Globalisation, derived demand, and the competitiveness of agricultural sub-sectors

Peter WALKENHORST *

1. Introduction

As a result of the Uruguay Round Agreement on Agriculture (URAA), international trade in agricultural products became subject to the disciplines of the GATT/WTO framework. Signatory countries agreed to liberalisation commitments regarding market access, export subsidies, and domestic support. However, the impact of the URAA on agricultural markets has been limited, because tariffs and export subsidy allowances have been bound at relatively high levels and many domestic support policies have been exempt from reductions (JOSLING, 1998).

Further liberalisation of international agricultural trade is expected to be one of the central issues in the "Millennium Round" of WTO trade negotiations. If an agreement on additional cuts in import tariffs, export subsidies, and domestic support would be reached, the excess protection frequently built into the URAA commitments might be squeezed out and the effects of less distorted trade flows might be felt more clearly on agricultural markets. It is thereby likely that the impacts of globalisation on the agricultural sector differ across countries, regions, and commodities.

One reason for expecting differences in the effects of trade liberalisation on different markets is that the level of protection varies considerably across geographical entities and agricultural commodities. For example, the OECD (1999) reported values for the Producer Support Estimate (PSE), a comprehensive measure of consumer and taxpayer transfers to farmers, that ranged from 1 per cent of production value in New Zealand to 69 per cent in Switzerland during the period 1996-98. Across commodities, the average product-specific PSE values in OECD countries during the same period varied between 7 per cent for wool and 74 per cent for rice. Even for individual countries the differences in support for different commodities vary substantially. In the EU, for example, PSEs during 1996-98 ranged from 4 per cent for pigmeat to 65 per cent for sheepmeat. Hence, sheep farmers received considerably higher support than pig farmers. Yet this also means that the former have much more to loose from further agricultural trade liberalisation than the latter, who might well gain from a reduction in trade barriers due to trade liberalisation induced reductions in feed costs and increases in world pigmeat prices. More generally, the incomes of farmers that currently receive relatively large amounts of support are more vulnerable to trade policy reform than the earnings of agricultural producers that serve less protected markets.

Another reason why the impact of further agricultural trade liberalisation might be expected to differ between sub-sectors is related to differing characteristics of agricultural production systems. Many agricultural commodities share a number of features which influence the exposure of farmers to changes in world market conditions: (i) agricultural commodities tend to be bulky, so that relatively high transport costs provide for natural protection; (ii) agricultural production relies on farmland as a sector-specific input, so that reductions in land rents might allow farmers to absorb price reductions without substantially reducing output; and (iii) agricultural products generally undergo some form of processing before becoming consumable, so that demand from local processors for raw materials, i.e. derived demand, might in the short term be more important than “direct” demand from world

* The author is economist in the Directorate for Food, Agriculture and Fisheries, Organisation for Economic Co-operation and Development, 2 rue André Pascal, F-75775 Paris Cedex 16. The views expressed are the author’s own and do not necessarily reflect those of the OECD or its Member countries.

markets. The degree to which different commodities exhibit these characteristics will likely influence the impact of further agricultural trade liberalisation on the respective markets.

Yet many studies of agricultural trade liberalisation do not explicitly consider the spatial character of agricultural production. Many omit the fact that the production of agricultural commodities relies on sector-specific production factors, such as farmland, whose prices are determined endogenously. Many do not take into account that capital-intensive downstream industries might adjust only slowly to changes in agro-food markets. And even fewer consider transport costs, land markets, and processing industries simultaneously.

This disregard for sectoral characteristics occurs despite recent evidence that such factors can have important implications for agricultural policy analysis. BIVINGS (1997) and MWANAUMO *et al*. (1997) showed that the liberalisations of the Mexican sorghum and Zambian maize markets, respectively, were misjudged, because decision makers failed to take the spatial dimension of trade into account. OECD (1998) reviewed a number of empirical studies that confirm the theoretically expected capitalisation of farm support in the prices of sector-specific fixed assets. And WILLIAMS and ISHAM (1999) found that the inclusion of processing industries can alter the results of policy analysis considerably.

Failing to take transport costs, land market adjustments, and processing sectors into account will tend to overestimate the effects of trade barrier reductions on domestic agricultural prices and farm incomes in high-protection countries. Indeed, as the omission of any one of the three sectoral characteristics biases the results of trade policy analysis in the same direction, their joint omission will have a cumulatively strong effect on the analytical outcome. This paper uses an empirically calibrated model to evaluate the relative importance of the three sectoral characteristics for the results of trade policy analysis. Particular attention is devoted to a comparison between the impact of trade liberalisation on the producers of agricultural commodities that differ with respect to the degree to which they reflect sectoral characteristics.

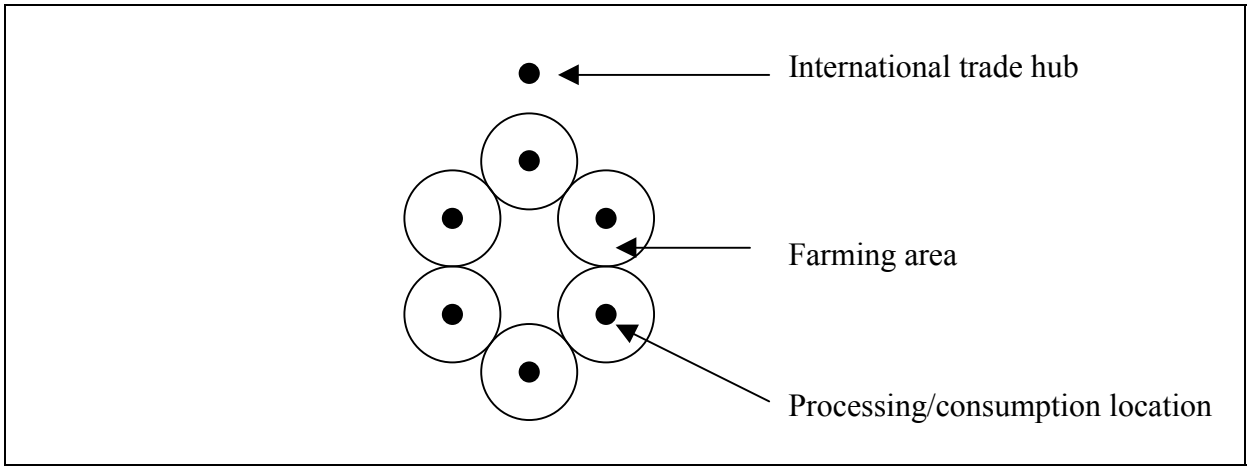
The remainder of the paper falls into three parts. Section 2 describes a stylised agricultural economy which reflects the spatial character of agricultural production, allows for adjustments in land rents, and explicitly considers processing industries. Section 3 presents a corresponding optimisation model that is subsequently used to analyse the effects of trade liberalisation on a previously protected agricultural economy. Then, section 4 reports results from a number of model runs that compare the implications of trade liberalisation under alternative model specifications. Finally, section 5 presents conclusions.

2. The agricultural economy

The analytical approach in this study builds on plant location studies, such as KILMER *et al*. (1983), GIBSON *et al*. (1991), and DURHAM *et al*. (1996). This line of research has aimed to weigh the balance between regional differences in farming costs, transport charges to ship the raw materials from the farming to the processing location, and scale-economies in processing. The model used in this paper deviates from the standard plant location set-up by explicitly allowing for changes in land rents and land use, as well as considering international trade in raw materials and food products as a substitute for domestic production.

The model's agricultural economy differentiates between six central processing/consumption locations, which are organised in hexagonal form and surrounded by circular farming areas (Figure 1). This spatial configuration has the advantage of symmetry and equal distances between neighbouring processing locations. The only spatial irregularity is due to a trade hub, which might be thought of as a port, through which all international trade is channelled.

Figure 1: Spatial configuration of the model economy



Source: Author.

Farmers in the model economy grow one crop, the production of which requires a combination of sector-specific and variable inputs. The former comprise farmland, but also the parts of the capital and labour inputs that would not be suitable for employment in non-agricultural sectors of the economy. For specificity, these fixed assets are called land, and the variable inputs are called fertiliser. The price of the latter is determined on world markets and its supply is perfectly elastic, as the model economy is assumed to be small.

Land throughout the economy is assumed to be of uniform quality, so that any land rents are due to differences in proximity to consumption centres. Land can be left idle, if the land rent from growing the crop would fall below zero. Crop yields depend on the level of fertiliser input, which in turn is assumed to vary proportionally with crop prices. The elasticity of yields with respect to crop prices is taken to be $\varepsilon = 1$.

The agricultural crop has to be transported to the central location, where it can either undergo processing, be shipped to another processing location, or be exported to the world market. In parallel, domestic processors have the choice to buy their raw materials from farmers in the vicinity, from other domestic agricultural producers, or from international trade partners. Imports of agricultural raw materials and food products are subject to tariffs, which are assumed to be the only trade policy instruments in the economy. Agro-processors can sell their output to local, other domestic, or foreign consumers.

Agro-processing facilities generally employ substantial quantities of industry-specific, long-lasting equipment that can not easily be dismantled and re-employed in other sectors or countries. As a result, past investments in processing plants are sunk. In the model economy's processing sector, it is assumed that these fixed costs account for half of the total processing costs at rated capacity. The other half of total costs is variable.

Consumption takes place at the central locations, which might be thought of as being towns, and the elasticity of demand for food products is taken to be $\eta = -0.3$. Consumers can buy food products from their local processor, from other domestic processors, and from international suppliers. Imports, however, are subject to tariffs.

World market supply and demand of agricultural raw materials and food products is taken to be perfectly elastic. Hence, changes in the model economy's volume of imports or exports do not affect world market prices. Technology and costs of international agro-processors are assumed to be identical to domestic ones, while total farming costs of world market producers are taken to equal variable farming costs in the model's agricultural economy if a 50 per cent tariff on food products is applied. Hence, international prices are below the domestic price level. To protect domestic producers against international

competition, tariffs on imports of agricultural and food products are applied. The structure of tariffs does not favour farming over processing, or *vice versa*. In other words, there is no tariff escalation or de-escalation.

3. The model

The algebraic formulation of the model is as follows:

$$
\begin{aligned}
(1)\ \textit{Max Surplus} = \ & \Sigma_k P_k^{Food}(Q_k^{Food} + Q_k^{Food\ Imports}) * (1 - 1/\eta) * (Q_k^{Food} + Q_k^{Food\ Imports}) * 0.5 - \\
& \Sigma_k [P_z^{Food} + T^{Food}] * Q_k^{Food\ Imports} + \Sigma_k P_z^{Food} * Q_k^{Food\ Exports} - \\
& \Sigma_k C_{k,z}^{Transport} * Q_k^{Food\ Imports} - \\
& \Sigma_k C_{k,z}^{Transport} * Q_k^{Food\ Exports} - \\
& \Sigma_j \Sigma_k C_{j,k}^{Transport} * Q_{j,k}^{Food\ Shipped} - \\
& \Sigma_j C_j^{Processing,\ Fixed} - \Sigma_j C_j^{Processing,\ Variable} * [Q_j^{Crop} + Q_j^{Crop\ Imports}] - \\
& \Sigma_j [P_z^{Crop} + T^{Crop}] * Q_j^{Crop\ Imports} + \Sigma_j P_z^{Crop} * Q_j^{Crop\ Exports} - \\
& \Sigma_j C_{j,z}^{Transport} * Q_j^{Crop\ Imports} - \\
& \Sigma_j C_{j,z}^{Transport} * Q_j^{Crop\ Exports} - \\
& \Sigma_i C_i^{Farming,\ Variable}(P_i^{Crop}) * Q_i^{Crop} - \\
& \Sigma_i \Sigma_{j \neq i} C_{i,j}^{Transport} * Q_{i,j}^{Crop\ Shipped} - \\
& \Sigma_i \Sigma_{j=i} C_{i,j}^{Transport}(Q_{i,j}^{Crop\ Shipped}) * Q_{i,j}^{Crop\ Shipped};
\end{aligned}
$$

where *Surplus* is the sum of the consumer and producer rents; *P, Q,* and *C* stand for price, quantity, and costs, respectively; *T* represents the import tariff; η stands for the elasticity of demand; *i* indexes the farming location, *j* the processing sites, and *k* the consumption location, while *z* stands for the location of the international trade hub.

The optimisation model is subject to the following constraints: first, the quantity of food consumed at location k cannot exceed total food shipments to the location:

$$
(2) \qquad Q_k^{Food} + Q_k^{Food\ Imports} \geq \Sigma_j \Sigma_k Q_{j,k}^{Food\ Shipped} + Q_k^{Food\ Imports},
$$

Second, the total quantity of food transported from processing location *j* for consumption cannot exceed food output at *j:*

$$
(3) \qquad \Sigma_j Q_{j,k}^{Food\ Shipped} \geq Q_j^{Food},
$$

Third, food output at processing location *j* has to be less or equal to the quantity of transformed agricultural raw material that is delivered to this processing plant:

$$
(4) \qquad \alpha * [\Sigma_i Q_{i,j}^{Crop\ Shipped} + Q_j^{Crop\ Imports}] \geq Q_j^{Food},
$$

where α is a technological coefficient that describes the crop to food transformation rate.

Finally, the production at farming location *i* has to exceed the quantity of crops shipped from there:

$$
(5) \qquad Q_i^{Crop}(P_i^{Crop}) \geq \Sigma_j Q_{i,j}^{Crop\ Shipped}.
$$

This model was specified by approximating empirical data on costs of sugarbeet farming, transport, and processing as reported by MAHLER (1994) and WALKENHORST (1998). It was calibrated such that the domestic price level before trade liberalisation makes

consumers indifferent about buying food products from domestic or foreign suppliers, and that domestic agricultural production is just sufficient to operate the existing processing facilities at rated capacity. The model was transcribed into a GAMS programme and solved using the non-linear MINOS algorithm.

4. Scenario description and model results

To evaluate the impact of characteristics of the agro-food sector on the results of trade liberalisation analysis, four model specifications, reflecting sectoral characteristics to varying degrees, are developed and their outcomes compared. The "reference model" is based on three assumptions: (i) land rents can fall if the domestic price level drops, (ii) half of total costs in the processing sector are fixed costs, and (iii) the agricultural crop is bulky and relatively costly to transport. In contrast, the "fixed rent" scenario takes the level of land rents before a reduction of border tariffs as being given, while maintaining all the other assumptions of the "reference model". The "flexible processing" scenario is identical to the "reference model" except for the assumption that only a quarter instead of half of total costs in the processing sector are fixed. Hence, the transformation of raw materials into food products adjusts more flexibly to the supply of agricultural products. Finally, in the "low-cost transport" scenario transport costs are assumed to be only half as high as those in the "reference model".

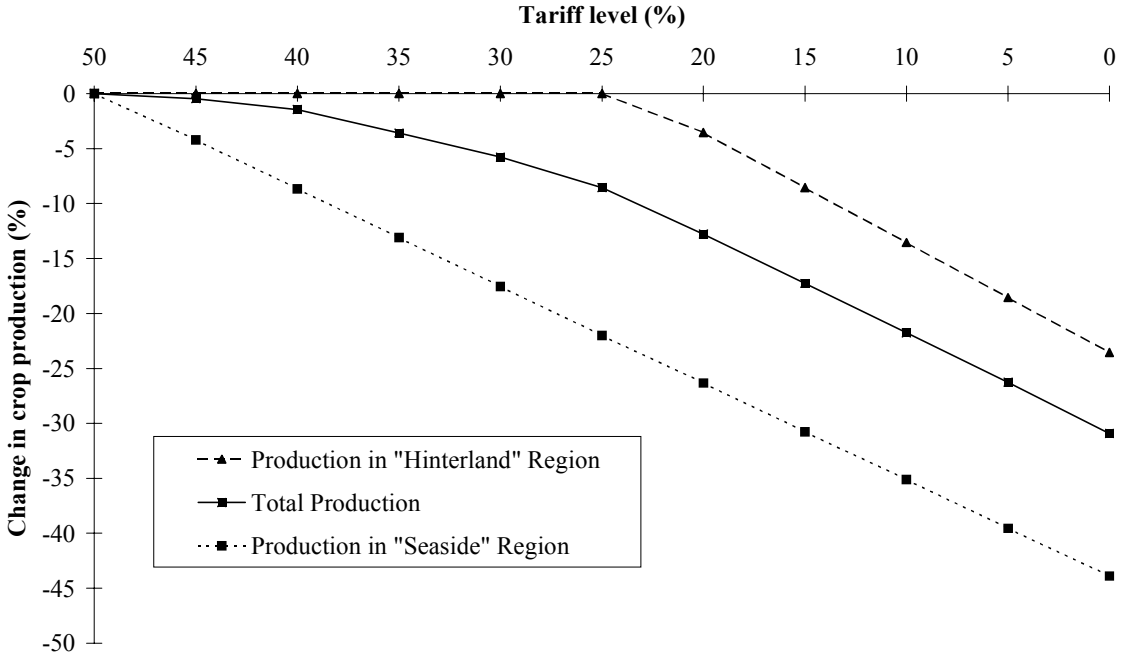
Figure 1 shows that results of a "reference model" run. As the external tariffs are lowered from their original level of 50 per cent to zero, total crop production in the agricultural economy decreases. However, the relationship between tariff levels and the decrease in domestic production is non-proportional and highly non-linear. The result that the percentage decrease in crop production is lower than the percentage reduction in tariffs is due to the existence of transport costs, while the non-linearity is caused by a processing sector that can not adjust its capacity easily.

Many agricultural products are bulky and, relative to their value, costly to transport. In the reference scenario, it is assumed that 7 tonnes of agricultural raw material are needed to produce one tonne of food. This ratio corresponds roughly to the technological relationship in the sugarbeet processing industry. With such high costs of transport, the location of production matters. In addition to the development of overall crop production in the model economy, figure 1 also shows the changes of crop production in two regions of the economy. The decline in production in the "seaside" region, i.e. the farming area close to the international trade hub, turns out to be much more pronounced than the decrease in the "hinterland" region, which is the model economy's region the furthest away from the trade hub. These differences reflect the "natural protection" that the "hinterland" region has due to the large distance to international markets. Farmers in the "hinterland" region are thus in a better position with respect to a reduction in trade barriers than agricultural producers in the "seaside" region.

The non-linearity in the relationship between tariff reductions and crop production is caused by the fact that the demand for the agricultural raw material is a derived demand. Consumers are not interested in buying sugarbeets, for example, but the processed product sugar. The demand for sugarbeets comes from processing factories instead. If the latter cannot adjust their production capacity easily to a new market situation they might not be able to pass price reductions in their output markets on to the suppliers of their raw material. As a result, farmers might be less adversely affected by trade barrier reductions than processors. Hence, farmers producing agricultural products that require processing in capital-intensive facilities, might be more competitive than the producers of farm products that do not require any substantial processing or whose processing industry can adjust its capacity easily.

However, in the longer term, capital-intensive processors will also adjust the size and location of their facilities, so that the competitive advantage of farmers in these sub-sectors will tend to be only temporary.

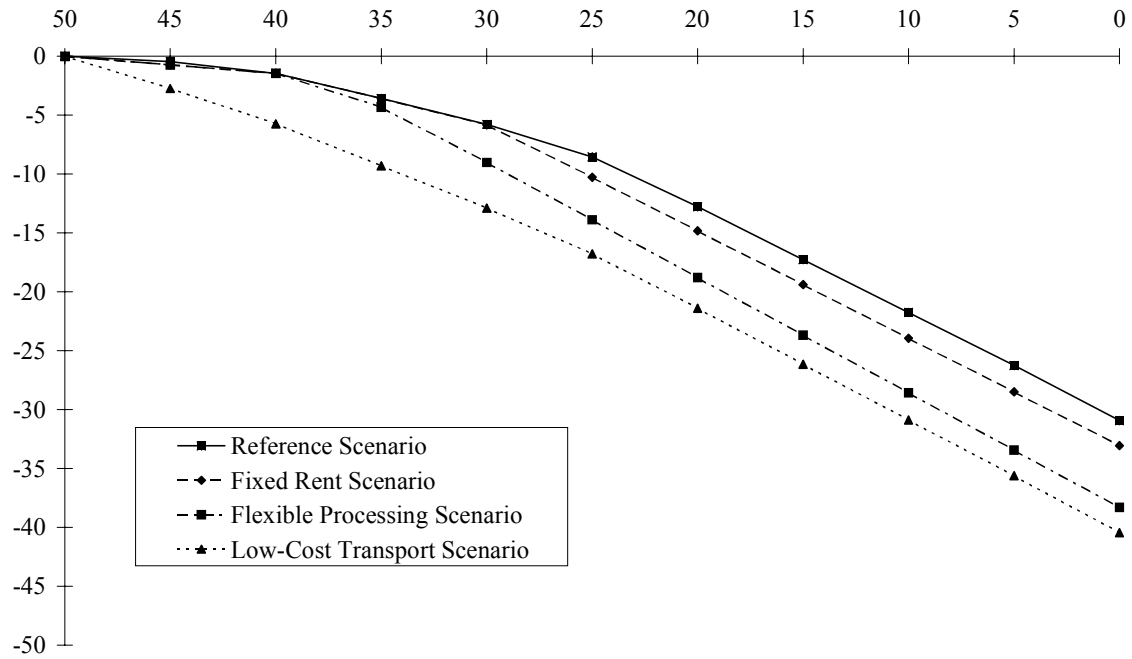
Figure 1: Results of trade liberalisation under the reference scenario



Source: Author.

Further scenario analysis with the model shows that sectoral characteristics, such as transport intensity, sector-specific inputs like farmland, and capital-intensive processing needs, can have a significant impact on the results of trade liberalisation analysis. Figure 2 presents the outcomes of model runs for the "low-cost transport", "fixed rent", and "flexible processing" scenarios in comparison with the "reference" scenario. All the alternative model specifications lead to results that predict more pronounced impacts of trade liberalisation on agricultural production. In other words, producers in sub-sectors where transport costs are relatively less important than under the assumptions of the "reference" scenario, or where land markets do not adjust as flexibly, or where fixed costs do not play such a large role in the downstream sector are relatively more vulnerable to reductions in trade barriers and relatively less competitive.

Figure 2: Results of trade liberalisation under alternative scenarios



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Moreover, the results of the scenario analysis point to the importance of incorporating features like transport costs, land rents, and processing needs into models of trade liberalisation. Without considering these sectoral characteristics, an analyst might predict a decrease of domestic prices and production equal or directly proportional to the reduction in tariffs. As a result, the welfare implications of trade liberalisation might be misinterpreted.

5. Conclusions

This paper used a spatial equilibrium model to analyse the impacts of agricultural trade liberalisation on the welfare and competitiveness of agricultural producers in different sub-sectors. The model takes farming costs, processing costs, and transport costs for shipments of agricultural raw materials and food products into account. Moreover, it allows to simulate differences between sub-sectors with respect to the transport intensity of agricultural products, the importance of local processing, and the degree of competition for sector-specific resources, such as farmland.

The results of the analysis indicate that high transport costs, large shares of fixed capital in the downstream sector, and flexible land markets in a particular sub-sector shield agricultural producers to a considerable extent from international competition after trade liberalisation. Farmers in such sub-sectors benefit from "natural protection" due to the distance to international trade hubs, and can pass on parts of the adverse income effects from decreases in domestic food prices to agro-processors and land owners. Hence, sectors like sugarbeet and dairy farming might be relatively less vulnerable to trade policy changes and appear relatively more competitive.

However, in the longer term, processing industries can adjust more flexibly than in the short run, and processing facilities that are not able to cover their total costs will shut down. This will leave farmers in the vicinity without a local processor for their products and their agricultural activities might then become rather non-competitive. This points to the necessity to consider farming and agro-processing simultaneously when investigating the

competitiveness of agricultural activities, and also to distinguish between short-run and longer-term competitiveness.

More generally, the results of the analysis highlight the importance of incorporating features like transport costs, land rents, and processing needs into models of trade liberalisation, whenever these characteristics might be significant for the commodities concerned. The welfare implications of trade policy changes might otherwise be fundamentally misjudged.

Extensions of the research might try to develop a more elaborate representation of the farming sector. In the presented model, farmers produce only one crop, so that the development of land rents was determined by the price of this single agricultural product. Considering several different cropping activities might allow to derive some additional insights into the determination of land rents and the relative competitiveness of agricultural crops. For example, a trade liberalisation-induced price reduction for one crop will tend to lower demand for land and reduce land rent. But this fall in land rents will benefit the producers of other commodities that are not to the same extent exposed to competition from international markets. The quantification of this interaction between producers in different sub-sectors through the land market might warrant additional research.

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