**ORANI-ESP: A Computable General Equilibrium Model For Agricultural Policy Analysis in Spain.**

**Part II: Modifications to the Standard ORANI-G model framework**

**Documento de Trabajo 2009/04**

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**October 2009**

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## 1. ORANI-G: A brief overview of the model

In part I of this report, a detailed explanation is provided on the many steps required in the data construction, data updating and parameter choices which feed into the ORANI-ESP (ORANI "España") 2005 database. ORANI-ESP is based on the 'generic' ORANI (ORANI-G) model computable general equilibrium (CGE) template, originally designed in the late seventies as a government sponsored policy evaluation tool for the Australian economy. ORANI-G is written almost exclusively in percentage change form and is implemented using the GEMPACK software (Harrison and Pearson, 1996). What follows is an abridged description of the ORANI-G model, whilst a detailed and accessible discussion of the model can be found in Horridge (2003). Moreover, for a discussion on the technicalities of CGE models (functional forms, nesting, closure, calibration etc), the reader should consult Karaca and Philippidis (2006).

As is typical to all CGE models, ORANI-G is a 'comparative static' representation in that it compares two points in time (i.e., there is no mechanism which examines the path from one point to another). Consequently, there is no explicit temporal mechanism in the model (see discussion on 'closure' below), whilst concepts such as capital accumulation are characterised employing a simple representation.[3] Common to all CGE models, ORANI is based on market clearing equations (i.e., supply equals demand) for each input and output market; and a series of accounting conventions (e.g., income equals expenditure equals output, zero long run profits in production).

These 'structural' equations are supplemented by a series of 'behavioural' equations which characterise the demand and supply responsiveness of agents to changing market conditions (i.e., prices). Given the complexity of CGE frameworks, convenient functional forms (i.e., Cobb-Douglas (CD), constant elasticity of transformation (CET), constant elasticity of substitution (CES)) tend to be favoured over fully flexible functions, since the calibration[4] of the functions (i.e., expenditure shares, cost shares) can be achieved more easily employing the underlying benchmark data.[5] Of course, the downside with convenient functions is that they impose restrictions on behaviour (i.e., price elasticities, income elasticities etc.). For this reason, ORANI employs an linear expenditure system (LES) to characterise private household demands. This function also belongs within the family of 'convenient' functions and is therefore relatively straightforward to calibrate, whilst it allows for a more flexible treatment of income and price elasticity responses in final demands.

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[3] As a response to this critique, in 'dynamic' CGE models, adaptive expectations and capital accumulation are characterised in much greater depth.

[4] Calibration involves the calculation of the parameter values of a mathematical function to replicate the existing benchmark data flows.

[5] In the case of the CES and CET functions, extraneous estimates of the elasticity of substitution/transformation are also required to complete this process.

A further 'trick' employed in CGE model frameworks is the usage of 'nesting'. Since CES/CET/CD/LES functions lack behavioural flexibility, the assumption of weak separability is employed to partition final and intermediate demands into 'nests' (multi-stage budgeting) based on conventional neo-classical behaviour (utility maximisation, cost minimisation). Thus, the decision to purchase a commodity/input 'i' is made independently of the source (i.e., domestic vs. imported) from which the commodity is purchased. In each nest, the user is free to employ an 'appropriate' elasticity parameter, although this approach is restricted by the limited availability of elasticity estimates in the literature.

In order to ensure a solution, the number of equations and endogenous variables in the model system must be equal. Thus, a certain number of variables must be held exogenous in order to ensure correct 'closure'. Typically, exogenous variables are limited to productivity variables, factor endowments or tax/subsidy variables. In addition, the choice of closure also forms some maintained hypothesis about the macroeconomic assumptions relating to the economy. For example, in the labour market, the modeller may wish to characterise the short run by holding wages fixed (i.e, exogenous) and allowing labour supply to adjust endogenously. Alternatively, via a closure swap, a neoclassical long-run closure could be employed where wages are fully flexible and long run labour employment is fixed (consistent with the NAIRU macro model). As another example, one may decide to hold the balance of trade as a proportion of GDP fixed, which supports the notion that in the long run, a large trade deficit is unsustainable.

## *1.1 The Theoretical Structure of ORANI-G*

### *1.1.1 Production*

Industries are assumed to be perfectly competitive profit maximizers. This means that input demand is consistent with cost-minimising (Hicksian) behaviour, as well as revenue-maximising output-choices in the cases where more than one good is produced by a single industry. ORANI-G accounts for multi-production of exports and can be tailored to characterise exports to EU and non-EU-countries (a feature of the ORANI-ESP model). Each industry minimises costs by choosing the input mix, subject to a three-tier constant-returns-to-scale input technology (see Figure 1).

**At the top level**, it is assumed that intermediate commodity composites, primary-factor composites and 'other costs' are combined using a Leontief function. **In the second level of the nest**, Hicksian demands for domestic and imported intermediate inputs are subject to a CES (constant elasticity of substitution) production function. The demands for land, labour and capital are also derived by minimising the cost of primary factor composites formed according to CES technology. **The bottom level** of the input technology is only applicable to labour. As in the case of the second level, composite labour is a CES aggregate of 'skilled' and 'unskilled' labour. The demands for labour in the

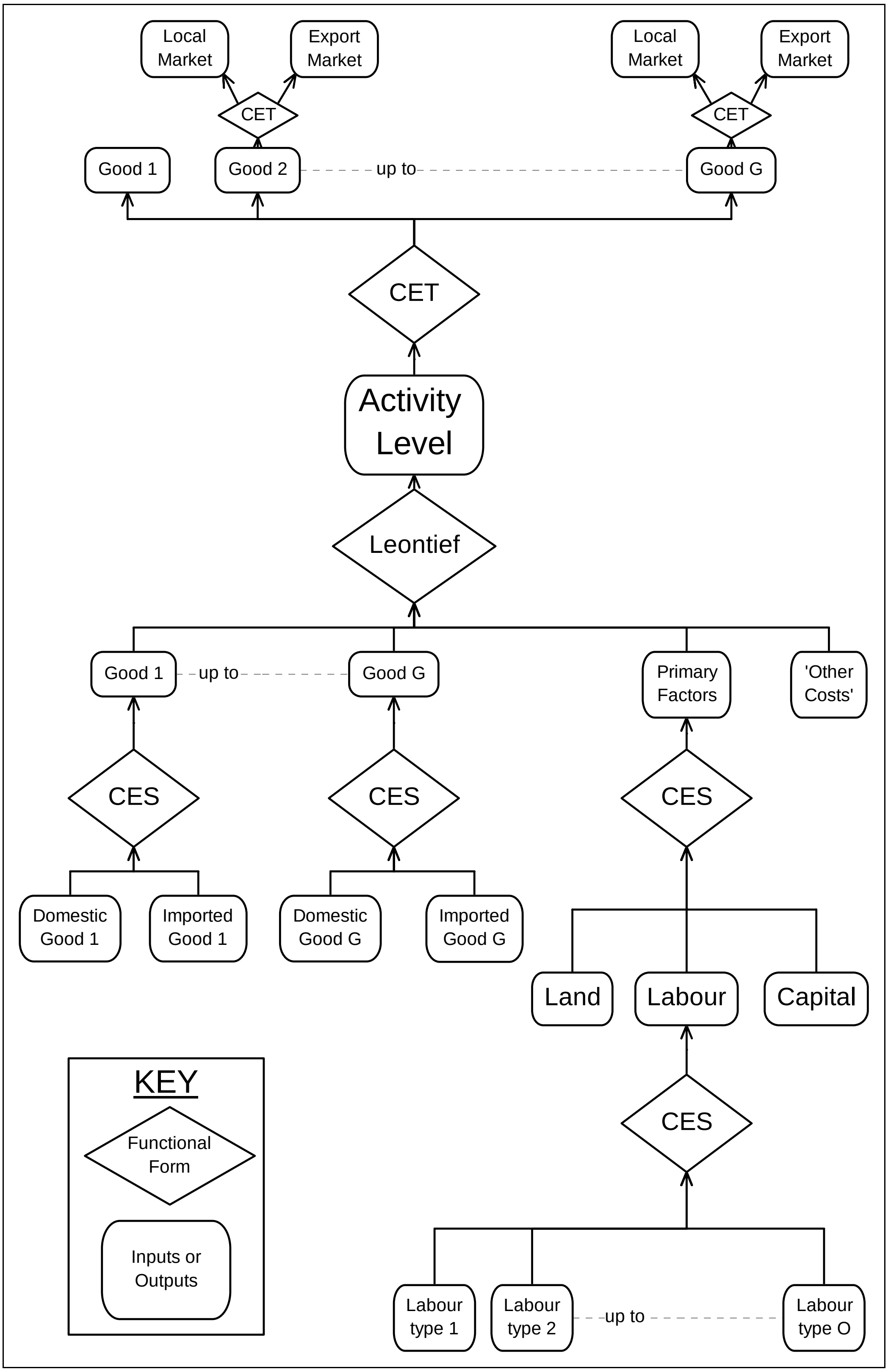


**Figure 1: The production structure of ORANI-G:**
**Source: Horridge (2003)**

two skill categories are derived by minimising labour costs subject to this technology. **On the output side**, each industry may produce both domestic and export goods. The choice on the composition of output is made subject to a CET (constant elasticity of transformation) production frontier. This multi-production decision is shown at the top of the production tree in Figure 1.

*1.1.2 Private Final Demand*

Final demand stems from four main sources: household consumption, investment/capital creation, government consumption and exports. This is also the classification of final demand adopted in input-output tables, the main source of the model database.

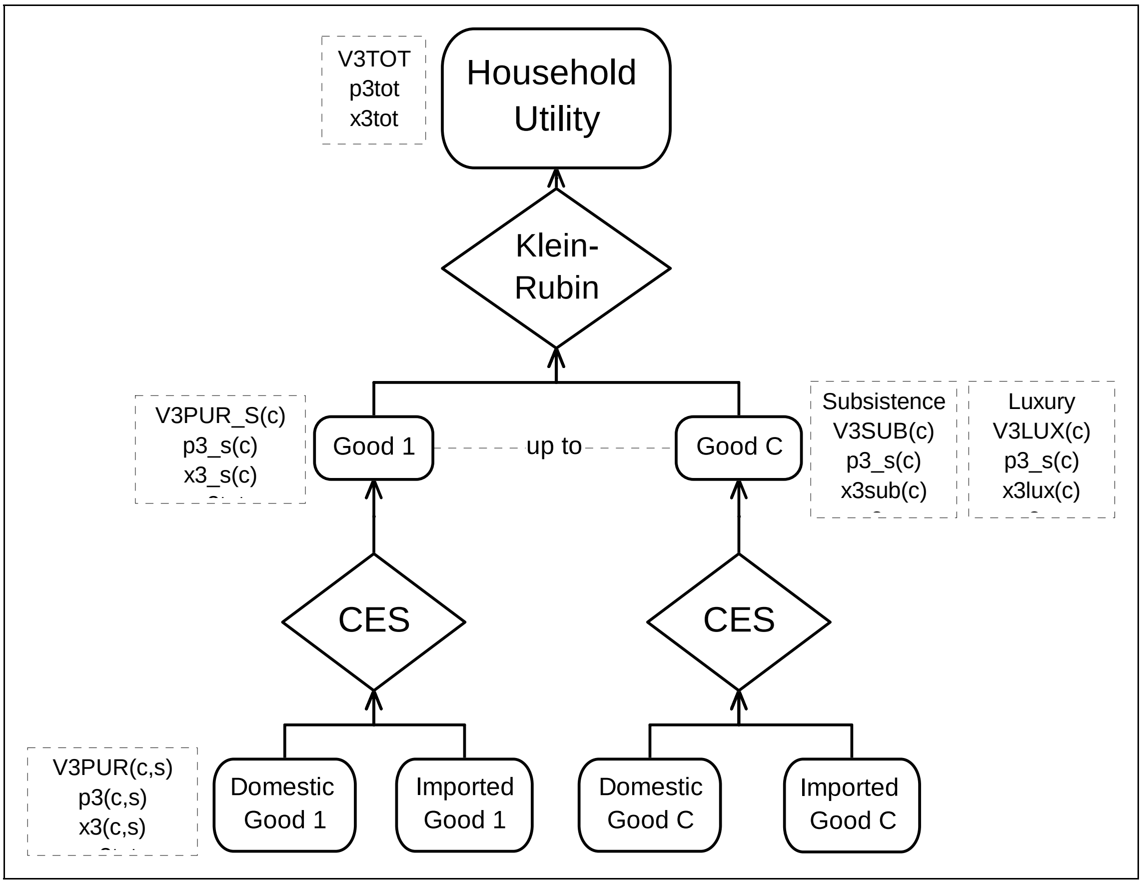


**Figure 2. Private Demands in ORANI-G**
**Source: Horridge (2003)**

Private final demands are characterised by a single representative household, which maximises a Klein-Rubin (a.k.a. Linear Expenditure System - LES) utility function subject to a budget constraint (see Figure 2). The household maximises utility allocating its budget across composite commodities consisting of domestic and imported goods. Household demand responds to changes in the relative prices of domestic and foreign commodities by substituting between domestic and imported goods (Armington, 1969). As noted above, the LES function is preferable to CES or CD functions since it permits non unitary income and price elasticities of demand. This is of particular relevance when characterising food demand which empirical work shows is typically income inelastic.

*1.1.3 Investment Final Demands*

Figure 3 illustrates the nesting structure for capital creation. A new unit of fixed capital used in industry 'j' is constructed according to a two-tiered technology. At the top level, industry minimises cost by choosing the composite goods subject to a Leontief production function, implying that all composite goods are used in fixed proportions. At the next level, substitution between domestic and imported goods is possible (Armington, 1969). It is assumed that primary factors are not employed in capital goods creation.

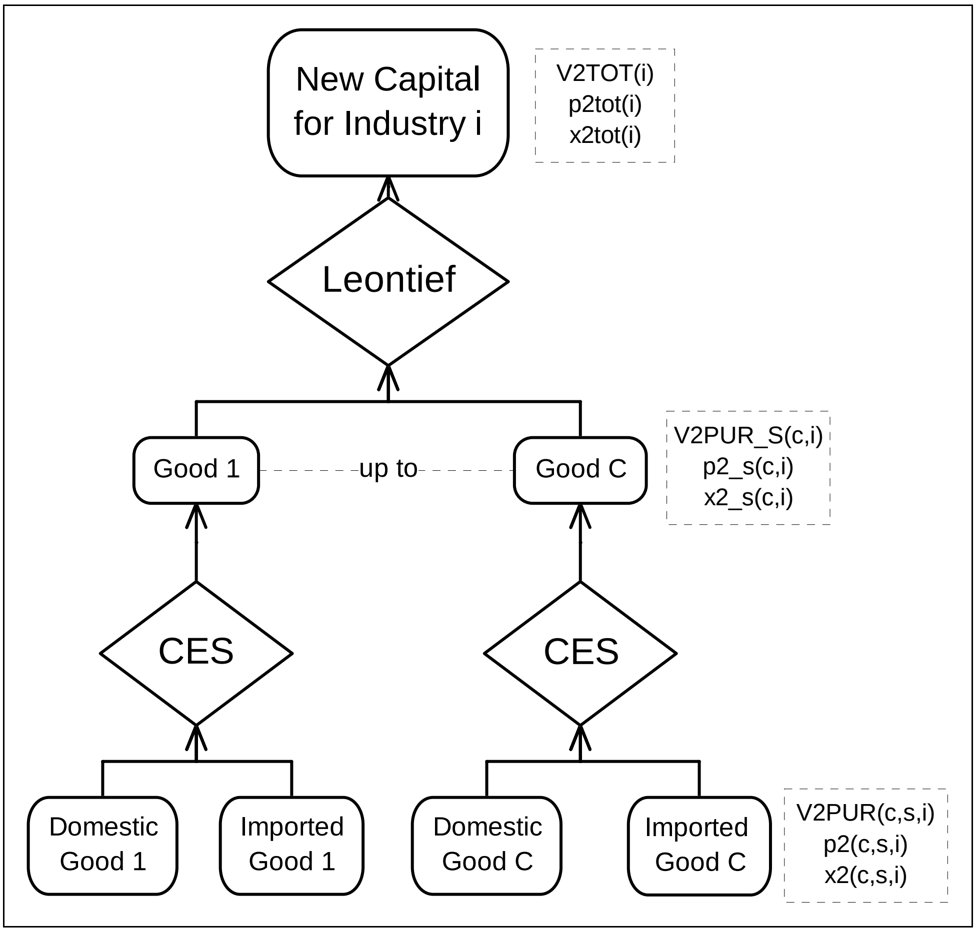


**Figure 3: Investment demands in the ORANI-G model.**
**Source: Horridge (2003)**

In the absence of a detailed 'dynamic' investment mechanism, ORANI-G offers the modeller a choice of three potential investment allocation mechanisms. **In rule 1** (model variable 'finv1(i)' exogenous), the accumulation of capital goods in industry 'i' to capital stock in industry 'i' is a direct function of changes in the rate of return in industry 'i' (defined as the ratio between the unit rent to capital and the unit price (average cost) of a unit of capital good construction) relative to the economy-wide rate of return (variable invslack).[6] **In rule 2** (model variable 'finv2(i)' exogenous), the production of capital goods in industry 'i' is directly proportional to the economy wide increase in capital goods production. This rule is more appropriate in those industries where investment is determined by government policy. **In rule 3** (model variable 'finv3(i)' exogenous), then new capital goods production in industry 'i' perfectly shadows the change in capital stock usage in industry 'i'. It should be noted that in none of these rules is the change in new capital goods fed into the endowment stock of capital (i.e., no capital accumulation). If the user requires an increase in the capital stock, a long run closure should be employed where capital stock is exogenous and shocked.

#### *1.1.4 Export and Public Demands*

**Export demand** is specified by a downward-sloping schedule. Export volume for each commodity is a declining function of its price in foreign currency. The sensitivity of export volume to the change in its price is determined by an export demand elasticity parameter. In the case of **public demands**, through a closure swap, the user may either specify an exogenous increase in public spending, or assume that public expenditure moves in tandem with changes in private household expenditure.

#### *1.1.5. Demand for 'Indirect' Margin Services*

**Indirect margin services** of domestic origin (i.e., wholesale, retail, transport etc.) are used to facilitate the flow of domestic and imported commodities to agents. These demands are assumed to be in direct proportion to the commodity flows with which each specific margin is associated. Note, that the model has nothing to say about international margin services which facilitate the flow of imported commodities from their countries of origin to the point of entry within the domestic economy.

#### *1.1.6. The Price System*

ORANI-G distinguishes two types of prices: **basic values and purchaser's prices**. For domestically produced goods, basic value is defined as the producer price, excluding commodity taxes and margins used to deliver goods to end users. For imported goods, basic value is the price received by importers (i.e., the cost insurance freight (c.i.f.) price), including the tariff, but excluding commodity taxes and margins used to deliver goods to end users. That is, the 'landed duty-paid' price. Purchasers' prices for both imported and domestically produced commodities are the basic prices plus sales taxes and margin costs. In the case of exports, the purchaser's prices include the margins and subsidy costs, thereby representing 'free on board' prices (fob).

[6] In the model, there is no explicit recognition of depreciation, although it is implicit in the sense that the rent on capital services is a gross rent figure (i.e., prior to depreciation).

In deriving equations representing the model's pricing system, the following simplifying assumptions are adopted. Pure profit does not prevail in any economic activity: production, capital creation, distribution, exporting or importing. Basic prices are uniform for all users and producing industries. This assumption implies that if a difference in purchasing prices exists across users, this is entirely due to the differences in the sales tax and margin costs. In other words, while the basic price is the same for all users, the purchaser's price paid by each user can differ. Since constant returns to scale are assumed, the industry's per unit cost and per unit revenue are independent of output level, being influenced only by the level of technology and the prices of commodities. With the above assumptions, the basic prices per unit of an industry's output equals the total payment for the inputs needed to produce one unit of output.

*1.1.7. Market Clearing Equations*

For domestically produced commodities, the total supply is driven by the sum of demands for (i) intermediate inputs to current production; (ii) capital creation; (iii) households' consumption; (iv) exports (v) government purchases; and for (vi) margin services.

Over the last 15-20 years, with significant developments in computational power the ORANI-G model has evolved in terms of its complexity (i.e., imperfect competition, dynamic investment behaviour), whilst retaining a high degree of flexibility. Indeed, the standard data resembles quite closely input-output (IO) national accounts, which makes the model accessible to those researchers interested in building their own CGE characterisations. Moreover, the model structure can be relatively easily modified (with sufficient knowledge of the underlying microeconomics and programming language) to incorporate additional modelling features.

In the next sections, this report divides the main extensions to the model into key areas:

**i.** The modelling of energy demands in the production and final demand nests for examining the growing importance of bio fuels usage on the agricultural industry, in particular the implications for land usage

**ii.** The increase in the final demand user accounts to include tourism and NGO demands, as well as the disaggregation of private households to allow the modeller to examine the distributive impacts of agricultural policy

**iii.** Characterisation of labour and capital usage in agricultural/non-agricultural sectors.

**iv.** Explicit modelling of primary agriculture to characterise the vagaries of agricultural output, factor and input markets.

**v.** The medium to long run closure in ORANI-ESP

## 2. Production nests in ORANI-ESP

The major modification which has been made to the nesting structure for each industry is the modelling of energy demands (see Figure 4). The structure of the production nesting to incorporate energy demands follows that employed in the GTAP-E variant (Birur et al. 2008) of the well known GTAP global trade model (Hertel, 1997). Thus, in the top nest of the input demands structure, a Leontief function is assumed when assigning aggregate expenditures on composite primary factors and energy (value added), 'other costs' and composite non-energy commodities. For each composite non energy commodity, an upper and lower Armington nest is employed to subdivide input expenditures into domestic and composite imports, and subsequently imports by origin (EU and non-EU source).

The value added and energy nest for each industry is a CES aggregate of labour costs, land costs and a capital-energy composite input. Labour is further subdivided into occupation types employing a CES substitution elasticity. The capital-energy aggregate input is subdivided into capital costs per industry and an energy composite input, subject to a CES technology. The disaggregation of the energy commodity is divided between 'electricity', 'coal' and a 'composite of other energy' types. This composite is split between 'crude oil', 'crude gas' and 'gas' commodities and a petroleum/nuclear and bio fuels composite good. The petroleum/nuclear and bio fuels composite good consists of petroleum/nuclear commodity, bio ethanol from cereals, bio ethanol from sugar cane (practically zero) and bio diesel from oilseeds and vegetable oils.

In the case of the each of the CES input demands for specific energy commodities, upper and lower Armington nests are employed to subdivide input costs into domestic and composite import substitutes, where the import composite is further subdivided into imports by region of origin (EU and non-EU imports).

In the top part of Figure 4, the disaggregation of industry activity into multi-product output is controlled employing revenue maximisation criteria subject to a constant elasticity of transformation function (CET) (with an elasticity of transformation of 0.5). Thus, in percentage change terms, employing the equation:

$$q1(c,i) = x1tot(i) + CET(i)\left[p0com(c) - p1tot(i)\right] \qquad (1)$$

then an increase in the commodity price compared with the average industry price induces an increase in the production of that commodity 'c' in industry 'i'

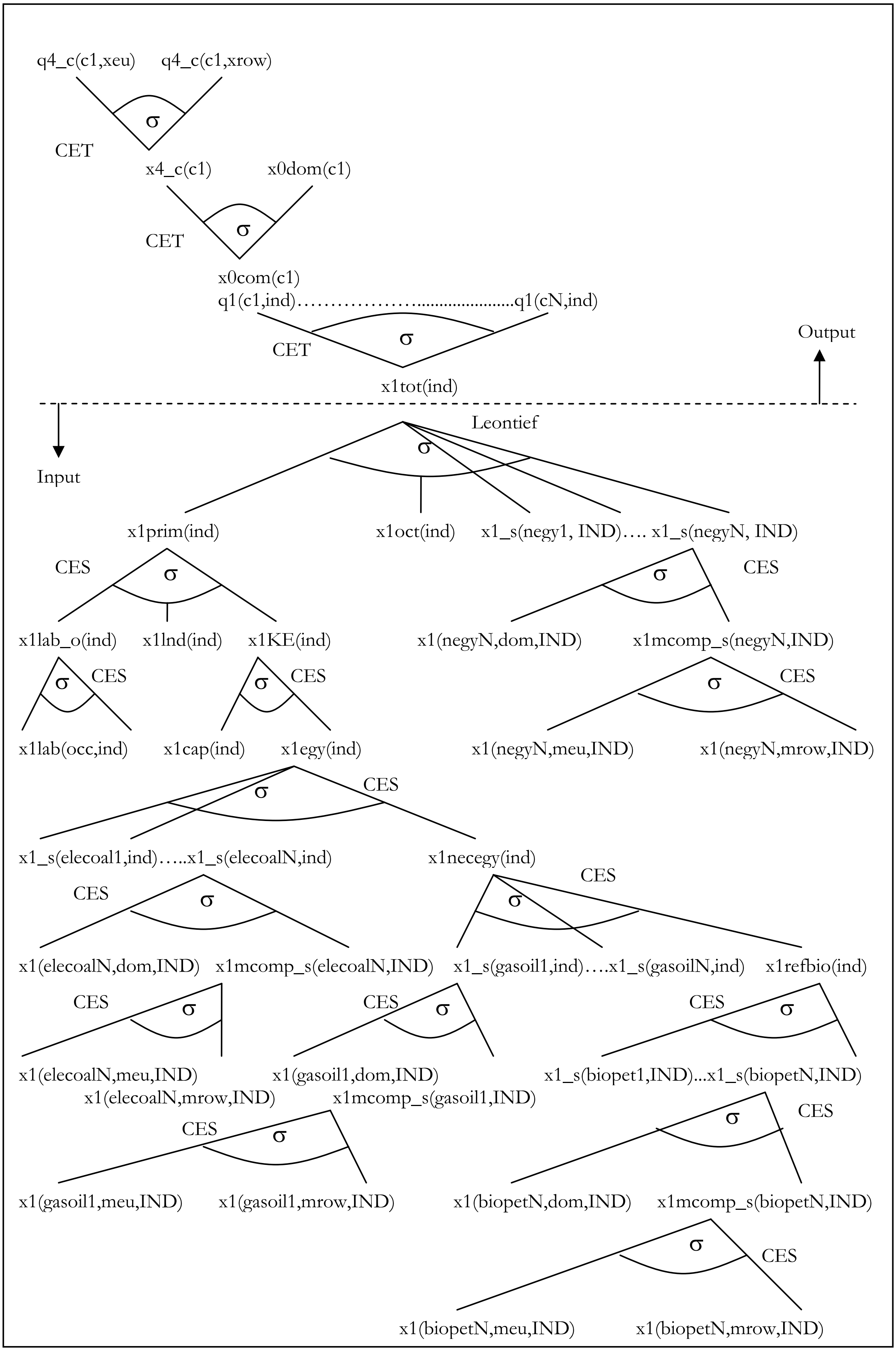


**Figure 4: The Production nest in ORANI-ESP.**

The output of commodity 'c' by industry 'i' is translated into commodity outputs via the market clearing equation:

$$x0com(c) = \left[ \frac{MAKE(c,i)}{MAKE\_I(i)} \right] \times q1(c,i) \qquad (2)$$

where the output of commodity 'c' is the sum of the industry 'i' output shares multiplied by their respective outputs of commodity 'c'. Employing a revenue maximising CET structure, the output of commodity 'c' is divided between exports, 'x4_c(c)' and domestic demands, 'x0com(c)'. Subsequently, a further CET function assigns exports between EU and non-EU export trade routes. In both cases, the absolute value of the CET parameter is 5.

**3. Final demands in ORANI-ESP - Private households, Tourism and NGOs**

In comparison with the standard ORANI model, ORANI-ESP includes two additional final demands accounts – inbound tourism subdivided by foreign and domestic tourists; and non-governmental organisation (NGO) demands for commodities. In addition, changes have been made to the private household nests to accommodate two modelling extensions: The first is the incorporation of multiple households, stratified by income groups. The second extension relates to the treatment of energy demands, in particular, the potential for substitutability between petroleum and bio fuels 'at the pump'.

Employing concepts of weak homothetic separability, additional layers of nesting facilitate greater detail in modelling substitution possibilities in the final demand structure (compare Figure 5 with Figure 2). More specifically, in Figure 5, ORANI-ESP incorporates a split between composite energy and non-energy demands in the linear expenditure system nest. Subsequently, CES energy demands are disaggregated between non-bio fuels and petroleum products, and bio fuels and petroleum products. In each case these are further subdivided employing upper and lower CES Armington nests. Thus, the upper nest contains a domestic commodity and the composite import substitute; which in the lower nest is subdivided between EU and non-EU import routes. Indeed, the subdivision of EU and non-EU import trade constitutes an additional nest in the ORANI-ESP model compared with the standard ORANI. A discussion of the elasticity estimates in each of the nests is provided in section 18.1 in part I of this report.

Whilst the CES elasticities are assumed constant over all 'h' private households (there are 8 in total), the LES expenditure elasticities in the top nest are differentiated by disposable income grouping.[7] Once aggregate household demands, 'x3tot(h)', are derived, these are aggregated over all 'h' to determine Spanish private household demand, 'x3tot_h'.

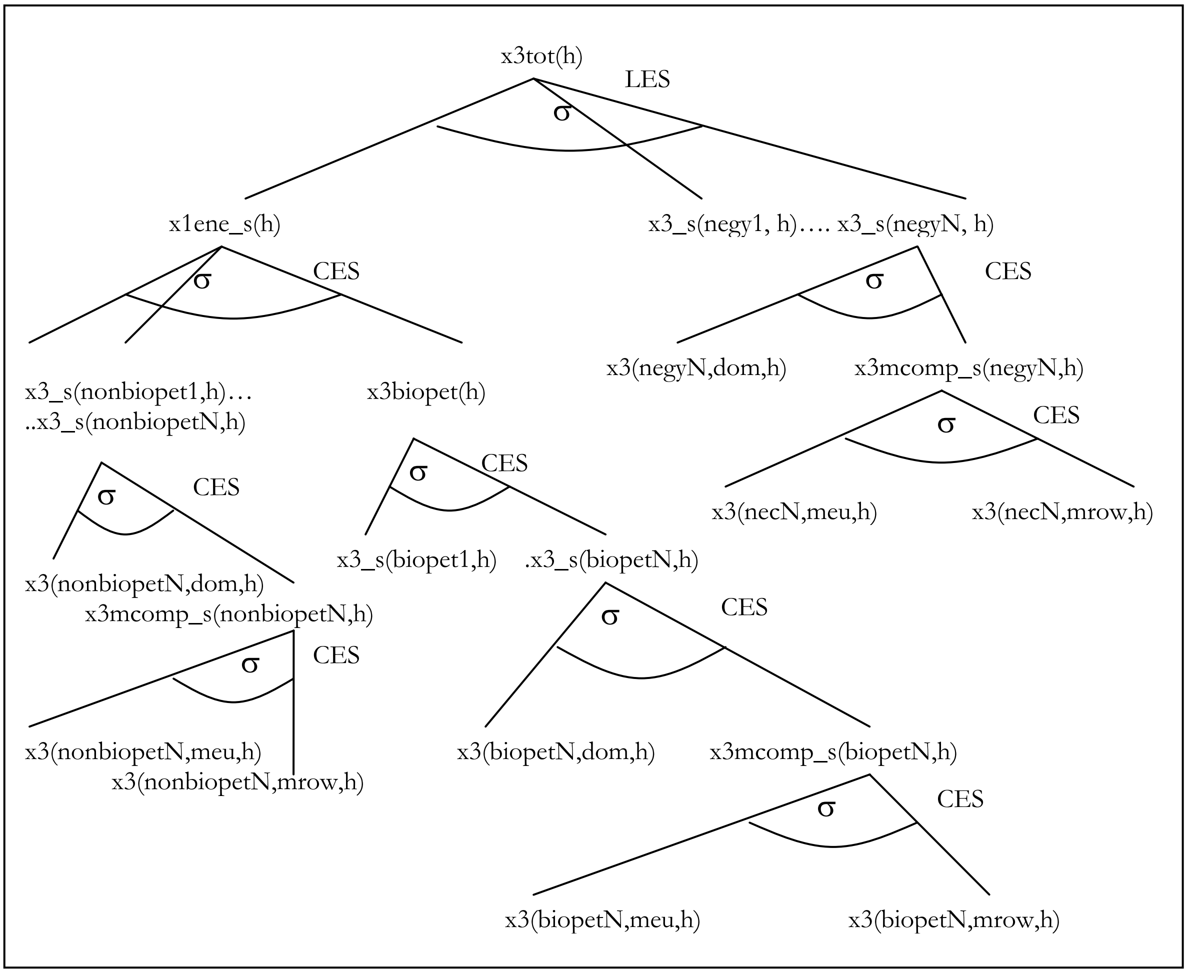


**Figure 5: The Private consumption nest for each household 'h' in ORANI-ESP.**

**'Inbound tourism'**, is defined as tourism expenditures within the territory of interest. In Figure 3 of part I of the report, the tourism account represents a new column addition in the ORANI-ESP database, labelled as account 7. The structure of 'inbound' tourism demands in the ORANI-ESP model is detailed in Figure 6. Since all of tourism expenditure is effectively a luxury or supernumerary expenditure, the usage of an LES function is not deemed appropriate.[8] In the ORANI-ESP model, the overall composition of commodity demands in inbound tourism is assumed to stay constant over time and changes in line with the fortunes of the tourism industry in Spain. Thus, in the top nest, a Leontief function is employed. Similarly, in the second nest, a Leontief function is also employed between domestic and foreign tourist expenditures on each composite

[7] A discussion of the relevant expenditure elasticities and Frisch parameters is provided in section 18.1 in part I of this report

[8] The LES function incorporates a subsistence and a supernumerary element to expenditure.

commodity. Domestic and foreign tourists are not seen as substitutes (i.e., greater domestic tourist demand does not imply reduced foreign tourist demand, or vice versa). Indeed, employing Leontief, we are assuming that the composition of foreign/tourist demand expenditure remains constant and also moves in direct proportion with the fortunes of the tourist industry. In the lower nests, Armington CES nests are employed to characterise the substitutability between a domestic commodity and an import composite commodity; and imports from the EU and non-EU regions, respectively. These lower level Armington elasticities are the same as those employed in the private household Armington nests.

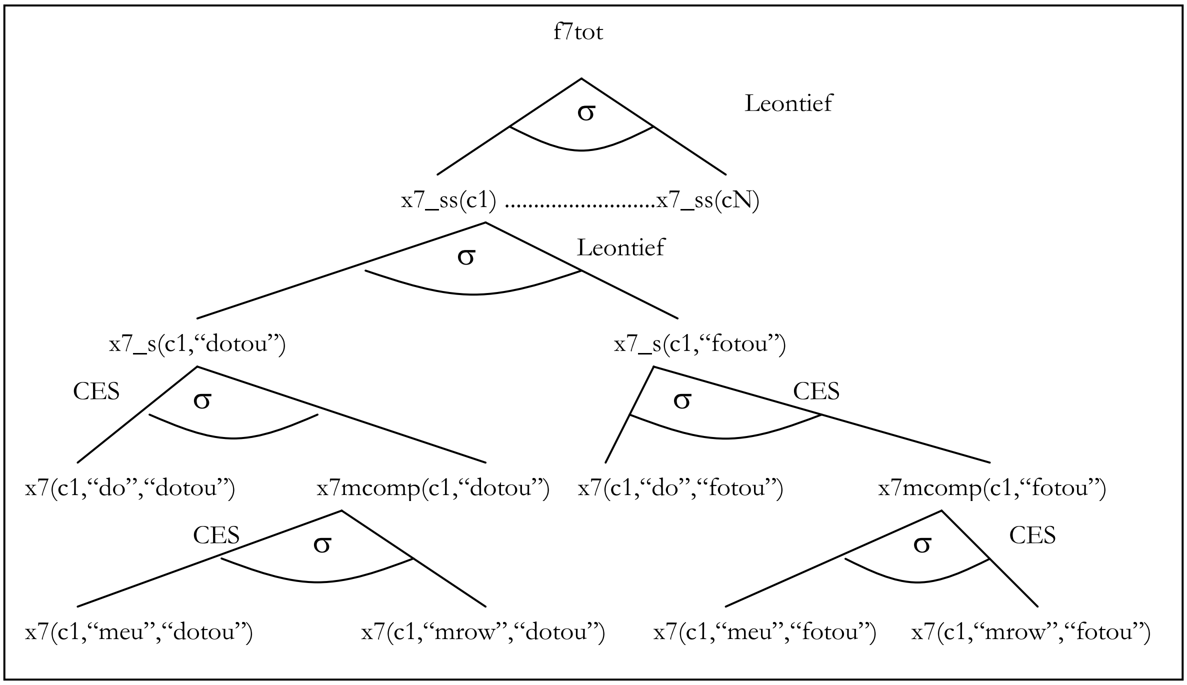


**Figure 6: The Tourism nest in ORANI-ESP.**

In the ORANI-ESP CGE database represented in Figure 3 of part I of the report, there is also a new account 8 which represents NGO expenditures on commodities. The model treatment for NGO expenditures follows the same simple structure that is used for government (public) demands in the ORANI model. Thus, changes in NGO demands, 'x8(c,s)', can be proportional to a simple exogenous aggregate shock variable (specified by the modeller). Alternatively, using a closure swap, it is possible to model changes in NGO demands in direct proportion to endogenous changes in real aggregate Spanish household demand.

**4. Labour and capital transfer in ORANI-ESP**

In the standard ORANI-G model, capital and labour may be allowed to move perfectly between using industries 'i'. This implies that the return of capital and labour is equal for each using industry 'i'. In the ORANI-ESP model, labour and capital transfer between the primary agricultural and non-primary agricultural sectors is made 'sluggish' via the usage of a CET function (see Figure 7). The policy implication is that in the real world, there are observed differences in the return to capital (rent) and labour (wages) between the two sub sectors. This concept follows the work on the agricultural variant of the GTAP model ('GTAP-AGR') by Keeney and Hertel (2006). In both cases, the elasticity of transformation in each nest is the same as that employed in the GTAP-AGR model.

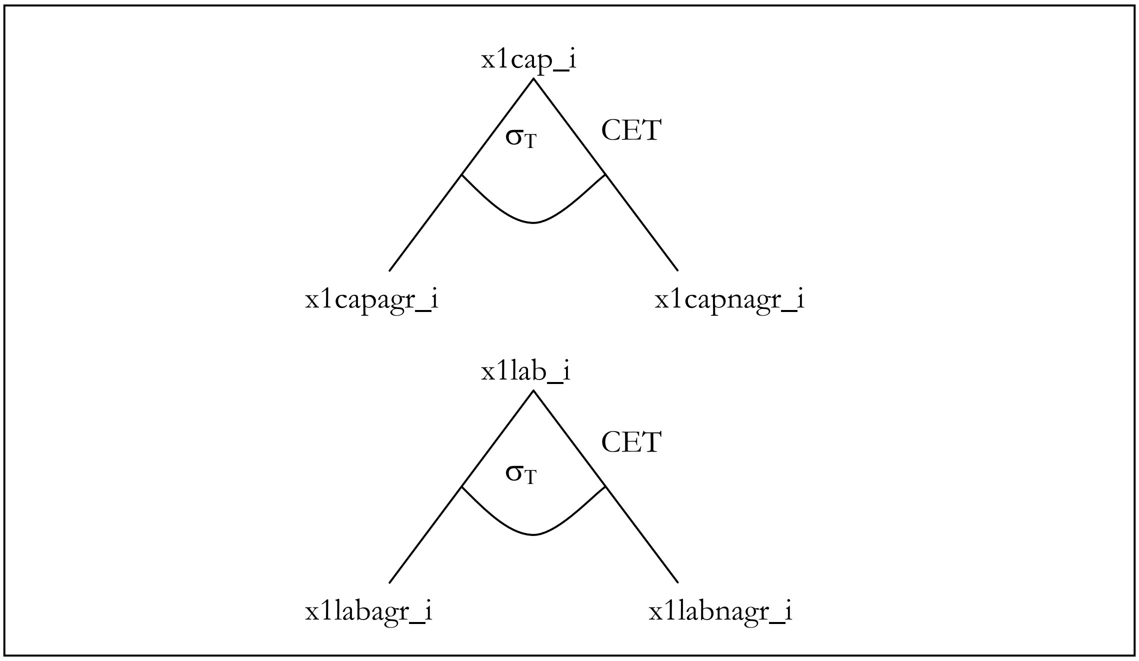


**Figure 7: The CET Labour/Capital Allocation between agricultural and non agricultural sub sectors.**

## 5. Explicit Modelling of Primary Agriculture

### *5.1. Production Quotas*[9]

In the ORANI-ESP database, milk and sugar production are divided into 'upstream' production (raw milk; sugar beet/cane) and 'downstream' production (dairy, sugar processing). The implementation of quotas is imposed on the upstream part of the supply chain.

In the standard GTAP model treatment (van Meijl and van Tongeren, 2002), a quantitative restriction is characterised as a simple closure swap. Thus, industry output, is exogenised and the output tax variable is endogenised. Thus, endogenous changes in the

[9] In ORANI-ESP, sugar and milk quotas use the same microeconomic framework. In the context of sugar, the advantage of this approach is that it does correctly characterise quota as an additional factor of production (read section 5.1 for further discussion) and also captures the binding/non-binding status of the quota mechanism. However, this treatment does not capture all of the nuances of the EU sugar policy, namely, the self financing principle and the A, B and C quota rates/price differentials.

production tax (now inclusive of quota rents) capture the necessary price changes in order to maintain production fixed. There are, however, 3 problems with this treatment.

1. It does not separate out taxes from quota rents (as they are assumed 'mixed together' in the tax wedge)

2. Characterising the quota rents as a tax does not capture the fact that the quota is an essential additional factor of production (that is, without quota, it is impossible to produce) and therefore, the rents accrued are analogous to a factor payment.

3. Given that output (qo) is exogenous, we are implicitly assuming that the quota is always binding, when this may not necessarily be the case.

For these reasons, ORANI-ESP takes advantage of GEMPACK's complementary slack code (Bach and Pearson, 1996) which allows an endogenous regime switch between binding and non-binding status in the quota and the modelling techniques of Lips and Rieder (2005). In the ORANI-ESP model database, the rent value is inserted as an additional factor of production (with intermediate and primary costs, production taxes and primary factor subsidies). This implies that given zero profits, changes in rents impact on final prices. Lips and Rieder (2005) employ such a modelling characterisation since they argue that, "producers get the quota rent in the form of a higher producer price and not as a transfer payment" (pp3). Also note that in the ORANI-ESP model, agricultural output is characterised by sector output, not by individual farming units. Thus, the quota must be modelled as sector-wide output constraint whilst the purchase/sales of quota between farms cannot be captured in this model, but is implicitly assumed to be efficient.

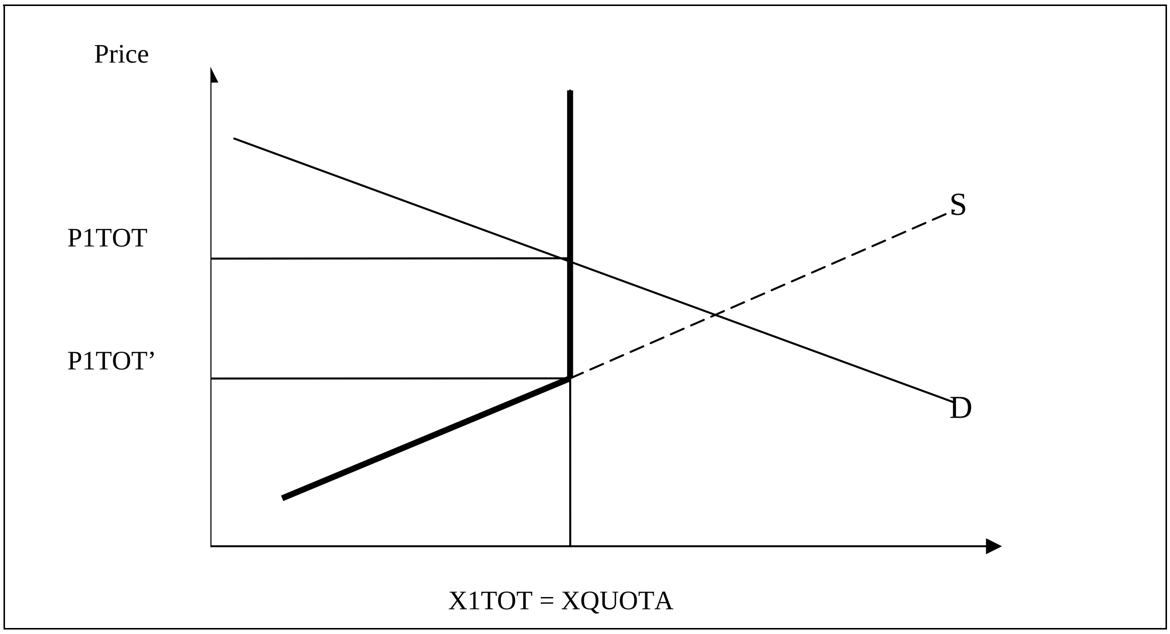


**Figure 8: Simple analytics of a quota**

Examining Figure 8, we see a hypothetical situation where the quota is binding (below the equilibrium) output level. In this case, the quota level of industry output and the current level of industry output are equal such that:

$$XR = X1TOT / XQUOTA = 1 \quad (3)$$

This implies that the shadow price or marginal cost unit price of production is at P1TOT' (governed by the intersection of the supply curve with the quota limit), whilst the market price of production is P1TOT. The difference between these prices is the per unit quota rent. If the supply or demand curve shifted to the left sufficiently, the quota would no longer be binding, such that:

$$XR = X1TOT / XQUOTA < 1 \quad (4)$$

and the quota rent would fall to zero. To characterise this either/or scenario, a **complementarity equation**[10] is employed into the GEMPACK model code which asserts that if the quota quantity ratio is binding (XR =1), then rent must be zero; whilst a less than binding value (i.e., $0 \leq XR < 1$) implies a positive rent value. Increases/decreases in quota allocations are implemented through increases/decreases to the exogenous variable XQUOTA. Assuming a binding status, a quota increase means that the ratio XR falls, thereby allowing X1TOT to increase endogenously to meet the additional allowable quota, or else the quota is non-binding and rent falls to zero (i.e., the shadow and producer prices are equal). The initial 2005 values of XR and 'rent' are discussed in section 18.2 of Part I of this report.

*5.2 Econometric Estimation of the Land Supply Function and implementation into ORANI-ESP*

In the standard CGE model treatments, land supply is exogeneous in each region. However, in reality, agricultural land supply can adjust due to the idling of agricultural land or the conversion of land to agricultural uses. The supply of agricultural land depends on its biophysical suitability, institutional factors (agricultural, urban and nature protection policies) and land price (Tabeau et al., 2006, p.3). Biophysical suitability refers to climate, soil and water conditions that make a plot of land suitable for cultivation. Accordingly, biophysical parameters will define the maximum potentially available land surface that can be used for agricultural purposes (the asymptote in Figure 9). At the outset, the most productive land is used first. With increases in land usage, farmers must employ less productive land implying that the marginal cost of conversion rises, which is reflected in a

[10] When we refer to a complementarity, we are saying that one of two expressions has a pre-designated (maximum or minimum) value.

higher land price. This relationship between land usage and prices gives an upward sloping supply curve (see Figure 9).

Any point along the supply curve is feasible from an agronomic point of view, however, every country/region will be positioned on a specific point, representing the current relative use of land in the agricultural sector. When the region is currently using a low proportion of all the potentially available land, any increase in demand for agricultural land will lead to conversion towards agricultural uses at a modest increase in price (e.g. point A in Figure 9). In this zone of the supply curve, the supply elasticity is relatively higher, and the marginal cost of converting non-agricultural land into agricultural land is relatively lower. However, when a region is currently cultivating most of the available land (e.g. point B in Figure 9), any increase in demand that requires the conversion of the scarce non-used land to agriculture, will lead to the conversion of the least productive land and at a relatively higher marginal cost (land supply elasticity is low).

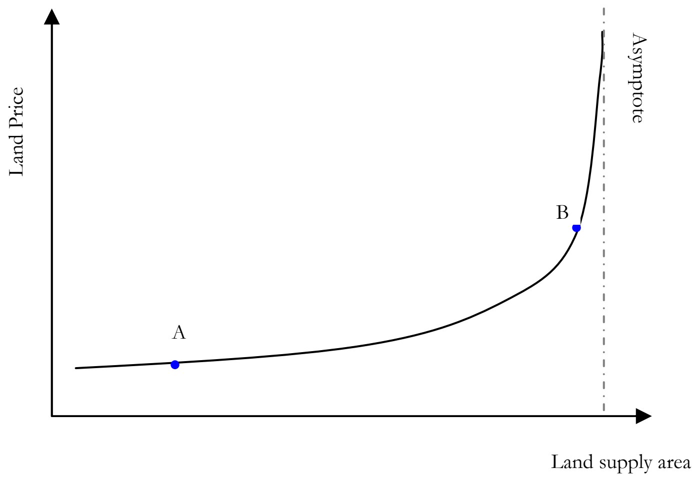


**Figure 9: Theoretical agricultural land supply curve**

Based on the work of van Meijl *et al.*, (2006) and Tabeau *et al.*, (2006) the land supply function in Figure 9 above takes the functional form:

$$Accumulated\ Area = a - \frac{b}{C_0 + \mathrm{Re}nt^{\rho}} \qquad (5)$$

where ‘a’ is the asymptote or maximum potentially available agricultural land; ‘b’, ‘C’ and ‘ρ’, are estimable parameters, and ‘Rent’ is the price of land.

In the estimation of the land supply function, data are employed on potential agricultural areas and yields provided by the bio-physical model: “Global Agro-ecological Assessment for Agriculture in the 21st Century: Methodology and Results” (GAEZ).

IIASA-FAO (RR-02-02). This source combines geo-referenced inventories of data for Spain on (i) the biophysical characteristics of the land resource, such as soil, terrain slope and climate; with (ii) growing requirements of crops (solar radiation, temperature, humidity, etc.), to calculate the amount of land that may be classified as suitable for producing each crop and the maximum potential and agronomical attainable yield. To proceed with the estimation of the land supply, first the yields data are sorted in descending order (with the corresponding potentially suitable areas), and second, the ascending area is accumulated. Then, following Tabeau et al., (2006) the variable 'land price' is defined as the inverse of the potential yield (1/yield). Thus, the relationship between the observations on accumulated land area and relative price follows an upward sloping curve (land supply). To improve the fit of the estimated supply parameters (b, C and ρ) to the observed data points, a Maximum Likelihood non linear regression method is employed.[11]

Writing the flexible non-linear expression for land supply in the ORANI-ESP code gives the following expression:

$$AREA = 1 - \left[ \frac{B}{C + RENT^{\rho}} \right] \quad (6)$$

where AREA is the levels variable for the change in "accumulated area" of land in Spain relative to the asymptote (a ratio which ranges between 0 and 1). The parameters B, C and ρ are econometrically estimated using the non-linear maximum likelihood procedure. Finally, RENT is the levels real price of land, which is calibrated given knowledge of the aggregated AREA variable and the parameters.

The update for the levels variable RENT is based on the corresponding percentage change linear variable (plandreal) in the model, which is a function of changes in the aggregated price of land in Spain, p1ld_m, and changes in the consumer price index, p3tot_h. In percentage terms:

$$plandreal = pldm\_i - p3tot\_h \quad (7)$$

Given changes in the real land price from the CGE model solution, and knowledge of the parameter values B, C and ρ, the flexible land supply calculates corresponding changes in land supply. Since the model solves in percentage changes, validating the implementation of the estimated land supply function in GTAP is given by checking that

[11] The smaller is the value b, the more inelastic is the land supply curve. The smaller is C, the more elastic is the land supply curve. The smaller is , the more inelastic is the land supply curve.

calculated land supply elasticities from the CGE model[12] from small incremental shocks are close to the initial single point elasticities calculated from the expression:

$$E^S = \frac{\partial Area}{\partial \mathrm{Re}nt} \bullet \frac{\mathrm{Re}nt_C}{Area_C} = \frac{\hat{b}^* \cdot \hat{p} \cdot \mathrm{Re}nt_C^{\hat{p}}}{(\hat{C}_0 + \mathrm{Re}nt_C^{\hat{p}})\left(\hat{C}_0 + \mathrm{Re}nt_C^{\hat{p}} - \hat{b}^*\right)} \qquad (8)$$

where the circumflex over the parameters indicate the econometrically estimated values.

*5.3 Introducing a Multi-Stage CET Function into the Land Market.*

In the standard ORANI model, Figure 10 shows how a CET function is introduced to model aggregate land allocation (variable x1lnd_i) across primary agricultural industries 'i' (variable q1lnd(i)).[13] The inclusion of a constant elasticity of transformation (CET) function captures the imperfect substitutability between different land types (i.e., land use in different industries implies different land types), although with only one CET nest, the degree of substitutability is equal between different land uses.

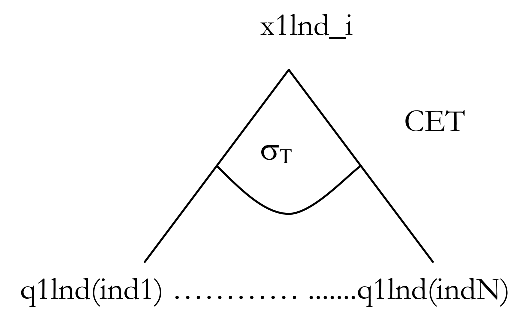


**Figure 10: The CET Land Allocation Tree in the Standard ORANI Model.**

In ORANI-ESP, we follow the characterisation of Tabeau et al. (2006) who used the allocation structure employed in the OECD's Policy Evaluation Model (OECD, 2003) by assuming that the substitutability of land allocation differs by land types. Figure 11 presents the modified allocation structure which is divided into three levels. The top nest controls the supply of land to the composite 'field crops and pastures' (FCP) sector and remaining primary agricultural sectors.

In the second nest, the FCP group is itself a CET aggregate of extensive livestock sectors (cattle, sheep and goats, raw milk), and a composite 'cereal, oilseed and protein'

[12] The supply elasticities are simply calculated as the ratio of the percentage change variables x1lnd_i/plandreal

[13] Only the primary agricultural sectors use the land factor in ORANI-ESP.

crops (COP). Finally, in the COP bottom nest, land is allocated between wheat, barley, maize, rice, 'other' cereals, sugar, oilseeds, textile crops and feedcrops.

Using this structure, one may specify an increasing degree of transformation (substitutability) between land types, where the more distinct are the agricultural activities (moving up the tree), the smaller are the elasticities. In the ORANI-ESP model, the CET elasticities in the lowest nest are identical to the standard GTAP model ($\sigma^T$=1). In the second nest, land substitutability between extensive livestock activities is modelled as more sluggish ($\sigma^T$=0.05). Similarly, in the top nest of Figure 11, land substitutability is assumed very sluggish between permanent crops (e.g., fruits sectors, olives, vegetables) and intensive livestock sectors such as pigs and poultry ($\sigma^T$=0.001).

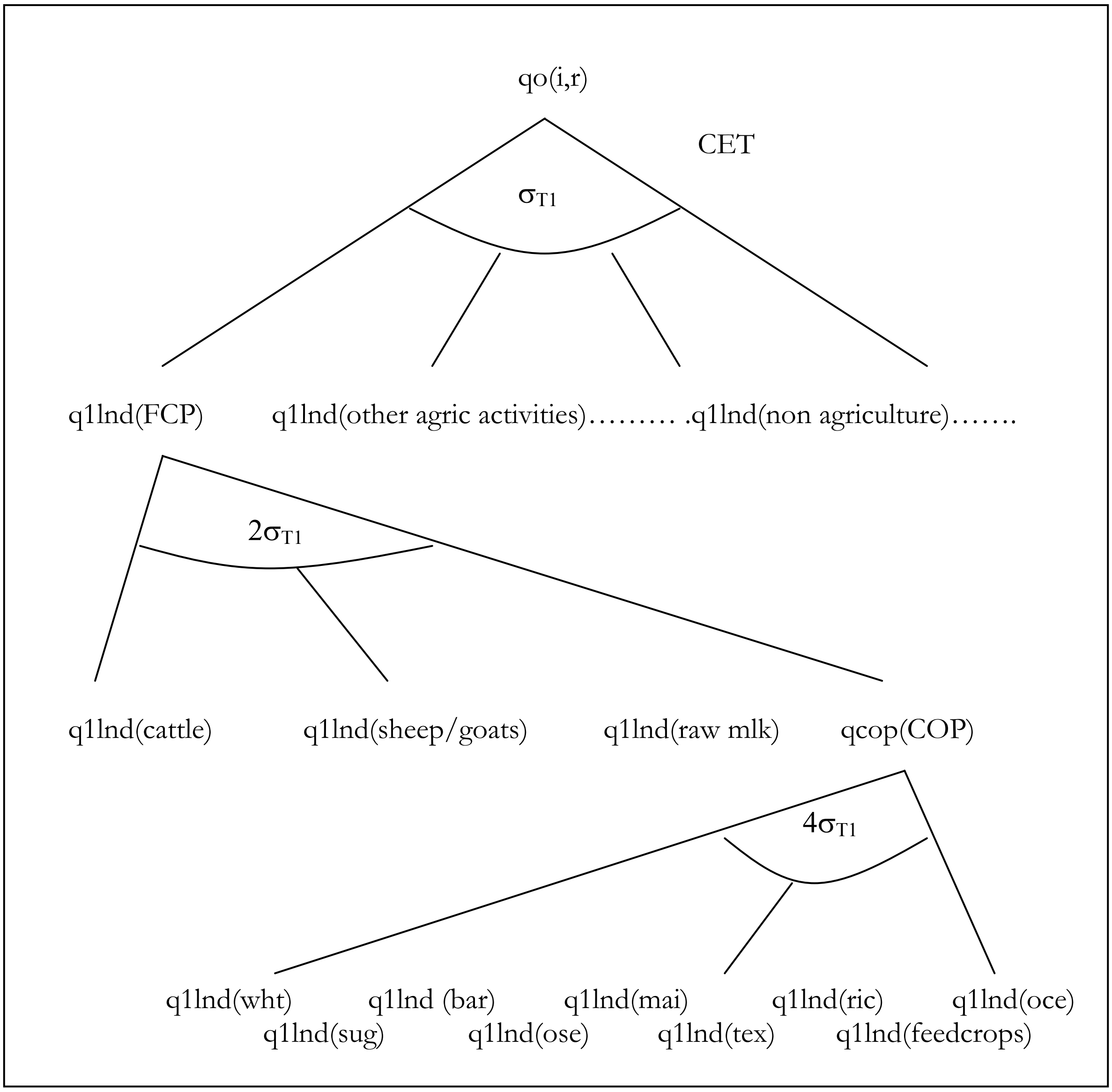


**Figure 11: A Modified 3 nested CET Land Allocation Tree.**

*5.4 The Single Farm Payment (SFP)*

The benchmark year for the ORANI-ESP database is 2005, which is one year prior to the implementation of the SFP in Spain. Thus, in the benchmark year, Spain is still operating under the 'old' Agenda 2000 system of area payment, set aside payments, headage payments, extensification premia etc. Following the characterisation in the GTAP CGE model, these quasi-decoupled payments are characterised as land and capital subsidies in the ORANI-ESP database (see section 17.10 in part I of this report).

To implement the SFP in the post 2005 period, we follow Frandsen et al. (2002). In their paper, the authors characterise the SFP as a uniform land payment on the 'registered land' area.[14] They show that the production response of the agricultural sectors under conditions of domestic support elimination compared with the implementation of the SFP are the same. This is because in 'relative' terms, uniform land payments do not favour any particular agricultural activity. The authors claim that such a modelling choice is useful in that the payment is decoupled from production, coupled to the land factor, and yields useful estimates on the extent to which the SFP is recapitalised into the value of the land factor (i.e., through increased market prices of land).

Notwithstanding, in Frandsen's study, it is assumed that the SFP affects all agricultural sectors. Although this is a plausible assumption for long run analysis, for medium run scenarios (i.e., the Mid Term Reform), certain agricultural sectors remain outside of the SFP scheme, whilst in those sectors that are covered by the SFP, extensions were granted to maintain coupled land payments within EU15 members to help transition to full decoupling. Firstly, this implies that the uniform payment should only be applied in specific agricultural sectors; and secondly, the insertion of the uniform payment into industry i's land subsidy wedge should be independent of the removal of agenda 2000 style payments from industry i's land subsidy wedge.

On the first issue, the implementation of a uniform land subsidy to specific agricultural sectors is achieved by fixing the SFP total across the set of agricultural industries. In this way, the SFP is strictly paid on the land factor employed by sectors within the SFP scheme.[15]

On the second issue, in the database, three land values are required: the agents (farmer) value of land, the market value of land (post SFP), and the market value of land (net of SFP). In the benchmark 2005 database, the latter two land values are equal, whilst an exogenous subsidy variable controls the per unit payment between each of these land values. Thus, one of the subsidy variables is used to (partially) strip out payments from

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[14] Unregistered agricultural land does not qualify for the SFP. Note that in the GTAP database, the land payment at agent's prices is calculated as 11% of value added payments in all sectors. In this way, the same uniform rate of land subsidy has a production neutral effect in the model.

[15] On a sector by sector basis, the SFP payments granted are equal to those coupled payments which have been withdrawn, which reduces the incentive to draw land away from other sectors not in the scheme. Moreover, the elasticity of transformation of land betwen sectors not in the scheme is very small (0.001) so this impact is minimal.

those agricultural sectors affected by the SFP, whilst the other is employed to insert the (uniform) SFP.

Data on the SFP payments to Spain are based on the value of removed coupled support payments in each of the scenarios. Thus, with greater levels of decoupling, the SFP totals increase. It should, however, be noted that 'pillar 1' SFP are reduced by 5% (10%) in the Mid Term Review (Health Check) scenarios to reflect modulation to Pillar 2.

*5.5 Export subsidy and quantity controls under the Uruguay Agreement and stock purchases*

This section explains the modelling required to maintain the Uruguay Round (UR) export subsidy and quantity limits and the implementation of stock buying. The benchmark year for the database is 2005, which implies that as a 'developed country', Spain has completed its UR export subsidy and quantity commitments. Thus, in a status quo scenario where the export subsidy is not eliminated, we must enforce the Spanish UR export commitments, whilst allowing for stock purchases.

In Figure 12, we see a simplified partial equilibrium analysis of the UR export subsidy and quantity relationships. It is assumed that the domestic market price, $P_m$ is fixed, which implies that the export subsidy expenditure function, in the lower part of the figure, is positive even at the free trade export quantity ($Q_f$). For the sake of argument, assume that the export quantity binding limit is $Q^o$, whilst the subsidy expenditure limit is $E_1$, then it is the quantity binding limit which is binding. Thus, the export quantity cannot exceed $Q^o$, whilst the export subsidy expenditure will only increase if the per unit export subsidy rate was exogenously increased (i.e., XS shifts to the left).

In terms of the model code, we must employ a COMPLEMENTARITY equation as follows:

```
COMPLEMENTARITY
(Variable = V4TAX, Lower_Bound = 0, Upper_Bound = V4LIMIT)            (9)
E_EXPSUB (all,c,EXPSET)(all,s,XROW) X4(c,s) - X4LIMIT(c,s) ;
```

In policy terms, this equation states that there are two limits to adhere to for the variable V4TAX (i.e., the export subsidy). The lower bound is zero, and the upper bound is the UR agreed limit set by the variable, V4LIMIT. The variable X4 is the export quantity, whilst X4LIMIT is the UR agreed export quantity constraint. Thus, if the export subsidy equals V4LIMIT, then the expression X4 – X4LIMIT must be less than zero (i.e., export quantity is below or equal to the ceiling limit). If the export subsidy is greater than zero but less than V4LIMIT, then the expression X4 – X4LIMIT must be zero (i.e., export quantity is equal to the ceiling limit - binding). If the export subsidy is zero, then the export quantity is greater than or equal to the UR limit.[16] Thus, if the export subsidy expenditure is binding, the quantity constraint less than or equal to the binding limit. If the quantity constraint is binding, then the export subsidy is less than or equal to the limit.[17]

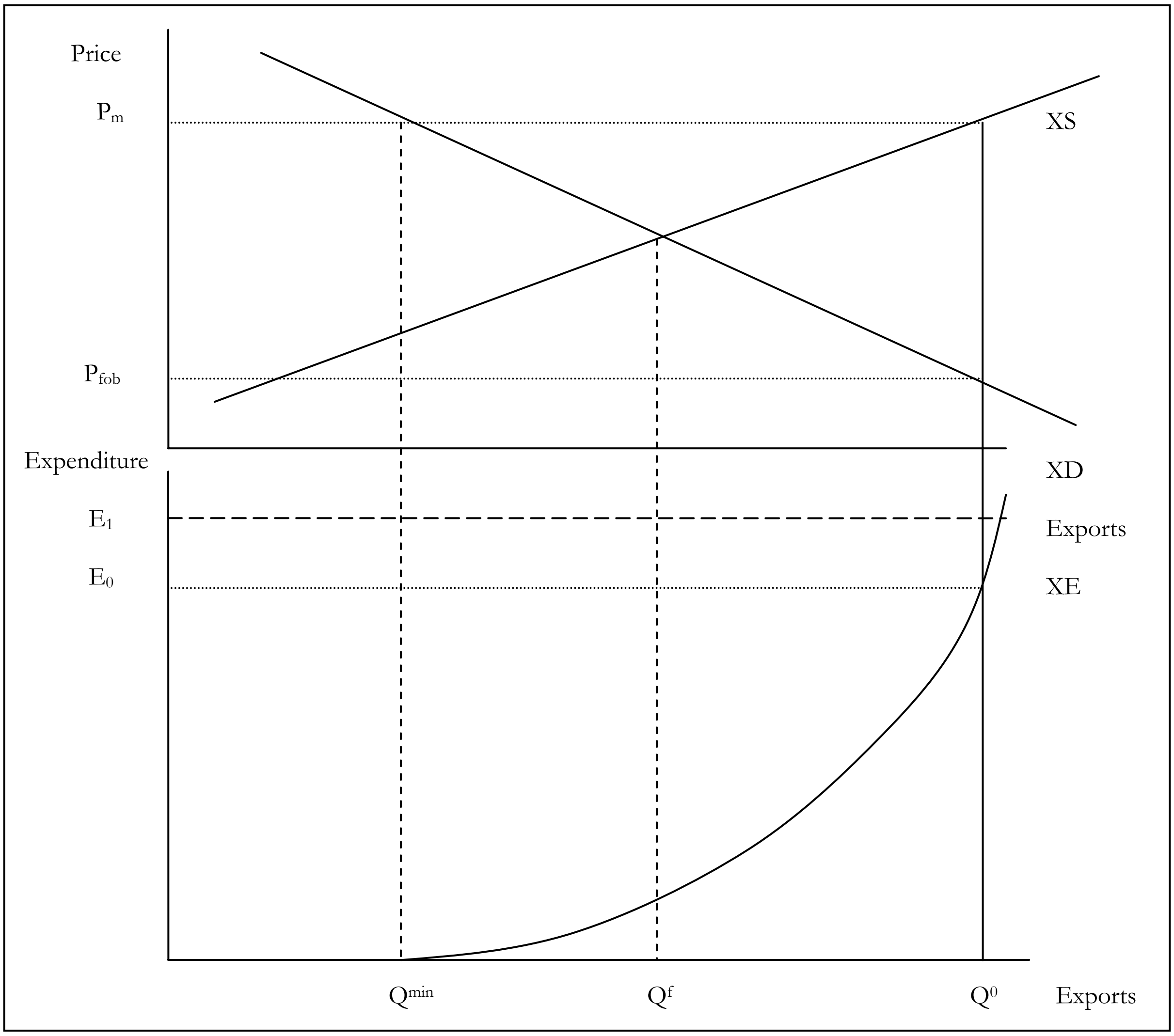


**Figure 12: UR Export Constraints for EU countries: A Partial Equilibrium Analysis**

In the ORANI-ESP model, the export subsidy rate (expt4) for non-EU exports is endogenised to pair off with the COMPLEMENTARITY equation and ensure closure. Note that the per unit subsidy is the difference between the 'basic' (i.e., domestic pre-subsidy) non-EU export price (pe) and the non-EU export f.o.b. world price (p4). In the model, the domestic commodity price (which is the internal market price), p0com, is a

[16] In practise, this state never occurs, since if we wanted to eliminate the export subsidy, we would simply apply an exogenous shock.
[17] The downside of this treatment is that it doesn't deal with a scenario when neither is binding. One, or the other, or both must be binding.

weighted average of the domestic sales price (p0dom) and the composite basic export price (pe_c).

Thus, the intervention prices are modelled employing a separate COMPLEMENTARITY expression:

COMPLEMENTARITY
(Variable = STOCKS, Lower_Bound = LOWER, Upper_Bound = CEILING) (10)
E_c_STOCKS (all,c,EXPSET)(ALL,s,DOMES) P0COM(c) - PINT(c,s) ;

The intervention price is an (exogenous) policy controlled variable, PINT. Thus, given knowledge of the ratio between the intervention price and the domestic Spanish price,[18] one knows how far P0COM has to fall in order to trigger stock purchases. For example, if P0COM has a value of 1, and we know that P0COM / PINT is 2, then we know that PINT is 0.5. In the equation, if P0COM – PINT is greater than zero (i.e., P0COM > PINT), then STOCKS are zero. If P0COM – PINT equals zero, then stocks are triggered (i.e., STOCKS > zero). If stocks reach their upper bound (denoted by CEILING which equal 5% of total commodity supply), then P0COM – PINT is less than zero. The intuition in the final state is that stock purchases are not indefinite and will ultimately cease, thereby allowing the market price to fall below the intervention price.

To model intervention price reductions, the variable **PINT is exogenously reduced by the relevant percentage to lower the stock triggering point**. Moreover, **to capture the economic impact of intervention price falls**, import prices are reduced through equivalent **percentage reductions in the variable pf0cif** on non-EU imports; and the fob price of exports is increased due to the reduction in the per unit export subsidy (see Figure 14) from reductions in the internal institutional prices. The fob price rise is achieved via a **decrease in the price shift variable 'f4p'** on non-EU exports.

*5.6 The farm household*

As a useful summary statistic to policy makers, further equations are inserted into the ORANI-ESP model code to calculate farming income changes. More specifically, farm household income is decomposed into two components:

(i) The **return to 'agricultural' capital, land and labour** at factor cost plus the **quota rent** from milk and sugar sectors.

(ii) **Support payments** on capital (headage payments, investment aids etc), land (set–aside, area compensation etc.), intermediate inputs (seed payments, young farmers allowance, LFA payments etc.), production (direct payments on olive oil, wine etc.) and export subsidies.

[18] See section 18.2 in Part I of this report.

In a separate equation, these are added together to form an aggregate calculation of farming income.

**6. The medium to long run closure in ORANI-ESP**

In the ORANI-ESP model, the number of variables (n) will exceed equations (m), which requires (n-m) exogenous variables. From a mathematical perspective, the exogenous-endogenous split must ensure that the endogenous coefficient matrix is invertible.[19] It is therefore the realm of economics to which we need to turn in order to guide our choice of appropriate closure. For example, if an import quantity is exogenised, the corresponding price imported will need to be endogenous (to capture, say an import quota). Likewise, with a price fixing closure (exogenous price), the quantity should be allowed to adjust given this constraint. If both price and quantity are exogenised in a given market, we must allow the non own-price determinants to change endogenously (i.e., allow the curve to shift) – which implies the need to endogenise taste (demand) or technology (supply) variables.

More pertinently, assuming that the mathematical condition for closure is met, the economic choice of closure is guided by three considerations:

Firstly, how available are the data? For example, the explanatory factors behind taste and technology changes in forward looking models are relatively vague. Both are a function of time, whilst economists have very little so say about taste changes and are not specific regarding technological advance. Accordingly, these variables lend themselves to an exogenous treatment. If 'acceptable' proxy data are available, then exogenous shocks may be applied within a baseline scenario.

Secondly, what is the maintained hypothesis for the macro economy. It may be that the modeller wishes to focus on the short run impacts. In this case, a closure where real wages are fixed (controlled by unions) under the 'sticky wages' hypothesis is more appropriate. With a closure change, a long run labour market scenario would imply fully flexible real wages.

Thirdly, there is the issue of what the focus of the simulation is. It may be that the impact of milk quotas is of paramount importance – thus, the milk quota must be exogenised, whilst rent adjusts endogenously. Alternatively, the modeller may be interested in targeting a specific employment rate (exogenous), whilst allowing the labour income tax to vary (such that the employment rate is achieved).

In the ORANI-ESP model, a long run closure is employed where all technological, taste and taxes/tariff/subsidies variables are exogenous. Moreover, given the small country assumption, it is assumed that the world price of import and exports are exogenous. In the long run baseline, productivity changes are exogenously applied to each sector, whilst a

[19] See appendix I of Karaca and Philippidis (2006) for a further discussion.

macro-wide productivity variable is swapped with real macro growth to allow the modeller to target GDP growth over the time horizon of the baseline. Private household and inbound tourism taste variables are also shocked to capture health trends which are moving in favour of white meat consumption and away from red meats. The stock of capital is held exogenous and shocked to crudely represent capital accumulation, whilst all sectors (bar the 'services' sector) follow the trend that the production of capital goods in industry 'i' is directly proportional to the economy wide increase in capital goods production (which itself is influenced by the exogenous increase in capital services). In the services sector, new capital goods production in services shadows the change in capital stock usage in services.

Both land and labour endowments in Spain change endogenously. In the former case, an exogenous land supply function has been estimated. In the latter, the real wage is fully flexible (long run), whilst through different supply elasticity functions for different labour occupations (more highly skilled implies lower supply elasticity), employment changes as a function of real wages (i.e., the wage deflated by the consumer price index). The usage of different supply elasticities also implies that the return to each labour occupation is different.

In terms of agricultural product markets, intervention prices are exogenous and shocked according to policy conditions, whilst the quota quantity limit is exogenous (allowing binding/non-binding status) and can be increased when examining gradual phasing out of quota. The quota rent adjust endogenously. The relevant agricultural land and capital subsidy shocks capture removal of direct (agenda 2000) subsidies, whilst shocks to exogenous production subsidy and intermediate input subsidy variables characterise policy reductions in other support which are reconstituted within the SFP.

Finally, the trade balance is assumed to be fixed as a proportion of GDP. It is therefore assumed that large trade surpluses/deficits are not indefinitely sustainable. This is achieved by swapping the endogenous variable describing the ratio of the trade balance to GDP (delB) with the exogenous exchange rate variable (phi). Thus, it is assumed that exchange rates adapt to changes in macro and trade conditions. Clearly, the disadvantage here is that there is no consideration for the fact that Spain is part of the Euro, and changes in the currency reflect the fortunes of <u>all</u> countries in the euro zone (not just Spain). On the other hand, given the small country assumption, this mechanism allows domestic and foreign prices to align with each other over the horizon of the scenario. For example, if a policy scenario implies general price falls in Spain, cheaper exports implies that the trade surplus improves, which (*ceteris paribus*) also results in an appreciating exchange rate (increased demand for domestic currency to buy Spanish exports). In the long run, it is assumed that a large trade surplus cannot persist. Thus, given the fixed ratio between the trade balance and GDP, an appreciating exchange rate makes imports cheaper, which pushes the exchange rate downwards again until the trade balance condition is met.

**7. Conclusions**

This document begins with a brief description of the standard ORANI-G model.[20] ORANI-G has received considerable recognition from modellers around the world since the data base and model structure are 'relatively' easily tailored to a set of published input-output accounts. Consequently, national economy models employing the ORANI-G template have been developed for over 30 countries around the world. Continuing in this tradition, the current document discusses the ORANI-ESP model; a specially tailored extension of the ORANI-G model for the Spanish economy. Since the priority of the model is to aid policy analysis in the agro-food sectors, the modelling of agricultural primary factor, intermediate input and output markets has been improved considerably. Moreover, given the rising importance of bio fuels and the implications for land usage, explicit modelling of energy demands in the private household and production nests provides flexibility in examining the impacts of fossil fuel price changes on bio fuels production through substitution possibilities within the nests. In addition, ORANI-ESP provides additional final demands accounts for 'inbound' tourism and NGO activity; labour and capital transfer between agricultural and non-agricultural sectors is modelled as sluggish; whilst trade links are now subdivided between EU and non.-EU routes.

Whilst ORANI-ESP represents an important departure from the standard ORANI-G model, and at the same time a useful policy analysis tool for agro-food policy, it should still be considered as a 'work in progress'. Further developments are likely to be included in the future, including an improved treatment of land to account for irrigated and non irrigated land substitutability in crops sectors, whilst also accounting for the importance of water demand in irrigated land. Further model developments centre on the macro/micro underpinnings of the model (i.e., imperfect competition in food processing, linking private households to factor returns, 'dynamic' investment behaviour), whilst some form of CAP budget would have implications for net injections/withdrawals from the Spanish economy and consequently the balance of trade sub-balance. In addition, improvements in the econometric specification of the model parameters (i.e., labour supply elasticities, expenditure elasticities, substitution elasticities) employing data specific to Spain, would enhance the quality of model estimates significantly.

Notwithstanding, with its detailed multi-commodity/industry database, ORANI-ESP is the first agro-food CGE model for Spain and constitutes a useful platform for detailed

[20] As noted in the introduction, for a detailed understanding of CGE models and the ORANI-G model, consult Karaca and Philippidis (2006) and Horridge (2003).

quantitative assessments of changes in domestic agricultural policy and changes related to the ongoing Doha reforms.

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