three categories are subdivided in more specific product categories, such as apples, tomatoes and cut flowers. Due to data availability, subdivision in more specific product categories is easier for fruits and vegetables than it is for ornamentals. HORTUS refers to all 25 EU-member states and two major non-EU Mediterranean countries: Turkey and Morocco. The latter two are included for illustrative reasons. All other countries are combined in one geographic region: Rest Of the World.

The report is constructed as follows. Chapter 2 derives the demand and supply relations employed in the model. Chapter 3 outlines the economic structure: (i) the relation between production, trade, consumption and other uses, and (ii) the relation between the prices in the supply chain. Chapter 4 indicates what data are used and how they are adapted in order to make them fit for the model. Chapter 5 presents some preliminary results. Chapter 6 concludes and presents a research agenda.

2. Supply and demand

This chapter lays down the demand and supply relations used in HORTUS. The demand and supply relations are derived from utility and production functions. One may guarantee economic consistency by relating demand and supply relations to utility and production functions. At the end of this chapter, we pay attention to matching supply and demand, i.e. market equilibrium.

2.1 Demand

The demand for individual commodities is determined using nested CES functions (Figure 2.1). Demand for all commodities within the nest is determined as a function of the nest's budget share and the prices of all commodities with the nest. The prices of all other commodities only effect demand in as far as they determine the nest's budget share. The aggregate price of fruits determines the budget share of fruits and vegetables. The price of Spanish tomatoes determines the budget share of Spanish versus Dutch tomatoes in Germany, but also the aggregate price of imported tomatoes in Germany. The price of Spanish tomatoes effects aggregate tomatoes imports in Germany only indirectly (by influencing the aggregate import price for tomatoes in Germany). There is a fixed budget for fruits and vegetables. Demand substitution between fruits and vegetables on one hand and all other commodities on the other hand will be considered in a later stage. Demand substitution between ornamentals on one hand and all other commodities on the other hand will also considered in a later stage. For the moment, we restrict our attention to the demand for fruits and vegetables on one hand and ornamentals on the other hand. The demand for processed products is neglected for the moment.

Since the demand for product groups and products are determined by CES functions, we derive demand only once. The CES function reads as follows:

$$Y = A\left(\sum_{i=1}^{N} \delta_i y_i^{\alpha}\right)^{1/\alpha} \tag{2.1}$$

Y represents the demand for the product group and y_i the demand for the individual commodities, where $Y = \sum y_i$. A, α and δ_i are parameters where $\sum \delta_i = 1$. Parameter α is related to the elasticity of substitution: $\sigma = 1/(1-\alpha)$. The utility maximisation problem for a nest is defined as follows:

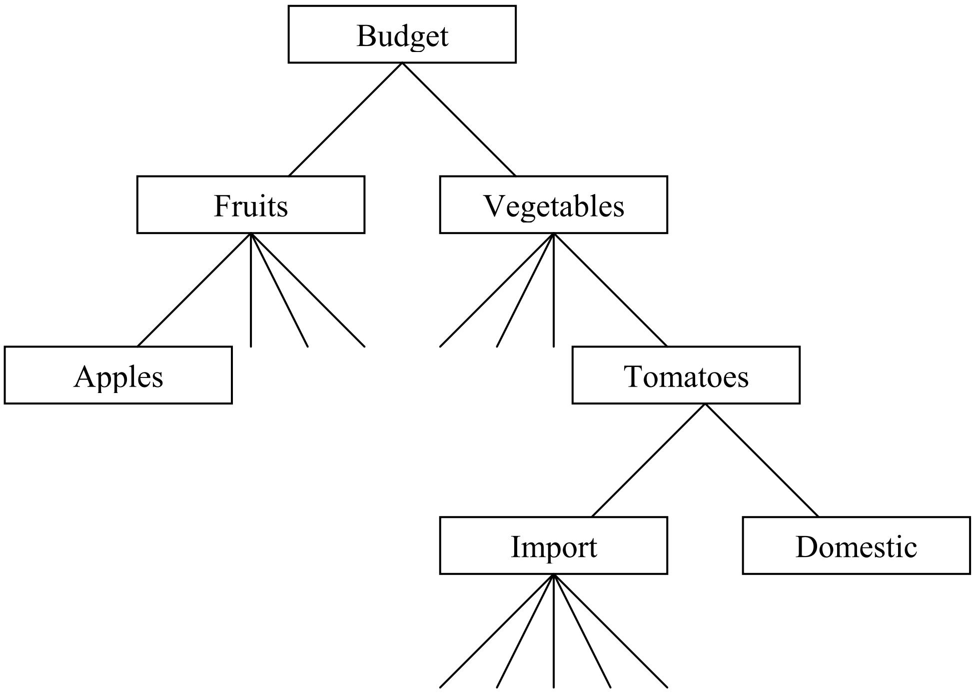

Figure 2.1 Demand structure

$$L = A\left(\sum_{i=1}^{N} \delta_i y_i^{\alpha}\right)^{1/\alpha} - \lambda\left(\sum_{i=1}^{N} p_i y_i - I\right) \tag{2.2}$$

where I indicates the budget and p_i commodity i's price. Utility maximisation gives the following first order condition.

$$\delta_i A\left(Y / y_i\right)^{1-\alpha} = \lambda\, p_i \tag{2.3}$$

Rewriting the first order condition as a function of y_i and substituting y_i in the budget constraint, enables one to rewrite λ as a function of income and prices. Substituting λ back into the first order condition enables one to derive commodity demand as a function of income and prices:

$$y_i = \frac{\delta_i^{\sigma} I}{p_i^{\sigma}\, \boldsymbol{p}^{1-\sigma}} \tag{2.4}$$

where $\boldsymbol{p} = \left(\sum_{i=1}^{N} \delta_i^{\sigma}\, p_i^{1-\sigma}\right)^{1/(1-\sigma)}$ represents the price index of Y. Equation (4) may be linearised by determining the total differential of the equation.

$$d\,y_i = \frac{y_i}{I}\,dI - \sigma\frac{y_i}{p_i}\,d\,p_i + (\sigma - 1)\frac{y_i}{\boldsymbol{p}}\,d\boldsymbol{p} \tag{2.5}$$

Dividing by y_i simplifies equation (5) to

$$\bar{y}_i = \bar{i} - \bar{\boldsymbol{p}} + \sigma\left(\bar{\boldsymbol{p}} - \bar{p}_i\right) \tag{2.6}$$

where the 'upper bar' denotes%age changes.

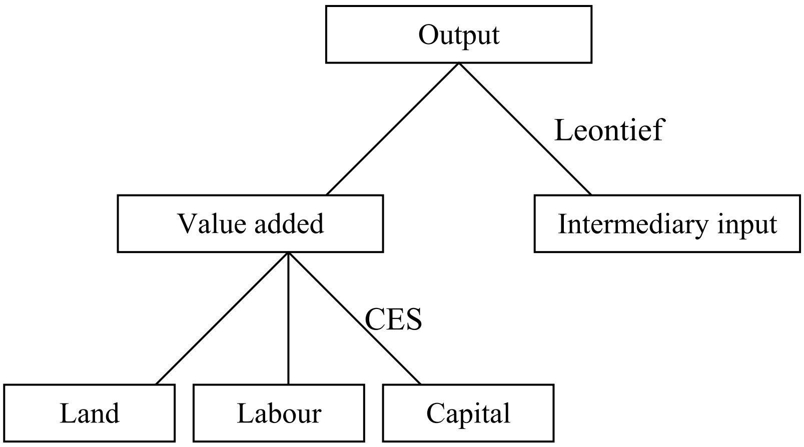

Figure 2.2 Supply structure

2.2 Supply

The production of each commodity j depends on the input of land, labour, capital and intermediary inputs (Figure 2.2). Following GTAP, we assume a Leontief relation between intermediary inputs on one hand and land, labour and capital on the other hand. The Leontief relation allows us to neglect intermediary inputs for the moment: there is simply a linear relation between production and intermediary inputs. The relation between the three production factors and output is modelled using a CES production function. Land is more or less a fixed factor whose input is combined with the input of labour and capital. The CES function employed is the following:

$$y_j = \left(\gamma_{haj} ha_j^{\varphi} + \sum_{i=1}^{M} \gamma_{ij} x_{ij}^{\varphi}\right)^{1/\varphi} \tag{2.7}$$

where y_j denotes output of commodity j, ha_j acreage employed in the production of commodity j; x_{ij} refers to the quantity of input i used in the production of commodity j; and γ_{ij} and φ are parameters. The elasticity of substitution τ is a function of φ: $\tau = 1/(1-\varphi)$. Acreage is modelled separately from the other inputs, because total acreage available for agricultural (horticultural) uses is more or less fixed and depends - among other things - on government decisions with respect to rural planning.

A representative producer decides on inputs and outputs using cost minimisation and profit maximisation objectives.

$$\max \Pi\left(y_j, ha_j, x_{ij}\right) = \sum_{j=1}^{M} p_j y_j - \sum_{j=1}^{M}\sum_{i=2}^{N} w_i x_{ij} - \mu\left(\sum_{j=1}^{M} ha_j - HA\right) \qquad (2.8)$$

Producer profits equal revenues: price times quantity (over j commodities) minus costs: input prices w times input quantities (over all j commodities and all i inputs). Finally profits depend on one physical constraint: the availability of land for horticultural uses. Profits may be maximised using a three step procedure: (1) deciding on non-land inputs by minimising costs; (2) deciding on output by maximising profits; and (3) deciding on acreage given short run output and price decisions.

Input demand

The cost minimisation problem is modelled as follows:

$$\min C\left(x_{ij}\right) = \sum_{j=1}^{M}\sum_{i=2}^{N} w_i x_{ij} - \lambda\left(\sum_{j=1}^{M}\left(\left(\gamma_{haj} ha_j^{\varphi} + \sum_{i=2}^{N} \gamma_{ij} x_{ij}^{\varphi}\right)^{1/\varphi} - y_j\right)\right) \qquad (2.9)$$

where C represents non-land production costs. The first order condition of the optimisation problem equals:

$$w_i = \lambda \gamma_{ij}\left(y_j / x_{ij}\right)^{1-\varphi} \qquad (2.10)$$

Rewriting the first order condition as a function of x_{ij} and substituting x_{ij} in the production function gives an expression for λ. Substituting λ back into the first order condition gives:

$$x_{ij} = y_j \left(\frac{\gamma_{ij} \mathbf{w_j}}{w_i}\right)^{\tau} \left(1 - \frac{MP_j}{AP_j}\right)^{1/\varphi} \qquad (2.11)$$

where $\mathbf{w_j} = \left(\sum_{i=2}^{N} \gamma_{ij}^{\tau} w_i^{1-\tau}\right)^{1/(1-\tau)}$ represents the aggregate input price for commodity j.

The demand for input i for the production of commodity j depends on the production of commodity j (y_j), the price of input i (w_i) versus the aggregate input price ($\mathbf{w_j}$) and the returns to non-land factor inputs $\frac{MP_{haj}}{AP_{haj}} = \gamma_{haj}\left(\frac{ha_j}{y_j}\right)^{\varphi}$, where MP_{haj} denotes the marginal product of land for commodity j and AP_{haj} the average product of land for commodity j, i.e. the yield for commodity j.

In a linearised form the demand for factor inputs transforms to:

$$\mathrm{d}\,x_{ij} = \frac{x_{ij}}{y_j}\mathrm{d}\,y_j + \tau\frac{x_{ij}}{\mathbf{w_j}}\mathrm{d}\,\mathbf{w_j} - \tau\frac{x_{ij}}{w_i}\mathrm{d}\,w_i - \left(\frac{MP_{haj}/AP_{haj}}{1 - MP_{haj}/AP_{haj}}\right)\frac{x_{ij}}{ha_j}\mathrm{d}\,ha_j + \left(\frac{MP_{haj}/AP_{haj}}{1 - MP_{haj}/AP_{haj}}\right)\frac{x_{ij}}{y_j}\mathrm{d}\,y_j$$

or

$$\overline{x_{ij}} = \overline{y_j} + \tau\left(\overline{\mathbf{w_j}} - \overline{w_i}\right) + \pi_j\left(\overline{y_j} - \overline{ha_j}\right). \qquad (2.12)$$

where $\pi_j = \left(\frac{MP_{haj}/AP_{haj}}{1 - MP_{haj}/AP_{haj}}\right)$. The last term on the right hand side models diminishing returns to labour and capital.[1] If output is to increase more than acreage input $\left(\overline{y_j} > \overline{ha_j}\right)$, labour and capital input should increase with a factor $\left(\pi_j\left(\overline{y_j} - \overline{ha_j}\right)\right)$ above the output increase $\left(\overline{y_j}\right)$.

Supply

One may derive short-run output y_j (or equivalently short-run price p_j) as a function of equilibrium inputs x_{ij} by substituting x_{ij} into the profit function (equation (2.9)) and maximising this function towards y_j.

$$\max\Pi\left(y_j\right) = \sum_{j=1}^{M} p_j y_j - \sum_{j=1}^{M}\sum_{i=2}^{N} w_i x_{ij} \qquad (2.13)$$

The first order derivative equals

$$\frac{\partial\Pi}{\partial y_j} = p_j - \sum_{i=2}^{N} w_i \frac{\partial x_{ij}}{\partial y_j} = 0 \Leftrightarrow$$

$$p_j = \mathbf{w_j}\left[1 - \frac{MP_{haj}}{AP_{haj}}\right]^{1/\varphi} \qquad (2.14)$$

using equation (2.12). The supply price p_j depends on aggregate input costs $\mathbf{w_j}$ and diminishing returns to capital and labour input given acreage. Linearising this function gives the short-run inverse supply function:

[1] Note that π_j is only positive when returns are in fact increasing: $MP_j < AP_j$. Note also that π_j is endogenous, since it depends on y_j and ha_j.

$$\overline{p_j} = \overline{\mathbf{w_j}} + \pi_j\left(\overline{y_j} - \overline{ha_j}\right) \tag{2.15}$$

Acreage
The last optimisation problem refers to acreage input: how does the producer divide available acreage over the respective commodities to be produced. This problem is solved by maximising the profit maximisation problem:

$$\max \Pi\left(ha_j\right) = \sum_{j=1}^{M} p_j y_j - \sum_{j=1}^{M}\sum_{i=2}^{N} w_i x_{ij} - \mu\left(\sum_{j=1}^{M} ha_j - HA\right) \tag{2.16}$$

The first order condition is as follows:

$$\frac{\partial \Pi\left(ha_j\right)}{\partial ha_j} = \sum_{j=1}^{M} \frac{\partial p_j y_j}{\partial ha_j} - \sum_{j=1}^{M}\sum_{i=2}^{N} \frac{\partial w_i x_{ij}}{\partial x_{ij}} \frac{\partial x_{ij}}{\partial ha_j} - \mu\left(\sum_{j=1}^{M} ha_j - HA\right) \tag{2.17}$$

Since $\partial w_i x_{ij}/\partial x_{ij} = 0$ due to the first order condition in the cost minimisation problem, this expression reduces to

$$\frac{\partial \Pi\left(ha_j\right)}{\partial ha_j} = \sum_{j=1}^{M} \frac{\partial p_j y_j}{\partial ha_j} - \mu\left(\sum_{j=1}^{M} ha_j - HA\right) \tag{2.18}$$

The first order condition thus equals:

$$p_j \gamma_{haj}\left(y_j / ha_j\right)^{1-\varphi} = \mu \tag{2.19}$$

Rewriting the first order condition as a function of ha_j and substituting ha_j in the production function gives an expression for μ. Substituting μ back into the first order condition gives:

$$ha_j = \frac{HA\, y_j\left(\gamma_{haj} p_j\right)^{1/(1-\varphi)}}{\left(\sum_{j=1}^{M}\left(y_j\left(\gamma_{haj} p_j\right)^{1/(1-\varphi)}\right)\right)} \tag{2.20}$$

One may linearise this equation to the following equation:

$$d\,ha_j = \frac{ha_j}{HA} dHA + \frac{ha_j}{y_j}\left[1 - \frac{ha_j}{HA}\right] d\,y_j + \tau \frac{ha_j}{p_j}\left[1 - \frac{ha_j}{HA}\right] d\,p_j - \sum_{k \neq j}^{M-1}\left(ha_j \frac{ha_k}{HA\, y_k} d\,y_k\right) - \sum_{k \neq j}^{M-1}\left(\tau ha_j \frac{ha_k}{HA\, p_k} d\,p_k\right)$$

or

$$\overline{ha}_j = \overline{HA} + [1 - s_j]\overline{y}_j + \tau[1 - s_j]\overline{p}_j - \sum_{k \neq j}^{M-1}\left(s_k \overline{y}_k\right) - \sum_{k \neq j}^{M-1}\left(\tau s_k \overline{p}_k\right) \tag{2.21}$$

where $s_j = ha_j/HA$ denotes the share of the land used for commodity j divided by all land available. Acreage available for commodity j depends positively on total acreage (HA) and the output and price of commodity j (y_j and p_j respectively) and the output and price of all other commodities k (y_k and p_k respectively).

3. Economic structure

This chapter presents the economic used in structure in HORTUS. Section 3.1 relates production and international trade to consumption and other uses. The economic structure is explained in terms of commodity balances, supply and use and ultimately input-output tables. Although the HORTUS model does not yet employ a full scale input-output structure it is nevertheless a useful way to discuss the economic relations in a multi-sector, multi-country model. Section 3.2 relates prices at the various stages of the supply chain to each other. The price relations make it possible to model changes in taxes and subsidies, and discern between prices at e.g. a consumer level and producer level.

3.1 Economic structure

The economic structure in HORTUS is based on commodity balances. Commodity balances are the most simple economic framework relating supply and use of a certain product in a certain country. Supply S in region r equals the sum of domestic production P and imports M.[1] Domestic use U equals the difference of supply S and exports X.[2] Domestic use U may be subdivided in human consumption C, processing I and other uses O (feed, seed, industrial use and other uses not else specified). In an equation:

$$P+M = S = X+U = X+C+I+O. \qquad (3.1)$$

Table 3.1 below shows commodity balances for tomatoes, for the EU-15 countries minus Luxemburg. HORTUS identifies quantities on the one hand and values and prices on the other hand. Note that the commodity balances are constructed on basis of quantities. Information on prices is added in a later stage to arrive at an economic structure in terms of monetary values.

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[1] Full scale supply tables relate the domestic supply of each product to each industry, recognizing the fact that some industries might produce more than one product and some products are produced by more than one industry.

[2] A full scale use table indicates the use of all goods and services by product and type of use: intermediate consumption by industry, final consumption by consumers and government, gross capital formation and exports. The use table also presents the elements of value added by industry.

Table 3.1 Commodity balances for fresh tomatoes (in tonnes)

	Production	Imports	Supply	Export	Domestic use	Consumption	Processing	Other uses	Consumption per capita
Belgium	315,503	49,450	364,953	174,975	189,978	161,973	7,847	20,158	15.3
Denmark	21,238	109,971	131,209	11,716	119,493	119,943	0	0	22.6
Germany	37,000	649,000	686,000	12,000	674,000	607,000	0	67,000	7.4
Greece	1,899,100	6,330	1,905,430	7,500	1,897,930	677,630	1,220,300	0	64.5
Spain	3,510,700	7,400	3,518,100	895,900	2,622,200	597,900	1,390,000	634,300	15.2
France	899,000	383,000	1,282,000	91,000	1,191,000	774,000	328,000	89,000	13.2
Ireland	7,000	15,000	22,000	1,000	21,000	20,000	0	1,000	5.4
Italy	5,977,000	38,000	6,013,000	126,000	5,889,000	1,525,000	4,352,000	12,000	26.5
Netherlands	510,000	168,000	678,000	636,000	42,000	42,000	0	0	2.7
Austria	16,900	49,100	66,000	2,100	63,900	57,300	0	6,600	7.1
Portugal	1,130,000	15,000	1,145,000	4,000	1,141,000	67,000	988,000	86,000	6.7
Finland	31,500	28,600	60,100	300	59,800	59,800	0	0	12.0
Sweden	23,900	65,100	89,000	700	88,300	69,400	0	18,900	7.9
UK	119,300	287,000	406,300	4,000	402,300	400,300	0	2,000	6.8

Source: Eurostat (2000).

In a later stage input-output data may be used as an input for HORTUS. Input-output tables comprise both use and supply tables (Table 3.2). Use tables identify all intermediary and final uses (expenditures in monetary terms) of a product or commodity: intermediary consumption (a1), exports (a2), final consumption (a3) - e.g. consumption, processing, feed, seed, industrial use - and gross capital formation (a4). Supply tables identify the production structure of a product: what inputs - intermediary inputs (b1 = a1) and value added (b2) - are used to produce a product in a certain amount. Commodity balances do not contain information on the production structure of a product, in particular the inputs used. Data requirements to construct full-scale input-output tables are too demanding at this moment. Nevertheless it is useful to present the input-output structure here. Note that the symmetric input-output table does not relate products to industries, but uses either a product to product approach or an industry to industry approach.

Table 3.2 Simplified (symmetric) input-output structure

		Products	ROW	Final consumption	Gross capital formation	Total
		(a1)	(a2)	(a3)	(a4)	(a5)
Products	(b1)	Intermediate inputs	Exports	Final consumption	Gross capital formation	**Total use** by product
Components of value added	(b2)	Value added				
ROW	(b3)	Imports				
Total	(b4)	**Total supply** by product				(b4) = (a5)

HORTUS follows the above mentioned commodity balance framework, instead of a full-scale input-output structure, and incorporates some additional cost information (see Chapter 4) to discern between the use of intermediate inputs and value added. The abbreviations used are the same as the ones used in the GTAP model (Hertel and Tsigas, 1997). The output value of commodity j in region s at market prices is indicated by VOM(j,s). The output value equals the sum of all intermediary inputs used in industry j in region r VIFM(j,s) and value added in industry j in region s $\sum_{i=1}^{2} VEFM(i,j,s)$, or b1 and b2 in Table 3.2 above:

$$VOM(j,s)=VIFM(j,s)+\sum_{i=1}^{2} VEFM(i,j,s) \qquad (3.2)$$

This equality implies that the output value equals the sum of all costs: intermediary inputs, labour and capital. The value of intermediary inputs is identified for each commodity j and each region s. Value added is identified for each production factor i, commodity j and region s. At this stage intermediary inputs are not subdivided into more specific categories such as expenses for energy, seed, pesticides, et cetera, and country of origin.

The available amount, or total supply of commodities in a country VOIM(j,s) equals the sum of production and imports.

$$VOIM(j,s)=VOM(j,s)+\sum_{r=1}^{R} VIMS(j,r,s) \qquad (3.3)$$

Import value VIM(j,r,s) is identified for each commodity j, country of origin r and country of destination s. There are two possible destinations for the supply available: domestic use and exports. Domestic use is subdivided into human consumption, processing and other uses. There is no subdivision into private and public purchases (consumers and firms versus government). Available supply in region s may thus be subdivided into:

$$VOIM(j,s)=VPM(j,s)+\sum_{s=1}^{R} VXMD(j,r,s) \qquad (3.4)$$

Private consumption is identified for each commodity j and region s. Exports are identified for each commodity j, country of origin r and country of destination s. Private consumption is subdivided into two categories: domestic origin (VDPM) and imports (VIPM)

$$VPM(j,s) = VDPM(j,s)+VIPM(j,s). \qquad (3.5)$$

Consumption is identified for each commodity j and region s. Imports are aggregated for this purpose.

3.2 Price relations

HORTUS identifies a great number of prices: producer prices, market prices, export prices, import prices and consumer prices. Figure 3.1 relates the prices identified in HORTUS. The prices differ from each other due to taxes, subsidies, import and export taxes and subsidies, trade margins and transport costs. In this section, we follow the product from producer to consumer and distinguish all relevant price levels (Figure 3.1).

The producer receives producer price PS. If the product is taxed or subsidised, output tax TO creates a wedge between the producer price PS and the market price PM. The commodity is sold for domestic use or exports. Consumer tax and trade margins TPD create a wedge between the market price PM and the consumer price PPD. Commodities are exported at export price P_{fob}. The difference between the market price PM and the export price P_{fob} is equal to the export tax TXS. Import prices P_{cif} are obtained by adding transport costs T_{cost} to the free on board export prices P_{fob}. The market price of imported commodities PMS may be obtained by adding import taxes TMS to the import price P_{cif}. Again, for imported products consumer taxes TPM create a wedge between market prices PM and consumer prices PPM. The model also identifies the input prices the producers face as well as the taxes and subsidies on these inputs. These taxes may be used to model e.g. changes in energy policy.

Figure 3.2 summarises the relations between the price in value terms: price times quantity. The difference between the values corresponds with the difference between the prices. Prices and values are identified for each commodity j and region s. Exports and imports are distinguished for country of origin r and country of destinations. Export and import taxes are origin and destination specific.

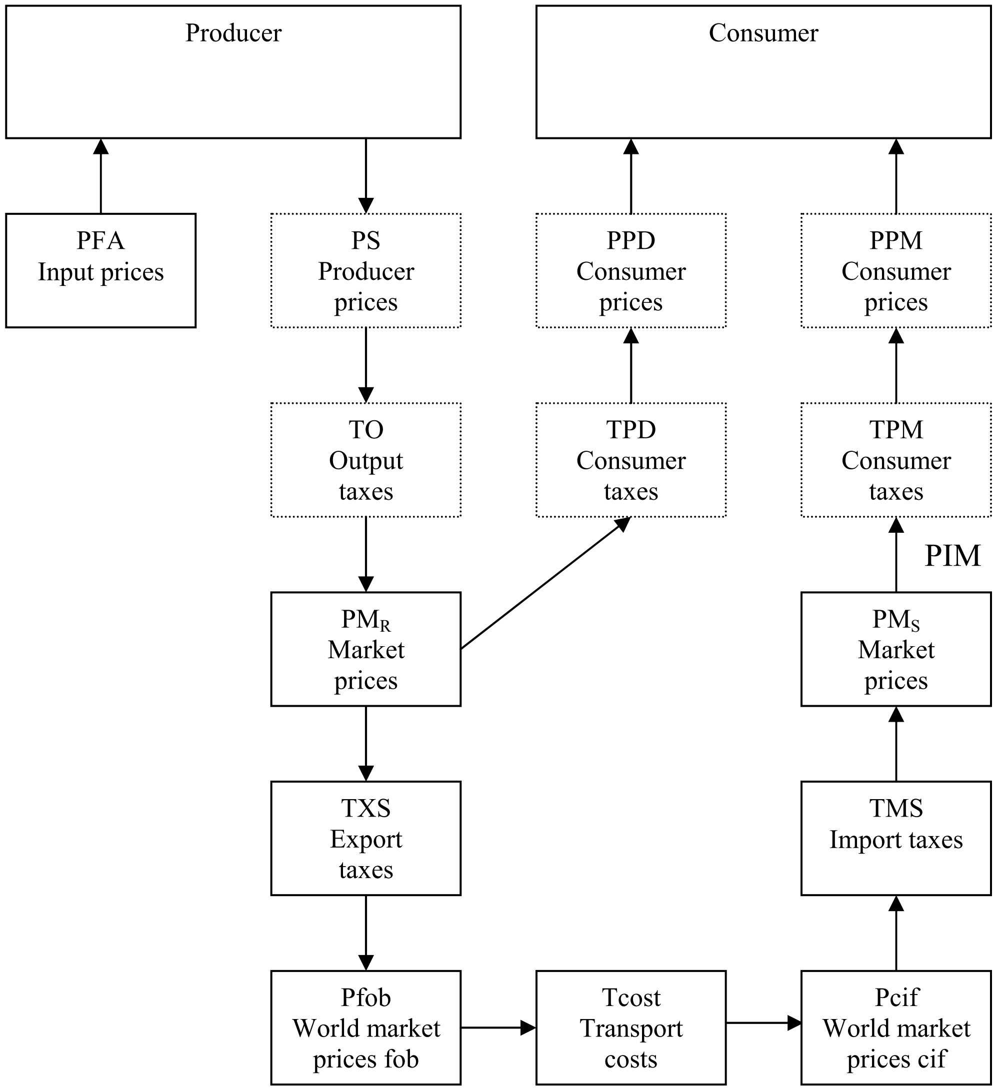

Figure 3.1 Price relations in HORTUS

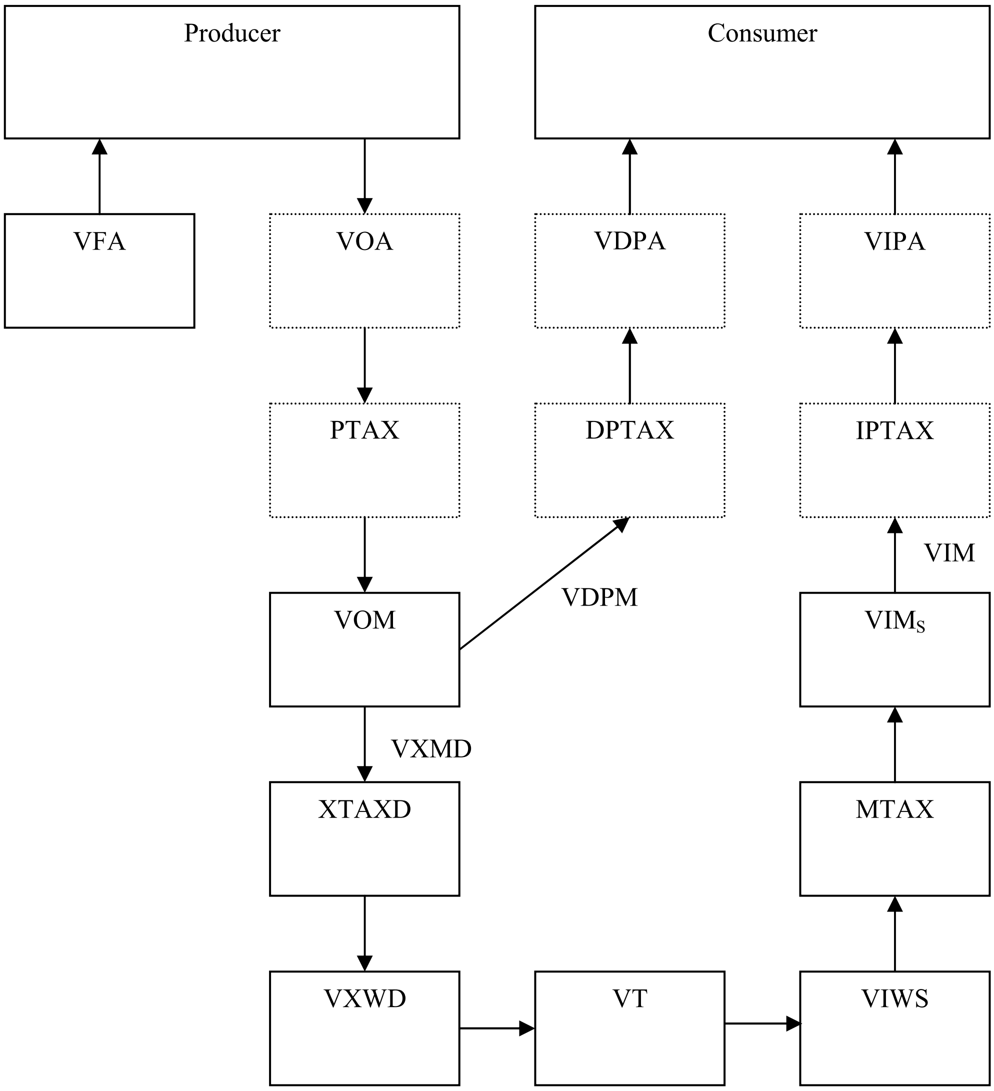

Figure 3.2   Relation between production, trade and consumption values in HORTUS

4. Data

This chapter describes the HORTUS data structure. This chapter indicates what data are in the HORTUS database and how we constructed this database. Section 4.1 presents the countries, products and inputs included in the database. Section 4.2 outlines what sources we used to construct the database. Section 4.2 and 4.3 both indicate how we adapted the data in order to construct an economically consistent data structure. The HORTUS dataset has 2000 as it's base year, the last year for which all needed statistics were available at the time of construction.

4.1 Countries, products and inputs

HORTUS distinguishes 27 regions: all 25 EU countries, Morocco, Turkey and the Rest of the World (Table 4.1). Belgium and Luxemburg are modelled as one region due to lack of data. Morocco and Turkey are specified separately for illustrative reasons. Expansion of the model with other countries is straightforward, but depends primarily on future demand.

Table 4.1 HORTUS Regions

EU15	EU10 2004 accession countries	Other countries
Austria	Cyprus	Morocco
Belgium and Luxemburg	Czech Republic	Turkey
Denmark	Estonia	Rest of the world
Finland	Hungary	
France	Latvia	
Germany	Lithuania	
Greece	Malta	
Ireland	Poland	
Italy	Slovak Republic	
Netherlands	Slovenia	
Portugal		
Spain		
Sweden		
United Kingdom		

HORTUS specifies thirteen products aggregated in three nests: fruits, vegetables and ornamentals. In future research, we may easily expand the number of products, especially since we have already gathered data on other products, e.g. cauliflowers and other cabbages, beans and peas, and pineapples. Table 4.2 lists the products in the current HORTUS dataset.

Table 4.2 HORTUS' Products

Fruits	Vegetables	Ornamentals
Grapes	Tomatoes	Ornamental flowers
Apples	Onions	Nursery plants
Citrus	Peppers	
Pears	Cucumbers	
Bananas	Other vegetables	
Other fruits		

HORTUS distinguishes four inputs: intermediary inputs, land, labour, capital. Land is measured in terms of acreage. Intermediary inputs, labour and capital are measured in values. As yet, intermediary inputs are not further subdivided into inputs such as energy, pesticides, nursery material and fertilizers.

4.2 Data sources

The data structure contains four elements:
1. supply or commodity balances (in tonnes);
2. bilateral trade data (in tonnes);
3. prices (in euro);
4. cost shares (in percentages).

These elements are needed to construct the simplified input-output table in section 3.1 and the price relations in section 3.2. The supply balance relation is presented in equation 3.1. The input-output relation (cost shares) is indicated in equation 3.2 and Table 3.2. The price relations are depicted in Figure 3.1. Information on these four elements has been gathered and processed as follows.

4.2.1 Supply balances

The backbone of the data structure is made up of a set of consistent supply balance sheets for each product in each region. The balances relate the supply in a region - the sum of domestic production and imports - to the use in that region - the sum of exports and domestic use, subdivided in human consumption and other uses (see section 3.1). For a definition of FAO and Eurostat supply and use categories, see Appendix 1.

> 'Commodity balances (or supply balance sheets) show balances of food and agricultural commodities in a standardized form. The scope of standardization is to present these data in a less detailed form for a selected number of commodities without causing any significant loss of the basic variables monitoring the agricultural sector. The selected commodities include the equivalents of their derived products falling in the same commodity group, but exclude the equivalents of by-products and derived commodities, which through processing, change their nature and become part of different commodity groups.' (Source: FAOstat)

We derive commodity balances from two main sources: FAOstat Supply Balance Sheets and Eurostat Agris Table. These sources contain more or less complete commodity balances for most products and countries. For other products - notably cucumbers, peppers and ornamentals - and countries, commodity balances have been constructed on basis of production and trade data (Appendix 2). For this purpose, FAOstat and ITC/WTO production and trade data have been used. For these cases, we assume that all domestic use equals human consumption. In general, if we do not have data on other uses, we assume that all domestic use equals human consumption. Appendix 2 gives an overview of the sources per product and per region.

HORTUS distinguishes two categories of domestic use: human consumption and other uses. Besides other uses such as industrial uses, seed and feed, the FAO and Eurostat supply balances distinguish losses and stock changes. Whenever other uses are positive, the data on losses and stock changes in the original data are reflected in other uses in the HORTUS dataset. If not, the data on losses and stock changes in the original data are reflected in human consumption in the HORTUS dataset.

We construct commodity balances for Other Fruits and Other Vegetables by adding up data for a number of individual products and product categories. Production and land area data, as well as aggregate imports and exports are taken from Faostat. Products included in the two categories are listed in Appendix 3. Bilateral trade data for Other Fruits and Other Vegetables include all fresh or chilled produce from ITC/WTO data not included in one of the other categories in the model. Producer prices of other vegetables and fruits are computed from Faostat local currency data, using average euro exchange rates for 2000 for the HORTUS countries.

There are little data for ornamentals. We distinguish two groups of ornamentals from the Eurostat Agris tables: Ornamental flowers and plants, and Nursery material. Supply balances are constructed on basis of production values rather than volumes as the former are more accurate and consistent. Ornamentals' prices are set equal to one, their numéraire value. To complete the supply balance sheets import and export values are added from the ITC/WTO bilateral trade database. Production in the Rest of the World is estimated on basis of AIPH data.

4.2.2 Bilateral trade data

Bilateral trade data have been collected for each product, each country of origin and each country of destination. The most important data source used for constructing the dataset on bilateral trade is the PCTAS database (ITC/WTO). PCTAS does not disaggregate products to the same levels as Comext does, but contains data on more countries than Comext does. Comext is only made up of EU countries. Only for peppers, one has to resort to Comext data. Bilateral trade relations involving the Rest of the World have been imputed from aggregate exports and imports and bilateral exports and imports of all other regions (Table 4.3).

Table 4.3 Bilateral trade data

- country of destination -

- country of origin -

	Austria Bellux …	Morocco Turkey	ROW	World
Austria Bellux … …	A	B	R_1=C-(A+B)	C
Morocco Turkey	D	E	R_2=F-(D+E)	F
ROW	R_3=G-(A+D)	R_4=H-(B+E)	R_5-(R_1+R_2) R_6-(R_3+R_4)	R_6=M-(C+F)
World	G	H	R_5=M-(G+H)	M=X

Bilateral trade data are not necessarily compatible with aggregate imports and exports data from the supply balance sheets (commodity balances). Generally, there are two problems with respect to compatibility:

- the sum of bilateral exports (imports) does not have to correspond with aggregate exports (imports) from the supply balance sheet;
- we have two observations of trade between two regions. For instance, the Netherlands reports its exports to Germany and Germany reports its imports from the Netherlands. These data should coincide in the model. Unfortunately, due to the nature of data collection, these data do not coincide.

We solved these problems as follows. The bilateral export data have been used to determine export shares for all countries of destination. These shares have been matched with aggregate exports from the supply balance sheet. Likewise, bilateral import data have been used to determine import shares for all countries of origin. These shares have been matched with aggregate imports from the supply balance

This solves the first problem, but not the second problem. We still have two possibly different observations for each bilateral trade relation. (When you match exports shares with aggregate exports, you do not necessarily match them to aggregate imports and *vice versa*.) Both adapted observations of bilateral trade - e.g. exports from the Netherlands to Germany and imports from the Netherlands in Germany - have been matched with aggregate imports and exports using a linear optimisation technique. The observations have been used as minimum and maximum value for the optimisation process. The aggregate import and export data from the supply sheets are imposed as row and column totals.[1]

4.2.3 Prices

The HORTUS dataset contains producer and export prices. Producer prices have been obtained from FAO. Export prices have been derived from the bilateral trade data collected in the previous section. If export prices were not available at the bilateral level, they have

[1] The optimisation technique is developed by Dr. Marcel Kornelis (LEI).

been substituted with export prices at the aggregate level. Ornamentals' export prices equal their numéraire value, i.e we set prices equal to 1 euro per kilogram for the moment.

At this moment, HORTUS calculates all values in the model using export prices. Producer prices are not used, as yet. At this moment, we compare export and producer prices before incorporating the latter into the model.

4.2.4 Costs

To relate horticultural output to its inputs we make use of the RICA database. This Eurostat database contains figures on production costs and value added for a selection of vegetables and fruits. These data are available for citrus fruit, grapes, tomatoes, leafy and stem vegetables, other vegetables, pomes, and tropical fruit. Each of the products identified in the model is put in one of the abovementioned categories. For some countries, notably small countries and the regions outside the EU, we used data on other countries. For small European countries we used data on neighbour countries (see Bunte 2000). For the non-EU regions, we used the average of a number of southern European countries.

From the RICA database we extract the following information:

- turnover;
- intermediary costs of production;
- expenses on labour and capital;
- opportunity costs of unpaid-labour and capital.

Expenses on intermediary inputs and paid labour and capital refer to actually incurred costs. The cost shares of these inputs are simply determined as their share in total turnover. For unpaid labour and capital, we determined their opportunity costs. These opportunity costs are matched proportionally to the difference between turnover and actual expenses on intermediary inputs and paid labour and capital.

4.3 Further data adjustments

The economic model specifies the country of origin for all products consumed. Germans consume X tonnes of domestic tomatoes, Y tonnes of Dutch tomatoes, Z tonnes of Spanish tomatoes and A tonnes of other tomatoes. Theoretically, we do not have a problem with this fact. In practice, re-exports complicate the picture. How Dutch are Dutch tomatoes? Countries may export products that they do not produce, e.g. bananas exported by Belgium. Countries may export more than they produce, e.g. Dutch tomatoes. Re-export poses a theoretical and an empirical challenge. The theoretical problem refers to the fact that if one allows both production and re-export in the model, one introduces two sources for exports in the model: producing countries and re-exporting countries. The import and exports variables would need 4 dimensions (section 3.1). The empirical problem refers to the distinction to be made in the data: what is export and what is re-export, and how are both variables linked. In order to keep things simple, we do not allow re-exports in the model. We source trade flows back to the producing country. This is appropriate, since we are primarily interested in the question how changes in international trade influence changes in horticultural production. In order to rule out re-exports, we have applied the following adjustments:

1. No production, but positive exports (e.g. bananas from Belgium)
   Countries that do not produce a certain product, do not export it. This holds primarily for tropical fruits: bananas, citrus and to some extent grapes. For these countries, we assume the following. Exports are zero, imports equal net imports leaving production (zero), human consumption and other uses unchanged. Bananas are produced in seven regions: Spain, Portugal, Greece, Cyprus, Morocco, Turkey and the Rest of the World. Citrus is produced in these seven countries plus France, Malta and Italy. Grapes are produced in all countries, except for Scandinavia, the Baltic States, Ireland and Poland. Chillies and peppers are produced in the grapes producing countries with the exception of Germany.

2. Positive production, but exports exceed production (e.g. tomatoes in the Netherlands)
   In a limited number of cases, a region exports more than it produces. This holds primarily for Belgium-Luxemburg and the Netherlands. In these cases, exports and imports have been adjusted downwards in the same amounts, leaving domestic use (and production) unaffected.

5. Results

In this section, we present the results of two simulations performed with HORTUS: (1) a general reduction in EU import barriers with respect to fruits and vegetables; and (2) an increase in gas prices in the Netherlands, for instance due to unilateral Dutch climate policy. The first simulation is discussed in section 5.1 and 5.2 and the second simulation in section 5.3.

5.1 A general reduction in EU import barriers with respect to fruits and vegetables

Table 5.1 presents some key data on the EU fruits and vegetables supply for the former EU15. Two thirds of the EU's fruits and vegetables consumption is produced domestically (excluding intra-European trade). So, one third of the EU's fruits and vegetables consumption is supplied through imports. More than 60% of EU imports is intra-EU trade. About 10% of European imports originates from Mediterranean countries and about a quarter of European imports is from the Rest of the world. There is some trade protection in the EU with respect to non-EU fruits and vegetables. The tariff-equivalent trade restrictions are roughly 5-6%. This means that all EU trade barriers on fruits and vegetables raise import price 5-6% above world price levels.

Table 5.1 Key figures on fruits and vegetables trade for the EU15 (in%)

	Household purchases		Tariff-equivalent trade barriers
Domestic supply	67		
Import supply	33		
Intra-EU15 trade		63	0
Mediterranean countries		10	5.1
Other countries		27	5.5

Source: GTAP.

The EU specifies import barriers for individual fruits and vegetables and individual countries of origin. The EU shelters European fruits and vegetables production using tariffs, quotas, tariff-quotas and entry price systems. The EU grants preferential trading arrangements to some countries, among which former colonies and neighbour countries. European banana imports are subject to tariff-quotas. Traditional ACP countries are exempt from these tariff quota's, but non-traditional ACP-countries and non-ACP countries pay tariffs up to 737 euro per ton for out-of-quota imports (Badinger et al., 2002). Other key fruits and vegetables are also subject to a system of entry prices. Tariffs on citrus, apples and tomatoes are related to daily adjusted entry prices (Cioffi and dell'Aquila, 2004).

In 2000, these tariffs amounted to 3-16% for citrus; 8-15% for tomatoes; and 9-11% for apples. Trade concessions - lower tariffs for specified quota - are granted to South Africa, Morocco, Brazil and Israel for citrus; to the Czech Republic, South Africa, Brazil and Chile for apples; and to Morocco, Turkey and Israel for tomatoes.

The previous paragraph shows that European import restrictions with respect to fruits and vegetables may be substantial. However, one should be careful, when assessing these data. Average tariff protection applies to both low-import and high-import seasons. Moreover, importers may prevent tariffs by storing products. In 2000 e.g., very little apple imports were subject to the daily adjusted tariffs. Moreover, these data do not take account of possible non-tariff barriers. Ideally, we would like to have product and country specific tariff equivalents for the simulation in this section. Unfortunately, we don't have data on these equivalents for individual products and individual countries of origin. Therefore, we apply the general level given from Table 5.1. This has one advantage. The results may be used as a benchmark. The simulation will indicate what fruits and vegetables are most sensitive to a general reduction in tariff equivalents and why.

In this section, we analyse the impact of a general reduction in import tariffs by the EU. The EU reduces its import tariffs to all non-EU countries. We further assume that due to the accession of 10 new countries into the EU, the new EU countries face lower import tariffs as well. Recall that our data refer to 2000: a year in which the new EU countries still faced EU import barriers. Table 5.2 shows the impact of a general reduction in import tariffs on aggregate import prices. The reduction has a particularly large influence on aggregate import prices of fruits, in particular bananas and citrus, since both fruits are imported on a large scale into Europe. This implies that a general reduction in EU import barriers leads to a price decrease of fruits relative to vegetables in Europe. Moreover, the prices of bananas and citrus decrease relative to the prices of native fruits.

Table 5.2 Aggregate import prices in Europe and the Rest of the World (in %)

	EU15	EU10	Morocco	Turkey	ROW
Apples	-2.3	-2.0	-0.4	-0.1	0.1
Bananas	-5.1	-5.3	-	0.2	0.2
Citrus	-3.2	-1.9	0.2	0.2	0.1
Cucumbers	-0.6	-2.6	-	0.2	0.1
Grapes	-2.8	-1.9	0.2	0.0	0.1
Onions	-1.9	-1.8	0.0	0.2	0.1
Other fruits	-2.5	-2.0	0.2	0.0	0.2
Other vegetables	-1.6	-1.8	-0.6	0.0	0.2
Pears	-2.1	-1.8	-0.4	0.2	-0.1
Peppers	-1.2	-3.5	-	0.2	0.1
Tomatoes	-1.2	-1.7	-0.2	0.2	0.1

Consumer demand for domestic fruits and to a lesser extent domestic vegetables decreases. As a result, the producer prices of European fruits fall substantially, while the producer prices of European vegetables fall to a little degree. This implies that in Europe the producer prices of vegetables rise relative to the producer prices of fruits. The opposite holds for Morocco, Turkey and the Rest of the World. As a result, European horticulture shifts land use from fruits to vegetables, while in Morocco, Turkey and the Rest of the World, land use shifts from vegetables to fruits (Table 5.3). The effects for European fruits production are particularly pronounced for citrus. For the EU15, land use will shift from citrus production to grapes and other vegetables production. In the accession countries, land use increases for vegetables, apples and grapes production and falls for other fruits and citrus production. In Morocco, land use will shift to citrus production. In Turkey, land use will shift to citrus and grapes production. In the Rest of the World, land use will shift to the production of apples, bananas and in particular citrus. Citrus benefits more in the Rest of the World than bananas do, due to substitution effects. Substitution from European production to ROW production is more likely for citrus than for bananas, since European citrus production is substantial, while European banana production is rather small.

Table 5.4 indicates which European countries are most effected in terms of production. The trade liberalisation is likely to lead to a substantial decrease in Portuguese and Spanish banana production, Spanish and Cyprian citrus production and Dutch and French apple production. This fact is due to the export orientation of these countries for these products. Moroccan production is likely to benefit more than Turkish production, at least in relative terms, since Moroccan production is more export oriented than Turkish production. Turkish production is primarily directed to its home market.

Table 5.3 Changes in hectare use in Europe and the Rest of the World

	EU15	EU10	Morocco	Turkey	ROW
Apples	-3,059	876	-492	-1,011	37,723
Bananas	-284	3	-64	-18	21,669
Citrus	-22,523	-288	3,091	544	211,654
Cucumbers	254	101	-10	-499	-11,492
Grapes	21,448	695	-752	7,383	4,260
Onions	869	-63	-419	-1,061	-13,770
Other fruits	-10,231	-2,746	-633	-1,041	-69,396
Other vegetables	10,609	1,396	-856	-1,928	-157,977
Pears	-137	-117	-62	-161	-2,502
Peppers	503	46	-86	-510	-7,734
Tomatoes	2,491	91	281	-1,710	-12,719

The fall in European producer prices leads to a fall in European horticultural output for fruits and for most vegetables. Given the land available for horticultural production, the use of labour and capital falls. The same amount of land is used to produce less output. Horticultural production becomes less labour and capital intensive and more land intensive (Table 5.5). As a result, the shadow prices of land fall. Notice that the model captures static effects only: input optimisation given the availability of land and input and production factor prices. Dynamic effects, in particular induced innovation, is not captured. The model also does not say much about what happens at the firm level. Firms may very well increase their scale and probably are likely to do so.

5.2 Trade regimes for fruits and vegetables

The precise impact of trade liberalization depends among other things upon the countries included. Trade liberalisation is negotiated at regional (bilateral) and world levels. The EU is involved in regional trade negotiations and in global negotiations. The current EU enlargement may be seen as a regional negotiation. The same holds for negotiations with Mediterranean countries. WTO negotiations (with respect to bananas e.g.) are an example of global negotiations.

Regional free trade agreements may lead to trade distortions, since trade may be diverted from the countries which are not a partner to the agreement to countries which are. With respect to the EU enlargement, EU imports of oranges may be diverted from Brazil (Rest of the World) to Cyprus, since Cyprus is treated as a preferential trade partner, while Brazil is not. This hurts the international division of production and exports if Brazil is a more efficient producer than Cyprus is.

Table 5.6 shows the effects of trade liberalisation under three scenarios. Scenario 1 refers to the current situation: EU enlargement. What happens to horticultural production now trade barriers between the EU and the new Member States are abolished? Note that the model data are from 2000, four years before the actual enlargement. Scenario 2 extends the EU enlargement in Scenario 1 with bilateral trade agreements with Morocco and Turkey. This is a likely scenario for the near future: bilateral arrangements between the EU and the Mediterranean region. Scenario 3 may be considered as a benchmark, since the trade liberalization does not discriminate between countries. The difference between scenario 1 on one hand and 2 and 3 on the other hand and the difference between scenario 2 and 3 give indications of the importance of trade diversion. Scenario 3 has been analysed in detail in the previous section.

Table 5.6 shows that trade diversion is likely to occur for citrus. Morocco and Turkey produce more citrus, but also less of all other fruits and vegetables, when they are treated preferentially. The rest of the world produces less citrus, when Morocco and Turkey are treated preferentially. Trade diversion also arises, among other things, for Turkish grapes and Cyprian citrus. Trade diversion is not that important for the current EU enlargement (scenario 1). The EU 15 and the ROW are generally speaking hardly effected. However, there are countries that are substantially effected for one or more products, as Table 5.4 shows.

Table 5.4 Output changes, % change

	Austria	BelLux	Cyprus	CzechRep	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Latvia
Apples	-1.39	-2.47	-2.33	5.00	0	-0.92	-1.62	-3.51	-0.82	0.10	-1.18	0	-1.06	-1.40
Bananas	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	0	0	6.47	0	0	0	0	0	0	-0.85	0	0	-0.71	0
Cucumbers	-0.19	1.07	-0.89	-1.82	0.21	1.40	0.79	0.20	-0.01	0.32	0.19	0.54	-0.11	0.05
Grapes	0.14	0	-0.22	-0.38	0	0	0	0.07	-0.04	-1.64	-0.51	0	-0.51	0
Onions	-0.65	0	-0.98	-0.87	-0.36	-1.33	0.65	-0.34	-0.86	0.29	-0.8	0.04	-0.25	-0.04
Other fruits	-1.42	0	-0.36	-0.17	-2.51	0	-2.7	-2.83	-0.95	-0.63	6.63	-2.54	-1.75	-0.78
Other vegetables	-0.23	-0.59	1.68	-0.47	-0.54	0.62	0.76	-0.10	0.13	0.36	0.40	-0.09	0.16	0.60
Pears	-0.88	-2.31	-1.35	-1.17	-0.79	0	0	-1.80	-1.37	-0.71	-0.11	0	-0.68	-0.90
Peppers	0	-0.32	-1.05	-3.39	0	0	0	0	0	0.26	0.71	0.15	0.12	0
Tomatoes	-0.23	0.19	-1.44	-0.03	-1.22	-0.15	0.25	-0.12	-1.01	0.37	0.39	0.49	0.23	-0.07

	Lithuania	Malta	Morocco	Netherlands	Poland	Portugal	ROW	SlovakRep	Slovenia	Spain	Sweden	Turkey	UK
Apples	-0.69	0	-0.66	-3.32	0	-0.82	1.21	-0.97	-0.29	0.22	-2.61	-0.34	-2.86
Bananas	0	0	-0.55	0	0	-7.88	0.92	0	0	-3.44	0	-0.45	0
Citrus	0	-0.10	3.08	0	0	-0.87	2.01	0	0	-4.94	0	0.87	0
Cucumbers	2.47	0	-0.18	0.38	0.18	0.22	-0.19	3.73	-1.40	0.99	0.58	-0.20	0.55
Grapes	0	-0.49	-0.49	0	0	0.16	0.52	1.37	-0.28	0.35	0	1.95	0
Onions	-0.03	0	-0.53	-0.02	2.51	0.23	-0.11	0.6	-0.85	0.73	0.39	-0.29	0.53
Other fruits	-1.64	-1.13	0.58	0	0.81	-0.97	0.07	-1.12	4.15	-2.90	-3.16	0.15	-3.17
Other vegetables	0.57	0	0.11	-0.36	0.19	0.19	-0.17	0.8	1.70	0.38	0.43	-0.11	0.31
Pears	-1.15	-0.32	-0.55	-2.53	-0.82	-1.21	0.22	-3.17	-0.51	-0.01	-2.13	0.13	-1.95
Peppers	0	0	-0.06	-0.52	0	0	-0.14	-0.68	0	0.28	0	-0.11	0.12
Tomatoes	6.00	0	2.17	-0.62	0.10	0.17	0.03	2.05	0	0.44	0.24	-0.17	0.71

Table 5.5 Demand for labour and capital, % change

	Austria	BelLux	Cyprus	CzechRep	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Latvia
Apples	-1.58	-2.94	-1.52	5.49	0	-1.07	-2.02	-3.67	-1.03	-0.25	-0.52	0	-1.32	-1.65
Bananas	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Citrus	0	0	7.28	0	0	0	0	0	0	-1.20	0	0	-0.97	0
Cucumbers	-0.38	0.60	-0.09	-1.33	-0.30	1.26	0.40	0.04	-0.22	-0.03	0.85	0.32	-0.37	-0.20
Grapes	-0.05	0	0.58	0.11	0	0	0	-0.09	-0.26	-1.99	0.15	-0.22	-0.76	0
Onions	-0.84	0	-0.18	-0.38	-0.87	-1.48	0.25	-0.50	-1.07	-0.06	-0.14	-0.18	-0.51	-0.29
Other fruits	-1.60	0	0.45	0.32	-3.02	0	-3.10	-2.99	-1.17	-0.98	7.29	-2.76	-2.01	-1.03
Other vegetables	-0.42	-1.06	2.49	0.02	-1.05	0.47	0.36	-0.26	-0.09	0.01	1.06	-0.31	-0.09	0.36
Pears	-1.07	-2.79	-0.54	-0.68	-1.30	0	0	-1.97	-1.58	-1.06	0.55	0	-0.93	-1.15
Peppers	0	-0.80	-0.24	-2.90	0	0	0	0	0	-0.09	1.37	-0.07	-0.13	0
Tomatoes	-0.42	-0.29	-0.64	0.46	-1.73	-0.30	-0.14	-0.28	-1.23	0.02	1.05	0.27	-0.03	-0.31

	Lithuania	Malta	Morocco	Netherlands	Poland	Portugal	ROW	SlovakRep	Slovenia	Spain	Sweden	Turkey	UK
Apples	-0.82	0	-0.11	-3.73	0.21	-0.98	1.41	-0.66	-0.20	-0.44	-2.90	-0.05	-3.00
Bananas	0	0	0.00	0	0	-8.04	1.12	0	0	-4.10	0	-0.16	0
Citrus	0	-0.25	3.62	0	0	-1.02	2.21	0	0	-5.60	0	1.16	0
Cucumbers	2.34	0	0.37	-0.04	0.39	0.07	0.01	4.04	-1.31	0.33	0.29	0.08	0.40
Grapes	0	-0.63	0.06	0	0	0.00	0.72	1.67	-0.20	-0.31	0	2.24	0
Onions	-0.16	0	0.01	-0.43	2.72	0.07	0.09	0.9	-0.77	0.07	0.09	-0.01	0.38
Other fruits	-1.77	-1.27	1.12	0	1.03	-1.12	0.27	-0.82	4.23	-3.56	-3.45	0.43	-3.32
Other vegetables	0.44	0	0.65	-0.78	0.40	0.04	0.03	1.11	1.78	-0.28	0.14	0.17	0.16
Pears	-1.28	-0.46	0.00	-2.94	-0.61	-1.36	0.42	-2.86	-0.43	-0.66	-2.42	0.42	-2.10
Peppers	0	0	0.48	-0.93	0	0	0.06	-0.37	0	-0.38	0	0.18	-0.03
Tomatoes	5.87	0	2.71	-1.03	0.32	0.02	0.23	2.36	0	-0.21	-0.05	0.11	0.56

Table 5.6 Trade regimes, %

	Morocco Scenario 1	Morocco Scenario 2	Morocco Scenario 3	Turkey Scenario 1	Turkey Scenario 2	Turkey Scenario 3	ROW Scenario 1	ROW Scenario 2	ROW Scenario 3
Apples	0.0	-1.1	-0.7	0.0	-0.5	-0.3	0.0	0.0	1.2
Bananas	0.0	-0.9	-0.6	0.0	-1.3	-0.5	0.0	0.0	0.9
Citrus	0.0	5.8	3.1	0.0	1.3	0.9	0.0	-0.2	2.0
Cucumbers	0.0	-0.5	-0.2	0.0	-0.4	-0.2	0.0	0.0	-0.2
Grapes	0.0	-0.8	-0.5	0.0	3.1	2.0	0.0	-0.2	0.5
Onions	0.0	-0.9	-0.5	0.0	-0.5	-0.3	0.0	0.0	-0.1
Other fruits	0.0	0.9	0.6	0.0	0.2	0.2	0.0	0.0	0.1
Other vegetables	0.0	-0.2	0.1	0.0	-0.3	-0.1	0.0	0.0	-0.2
Pears	0.0	-0.9	-0.6	0.0	0.1	0.1	0.0	0.0	0.2
Peppers	0.0	-0.4	-0.1	0.0	-0.2	-0.1	0.0	0.0	-0.1
Tomatoes	0.0	1.8	2.2	0.0	-0.4	-0.2	0.0	0.0	0.0

	EU15 Scenario 1	EU15 Scenario 2	EU15 Scenario 3	EU10 Scenario 1	EU10 Scenario 2	EU10 Scenario 3
Apples	0.0	0.0	-1.8	0.1	0.2	0.2
Bananas	0.0	0.1	-3.7	0.0	0.0	0.0
Citrus	0.0	-0.3	-3.0	10.1	9.7	6.4
Cucumbers	-0.1	0.0	0.5	0.3	0.3	0.3
Grapes	0.0	-0.1	-0.1	-0.4	-0.5	-0.3
Onions	-0.1	0.0	-0.2	-0.9	-0.9	-0.8
Other fruits	-0.1	-0.2	-1.8	2.4	2.3	1.3
Other vegetables	-0.1	-0.1	0.0	0.2	0.3	0.4
Pears	0.0	0.0	-0.8	-0.1	-0.1	-0.9
Peppers	0.0	0.0	0.0	0.0	0.0	-0.1
Tomatoes	0.0	-0.1	0.2	0.3	0.2	0.2

Scenario 1: EU enlargement; Scenario 2: EU enlargement plus bilateral trade agreements with Morocco and Turkey; Scenario 3: General reductions in import barriers

5.3 A rise in Dutch energy costs

This section presents the results of a second simulation: an increase in energy costs in the Netherlands. Energy costs would rise in the Netherlands, if the Netherlands would sharpen its energy or climate policy unilaterally. A rise in energy costs in the Netherlands with 25% would lead to an increase in the price index of intermediary inputs with 10%. The energy price rise is modelled by raising the price of intermediary inputs with 10% for all glasshouse crops (cucumbers, sweet peppers, ornamental flowers and tomatoes) and with 5% for nursery material (pot plants and nursery material). All other products are not affected. In the analysis we will pinpoint out attention on the competitive position of Dutch glasshouse vegetables versus Dutch ornamentals.

Producer prices

The rise in prices of intermediates increases producer prices in the Netherlands (Table 5.7). Naturally, this increase is more pronounced for ornamental flowers and glasshouse vegetables than for nursery plants, since the price increase modelled was lower for the latter. For reasons beyond the scope of this article, the increase in producer prices of nursery plants is counterbalanced by an increase in the availability of land formerly occupied by ornamentals and glasshouse vegetables sectors. Producer prices increase more for ornamental flowers than they do for glasshouse vegetables, since producers of ornamental flowers are better able to pass on cost increases to consumers. Dutch ornamental flower producers face less competition than producers of glasshouse vegetables do.

Table 5.7 Changes in producer prices in the Netherlands, % change

Apples	-0.40
Bananas	-0.40
Citrus	-0.40
Cucumbers	4.24
Grapes	-0.40
Nursery Plants	0.70
Onions	-0.27
Ornamental flowers	4.79
Other Fruits	-0.40
Other Vegetables	-0.27
Pears	-0.40
Peppers	4.24
Tomatoes	4.09

Land use

We notice that land used for the production of both glasshouse vegetables and ornamentals decreases considerably in the Netherlands. As expected, the burden falls more heavily on vegetables than on ornamentals flowers. Dutch producers of glasshouse vegetables face more competition and more actual substitution than Dutch producers of ornamental flowers do. For this reason, Dutch producers switch from glasshouse vegetables to ornamental flowers and nursery material, including pot plants. Tomatoes are affected relatively badly, since they face fiercer competition on the respective import markets than cucumber and pepper producers do (See Table 5.8).

Table 5.8 Absolute changes in land use, hectares (% change between brackets)

	Netherlands	Spain	Rest EU-15	New EU members	Morocco	Turkey	Rest of the World
Apples	263 (2.05)	-29 (-0.06)	-215	-93	-3	-11	-943
Bananas	0	-4 (-0.05)	0	0	0	0	-417
Citrus	0	-526 (-0.09)	0	-1	-31	-18	-1298
Cucumbers	-69 (-10.51)	343 (4.83)	116	51	0	13	390
Grapes	0.3 (0.79)	-447 (-0.04)	-43	-16	0	-54	0
Nursery material	115 (1.01)	-0.4 (-0.02)	-194	-8	0	-1	0
Onions	189 (1.43)	-14 (-0.06)	18	-28	0	-12	0
Ornamentals	-1,189 (-4.52)	23 (0.42)	95	14	9	14	150
Other fruits	40 (0.79)	-215 (-0.08)	-262	-64	-12	-25	0
Other vegetables	821 (1.47)	-107 (-0.05)	384	11	-9	0	0
Pears	121 (2.01)	-36 (-0.09)	-75	-7	0	-4	-139
Peppers	-144 (-11.98)	436 (1.88)	40	60	4	45	859
Tomatoes	-146 (-12.92)	512 (0.85)	160	82	34	68	1719

Sector output

Table 5.9 and 5.10 present the results of the energy price increase for sectoral output and demand for intermediate inputs, and demand for labour and capital in all regions. These tables describe in detail what happens to production and consumption. The results show that in terms of production tomato producers are worse off than producers of ornamental flowers and other glasshouse vegetables. This result might seem peculiar, because producer prices of tomatoes increase less than those of the other affected products. We can explain this fact by looking at the economic structure of the model. There are at least two explanations.

First, why does vegetables' output decline more than ornamental output? Exporters of ornamentals face less competition and are better able to pass on price increases. In other words, in vegetable markets there are more suppliers and consequently the increase in Dutch export prices is more pronounced vis-à-vis average export prices of its competitors.

Second, why are tomato producers in a less favourable position than cucumber or pepper producers? This is partly explained by the fact that the Dutch export ratio is higher for tomatoes than it is for the other two products. However, the difference is small, the export ratio is 81% for tomatoes, against 79 and 75% for peppers and cucumbers respectively. However, Dutch tomato producers face more competition from foreign - i.e. Spanish - producers than cucumber and pepper producers do, especially in Germany, Netherlands' most important export market. Dutch exporters have a market share above 50% for cucumbers, but only a 33% market share for tomatoes.

Table 5.9 Changes in output and demand for intermediate inputs (% change)

	Apples	Bananas	Citrus	Cucumbers	Grapes	Nurs. Mat	Onions	Ornamentals	Oth. Fruits	Oth. Vegs	Pears	Peppers	Tomatoes
Austria	-0.07	0.00	0.00	1.42	0.00	-0.37	-0.01	0.16	-0.02	0.04	-0.04	0.00	0.51
Belgium & Lux.	-0.15	0.00	0.00	2.99	0.00	-0.26	0.00	0.90	0.00	0.00	-0.21	2.64	2.28
Cyprus	-0.02	0.00	-0.02	0.03	0.00	0.00	0.02	0.00	-0.01	0.02	-0.02	0.20	0.19
Czech Rep.	-0.07	0.00	0.00	0.15	0.00	-0.27	0.02	0.04	-0.01	0.03	-0.02	0.23	0.27
Denmark	0.00	0.00	0.00	1.11	0.00	0.20	0.06	3.13	-0.14	0.06	-0.29	0.00	1.82
Estonia	-0.05	0.00	0.00	0.53	0.00	0.00	-0.03	0.00	0.00	0.04	0.00	0.00	0.92
Finland	-0.09	0.00	0.00	0.17	0.00	-0.16	0.02	0.02	-0.04	0.05	0.00	0.00	0.53
France	-0.07	0.00	0.00	0.55	0.00	-0.26	-0.02	0.08	-0.01	0.01	-0.06	0.00	0.41
Germany	-0.15	0.00	0.00	2.01	-0.03	-0.42	0.18	0.06	-0.11	0.22	-0.17	0.00	1.66
Greece	0.00	0.00	0.00	0.63	-0.02	-0.18	0.00	-0.06	-0.01	0.00	-0.05	0.18	0.01
Hungary	-0.02	0.00	0.00	0.19	-0.01	-0.09	-0.02	0.26	-0.04	-0.01	-0.02	0.80	0.22
Ireland	0.00	0.00	0.00	1.31	0.00	-0.20	0.01	0.61	-0.08	0.02	0.00	3.21	1.38
Italy	-0.09	0.00	0.00	0.39	0.00	0.05	-0.01	0.31	-0.02	0.00	-0.07	0.15	0.07
Latvia	-0.06	0.00	0.00	0.12	0.00	0.00	0.00	-0.38	-0.03	0.03	-0.12	0.00	0.63
Lithuania	-0.05	0.00	0.00	0.62	0.00	0.00	-0.02	0.00	-0.03	0.00	-0.09	0.00	2.24
Malta	0.00	0.00	-0.02	0.00	-0.04	0.00	0.00	0.00	-0.06	0.00	-0.08	0.00	0.00
Morocco	0.00	0.00	-0.02	0.04	0.00	0.01	0.00	4.71	0.00	0.00	0.00	0.06	0.13
Netherlands	1.26	0.00	0.00	-10.84	0.00	-1.48	0.89	-5.95	0.00	0.92	1.22	-12.31	-12.95
Poland	-0.02	0.00	0.00	0.08	0.00	0.00	-0.07	0.61	-0.01	0.00	-0.02	0.00	0.17
Portugal	-0.01	0.00	0.00	0.01	0.00	-0.16	0.00	-0.03	0.00	0.00	-0.07	0.00	0.04
ROW	-0.02	-0.01	0.00	0.02	0.00	0.00	0.00	0.07	0.00	0.00	-0.01	0.06	0.05
Slovak Rep.	-0.03	0.00	0.00	0.24	-0.01	0.00	-0.04	0.08	-0.01	-0.02	-0.04	0.24	0.14
Slovenia	-0.02	0.00	0.00	-0.01	-0.01	-0.71	-0.06	0.38	-0.02	-0.02	-0.01	0.00	0.00
Spain	-0.04	-0.02	-0.06	4.86	-0.01	0.00	-0.04	0.45	-0.06	-0.03	-0.06	1.90	0.88
Sweden	-0.28	0.00	0.00	1.40	0.00	-0.33	0.25	0.00	-0.21	0.23	-0.30	0.00	1.76
Turkey	0.00	0.00	-0.01	0.03	-0.01	-0.34	0.00	3.94	0.00	0.00	-0.01	0.07	0.03
United Kingdom	-0.12	0.00	0.00	0.86	0.00	-0.58	0.09	0.20	-0.10	0.08	-0.21	1.94	0.45

Table 5.10 Changes in demand for labour and capital (% change)

	Apples	Bananas	Citrus	Cucumbers	Grapes	Nurs. Mat	Onions	Ornamentals	Oth. Fruits	Oth. Vegs	Pears	Peppers	Tomatoes
Austria	-0.07	0.00	0.00	1.42	0.00	-0.37	-0.02	0.16	-0.02	0.04	-0.04	0.00	0.51
Belgium & Lux.	-0.15	0.00	0.00	2.99	0.00	-0.26	0.00	0.90	0.00	0.00	-0.21	2.64	2.28
Cyprus	-0.02	0.00	-0.02	0.03	-0.01	0.00	0.02	0.00	-0.02	0.02	-0.02	0.19	0.19
Czech Rep.	-0.07	0.00	0.00	0.14	-0.01	-0.28	0.02	0.04	-0.02	0.03	-0.02	0.22	0.26
Denmark	0.02	0.02	0.02	1.14	0.02	0.22	0.08	3.15	-0.12	0.08	-0.27	0.02	1.84
Estonia	-0.05	0.00	0.00	0.53	0.00	0.00	-0.04	0.00	0.00	0.04	0.00	0.00	0.92
Finland	-0.09	0.00	0.00	0.17	0.00	-0.16	0.02	0.02	-0.04	0.05	0.00	0.00	0.53
France	-0.07	0.00	0.00	0.54	0.00	-0.26	-0.02	0.08	-0.01	0.00	-0.07	0.00	0.40
Germany	-0.15	0.00	0.00	2.00	-0.04	-0.42	0.18	0.05	-0.11	0.22	-0.18	0.00	1.66
Greece	0.00	0.00	0.00	0.62	-0.02	-0.19	0.00	-0.06	-0.01	0.00	-0.05	0.18	0.00
Hungary	-0.02	0.00	0.00	0.19	0.00	-0.09	-0.01	0.26	-0.04	0.00	-0.02	0.81	0.22
Ireland	0.02	0.02	0.02	1.32	0.02	-0.19	0.02	0.63	-0.07	0.04	0.02	3.23	1.39
Italy	-0.09	0.00	0.00	0.39	0.00	0.05	-0.01	0.31	-0.02	0.00	-0.07	0.15	0.07
Latvia	-0.07	0.00	0.00	0.12	0.00	0.00	0.00	-0.39	-0.03	0.02	-0.12	0.00	0.63
Lithuania	-0.04	0.01	0.01	0.63	0.01	0.01	-0.01	0.01	-0.02	0.01	-0.09	0.01	2.24
Malta	-0.01	-0.01	-0.02	-0.01	-0.05	-0.01	-0.01	-0.01	-0.07	-0.01	-0.09	-0.01	-0.01
Morocco	0.00	0.00	-0.01	0.04	0.00	0.01	0.00	4.71	0.00	0.00	0.00	0.06	0.13
Netherlands	0.86	-0.40	-0.40	-11.00	-0.40	-2.73	0.62	-6.67	-0.40	0.65	0.82	-12.48	-12.96
Poland	-0.02	0.00	0.00	0.08	0.00	0.00	-0.07	0.61	-0.01	0.00	-0.02	0.00	0.17
Portugal	-0.01	0.00	0.00	0.01	0.00	-0.16	0.00	-0.03	0.00	0.00	-0.07	0.00	0.04
ROW	-0.02	-0.01	0.00	0.02	0.00	0.00	0.00	0.07	0.00	0.00	-0.01	0.06	0.05
Slovak Rep.	-0.02	0.01	0.01	0.25	-0.01	0.01	-0.03	0.09	0.00	-0.01	-0.03	0.25	0.15
Slovenia	-0.01	0.01	0.01	0.00	0.00	-0.70	-0.05	0.39	-0.02	-0.01	0.00	0.01	0.01
Spain	-0.03	-0.01	-0.05	4.87	0.00	0.01	-0.02	0.46	-0.05	-0.02	-0.05	1.91	0.89
Sweden	-0.24	0.04	0.04	1.44	0.04	-0.29	0.30	0.04	-0.17	0.27	-0.26	0.04	1.80
Turkey	0.00	0.00	0.00	0.03	-0.01	-0.34	0.00	3.95	0.00	0.00	-0.01	0.07	0.03
United Kingdom	-0.10	0.02	0.02	0.88	0.02	-0.56	0.11	0.22	-0.08	0.10	-0.19	1.96	0.47

6. Research agenda

This study makes a first step in developing an applied partial equilibrium model for European horticulture. The model outlined in this study is made up of three elements:

1. A set of behavioural equations, more specifically:
   - consumer demand for fruits, vegetables and ornamentals;
   - food industry demand for fruits and vegetables;
   - producer demand for intermediary inputs, land, labour and capital;
   - producer supply of fruits, vegetables and ornamentals;
2. A market clearing condition equating demand and supply of fruits, vegetables and ornamentals.
3. A database relating production, trade and consumption of fruits, vegetables and ornamentals. More specifically the database contains:
   - supply balance sheets, in tonnes, relating production, imports, exports, human consumption and other uses for every product and region identified (Table 6.1);
   - bilateral trade data consistent with aggregate imports and exports from the supply balance sheets;
   - producer and export prices. At this stage, only export prices are used in the model;
   - cost shares of intermediary inputs, labour and capital and land use for every product and region identified.

HORTUS specifies supply and demand for six fruits, five vegetables and two ornamentals for 27 regions: the EU25, Morocco, Turkey and the Rest of the World. Morocco and Turkey are modelled for illustrative reasons, since trade relations with Mediterranean countries are expected to be an interesting policy area in the near future (Table 6.1). Further extension of the model with new countries and products is relatively straightforward. Whether such extensions are meaningful depends on future demand for research.

Table 6.1 Product, country and inputs choice

Vegetables	Fruit	Ornamentals	Countries	Inputs
Cucumbers	Apples	Ornamental flowers	EU-25	Land (area)
Onions	Bananas	Nursery plants	Morocco	Intermediary inputs
Sweet peppers	Citrus		Turkey	Labour
Tomatoes	Grapes		Rest of the World	Capital
Other vegetables	Pears			
	Other fruit			

HORTUS may be used to study the impact of changes in the environment of the horticultural supply on the key economic variables in the supply chain. The environmental (exogenous) variables modelled in HORTUS are given in Table 6.2 together with the key economic (endogenous) variables. HORTUS may be used to determine the policy implications of changes in environmental variables that may be influenced by public policy and enterprise strategy, e.g. import tariffs, energy taxes.

HORTUS will be used as a building stone of the Baseline scenario framework developed at LEI. The Baseline scenario generates a projection of the future development of Dutch agriculture and horticulture and the impact of major policy and environmental changes on these projections.

HORTUS may be improved by extending and improving the underlying database. Underdeveloped in the HORTUS model are data on:

- the price structure is weakly developed, since HORTUS only defines export prices. Producer prices, market prices, import prices and consumer prices are not incorporated in the model as yet (see section 3.2). This does not invalidate the model as such, since the model is built on a consistent set of supply balances in tonnes and primarily depends on reasonable estimates of price, income and substitution elasticities;
- the price, income and substitution elasticities used in the current version of the model are simply chosen. Literature and empirical research may be used to come to less arbitrary estimates. This does not invalidate the current model, since sensitivity analyses are relatively straightforward;

The quality of the data may be improved by relating information from the supply balance sheets with information from other sources, notably information on consumer and industrial buying behaviour. The data on ornamentals require thorough investigating. The best way to guarantee the quality of the data required is co-operation within a consortium.

Table 6.2 Exogenous and endogenous variables

Exogenous variables	Endogenous variables
Prices endowments and intermediary inputs	Product prices on the following levels: production, market, exports, imports and consumption
Population	Production
Income per capita	Bilateral trade
Technological growth	Demand for land endowments and intermediary inputs
Taxes and subsidies on consumption, imports, exports and production	Consumption and industrial use
International transport costs	
Total acreage available for horticulture	

References

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Appendix 1 Definitions of supply balance elements

Table A1 Definitions of commodity balance elements from different sources

Information on:	Faostat definition	Eurostat definition
Production	Figures relate to the total domestic production whether inside or outside the agricultural sector, i.e. it includes non-commercial production and production from kitchen gardens. Unless otherwise indicated, production is reported at the farm level for crop (i.e. in the case of crops, excluding harvesting losses).	Usable production comprises all usable quantities comprised from the production process, including the quantities used for 'own consumption' by producers. Losses occurring during the production process are not included.
Imports and exports	Cover all movements into/out of the country of the commodity in question. It includes commercial trade, food aid granted on specific terms, donated quantities and estimates of unrecorded trade. As a general rule, figures are reported in terms of net weight, i.e. excluding the weight of the container.	Data are taken from official external trade statistics entering or leaving the territory of the Community or circulating between the territories of the Member States (intra-EU-trade).
Human Consumption	Comprises the amounts of the commodity in question and of any commodity derived therefrom not further pursued in the food balance sheet, available for human consumption during the reference period.	Quantities of products made available for human consumption in all forms: quantities consumed without further processing and quantities supplied by the distributive trades and the food industry.
Processing	The amounts used during the reference period for manufacture of processed commodities which could not be converted back to their originating primary commodities or which are part of a separate food groups (e.g., sugar, fats and oils, alcoholic beverages) are shown here.	Quantities of products used to produce a derived food product for which there is a specific balance sheet.
Waste	Comprises the amounts of the commodity in question and it's derivatives not further pursued in the balances, lost through waste at all stages between the level at which production is recorded and the household. Losses before and during harvest are excluded.	Losses arising subsequent to the production process, during transport, storage or packaging. They include quantities withdrawn from the market and made unfit for consumption.
Other uses	Seed, Feed, Other uses	Seeds, Animal Feed, Industrial uses

Source: UN/ECE Statistical Division, Handbook of Agricultural Statistics.

Appendix 2 Data availability

Table B1.1 gives an overview of the data used to construct consistent commodity balances (in 1.000 tonnes) and the availability for the products and countries in the model. By putting the available data together we have been able to construct commodity balances for all products and countries included in the model.

Table B1.1 Availability and use of data from Eurostat Agris and Faostat, 2000

	Eurostat Agris Table							Faostat Commodity balances					Fao crops primary		Fao trade	
	Area	Production	Usable production	Imports	Exports	Consumption	Processing	Production	Imports	Exports	Consumption	Manufacturing	Area	Production	Imports	Exports
EU-15	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
EU-25 from '02	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Other countries	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*
Vegetables																
Cucumbers	-	-	-	-	-	-	-	-	-	-	-	-	*[1]	*[1]	*[1]	*[1]
Onions	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*
Chillies/Peppers	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*
Tomatoes	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Fruits																
Apples	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Bananas	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*
Citrus	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*
Grapes	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*
Pears	*	*	*	*	*	*	*	-	-	-	-	-	*	*	*	*
Ornamentals																
Ornamental flowers / plants	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-	-
Nursery material	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-	-

[1] Including Gherkins

Appendix 3 Concordance tables for fruits and vegetables

ITEMHORTUS	*FAO TRADE & PRODUCTION*	*FAO Commodity Balance*	*EU Supply Balance Sheets*	*PCTAS*	*COMEXT*
Fruit					
Apples	Apples (515)	Apples (2617)	APPL Apples	0574 Apples, fresh	-
Bananas	Bananas (486)	Bananas (2615)	-	0573 Bananas, fresh or dried	-
Citrus	Citrus Fruit,Total (1804)	-		0571 Oranges, etc. 0572 Oth.citrus, fresh, dried	-
	Oranges (490)	Oranges, Mandarines (2611)	-		-
	Tang.Mand.Clement.Satsma (495)		-		-
	Lemons and Limes (497)	Lemons, Limes (2612)	-		-
	Grapefruit and Pomelos (507)	Grapefruit (2613)	-		-
	Citrus Fruit nes (512)	Citrus, Other (2614)	-		-
Grapes	Grapes (560)	Grapes (2620)	-	0575 Grapes, fresh or dried	-
Pears	Pears (521)	-	PEAR Pears	05792 Pears and quinces, fresh	-
Other fruits	Apricots Avocados Berries nes Blueberries Cantaloupes and other melons Carobs Cashewapples Cherries Cranberries Currants Dates Figs Fruit Fresh nes Fruit Tropical Fresh nes Kiwi Fruit Mangoes Papayas Peaches and Nectarines Persimmons Pineapples Plums Pome Fruit nes, Fresh Raspberries Sour Cherries Stone Fruit nes, Fresh Strawberries Watermelons	-	-	0576 Figs, fresh or dried 05791 Melons, papayas, fresh 05793 Stone fruit, nes, fresh 05794 Berries fresh 05795 Pineapples, fresh, dried 05796 Dates, fresh or dried 05797 Avocado, guava, mango, 05798 Other fresh fruit	-

ITEMHORTUS	*FAO TRADE & PRODUCTION*	*FAO Commodity Balance*	*EU Supply Balance Sheets*	*PCTAS*	*COMEXT*
Vegetables					
Cucumbers	Cucumbers and Gherkins (397)	-	-	05456 Cucumbers, fresh, chilled	-
Onions	Onions, Dry (403) Onions and Shallots, Green (401)	Onions (2602)		05451 Onions and shallots, fresh, chilled	-
Peppers	Chillies and Peppers, Green (401)	-	-	-	07096010 Fresh or chilled sweet peppers 07096091 Fresh or chilled fruit of genus capsicum for industrial manufacture 07096095 Fresh or chilled fruits of genus capsicum or pimenta for .. oils or resinoids 07096099 Fresh or chilled fruits of genus capsicum or pimenta, other
Tomatoes	Tomatoes	Tomatoes (2601)	TOMA Tomatoes	0544 Tomatoes, fresh, chilled	-
Other vegetables	Artichokes Green Corn (Maize) Asparagus Leeks / other alliac vegetables Beans, Green Lettuce Broad Beans, Green Mushrooms Cabbages Okra Carrots Peas, Green Cassava Leaves Pumpkins, Squash, Gourds Cauliflower Spinach Eggplants String Beans Garlic Vegetables Fresh nes	-	-	05452 Garlic, leek, other alliac vegetables 05453 Cabbage fresh or chilled 05454 Lettuce fresh or chilled 05455 Edible roots, fresh, chilled 05457 Legumes, fresh or chilled 05458 Mushroom, truffles, fresh, chilled 05459 Other vegetables, fresh, chilled	-
Ornamentals					
Flowers	-	-	ORNA Ornamental plants and flowers	2927 Cut flowers and foliage	-
Nursery material	-	-	NURS Nursery plants	2926 Bulbs, cuttings, live plant	-

(1) excluding cauliflowers and broccoli

(2) only in TRADE statistics

(3) selection of several other classifications
(4) only EAAB and EAAP