HOW ROBUST ARE WALRAS RESULTS?

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INTRODUCTION

The aim of this paper is to assess the robustness of simulation results from the WALRAS model. As such, it is a direct extension of the paper by Martin *et al.* in this volume which presented a range of policy-relevant scenarios with the model. In particular, the former paper suggested that agricultural policies in OECD countries are costly to the OECD countries themselves – one estimate was that the average 1986-88 levels of farm-support policies cost the six main agricultural trading countries/regions almost 1 per cent of their real income. However, decisions to change present policies cannot be taken on the basis of such results alone without an assessment of their robustness.

Results from applied general equilibrium (AGE) models are often presented as a single solution of a deterministic system[1]. Nonetheless, there are several features of AGE models which give rise to uncertainty concerning the reliability of the solution. These uncertainties fall into three broad categories. The first is uncertainty about model specification, i.e. how the behaviour of economic agents should be modelled or which functional form should be used to proxy the underlying supply and demand functions. The second category of uncertainty pertains to the choice of macro-closure imposed upon the model, e.g. the choice between an exogenous government deficit with a variable tax rate or a fixed tax rate and an endogenous deficit, the specification of the foreign sector, etc.

The third category of uncertainty concerns the values of key model parameters. AGE models typically require exogenous information on many parameter values in order to calibrate the model to a benchmark data set. The sources for these parameter values are the relevant econometric literature and/or the best judgement of the model builders. Even in cases where there is a large econometric literature to draw upon, there is often a great deal of variation in the estimated parameters for a variety of reasons. While much of the criticism of AGE models relates to the plausibility of the chosen values of the parameters used in the calibration process, the real issue is the degree of sensitivity of the solution results to the variation in these parameter values. Thus, sensitivity analysis with respect to the exogenous parameter values is an important element in any AGE modelling project[2].

This paper presents the results of sensitivity analysis with respect to both the specification of the WALRAS model and the choice of key exogenous parameter values. Section I analyses the results of testing different model specifications. Section II reports the results of perturbing certain key sets of model parameters, paying particular attention to the values of the foreign trade elasticities. Although AGE models are also sensitive to macro-closure choices, no analysis of this issue is presented here[3]. The final section summarises the main findings and draws some conclusions.

All results presented in this paper refer to changes in model results compared with a particular reference scenario which, for convenience, is referred to here as the "base case". The reference scenario simulates the effects of a complete multilateral liberalisation of the average **1986-88** levels of agricultural protection in the six OECD countries/regions using the standard version of WALRAS – for full details on the base-case results, see the paper by Martin ***et al.*** in this volume.

I. CHANGES IN MODEL SPECIFICATION

There have been significant changes in the specification of WALRAS since the original version of the model was developed by Burniaux ***er al.*** **(1988).** These changes include the introduction of partial factor mobility and the constant-elasticity-of-transformation (CET) specification for export supply. Furthermore, an independent version of the Japanese model was developed which allows for land use in the non-agricultural sectors and partial mobility of land between rural and urban sectors. In order to assess the impact of these model changes, simulations were performed eliminating each one of the model changes individually[4].

A. Factor mobility

As regards use of the primary factors of production, WALRAS distinguishes between two broad sectors, agriculture and non-agriculture (the former sector incorporates the first two sub-sectors of the WALRAS model, i.e. livestock and other agriculture). Capital and labour are assumed to be perfectly mobile ***within*** each of the two broad sectors, but only partially mobile ***between*** them. Changes in the distribution of factors between the two sectors are assumed to be a function of relative wages and capital rentals.

If the assumption of imperfect factor mobility between the two sectors is replaced by one of perfect factor mobility – as in Burniaux ***et al.*** **(1988)** – this would lower the real income gain for the area as a whole from **0.9** per cent in the base case to 0.8 per cent (see Table 1). The typical dichotomy between the food importers and exporters manifests itself as the former have slightly lower and the latter slightly larger real income gains compared with the base case.

It may seem surprising at first sight that perfect factor mobility results in slightly lower welfare gains. The reasons for expecting this result in WALRAS are spelt out in the article by Burniaux *et al.* in this volume. In short, perfect factor mobility leads to a larger responsiveness of agricultural supply to changes in relative prices which, under the assumption of a fixed current account, leads to a larger deterioration in the terms of trade, and hence somewhat lower real income gains for the food importers.

Table 1. Impact of model specification changes

Per cent changes compared with benchmark year[a]

	Australia	Canada	EC	Japan	New Zealand	United States	OECD[b]
Real income gains							
Base (1986-88 levels)	0.8	1.3	1.4	1.1	2.7	0.3	0.9
Perfect factor mobility	1.0	1.2	1.3	0.8	3.3	0.3	0.8
Land in Japan	0.8	1.4	1.4	1.1	2.7	0.3	0.9
No CET	0.9	1.5	1.4	1.1	2.8	0.3	0.9
Agricultural output							
Base (1986-88 levels)	4.4	−16.7	−18.7	−242	7.9	−7.0	−13.6
Perfect factor mobility	10.0	−21.7	−21.5	−37.4	18.3	−7.8	−16.4
Land in Japan	4.4	−16.8	−18.6	−22.3	8.0	−6.9	−13.3
No CET	4.0	−15.3	−18.1	−23.1	8.2	−7.1	−13.2
Foodprocessing output							
Base (1986-88 levels)	14.6	1.0	−21.3	−13.9	18.9	−2.8	−11.9
Perfect factor mobility	18.3	−0.9	−22.1	−16.0	28.9	−2.6	−12.4
Land in Japan	14.2	1.0	−21.2	−11.4	19.1	−2.7	−11.5
No CET	25.1	5.3	−21.5	−15.0	26.2	−3.0	−11.7
Non-food manufacturing and private services output							
Base (1986-88 levels)	−0.7	0.9	2.1	1.2	−2.4	0.4	1.1
Perfect factor mobility	−1.3	1.1	2.3	1.6	−4.3	0.4	1.3
Land in Japan	−0.7	0.9	2.1	1.2	−2.4	0.4	1.1
No CET	−1.0	0.8	2.1	1.1	−2.9	0.4	1.1

a) The benchmark year for the WALRAS model is 1980 or 1981, depending upon the country/region in question. The per cent changes in the variables are measured relative to the 1980 or 1981 levels.

b) Total of six countries/regions.

B. Introduction of non-agricultural land in Japan

Land is assumed to be a factor of production in only the two primary agricultural sectors in WALRAS. This is obviously unrealistic and the possibility of incorporating land use in all sectors was investigated. Unfortunately, land-use data are virtually non-existent for most of the sectors included in the model. However, by drawing upon available data sources and making some assumptions, it proved possible to assemble data on land use by sector in Japan and these data were incorporated into the model – for details, see the Annex. Land, like capital and labour, was modelled as being perfectly mobile within each of the two broad sectors, agriculture and non-agriculture, but only partially mobile between rural and urban uses. Due to the nature of land, the degree of substitution between rural and urban uses in response to changes in land rentals was assumed to be low as compared with the corresponding rural-urban migration elasticities for capital and labour.

Table 1 shows that the introduction of land in the non-agricultural sectors has very little effect on the magnitude of the real income gain and on the composition of production in Japan[5]. The main change is reflected in the returns to agricultural land which decrease by a smaller amount: they decline by 26 per cent instead of 44 per cent in the base case. In the non-agricultural sector, the land rental decreases by 2.3 per cent. The shift in land resources between the two sectors is only 2 per cent[6]. One implication of these results is that, contrary to what has sometimes been argued, agricultural policy is not a major factor behind high urban land prices in Japan[7].

C. CET specification of export supply

While most AGE models treat imports and domestic goods as imperfect substitutes, they often assume that exports and domestically-sold goods are perfect substitutes. This specification of export supply, however, overstates both the links between export and domestic prices and the responsiveness of exports to demand shifts on world markets. In order to take account of this in WALRAS, producers are assumed to choose the optimal output-mix between exports and domestic supplies in response to the market-clearing price differential between domestic and export markets. This specification, the so-called CET approach, was only introduced in five of the thirteen sectors – the two farm sectors, other manufacturing industries, wholesale and retail trade, and other private services – for reasons which are explained in the paper by Burniaux *et al.* in this volume.

Elimination of the CET in these five sectors (i.e. treating exports and domestic output in *all* sectors as perfect substitutes) has virtually no effect on the size of the aggregate real income gain for the OECD area. The main effect is that the food exporters gain slightly more as compared with the base case since their terms-of-trade improvement is slightly larger, although overall, the composition of production is relatively unchanged.

II. SENSITIVITY OF WALRAS RESULTS TO CHANGES IN KEY PARAMETER VALUES

A. Introduction

Due to the nature of AGE models, most parameters are calculated so as to calibrate the model to the benchmark data set[8]. Formally, the model may be written as:

$$F(x, y, z; \theta, \psi) = 0$$

where x, y and z represent, respectively, exogenous, endogenous and policy variables, θ is a set of exogenous parameters, and ψ is the set of calibration parameters. F is a multi-valued function with the same dimension as y. In the calibration process, x and y are both treated as exogenous and come from the benchmark data set. ψ is then a function of θ, z and the benchmark data.

Performing sensitivity analysis involves perturbing a sub-set of the parameters θ, re-calibrating the model to obtain a new set of parameters ψ, and then performing the simulation. The set of parameters θ is often partitioned into different key blocks, which in the WALRAS model are as follows:

Key parameter blocks in the WALRAS model

Elasticities of substitution between labour and capital.
Elasticities of substitution between land and the labour-capital bundle.
Price elasticities for imported intermediate demand.
Price elasticities of import demand for consumer goods.
Income elasticities of demand for consumer goods.
Elasticities of substitution between types of government expenditures.
Export demand elasticities.
Factor migration elasticities.
Transformation elasticities between domestic and export supply.
Supply elasticity of the rest of the world.

Most blocks contain many parameters, first a set for all six countries/regions, and within each country/region there are parameters for each of the thirteen sectors (e.g. there are 78 parameters of substitution for capital and labour in the model).

Two basic approaches have been followed to quantify the sensitivity of outcomes to changing exogenous parameter values in AGE models. One method – a Monte Carlo approach – is to attach a probability distribution to each parameter. Multiple simulations are then performed, each time perturbing the parameters according to their probability distribution. This produces an implicit probability distribution for the model results to which appropriate confidence intervals can be attached.

While this approach is sound theoretically, there are several problems in applying it. First, not all key parameters have been estimated in the literature, therefore a distribution must be imposed for some parameters. Second, even for estimated parameters, there is usually a wide range of values to choose from in the literature. Third, most models have *so* many parameters that a vast number of simulations would have to be performed and analysed. For these reasons, the Monte Carlo approach has not been adopted in this paper.

Instead, the second main approach to parameter sensitivity, which is more ad ***hoc,*** has been adopted. It involves selecting key blocks of parameters and perturbing them from their base values by the same scalar value, rather than conducting experiments with individual parameters. Since the WALRAS model consists of over 8 000 equations and thousands of parameters, this was the only practical course to follow.

The next sub-section reports the results of perturbing some of the non-trade elasticities. This is followed by a sub-section on the sensitivity of the simulation results to the trade elasticities which prove to be the most important parameters of the model.

B. Sensitivity to non-trade elasticities

a) ***Supply elasticity in the rest of the world***

The rest of the world (ROW) has been modelled very simply in WALRAS via a set of import demand equations and one supply equation for the agricultural sector (see Burniaux ***er al.*** in this volume). Ideally, one would want to develop a full general equilibrium model for ROW. Given a lack of time and resources, the testing of the ROW model has been limited to varying its supply responsiveness.

In the base-case scenario, the ROW supply elasticity was set at two, equal to the OECD average. Two simulations were performed in order to assess the sensitivity of the results to this supply elasticity. One set the elasticity at an unrealistically low level, 1, the other at a very high level, 100. These two values were chosen to approximate the extreme cases of inelastic and perfectly elastic supply, respectively.

Table 2a presents some results for these simulations. With a unitary supply elasticity in ROW, the aggregate gain in real income is unchanged. The food exporters, Australia, New Zealand and the United States, gain slightly compared with the base-case as they are able to increase their agricultural exports at the expense of ROW and, in the case of Australia and New Zealand, benefit from a stronger terms-of-trade improvement due to higher world market prices for agricultural products. The United States, which suffers a slight terms-of-trade loss in the base case, enjoys a slight improvement when ROW's supply responsiveness is very low. The **EC** and Japan lose slightly relative to the base case for the opposite reason, i.e. their terms of trade deteriorate even more as compared with the base case, since less-elastic ROW supply induces an increase in world agricultural prices. When ROW supply is highly elastic, the real income gain for the **OECD** area increases slightly. The food exporters record slightly smaller welfare gains as compared with the base case, and the **EC** and Japan somewhat larger gains.

Table **2a.** Sensitivity with respect to agricultural supply elasticity in ROW

Per cent changes compared with benchmark year

	Australia	Canada	EC	Japan	New Zealand	United States	OECD[a]
Real income gains							
Elasticity = 1	0.9	1.4	1.3	1.0	3.0	0.4	0.9
Elasticity = 2 (base)	0.8	1.3	1.4	1.1	2.7	0.3	0.9
Elasticity = 100	0.6	1.4	1.7	1.3	2.2	0.3	1.1
Agricultural output							
Elasticity = 1	5.7	−14.4	−16.9	−22.9	9.2	−5.6	−12.0
Elasticity = 2 (base)	4.4	−16.7	−18.7	−24.2	7.9	−7.0	−13.6
Elasticity = 100	2.4	−20.5	−21.6	−26.5	5.6	−9.4	−16.2
Foodprocessing output							
Elasticity = 1	16.3	4.0	−20.3	−13.0	20.9	−1.3	−10.6
Elasticity = 2 (base)	14.6	1.0	−21.3	−13.9	18.9	−2.8	−11.9
Elasticity = 100	11.7	−3.7	−23.0	−15.4	15.4	−5.3	−14.0
Non-food manufacturing and private services output							
Elasticity = 1	−0.9	0.7	2.0	1.0	−2.8	0.3	1.0
Elasticity = 2 (base)	−0.7	0.9	2.1	1.2	−2.4	0.4	1.1
Elasticity = 100	−0.4	1.2	2.4	1.3	−1.8	0.6	1.3

a) Total of six countries/regions.

In sum, these simulations indicate that the model results are relatively robust even to extreme values of the ROW supply elasticity. The magnitude of the real income gain for the six countries/regions only varies between 0.9 and 1.1 per cent.

b) *Capital-labour elasticity of substitution*

Two simulations were run with equivalent changes in the elasticity of capital-labour substitution in all sectors and in all countries/regions. These involved, respectively, a cut and a rise of 50 per cent from the base values – which are set out in Table 2 in the paper by Burniaux *et al.* in this volume. Table 2b presents the results of these simulations. Output in all sectors is virtually insensitive to changes in this parameter, and changes in the magnitude of the real income gain are minor.

Table 2b. Sensitivity with respect to capital-labour elasticity of substitution

Per cent changes compared with benchmark year

	Australia	Canada	EC	Japan	New Zealand	United States	OECD[a]
Real income gains							
Base elasticity –50%	0.8	1.5	1.6	1.1	2.7	0.3	1.0
Base elasticity	0.8	1.3	1.4	1.1	2.7	0.3	0.9
Base elasticity +50%	0.8	1.4	1.4	1.1	2.7	0.3	0.9
Agricultural output							
Base elasticity –50%	4.4	–16.7	–18.5	–24.3	7.5	–7.1	–13.6
Base elasticity	4.4	–16.7	–18.7	–24.2	7.9	–7.0	–13.6
Base elasticity +50%	4.5	–16.7	–18.7	–24.3	8.1	–7.0	–13.6
Food-processing output							
Base elasticity –50%	14.5	1.0	–21.2	–14.0	18.6	–2.8	–11.9
Base elasticity	14.6	1.0	–21.3	–13.9	18.9	–2.8	–11.9
Base elasticity +50%	14.6	1.0	–21.4	–14.0	19.1	–2.8	–11.9
Non-food manufacturing and private services output							
Base elasticity –50%	–0.7	0.9	2.1	1.1	–2.4	0.4	1.1
Base elasticity	–0.7	0.9	2.1	1.2	–2.4	0.4	1.1
Base elasticity +50%	–0.7	0.9	2.1	1.1	–2.5	0.4	1.1

a) Total of six countries/regions.

c) *Elasticity of substitution between land and the capital-labour bundle*

Once again, two simulations were performed, setting the values of this elasticity 50 per cent below and 50 per cent above the base values in the agricultural sector in all countries/regions. The results in Table 2c show that these changes had virtually no effect on the magnitude of the real income gain. In all countries/regions, a reduction in this elasticity lowers agricultural supply responsiveness and an increase magnifies supply responsiveness. A decrease in the elasticity widens the wedge between the land rental and the prices of the other two primary factors: the drop in the real land rental in the OECD area ranges from 32 to 54 per cent when the substitution elasticity is varied between these bounds.

Table 2c. Sensitivity with respect to the capital-labour bundle and land elasticity of substitution

Per cent changes compared with benchmark year

	Australia	Canada	EC	Japan	New Zealand	United States	OECD[a]
Real income gains							
Base elasticity –50%	0.7	1.5	1.4	1.2	2.6	0.3	0.9
Base elasticity	0.8	1.3	1.4	1.1	2.7	0.3	0.9
Base elasticity +50%	0.8	1.5	1.4	1.2	2.8	0.3	0.9
Agricultural output							
Base elasticity –50%	4.0	–13.5	–17.8	–24.1	5.7	–4.8	–12.3
Base elasticity	4.4	–16.7	–18.7	–24.2	7.9	–7.0	–13.6
Base elasticity +50%	4.7	–18.4	–19.0	–24.3	8.9	–8.2	–14.3
Food-processing output							
Base elasticity –50%	13.9	2.0	–21.1	–14.0	16.5	–2.5	–11.7
Base elasticity	14.6	1.0	–21.3	–13.9	18.9	–2.8	–11.9
Base elasticity +50%	14.9	0.5	–21.4	–13.9	20.0	–3.0	–12.0
Non-food manufacturing and private services output							
Base elasticity –50%	–0.7	0.7	2.1	1.1	–2.0	0.3	1.1
Base elasticity	–0.7	0.9	2.1	1.2	–2.4	0.4	1.1
Base elasticity +50%	–0.8	1.0	2.1	1.2	–2.6	0.5	1.2

a) Total of six countries/regions

C. Sensitivity to trade elasticities

a) Introduction

In the WALRAS model, demand for goods and services can be viewed as a three-step procedure. In the first step, demand for a composite good is decided. In the second step, demand for this composite is split between domestic and import goods under the assumption that they are imperfect substitutes – this is known as the Armington assumption. The import demand elasticity of substitution measures the degree of responsiveness of import demand to the relative price difference between domestic and import prices. The higher the elasticity, the more domestic goods and imports are viewed as perfect substitutes by consumers. In the third step, import demand is split according to country of origin, i.e. export demand for each country is a function of its export price relative to the world price. The higher the export demand elasticity, the more exports from different countries are perceived as close substitutes. At very high levels for both import and export demand elasticities, the model approaches the law of one price, i.e. there is little product differentiation between home and foreign goods, and little differentiation between foreign goods from different origins.

Three sets of four simulations were performed to assess the sensitivity of simulation results with respect to the trade elasticities. In the first set, both import and export trade elasticities were perturbed simultaneously and by the same scalar. The trade elasticities in the base case were cut by 87.5 per cent, 75 per cent, 50 per cent and increased by 50 per cent. In the second set of simulations, only the export demand elasticities were modified. In the final set of simulations, only the import demand elasticities were varied. The basic elasticity values used in each of the simulations were as follows:

Typical values of the trade elasticities

	–87.5%	–75%	–50%	Base	+50%
Export demand	1.3 to 2.5	2.5 to 5	5 to 10	10 to 20	15 to 30
Import demand	0.7 to 0.8	1.3 to 1.5	2.5 to 3	5 to 6	8 to 9

b) Impact of varying trade elasticities on world prices and trade volumes

A key to understanding the simulation results is the influence of the trade elasticities on world prices and world trade flows. Table 3 presents changes in world trade volumes and real world prices[g] for each of the twelve simulations and the base run. This table indicates that, as the trade elasticities increase, the variation of world food prices decreases in response to multilateral liberalisation

Table 3. Impact of trade elasticities on world trade prices and trade volumes

Per cent changes compared with benchmark year

a) ***World trade prices***

	−87.5%	−15%	−50%	Base	+50%
A. ***Simultaneous changes***					
Livestock and livestock products	3.5	4.3	4.7	5.9	7.1
Other agricultural industries	5.4	5.4	5.4	5.9	6.5
Meat products	14.3	13.8	11.7	9.8	9.5
Oairy products	35.1	29.3	20.4	13.8	11.8
Other food products	5.6	5.6	5.3	5.0	4.9
All agricultural products	6.2	6.5	6.6	7.2	7.6
All non-agricultural products	0.1	0.2	0.2	0.1	0.1
0. ***Change in export demand elasticities***					
Livestock and livestock products	7.9	7.1	6.5	5.9	5.5
Other agricultural industries	7.0	6.7	6.3	5.9	5.6
Meat products	20.6	17.2	13.3	9.8	8.3
Dairy products	49.1	36.0	22.6	13.8	10.7
Other food products	6.3	6.2	5.8	5.0	4.4
All agricultural products	10.6	9.9	8.7	7.2	6.3
All non-agricultural products	0.3	0.2	0.2	0.1	0.1
C. ***Change in import demand elasticities***					
Livestock and livestock products	3.2	3.6	4.3	5.9	7.5
Other agricultural industries	3.9	4.3	4.8	5.9	6.8
Meat products	6.9	7.4	8.3	9.8	11.0
Oairy products	11.7	11.9	12.5	13.8	14.9
Other food products	4.0	4.2	4.4	5.0	5.6
All agricultural products	4.4	4.8	5.4	7.2	8.6
All non-agricultural products	0.1	0.1	0.1	0.1	0.2

b) ***World trade volumes***

	−07.5%	−75%	−50%	Base	+50%
A. ***Simultaneous changes***					
livestock and livestock products	−2.0	−2.2	−0.1	24.1	68.9
Other agricultural industries	−11.4	−9.1	−6.5	−9.8	−16.3
Meat products	−34.1	−14.5	32.3	146.8	273.9
Oairy products	−80.4	−63.3	−3.3	245.3	516.5
Other food products	−15.3	−10.0	0.5	18.5	33.7
All agricultural products	−16.9	−11.6	−0.0	26.2	53.2
All non-agricultural products	2.1	2.0	1.9	1.7	1.3
0. ***Change in export demand elasticities***					
Livestock and livestock products	3.4	10.0	17.6	24.1	27.2
Other agricultural industries	−14.5	−13.3	−11.6	−9.8	−8.5
Meat products	65.2	88.8	118.8	146.8	160.0
Dairy products	20.0	84.2	175.4	245.3	274.0
Other food products	7.4	8.9	12.3	18.5	23.6
All agricultural products	2.6	8.8	17.5	26.2	31.0
All non-agricultural products	2.4	2.3	2.0	1.7	1.4
C. ***Change in import demand elasticities***					
Livestock and livestock products	−1.9	−0.6	2.3	24.1	63.9
Other agricultural industries	−5.1	−4.0	−3.8	−9.8	−17.2
Meat products	−2.8	11.8	48.9	146.8	254.6
Dairy products	−30.8	−18.9	27.7	245.3	480.5
Other food oroducts	−5.1	−1.2	6.2	18.5	27.0
All agricultural products	−5.7	−2.0	6.0	26.2	47.1
All non-agricultural products	1.2	1.4	1.4	1.7	1.6

and world trade volumes expand dramatically. This is a consequence of the fact that the model approaches the law of one price at high trade elasticities.

When export demand elasticities are varied alone, the change in trade volumes varies less compared with the base case than when both sets of elasticities are varied. World prices, however, become more volatile and vary inversely with the size of the elasticities. Maintaining the import demand elasticities at the relatively high levels of the base case ensures that countries will react significantly to price wedges between domestic and world markets, resulting in substantial trade flows. However, when export demand elasticities are low, exporting countries maintain a certain market power, resulting in higher world prices. For example, when both trade elasticities are slashed by 87.5 per cent of the base values, trade in meat products declines by 34 per cent and the world price increases by 14 per cent. If the export demand elasticities alone are cut by 87.5 per cent, trade volumes in meat products increase by 65 per cent and the world price increases by 21 per cent.

In contrast, perturbing the import demand elasticities alone lowers the sensitivity of world trade volumes compared with perturbing all trade elasticities together. Since the export demand elasticities are kept at their base levels, countries have relatively little market power and world trade prices will be less volatile than with low export demand elasticities, even when import elasticities are low. Since world prices are lower, ***ceteris paribus,*** world trade volumes will be greater. For example, lowering import demand elasticities by 87.5 per cent of the base-case levels reduces trade volumes of meat products by only 3 per cent (compared with 34 per cent when both elasticities are reduced); and the world price only increases by 7 per cent (compared with 14 per cent).

c) Country/region-specific sensitivities

Tables 4a to 4f present the results of the simulations for each of the six countries/regions. For the output and real income variables, an additional statistic has been computed – called the S-elasticity (sensitivity elasticity). This measures the percentage change of the variable from the base case compared with the percentage change in the parameters". An S-elasticity of one indicates that the change in the variable is equi-proportionate to the change in the parameter. The tables are supplemented by Charts A to D which present graphically the changes in real income for each of the three sets of simulations. From the tables and charts, the following conclusions can be drawn:

- The trade elasticities matter, even within the range of –50 to +50 per cent around the base-case values. This is in sharp contrast to the simulations with the other key parameters.

Table 4a. Trade sensitivity analysis for Australia

Per cent changes compared with benchmark year

	Base	Simultaneous variations of export and import demand elasticities				Variations of export demand elasticities				Variations of import demand elasticities			
		-87.5%	-75%	-50%	+50%	-87.5%	-15%	-50%	+50%	-81.5%	-75%	-50%	+50%
Agriculture													
output	4.4	−2.8	−1.4	1.1	6.5	2.7	3.9	4.5	4.1	−0.7	−0.0	1.4	7.0
S-elasticity – Output		1.9	1.8	1.5	0.9	0.5	0.2	−0.0	−0.2	1.3	1.3	1.4	1.2
Producer price	11.1	3.4	4.9	7.7	12.8	9.4	10.6	11.4	10.5	5.8	6.5	8.0	13.6
Import volume	51.0	−2.9	1.3	14.0	92.5	57.7	65.6	61.9	42.1	−1.5	1.5	11.9	111.6
Export volume	−30.8	−5.5	−11.3	−21.5	−32.5	−19.6	−24.7	−29.1	−30.0	−13.8	−16.9	−23.2	−32.7
Food processing and beverages													
output	14.6	−2.0	1.5	7.8	17.1	11.6	14.4	15.4	12.9	2.1	4.0	8.0	19.2
S-elasticity – Output	. .	1.3	1.2	0.9	0.4	0.2	0.0	−0.1	−0.2	1.0	1.0	0.9	0.6
Producer price	5.0	1.9	2.3	3.5	5.7	3.7	4.3	4.9	4.8	2.8	3.1	3.7	5.9
Import volume	37.5	−2.0	1.3	8.9	87.9	18.7	24.3	30.5	39.9	−0.8	1.8	9.8	80.6
Export volume	71.1	−9.6	6.4	35.2	93.8	57.8	71.2	74.6	64.3	8.0	16.9	35.8	101.5
Non-food manufacturing and private services													
output	−0.7	0.4	0.1	−0.3	−0.9	−0.9	−1.0	−0.9	−0.6	0.1	0.0	−0.2	−1.1
S-elasticity – Output	. .	1.8	1.6	1.3	0.5	−0.3	−0.5	−0.5	−0.4	1.4	1.4	1.4	1.1
Producer price	−0.4	0.7	0.2	−0.1	−0.5	−1.0	−1.0	−0.7	−0.2	0.4	0.3	0.1	−0.7
Import volume	5.0	0.4	1.7	3.1	6.1	13.1	11.4	8.1	3.5	0.3	0.6	1.8	8.3
Export volume	−7.4	2.1	−1.6	−4.8	−8.1	0.8	−3.1	−6.0	−7.4	−2.1	−3.4	−5.5	−7.8
Other indicators													
Terms of trade	4.1	1.0	3.2	3.8	4.1	7.8	7.4	5.6	3.4	1.7	2.1	2.8	4.9
Import price	−1.8	0.8	−1.7	−2.1	−1.4	−5.0	−4.5	−3.1	−1.2	−0.1	−0.5	−1.1	−2.0
Export price	2.2	1.7	1.4	1.6	2.6	2.4	2.6	2.3	2.1	1.6	1.6	1.7	2.7
Consumer price	0.2	0.9	0.4	0.3	0.1	−0.6	−0.5	−0.1	0.4	0.7	0.7	0.5	−0.0
Domestic food price	5.2	2.2	2.6	3.9	5.6	4.3	4.8	5.3	5.0	3.1	3.4	4.1	6.0
Real income	0.8	0.3	0.6	0.7	0.9	1.5	1.4	1.1	0.7	0.4	0.4	0.5	1.0
S-elasticity – Real income	. .	0.7	0.2	0.2	0.3	−1.1	−1.2	−0.8	−0.3	0.6	0.6	0.6	0.7

Table 4b. Trade sensitivity analysis for Canada

Per cent changes compared with benchmark year

	Base	Simultaneous variations of export and import demand elasticities				Variations of export demand elasticities				Variations of import demand elasticities			
		-87.5%	-75%	-50%	+50%	-87.5%	-75%	-50%	+50%	-87.5%	-75%	-50%	+50%
Agriculture													
output	−16.7	−9.8	−11.2	−13.0	−17.6	−8.2	−10.2	−13.1	−19.3	−15.9	−15.8	−16.0	−14.9
S-elasticity – Output	. .	0.5	0.4	0.4	0.1	0.6	0.5	0.4	0.3	0.1	0.1	0.1	−0.2
Producer price	9.8	15.8	13.9	11.9	9.0	14.6	13.1	11.4	8.7	10.1	10.1	10.0	9.9
Import volume	27.9	2.4	6.7	15.2	40.9	46.5	40.0	33.4	24.6	1.2	5.1	12.9	46.2
Export volume	−42.5	−30.2	−36.6	−42.0	−41.6	−30.2	−35.5	−40.0	−43.2	−48.4	−47.6	−46.0	−40.8
Food processing and beverages													
output	1.0	−1.7	−0.5	0.8	3.9	4.8	4.2	2.6	−0.2	−1.7	−1.2	−0.3	4.9'
S-elasticity – Output	. .	3.0	2.0	0.4	5.7	−4.3	−4.1	−3.2	−2.3	3.1	2.8	2.5	1.6
Producer price	4.0	5.9	5.5	4.8	3.6	5.3	5.0	4.5	3.6	4.5	4.5	4.3	3.9
Import volume	156.1	2.7	9.0	38.3	221.1	42.1	72.3	122.8	168.3	6.4	16.1	49.8	208.7
Export volume	70.8	−13.5	−4.1	16.9	124.4	47.0	56.0	67.0	69.0	−13.8	−5.7	14.7	123.6
Non-food manufacturing and private services													
output	0.9	0.6	0.8	0.8	0.7	**0.5**	0.6	0.7	0.9	1.0	1.0	1.0	0.7
S-elasticity – Output	. .	0.3	0.2	0.2	−0.4	0.6	0.5	0.4	0.1	−0.2	−0.2	−0.1	−0.5
Producer price	2.3	2.0	2.1	2.2	2.2	1.6	1.8	2.1	2.4	2.4	2.4	2.4	2.1
Import volume	0.2	−0.2	−0.2	−0.1	0.7	0.9	0.3	**0.0**	0.3	**0.5**	0.3	0.1	0.6
Export volume	2.6	2.5	2.7	2.7	1.4	1.0	1.0	1.6	2.7	4.6	4.3	3.4	1.1
Other indicators													
Terms of trade	−0.7	−0.9	−0.6	−0.5	−0.5	−0.1	−0.8	**−0.9**	−0.6	−0.4	−0.3	−0.4	−0.7
Import price	3.9	4.2	3.8	3.5	3.7	3.2	4.0	4.1	3.7	3.4	3.4	3.4	3.9
Export price	3.2	3.3	3.2	3.1	3.1	3.1	3.1	3.2	3.1	3.0	3.0	3.0	3.2
Consumer price	1.5	2.6	2.6	2.4	0.9	2.0	1.9	1.7	1.4	2.7	2.7	2.4	0.9
Domestic food price	1.6	**5.5**	**5.0**	4.1	−0.7	4.7	3.9	2.6	1.0	4.1	3.9	3.4	−0.1
Real income	1.3	0.6	0.7	0.9	1.9	1.1	1.2	1.3	1.4	0.7	0.7	1.0	1.9
S-elasticity – Real income	. .	0.6	0.6	0.7	0.9	0.2	0.2	0.0	0.1	0.5	0.6	0.6	0.9

Table 4c. Trade sensitivity analysis for the EC

Per cent changes compared with benchmark year

	Base	Simultaneous variations of export and import demand elasticities				Variations of export demand elasticities				Variations of import demand elasticities			
		-87.5%	-75%	-50%	+50%	-87.5%	-75%	-50%	+50%	-87.5%	-75%	-50%	+50%
Agriculture													
output	–18.7	–5.2	– 6.7	– 9.7	–29.7	–13.1	–14.9	–16.9	–19.5	–6.7	–7.8	–10.5	–28.5
S-elasticity – Output	. .	0.8	0.9	1.0	1.2	0.3	0.3	0.2	0.1	0.7	0.8	0.9	1.1
Producer price	–4.6	1.0	0.4	–1.0	–8.8	–2.3	–3.0	–3.8	–5.0	0.3	–0.2	–1.4	–8.2
Import volume	– 17.4	–2.3	–2.9	–5.4	–28.8	–13.8	–15.7	–17.1	–16.9	–4.6	–4.1	–5.5	–29.8
Export volume	–59.7	–41.6	–50.8	–58.9	–54.2	–36.1	–43.4	–52.0	–63.4	–71.4	–70.1	–67.5	–50.7
Food processing and beverages													
output	–21.3	–4.8	–6.4	–10.2	–33.8	–15.7	–17.5	–19.5	–22.1	–6.4	–7.6	–11.0	–32.6
S-elasticity – Output	. .	0.9	0.9	1.1	1.2	0.3	0.2	0.2	0.1	0.8	0.9	1.0	1.1
Producer price	–1.3	0.8	0.6	0.1	–2.7	–0.4	–0.7	– 1.0	–1.5	0.6	0.4	–0.1	–2.5
Import volume	389.5	17.7	42.6	115.9	711.7	262.4	304.2	350.7	408.4	16.3	44.2	122.9	683.5
Export volume	–79.6	–61.6	–67.1	–74.2	–80.1	–53.2	–60.6	–70.8	–83.1	–83.9	–83.4	–82.4	–76.1
Non-food manufacturing and private services													
output	2.1	0.6	0.8	1.1	3.2	1.6	1.7	1.9	2.2	0.8	0.9	1.2	3.1
S-elasticity – Output	. .	0.9	0.9	0.9	1.1	0.3	0.3	0.2	0.1	0.7	0.8	0.9	0.9
Producer price	1.5	1.0	1.1	1.2	17	1.3	1.4	1.4	1.4	1.1	1.1	1.2	1.7
Import volume	–2.9	–0.1	–0.6	–1.3	–4.6	–4.8	–4.6	–4.0	–2.2	0.3	–0.0	–0.8	–5.8
Export volume	13.4	4.9	6.2	8.4	18.6	7.6	9.2	11.1	14.5	7.3	8.2	9.4	16.9
Other indicators													
Terms of trade	–3.0	–1.2	–1.7	–2.1	–3.7	–4.2	–4.1	–3.7	–2.6	–1.1	–1.3	–1.7	–4.4
Import price	5.4	3.3	3.7	4.1	6.5	7.2	6.9	6.3	4.8	2.7	3.0	3.5	7.3
Export price	2.2	2.1	2.0	20	2.5	2.7	2.5	2.3	2.1	1.5	1.6	1.7	2.6
Consumer price	–0.6	0.8	0.8	0.6	–2.4	0.2	0.0	–0.3	–0.8	0.8	0.8	0.5	–2.1
Oomestic food price	–3.0	0.4	0.1	–0.6	–6.4	–1.4	–1.9	–2.5	–3.4	0.2	–0.1	–0.9	–6.0
Real income	1.4	0.1	0.1	0.4	2.8	0.8	1.0	1.2	1.6	0.1	0.2	0.5	2.6
S-elasticity – Real income	. .	1.1	1.2	1.5	2.1	0.5	0.4	0.3	0.2	1.1	1.2	1.3	1.8

Table 4d. Trade sensitivity analysis for Japan

Per cent changes compared with benchmark year

	Base	Simultaneous variations of export and import demand elasticities				Variations of export demand elasticities				Variations of import demand elasticities			
		−87.5%	−75%	−50%	+50%	−87.5%	−75%	−50%	+50%	−87.5%	−15%	−50%	+50%
Agriculture													
output	−24.2	−4.4	− 7.8	−13.6	−28.6	−19.8	−21.2	−23.1	−24.7	−4.3	−8.1	−14.4	−28.6
S-elasticity – Output	. .	0.9	0.9	0.9	0.4	0.2	0.2	0.1	0.0	0.9	0.9	0.8	0.4
Producer price	−6.9	3.6	1.2	−2.3	−8.6	−4.8	−5.6	−6.3	−7.0	3.7	1.0	−2.7	−8.6
Import volume	24.8	11.9	19.6	26.0	28.8	17.1	18.4	20.4	30.6	14.3	23.4	30.1	21.3
Export volume	109.2	−11.6	4.0	37.8	154.4	12.2	39.6	75.8	119.7	−2.6	16.9	51.7	139.3
Food processing and beverages													
output	− 13.9	−1.7	−2.9	−6.2	−15.3	−12.0	−13.0	−14.2	−12.5	−0.8	−2.2	−5.7	−17.5
S-elasticity – Output	. .	1.0	1.1	1.1	0.2	0.2	0.1	−0.0	−0.2	1.1	1.1	1.2	0.5
Producer price	−3.1	−0.3	−1.0	−2.0	−3.4	−2.1	−2.4	−2.7	−3.2	−0.6	−1.4	−2.4	−3.3
Import volume	275.8	18.9	40.5	100.6	347.0	160.8	189.1	234.4	295.5	23.1	49.7	115.9	330.0
Export volume	158.0	−21.5	−8.3	28.5	374.7	−0.0	16.1	54.9	291.6	34.4	55.7	93.3	200.1
Non-food manufacturing and private services													
output	1.2	0.3	0.4	0.7	1.2	1.0	1.0	1.0	1.1	0.2	0.4	0.7	1.3
S-elasticity – Output	. .	0.9	0.9	0.8	0.1	0.2	0.2	0.2	−0.2	0.9	0.9	0.9	0.2
Producer price	0.7	0.3	0.4	0.6	0.7	1.0	0.9	0.9	0.6	0.1	0.3	0.5	0.7
Import volume	−1.0	0.1	−0.1	−0.4	−1.2	−3.6	−2.7	−1.8	−0.5	0.1	0.1	−0.1	−1.9
Export volume	9.1	3.2	4.3	6.2	8.7	7.0	7.9	8.5	8.2	2.1	3.6	5.8	9.2
Other indicators													
Terms of trade	−3.6	−1.8	−2.4	−2.8	−3.4	−6.8	−6.1	−4.9	−2.8	−0.9	−1.3	−2.0	−4.2
Import price	4.6	2.2	3.0	3.7	4.3	8.6	7.7	6.4	3.6	1.1	1.7	2.6	5.4
Export price	0.9	0.4	0.6	0.8	0.8	1.2	1.1	1.1	0.7	0.2	0.4	0.6	0.9
Consumer price	−1.9	0.1	−0.0	−0.4	−2.5	−0.4	−0.8	−1.3	−2.2	−0.1	−0.2	−0.7	−2.3
Domestic food price	−5.3	−0.7	−1.4	−2.7	−7.1	−3.2	−3.7	−4.5	−5.7	−1.0	−1.8	−3.1	−6.8
Real income	1.1	−0.1	−0.0	0.3	1.6	0.3	0.5	0.7	1.3	0.0	0.2	0.5	1.5
S-elasticity – Real income	. .	1.3	1.4	1.5	1.0	0.9	0.8	0.7	0.3	1.1	1.2	1.2	0.7

Table 4e. Trade sensitivity analysis for New Zealand

Per cent changes compared with benchmark year

	Base	Simultaneous variations of export and import demand elasticities				Variations of export demand elasticities				Variations of import demand elasticities			
		-87.5%	–15%	–50%	+50%	-87.5%	–15%	–50%	+50%	-87.5%	–15%	–50%	+50%
Agriculture													
output	–7.9	–3.4	0.0	4.8	7.7	20.0	17.2	12.9	5.3	–1.0	0.2	2.7	11.0
S-elasticity – Output	. .	1.6	1.3	0.8	–0.0	–1.8	–1.6	–1.3	–0.7	1.3	1.3	1.3	0.8
Producer price	20.3	6.3	9.8	15.8	20.3	34.3	31.4	26.4	17.1	9.3	10.7	13.7	24.4
Import volume	48.4	–2.9	5.6	21.4	62.2	384.1	244.3	122.3	24.9	–0.8	0.4	8.0	118.6
Export volume	–58.2	–5.4	–27.9	–49.9	–54.0	–56.1	–65.6	–66.3	–51.2	–29.0	–34.3	–45.1	–61.1
Food processing and beverages													
output	18.9	–2.9	4.9	13.9	19.1	34.2	31.5	25.9	15.0	4.6	6.7	11.2	24.0
S-elasticity – Output	. .	1.3	1.0	0.5	0.0	–0.9	–0.9	–0.7	–0.4	0.9	0.9	0.8	0.6
Producer price	10.0	4.0	5.1	7.8	10.0	14.2	13.8	12.2	8.7	5.3	5.9	7.2	11.7
Import volume	16.8	–1.4	4.3	10.8	18.3	144.7	91.9	44.9	8.7	0.4	0.8	3.7	33.4
Export volume	42.3	–6.1	11.3	31.4	42.5	88.6	77.6	60.7	32.7	9.6	14.4	24.3	55.3
Non-food manufacturing and private services													
output	–2.4	0.6	–0.4	–1.7	–2.5	–6.5	–5.4	–3.9	–1.7	–0.1	–0.4	–1.1	–3.4
S-elasticity – Output	. .	1.5	1.1	0.6	0.1	–1.9	–1.7	–1.2	–0.6	1.1	1.1	1.1	0.9
Producer price	–2.7	1.1	–0.7	–2.1	–2.5	–11.1	–8.6	–5.5	–1.6	0.4	0.0	–0.9	–4.0
Import volume	8.9	0.6	4.2	7.1	9.0	55.3	36.8	19.7	5.5	0.8	1.4	3.3	14.2
Export volume	–18.1	2.7	–8.3	–16.2	–16.5	–14.0	–20.4	–22.1	–14.9	–6.0	–8.3	–12.8	–19.3
Other indicators													
Terms of trade	10.6	1.5	7.9	10.5	9.3	39.8	30.1	19.1	7.5	3.3	4.1	6.2	13.2
Import price	–5.2	1.3	–5.1	–6.2	–4.0	–24.1	–18.1	–11.0	–3.0	–0.4	–1.0	–2.6	–6.5
Export price	4.9	2.8	2.4	3.6	5.0	6.1	6.5	6.0	4.3	2.9	3.1	3.5	5.9
Consumer price	–1.6	1.4	–0.5	–1.4	–1.3	–11.5	–8.0	–4.3	–0.6	0.9	0.6	–0.1	–2.6
Domestic food price	5.8	3.2	3.2	4.5	6.0	3.4	4.9	5.8	5.4	3.8	4.1	4.6	6.4
Real income	2.7	0.8	2.3	2.8	2.4	11.5	8.2	4.9	2.0	1.1	1.3	1.7	3.4
S-elasticity – Real income		0.8	0.2	–0.1	–0.2	–3.8	–2.7	–1.7	–0.5	0.7	0.7	0.7	0.5

Table 4f. Trade sensitivity analysis for the United States

Per cent changes compared with benchmark year

	Base	Simultaneous variations of export and import demand elasticities				Variations of export demand elasticities				Variations of import demand elasticities			
		-87.5%	-75%	-50%	+50%	-87.5%	-75%	-50%	+50%	-87.5%	-75%	-50%	+50%
Agriculture													
Output	-7.0	-4.6	-4.8	-5.3	-9.8	-3.4	-4.3	-5.8	-7.4	-5.7	-5.7	-6.0	-9.1
S-elasticity - Output	..	0.4	0.4	0.5	0.8	0.6	0.5	0.4	0.1	0.2	0.3	0.3	0.6
Producer price	4.2	4.9	4.9	4.7	3.3	5.5	5.1	4.6	4.0	4.2	4.4	4.3	3.5
Import volume	1.7	-0.0	1.4	3.0	-3.3	5.9	4.1	1.5	3.7	0.9	2.1	3.7	-6.5
Export volume	-5.7	-12.3	-11.6	-10.2	3.7	-12.3	-10.2	-7.1	-6.6	-16.7	-15.0	-12.3	2.5
Food processing and beverages													
Output	-2.8	-1.8	-1.7	-1.8	-5.2	-1.1	-1.9	-2.9	-1.9	-0.5	-0.6	-1.1	-6.0
S-elasticity - Output	..	0.4	0.5	0.7	1.7	0.7	0.5	-0.1	-0.6	0.9	1.0	1.2	2.3
Producer price	1.6	2.3	2.2	2.1	1.3	2.4	2.2	2.0	1.7	2.0	2.0	2.0	1.5
Import volume	114.7	6.7	15.1	36.6	257.1	51.3	64.9	88.9	129.4	8.8	18.5	42.3	224.2
Export volume	28.8	-23.9	-17.8	-5.1	78.9	24.4	20.2	16.1	48.7	-7.4	-2.5	7.1	51.1
Non-food manufacturing and private services													
output	0.4	0.4	0.4	0.4	0.5	0.3	0.3	0.4	0.4	0.3	0.4	0.4	0.5
S-elasticity - Output	..	0.1	0.2	0.2	0.3	0.3	0.2	0.1	-0.2	0.2	0.2	0.3	0.4
Producer price	0.9	0.8	0.8	0.8	0.9	0.7	0.7	0.8	0.9	0.9	0.9	0.8	0.9
Import volume	-0.1	0.2	0.3	0.2	-0.6	0.8	0.4	-0.1	0.1	0.3	0.2	0.2	-0.9
Export volume	3.0	2.8	2.3	2.4	3.3	2.2	2.2	2.7	2.4	2.1	2.4	2.1	3.6
Other indicators													
Terms of trade	-0.2	0.3	0.5	0.2	-0.8	0.7	0.4	-0.1	-0.2	0.2	0.2	0.1	-0.9
Import price	1.9	1.4	1.2	1.4	2.5	1.4	1.6	1.9	1.7	1.2	1.3	1.3	2.7
Export price	1.6	1.7	1.7	1.6	1.7	2.1	2.0	1.8	1.5	1.4	1.5	1.5	1.8
Consumer price	1.0	1.0	1.0	1.0	0.7	0.9	0.9	0.9	0.9	1.0	1.1	1.0	0.8
Domestic food price	2.0	2.5	2.4	2.3	1.2	2.6	2.4	2.2	1.8	2.3	2.3	2.2	1.4
Real income	0.3	0.3	0.4	0.3	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.4
S-elasticity - Real income	..	-0.0	-0.2	-0.2	0.5	-0.5	-0.4	-0.3	0.3	-0.1	0.0	-0.2	0.3

- Whether the elasticities are modified together or separately also matters. Changing the export demand elasticities alone gives rise to terms-of-trade movements. Changes in the import substitution elasticities give rise to additional welfare effects from induced shifts in consumer demand.
- The presumption that OECD agricultural liberalisation should lead to real income gains is a very robust one. Although the WALRAS model is sensitive to the trade elasticities, it is noteworthy that the OECD area never incurs a welfare loss in any of the twelve variant simulations which cover a wide range of elasticity values. Indeed, there are only two out of a possible seventy-two cases where an individual country/region incurs a slight welfare loss. In both cases, the loss occurs in Japan when both import and export elasticities are set at low levels.

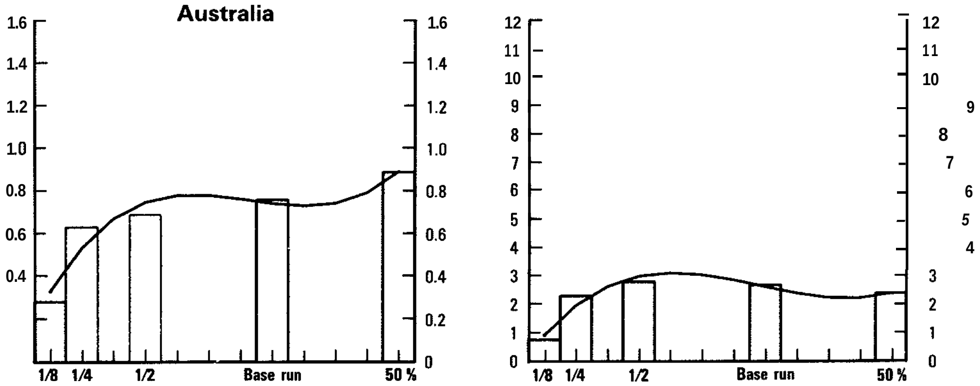
The countries/regions in the WALRAS model can be partitioned into four groups. The small food exporters, Australia and New Zealand, are in one group. The large food importers, the EC and Japan, are in a second group. Canada is the only country where the food trade balance shifts from a net importing to a net exporting position when the substitution elasticities are raised from the base-case levels. The United States is largely unaffected by any change, although it has a profile somewhat similar to the food exporters. The remainder of this section discusses each of these groups in turn.

i) Small food exporters

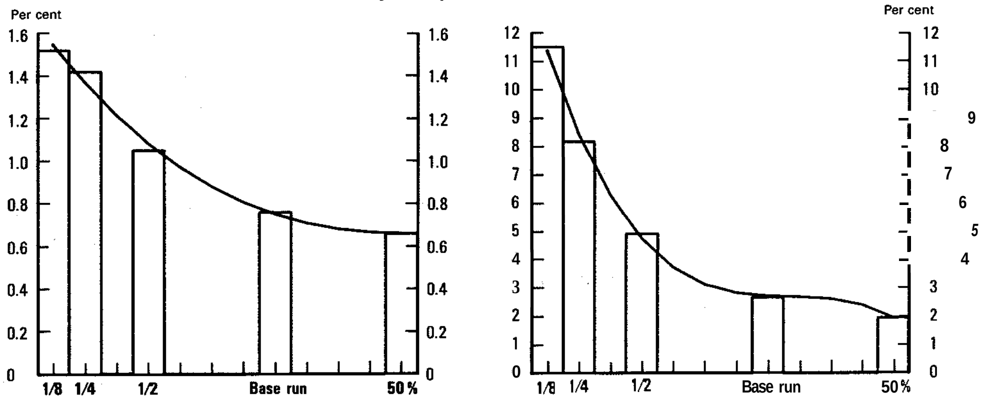
When both trade elasticities are perturbed, the food-exporting countries, Australia and New Zealand, follow a similar pattern – see Chart A. At very low trade elasticities, both countries suffer because the rest of the world has a low propensity to import and imported goods are very differentiated. Although the world price of their main export, food, increases more than in the base case, this is accompanied by a net fall in their food exports as overall world trade declines. As the trade elasticities increase, their terms of trade improve. At high trade elasticities, there is a levelling off, in New Zealand's case even a decrease, in real income gains. This is essentially due to a levelling off in the terms-of-trade improvement since, at high trade elasticities, the world price of food products does not increase as much.

Both countries are much more sensitive to the export demand elasticities alone, particularly when they are low. In the latter situation, the food exporters benefit from significant market power since exports are highly differentiated. In addition, the import demand elasticities are maintained at the relatively high values of the base case, therefore the propensity for the other countries to import is high. Both Australia and New Zealand would achieve their highest gain in real income under this scenario, with the latter country recording a gain of over 11 per

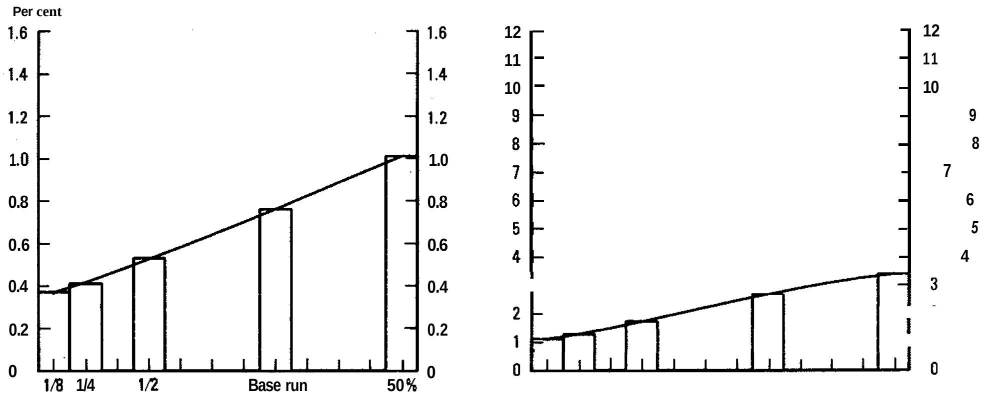
Australia



Sensitivity to export demand elasticities



Sensitivity to import



cent. As the export demand elasticities increase, their market power declines and their terms-of-trade improvement decreases accordingly.

Australia and New Zealand are less sensitive to variations in the import demand elasticities, both countries exhibiting an almost linear relation between changes in real income and changes in the elasticity. At the lower range of the import demand elasticities, the propensity of the other countries/regions to import is relatively low. For example, Australian exports of food only increase by **8** per cent under the scenario of an **87.5** per cent cut compared with an increase of **71** per cent under the base scenario.

In summary, the results for Australia and New Zealand are quite sensitive to the size of the export demand elasticities; these countries gain significantly when these elasticities are low since their exporters are able to exploit their market power. They also benefit from high import demand elasticities as the propensity of the rest of the world to consume their exports is high and their import prices are lower.

ii) Large food importers

Real income gains in both the EC and Japan are very sensitive to simultaneous changes in the trade elasticities – see Chart B. When both import and export elasticities are very low, the EC would gain very little and Japan would suffer a slight loss. When they are very high, the EC would achieve a real income gain of 2.8 per cent and Japan a gain of **1.6** per cent. Real income gains for Japan stabilise at the very high end, when domestic demand is saturated by imports. This does not occur in the **EC** which still has an S-elasticity well in excess of unity, even when both trade elasticities are very high.

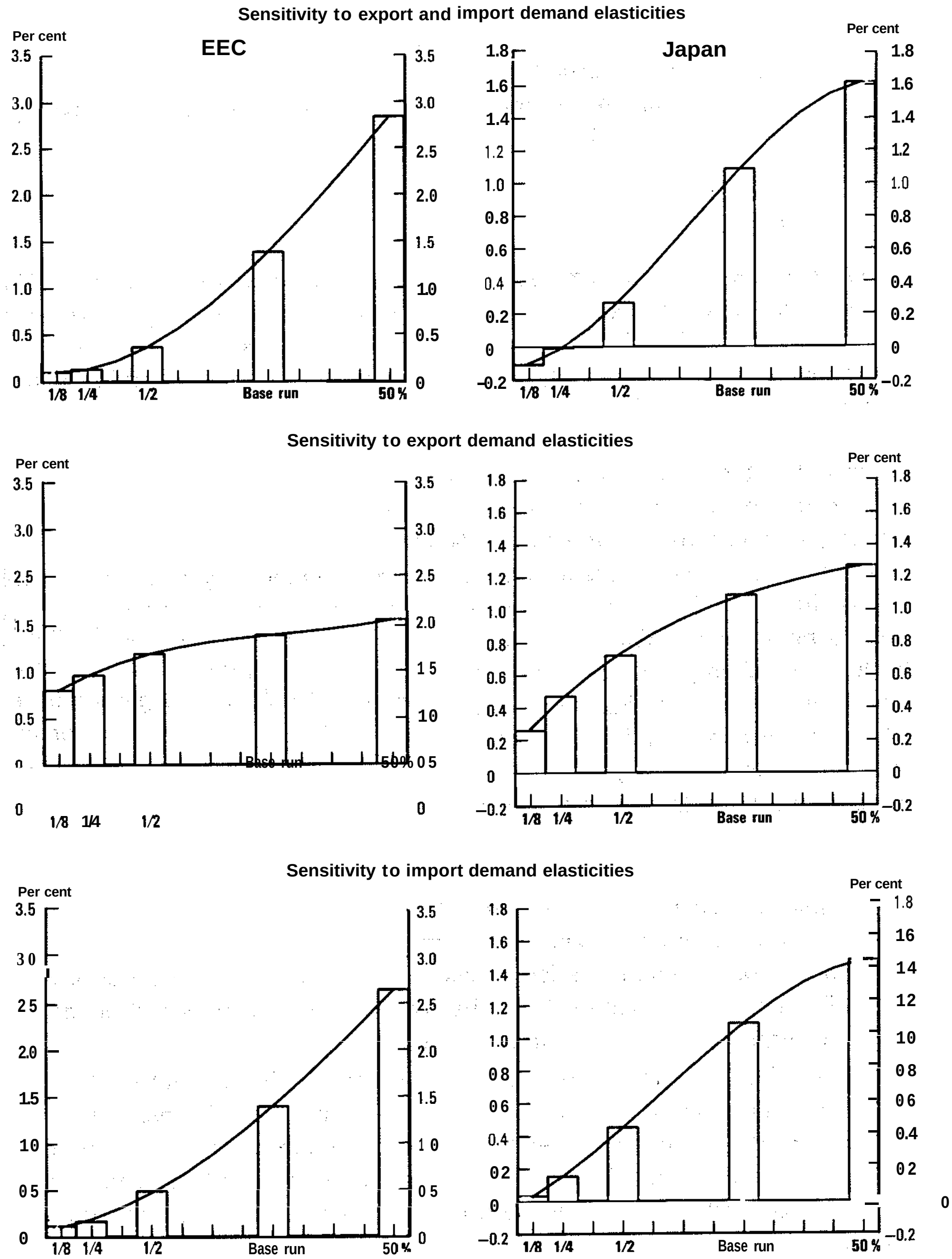
With very low import demand elasticities, neither the EC nor Japan benefit much from the removal of protection since substitution possibilities towards the relatively cheaper imports are low. Low export demand elasticities reinforce this effect since, ***ceteris paribus,*** world agricultural prices, and therefore import prices, are higher. The opposite occurs when import demand elasticities are high. In this case, the EC and Japan reap large benefits from the removal of protection because demand shifts strongly towards (relatively) cheaper imports. High export demand elasticities reinforce the shift towards imports since world agricultural prices are lower. As an example, food prices in the EC increase by 0.4 per cent when both trade elasticities are low compared with a decrease of over 6 per cent when the base elasticities are raised by 50 per cent.

When the export demand elasticities are varied separately, the real income gain varies within a much narrower band **(0.8** to **1.6** per cent in the EC and **0.3** to **1.3** per cent in Japan). This is due to the fact that the import demand effect dominates the effect of the increase in price of domestic supply – the levels of border protection are particularly high in the **EC** and Japan. Therefore, even when

CHART E

CHANGES IN REAL INCOME IN THE EEC AND JAPAN

Per cent changes compared with benchmark year



export demand elasticities are very low and other countries exercise a greater degree of market power, thereby producing larger increases in world agricultural prices, both the EC and Japan still benefit significantly from lower domestic prices for food.

The EC and Japan are significantly more sensitive to changes in the import demand elasticities – as is natural for large food importers. Chart B shows that changes in the import demand elasticities closely parallel the effects of changing both elasticities simultaneously.

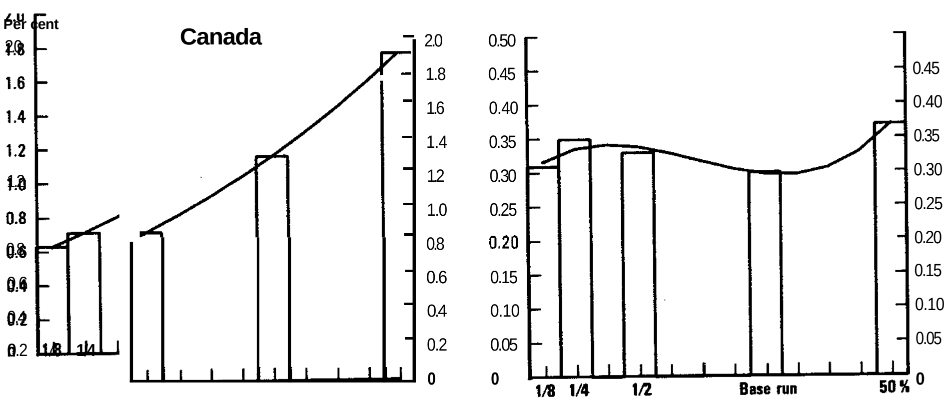
iii) Canada

Chart C shows that the simulation results are not additive for Canada. When the elasticities are very low, Canada has a higher real income gain when the elasticities are varied individually compared with the outcomes of varying them simultaneously. When both elasticities are perturbed together, Canada exhibits behaviour that is very similar to the food importers, the EC and Japan, albeit with a higher real income gain at the low end. However, the Canadian results differ from those for the large food importers in two respects. First, the range of variation in the real income gain is much smaller. Second, Canada's farm-support policies rely much more on output subsidies than border measures. Eliminating all farm support increases domestic producer prices significantly but it has a relatively less dramatic effect on food import prices since levels of border protection are low to begin with. When the trade elasticities are low, Canada experiences relatively large changes in the price of food imports (without the benefit of decreases due to high tariffs), large changes in domestic producer prices, and a slightly larger deterioration in its terms of trade. This results in a larger increase in domestic food prices (5.5 per cent for the scenario of a cut of 87.5 per cent, compared with 1.6 per cent in the base scenario).

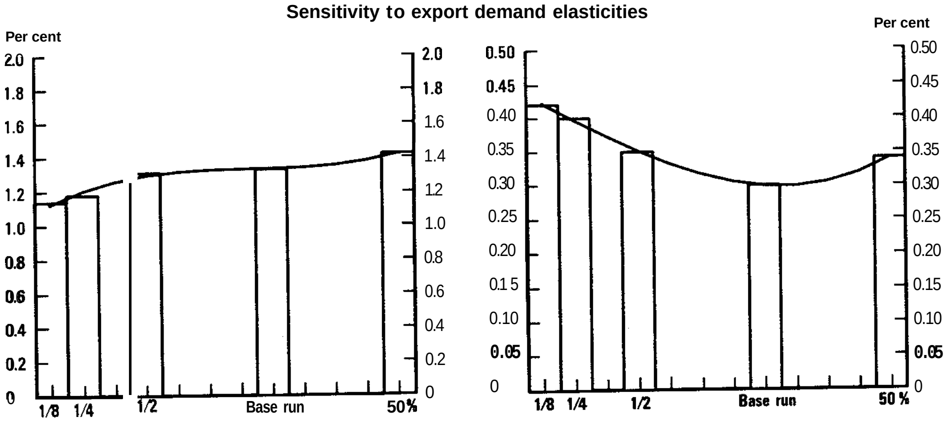
When the export demand elasticities alone are perturbed, Canada exhibits much less sensitivity. When export demand elasticities are low, Canada benefits from a certain degree of market power. Because of this, its terms of trade are virtually unchanged (comparedwith a drop of 1 per cent when both elasticities are low). As the export demand elasticity rises, Canada becomes a net food importer and Canadian consumers benefit from the overall reduction of world prices. This results in a rather flat curve for the real income gain".

As in the EC and Japan, real income varies more with respect to the import demand elasticities than it does with the export demand elasticities. This reflects a combination of the switch to relatively cheaper imports at high levels of the elasticities and the dampening in the rise in domestic producer prices in the agricultural and food sectors. This results in smaller increases in consumer and food prices.

CHART C



Sensitivity to export demand elasticities



Sensitivity to import demand elasticities

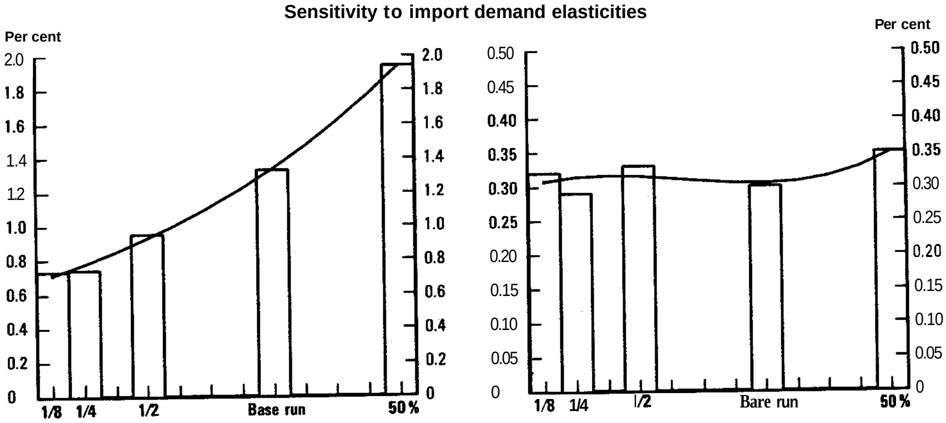
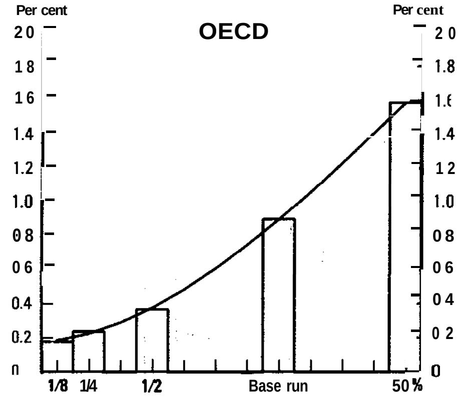


CHART D

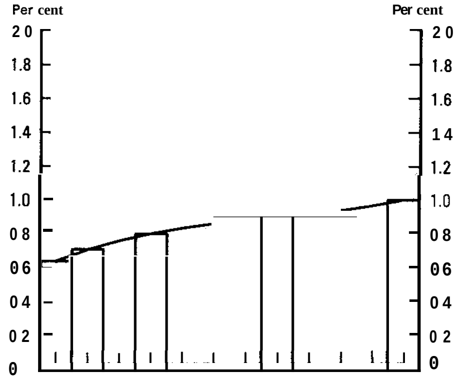
CHANGES IN REAL INCOME IN THE OECD (1)

Per cent changes compared with benchmark year

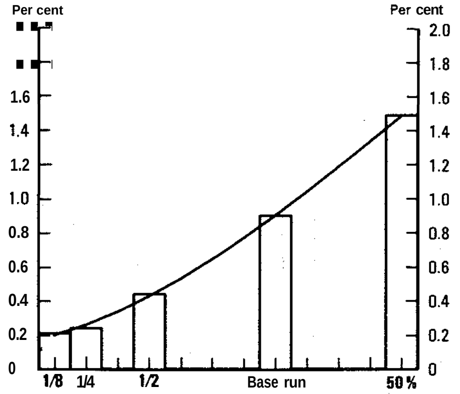
Sensitivity to export and import demand elasticities



Sensitivity to export demand elasticities



Sensitivity to import demand elasticities



1. Total of the six countries/regions

iv) United States

The United States is the least sensitive of the six countries/regions to changes in the trade elasticities (changes in real income range from 0.3 to 0.4 per cent) – see Chart C. When both trade elasticities are low, it benefits from a certain degree of market power on world markets, thereby improving its terms of trade slightly. This is partly offset by the lower degree of consumer demand reallocation resulting from higher food prices on the domestic market. Liberalisation raises domestic food prices, but as import demand elasticities are low, these price rises are not dampened by a shift to cheaper imports. As both elasticities rise, the reverse happens. The United States loses its terms-of-trade improvement but benefits from greater consumption of cheaper food imports.

When export demand elasticities are varied alone, the United States benefits from market power when the elasticities are low. This is only partially offset by higher world food prices. As the elasticities rise, the terms-of-trade improvement disappears and even turns slightly negative.

Varying the import demand elasticities alone has almost no effect on the magnitude of the real income gain except when they are raised by 50 per cent compared with the base-case set. Even though this latter variation gives rise to a larger terms-of-trade deterioration, the negative effect on real income is more than offset by larger efficiency gains in production and consumption.

SUMMARY AND CONCLUSIONS

The purpose of this paper has been to assess the robustness of WALRAS results to changes in both the specification of the model and key parameter values. None of the three changes to model specification examined in this paper – varying the degree of factor mobility, the CET specification and allowing for land use in the non-agricultural sectors – makes a major difference to the base-case simulation results. Varying the degree of factor mobility appears to make the most difference to the real income gains, but even this is marginal. Allowing for land use in the non-agricultural sectors and partial mobility of land between agricultural and non-agricultural uses – a change in specification which was implemented in the model for Japan only – made a significant difference to the effects of liberalisation on land rentals. It moderated significantly the fall in the land rental in the agricultural sector, led to a small fall in land rents in the non-agricultural sector and a small shift in land resources between the two sectors.

The sensitivity of simulation results to variations in parameter values was examined for several key parameter blocks in the model: the ROW supply elasticity, the capital-labour elasticity of substitution, the elasticity of substitution between land and the capital-labour bundle, and the trade elasticities.

The main conclusion from testing the non-trade parameters is that the base-case model results are very robust, even to rather large perturbations of these elasticities. A caveat to this conclusion is that these parameters have been modified one at a time. It is possible that a combination of changes could lead to different results. In particular, the model might be more sensitive to these parameters at lower levels of the base-case trade elasticities.

Extensive sensitivity analysis revealed that the trade elasticities are the most crucial exogenous parameters in WALRAS. At one extreme is New Zealand which, due to its dependence on export markets, is very sensitive to the export demand elasticities. Its own relatively low level of protection makes it much less sensitive to import demand elasticities. At the other extreme is the United States. With its large internal market and relatively low level of both imports and exports (imports represent 3.4 per cent of total output in the agricultural and food processing sectors in the benchmark data set), the real income outcomes for the United States stay within a narrow range. Both the EC and Japan as net food importers are more sensitive to the import demand elasticities. Canada, though a net food exporter in the benchmark data, is more dependent than the United States on food imports and has higher rates of protection on imports (and higher levels of production subsidies). These factors explain why the Canadian profile more closely resembles those of the EC and Japan.

Limiting the trade elasticities in the range −50 per cent to +50 per cent around the base levels, the aggregate real income gains for the total of the six countries/regions ranged between 0.4 and 1.6 per cent, or $34 to $136 billion (measured at 1988 prices and exchange rates). Within this range the structural indicators change in magnitude but never in sign. This leads us to conclude that the basic mechanisms and results described in the paper by Martin *er al.* in this volume are robust.

NOTES

1. See Mansur and Whalley (1984) for a discussion on estimation ***versus*** calibration of AGE models. Borges (1986) discusses the strengths and weaknesses of AGE models.
2. To a large extent AGE modellers have not attempted systematic sensitivity analyses due to the complexity of large AGE models and limited resources. More recently, there have been several papers devoted to the sensitivity issue. Pagan and Shannon (1987) perform a suite of tests with the Australian ORANI model. Harrison *et al.* (1987) analyse some of the methodological issues concerning sensitivity analysis and present several different approaches to the issue. They also illustrate the application of various approaches using four different AGE models. Kirkpatrick (1990) also discusses some of the issues related to sensitivity analysis and performs a series of tests on an AGE model of the German economy in order to draw conclusions about the robustness of the base results.
3. Burniaux *et al.* (1988) report some experiments with different closures for the WALRAS model.
4. An additional model change was implemented, the results of which are not reported here. The WALRAS model differentiates production goods from consumer goods. Consumer goods are related to production goods via a fixed-coefficients transition matrix. The original model had ten consumer goods, including total food consumption as one aggregate good. Agricultural policies are essentially concentrated at the production level and the effects of removing them were diluted at the consumer level because of the degre of aggregation of food consumption. In order to remedy this problem, the consumer food aggregate was split into four (increasing the number of consumer goods from ten to thirteen). This change produces a more direct link between agricultural protection on the production side and price movements on the consumption side. Comparison with earlier results indicates that this modification had a significant effect for Canada and the EC (in both cases the real income gain nearly doubles under the new transition matrix).
5. Although agricultural land use decreases by 2 per cent, total output of the two farm sectors decreases less than in the base-case scenario (–22.3 compared with –24.3 per cent). This reflects the fact that factor reallocation is higher within the agricultural sector than between agriculture and the rest of the economy. Other agricultural products (mainly crops) are more land-intensive than livestock products.' Since agricultural land can be diverted to non-agricultural uses, prices of other agricultural products decline less relative to livestock products than in the base-case scenario. Partial land mobility in fact implies that the effective rate of protection in other agriculture is higher relative to livestock and liberalisation, therefore, is less detrimental to the livestock sector than is the case when there is no land mobility. In comparison with the base-case scenario, overall agricultural productivity increases as liberalisation implies a further reallocation in favour of the livestock sector, which uses primary factors less intensively.

6. Further sensitivity analysis with the model indicates that the results overall are quite insensitive to the value of the land migration elasticity. The only variable which appears to be sensitive to the migration elasticity is the agricultural land rental. Varying the elasticity of substitution between land and the capital-labour bundle has virtually no effect on the results.

7. See Boone (1989) for a similar conclusion. See also Takagi (1989) who emphasises the fundamental role of the land taxation system in the determination of Japanese land prices.

8. See Shoven and Whalley (1984) for a succinct introduction to calibration of AGE models.

9. The nominal world price changes are deflated by the numéraire of the model, which is the ROW price of other manufactured goods.

10. Formally, the S-elasticity is defined as:

$$S(y, \theta) = \frac{\delta y}{\delta \theta} \frac{\theta}{y}$$

where y is the percentage change of a given variable from its base value, and θ is a scalar multiplying a block of parameters. The results reported in the tables only approximate the S-elasticity since the calculations are performed using Δy and $\Delta \theta$.

11. For Canada, the impact of changing trade elasticities on real income depends on what happens to the net food trade balance. When export demand elasticities alone are raised, the terms-of-trade deterioration tends to increase so long as the food trade balance is positive; the terms of trade deteriorate less when Canada switches to a net food importer. When Canada is close to self-sufficiency in food, terms-of-trade changes have almost no effect on welfare, but consumers benefit more from food imports at higher values of the export elasticities as world food prices fall.

Annex

NON-AGRICULTURAL LAND IN JAPAN

This Annex describes how non-agricultural "capital" in Japan was split between land and capital.

The value of the total land stock in Japan is available in the Annual Report on National Accounts, 1987, published by the Economic Planning Agency (EPA). The data relating to the end of 1980, the base-year in the WALRAS model, indicate that agricultural ("cultivated") land accounted for almost 15 per cent of all private sector land in Japan. Nearly 80 per cent of the value of land is underlying buildings. The remaining portion relates mainly to recreational land, which is allocated to the "other services" sector of the WALRAS model, and land underlying forests, which is allocated to the "other primary industries" sector.

The major task was to split the land underlying urban buildings between the eleven non-agricultural sectors of the WALRAS model. The EPA does not publish a breakdown of urban land by industrial sector, and an indirect method was used to estimate this in two stages. First, it was assumed that the sectoral split of land underlying buildings is proportional to the value of buildings standing on the land i.e. the construction component in capital stock data. The EPA data provided the split between residential and non-residential construction. The residential component was allocated entirely to the "other services" sector of the WALRAS data base, since this is where the "house rent" industry is included. Second, the value of the assets of non-residential construction was split between sectors on the basis of a second EPA source, the Gross Capital Stock of Private Enterprises, 1988. The available sectoral split is adequate for the eleven non-agricultural sectors except that "food, beverages and tobacco" is not disaggregated. The food-processing industries were further disaggregated on the basis of gross output shares.

The above method appears to gives sensible results for the eleven non-agricultural sectors. On average, non-agricultural land was estimated to account for 5 per cent of the total of capital plus land, in contrast to 23 per cent for the agricultural sector in the WALRAS data base.

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