SALTER: A General Equilibrium Model of the World Economy

by

J. Zeitsch., R. McDougall., P. Jomini., A. Welsh., J. Hambley., S. Brown., and J. Kelly

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SALTER WORKING PAPERS[a]

No.

1 McDougall, R. *Linking CGE Country Models: An Example Using the OECD's WALRAS Model*

2 McDougall, R. *Linking Regional Models in WALRAS*

3 McDougall, R. and Sugden, C. *Implementation of the WALRAS Model of the Australian Economy*

4 Zeitsch, J., McDougall, R., Jomini, P., Welsh, A., Hambley, J., Brown, S. and Kelly, J. *SALTER: A General Equilibrium of the World Economy*

5 Brown, S. *NERAM: A Nominal and Effective Rates of Assistance Model for the SALTER World Trade Model*

[a] SALTER working papers document work in progress on the development of the SALTER model of the world economy. They are made available to allow scrutiny of the work undertaken but should not be quoted without the permission of the author(s).

PREFACE

In December 1988 the Department of Foreign Affairs and Trade approached the then Industries Assistance Commission to conduct an analysis of the economic effects of alternative trade liberalisation scenarios. The analysis was to be based on a version of the Organisation for Economic Co-operation and Development's WALRAS world trade model. The data needed to construct a new version of the model had been made available by the Growth Studies Division of the Organisation for Economic Co-operation and Development.

While the WALRAS model could provide valuable insights into the effects of trade liberalisation, to be of maximum policy relevance the country coverage and commodity detail contained in the original WALRAS model needed to be extended. In particular, given the Prime Minister's (APEC) initiative to enhance interchange of views between Australia and its near trading partners, it was considered essential that any analysis of trade liberalisation also include the ASEAN region and Korea. It was also considered necessary that the model identify commodities of special concern to Australia's near trading partners.

The Department of Foreign Affairs and Trade commissioned the Industries Assistance Commission to develop a model which covered 8 countries or groups of countries and up to 34 industries and commodities.

This report documents the theoretical structure of the model, its database and parameters. Two applications of the model are also reported. It is being provided to enable scrutiny of the work undertaken so far. It is hoped that this process will enable the document and model to be further refined before undertaking a major analysis of the benefits from further trade liberalisation in the Asia-Pacific region and the world as a whole.

The world trade model has been named after the distinguished Australian economist Wilfred Salter. As outlined above, the development of the SALTER model was largely inspired by the creation of the WALRAS world trade model developed by the Growth Studies Division of the Organisation for Economic Co-operation and Development. The co-operation and encouragement provided by John Martin and his team at the Organisation for Economic Co-operation and Development has been greatly appreciated.

The economic specification of the WALRAS model was extended by Robert McDougall to create the SALTER model. Craig Sugden developed the original computer implementation of the model which has been ably continued and extended by Andrew Welsh.

John Hambley almost single-handedly developed the model's database, while Patrick Jomini put together the model's parameter database and documentation. Ruth Thomson, Stephen Brown and Simon Wear have spent long hours developing various components of the model.

Several consultants were employed to assist in developing the model. Dr Ken Pearson extended the GEMPACK modelling software to enable the model's database to be updated and to obtain large change solutions of the model. Dr Cillian Ryan of the University of North Wales constructed the database for the European Community country component of the model. The Institute of Applied Economic and Social Research provided a review of existing multi-country models.

Top class clerical support for the project was provided by Roberta Wise, Christine Hryhoriak and Malcolm Fisher.

The SALTER model has the potential to significantly affect trade debates. It can highlight the economic and social effects of continued protection policies in the world economy. Having such a tool available at the present time is most opportune.

John Zeitsch

Project Leader

Wilfred Edward Graham Salter

The world trade model developed for the Department of Foreign Affairs and Trade has been given the acronym SALTER (Sectoral Analysis of Liberalisation of Trade in the East Asian Region)

Wilfred Salter was born in Western Australia in 1929. He graduated with first-class honours from the University of Western Australia in 1952, and gained his Ph.D. from Clare College, Cambridge, in 1955, for his thesis *A Consideration of Technological Change with Special Reference to Labour Productivity*. His research continued at John Hopkins and the Australian National University, culminating in the publication in 1960 of his most important work, *Productivity and Technical Change* - 'one of the finest - and earliest - examples of the embodiment hypothesis' (Harcourt, 1972). In 1960 he left the Australian National University to become Assistant Secretary in the Economic Section of the Prime Minister's Department. Taking leave from the public service in 1962, he joined the Harvard Advisory Group as Economic Adviser to the Government of West Pakistan. He died in Lahore in 1963.

> The activities of the last four years of his life show Salter's view of what an economist should be. Not content with even the most thorough academic training, with spinning theories, or with analysing cold statistics, he believed that an economist should learn his trade by responsible experience in varied fields. His decisions to join the Commonwealth Service and to work in Pakistan were part of a deliberate plan to fit himself for an economist's job, whether his future might lie in academic or in government service (Swan, 1963).

> Salter's work [on productivity and technical change] is a model which all aspiring (and established) economists could profitably have before them. Its characteristics are a flair for formulating relevant theory which, clearly, neatly and excitingly expressed, is carried no further than the requirements of the problem in hand - and is immediately tested against the facts (Harcourt, 1972).

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1 EXECUTIVE SUMMARY

The Industry Commission has constructed a world trade model for the Department of Foreign Affairs and Trade. The model simulates production, consumption and trade in 34 commodities produced in 8 countries or groups of countries. The model has been given the acronym SALTER (Sectoral Analysis of Liberalisation of Trade in the East-Asian Region) - after the late distinguished Australian economist Wilfred Salter. This Draft Working Document provides details of the model's specification and database, and provides results of two applications of the model. These include:

- removal of Japanese agricultural assistance; and
- a short-run analysis of the international implications of recent oil price rises.

REMOVAL OF JAPANESE AGRICULTURAL ASSISTANCE

Japanese agricultural producers are amongst the world's most heavily assisted. Assistance estimates prepared by the Organisation for Economic Co-operation and Development indicate that in 1988 over 80 per cent of the income received by Japanese farmers for 10 commodities was derived from government support. Most of this assistance is derived through market price support mechanisms although significant support is provided by production subsidies.

Assistance provided Japanese farmers has not always been as high as it is today. It has risen steadily since the last world war as ever increasing levels of assistance were required to achieve the agricultural policy objective of maintaining farmers' real incomes in the face of intense intersectoral pressures created by the rapid growth of the non-agricultural sector. The end result has been an agricultural sector in which producer returns are almost totally insulated from international market conditions. For example, Japanese sugar and wheat producer prices are estimated to be over 1000 per cent above world parity levels and rice prices are in excess of 400 per cent above export parity levels.

To maintain these very high levels of assistance Japanese imports of most agricultural commodities are heavily regulated and extensive use is made of import quotas. These have raised prices faced by Japanese consumers. Thus the policies contract domestic demand and expand supply which reduces market opportunities for Japan's trading partners.

To assess what these policies are costing the Japanese economy and its trading partners, their removal was simulated in the SALTER world trade model. Effects were evaluated over the medium-term (5 year), which allows industry capital stocks to adjust but holds the economy wide stock of capital fixed. Wage rates adjust to ensure that changes in labour demand are matched by changes in labour supply and income tax rates adjust to maintain a fixed public sector borrowing requirement.

The simulations with the SALTER model indicate that removal of Japanese agricultural assistance would lead to the demise of Japan's wheat and coarse grains industries and livestock industries would contract by about 10 per cent. This contraction in livestock industries would create significant increases in imports of dairy and meat products into Japan. Similarly, grain exports to Japan would also increase but, as Japan already imports most of its wheat and coarse grain requirements, only a modest expansion in exports of these commodities is indicated. Also Japan would require less coarse grains as livestock output also falls.

Existing exporters to Japan would all experience greater trade, for example, Australian exports of dairy products and meat products were simulated to rise by 30 per cent and 80 per cent respectively.

The assistance reductions to the Japanese agricultural sector led to large reductions in Japanese farm income rather than large contractions in output. Gross agricultural output was simulated to fall by 3.6 per cent whereas farm income was estimated to fall by 22 per cent. However, if the model had been able to assess more accurately the implication of reduced rice assistance and if assistance provided fruit and vegetables had been assessed and its removal simulated, the indicated output declines would have been substantially greater.

Removing agricultural assistance was simulated to be good for the Japanese economy as resources released from the agricultural sector found more efficient employment opportunities in the non-agricultural sector. The more efficient allocation of resources was estimated to generate an extra US$5.2 billion in output and real consumption rose by US$8.9 billion or US$234 per Japanese household per year.

Most of Japan's trading partners benefit through removal of agricultural assistance in Japan. They benefit largely through terms of trade gains which accrue through increased demand for imports by Japan. Australia and New Zealand benefit most as Japan is a significant market outlet for their agricultural exports. Korea is the only country simulated to lose. It faces reduced demand for its exports of non-grain crops and leather and fur products and thus suffers a terms of trade loss.

IMPLICATIONS OF RECENT OIL PRICE RISES

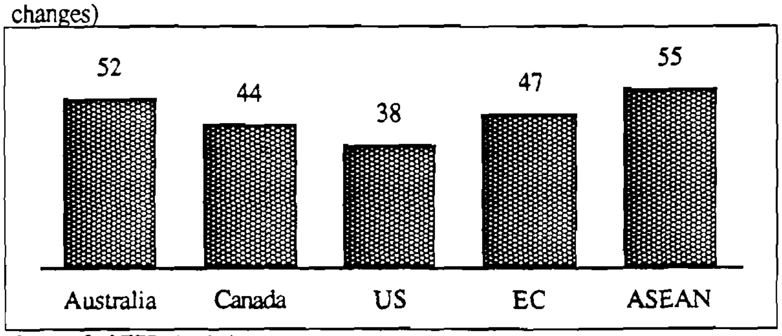
After Iraq's 2 August 1990 invasion of Kuwait, oil prices have risen sharply as a result of both the cut-off of 4.3m barrels a day of Iraqi and Kuwaiti exports as well as fears that Saudi Arabian oil exports could be disrupted in the event of war.

However, the world has responded remarkably well to the oil price rises of 1990. Members of OPEC have boosted oil production much faster than generally thought possible. While most analysts had believed Saudi Arabia could not sustain production much above 7m barrels per day, by December 1990 it was believed to be producing well over 8 m barrels per day. Also, Malaysia increased its production late in August. As a result, by the end of 1990 nearly all the oil exports from Iraq and Kuwait have been replaced from other sources - although with somewhat lower quality oil. Prices have however stabilised and on 2 January 1991 were around US$26 per barrel compared to around US$16 a barrel at the time of Iraq's invasion of Kuwait.

The oil price rise was simulated by assuming that the price of oil and gas supplied by the Rest-of-the-World would rise by 60 per cent with a flow-on increase in the price of their refined oil and coal products of 20 per cent.

Most analysts believe that higher oil prices will not be maintained once diplomatic relations return to normal in the gulf area. Their effects were therefore evaluated over a short-term (2 year) horizon..Within this time it is assumed that producers will have insufficient time to adjust industry capital stocks and real wages will be held constant. Labour employment rates are thus assumed to adjust to match movements in labour demand and savings are assumed to be a fixed proportion of disposable income. Tax rates are held constant and the public sector borrowing requirement is determined by the model. The balance of trade thus adjusts to equate movements in net household savings and movements in the public sector borrowing requirement.

Figure 1.1: **Impact of Rest-of-the-World Oil and gas price rises on Oil and gas prices in selected countries** (per cent changes)

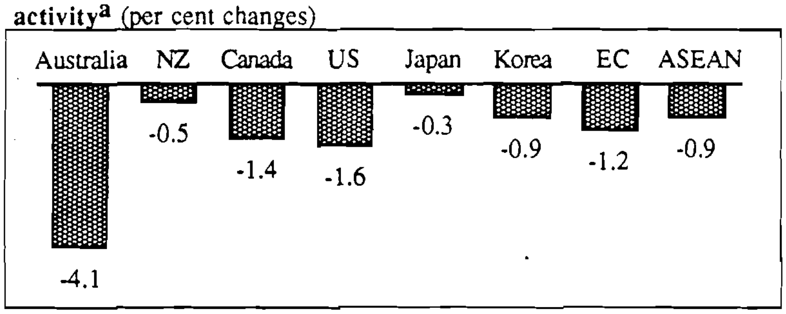


Source: SALTER simulations.

The rise in the price of Oil and gas in the Rest-of-the-World stimulated oil and gas prices throughout the world (Figure 1.1) leading to increased output in other countries. Because of its structure, the model has difficulty reflecting the high degree of integration of the world Oil and gas market which leads to rapid and similar price adaptations in most regional markets. Results for the Oil and gas industry are therefore believed to be indicative of the direction in which quantity movements can be expected to occur, but do not constitute a reliable estimate of the magnitudes of these movements. However, since the Oil and gas industries account for less than 3 per cent of output in most modelled regions, unreliable results concerning these industries will not significantly impact on the overall results. The model was therefore considered to provide valid insights into the economic effects of higher prices in this important energy input.

The effect of higher Oil and gas prices on particular industries in a given country depends on how important oil and petroleum products are in the costs of production in that country, relative to what they are in other countries. Australian and US exports are composed of commodities whose production is relatively energy intensive and are thus significantly affected by a rise in oil prices. This can be seen in Figure 1.2 where output of both the Australian and US economies fall significantly.

Figure 1.2: **Effects of higher Oil and gas prices on economic activity**[a] (per cent changes)



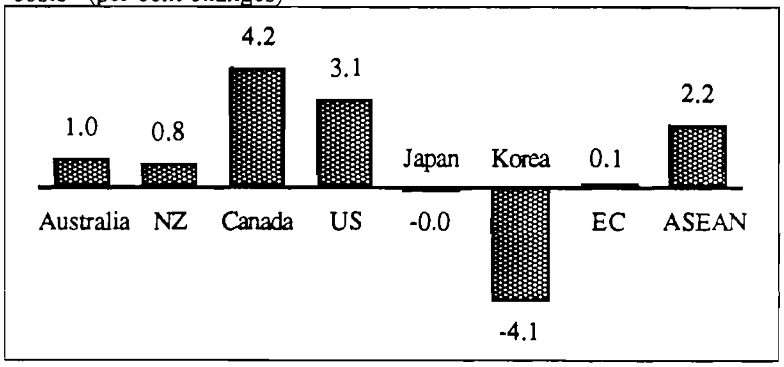
[a] Calculated as the percentage change in real net domestic product.

Source: SALTER simulations

The rise in the price of oil and gas worsens the terms of trade for oil-importing regions (Korea, Japan, the EC and New Zealand). A deterioration in the terms of trade reduces the income a region receives for its exports. To restore balance between income and consumption, household consumption declines. The decline in consumption reduced demand for factors of production leading to only modest rises in the relative costs of primary inputs in the EC and to falls in Korean and Japanese costs (Figure 1.3). The small change in costs in the EC and lower costs in Japan and Korea enhanced the competitiveness of these regions, allowing them to expand exports. Exports grew by about 4 per cent in Korea, by 3.7 per cent in the EC and by 1.3 per cent in Japan.

Australia, Canada, US and ASEAN experienced a terms of trade improvement. But the improvement for most of these countries, was the result of higher costs of production rather than increased export demand. Higher costs of production led to lost export sales, reducing returns to land and capital. This drove down real disposable income and thus real consumption.

Figure 1.3: **Effects of higher oil prices on relative production costs[a]** (per cent changes)



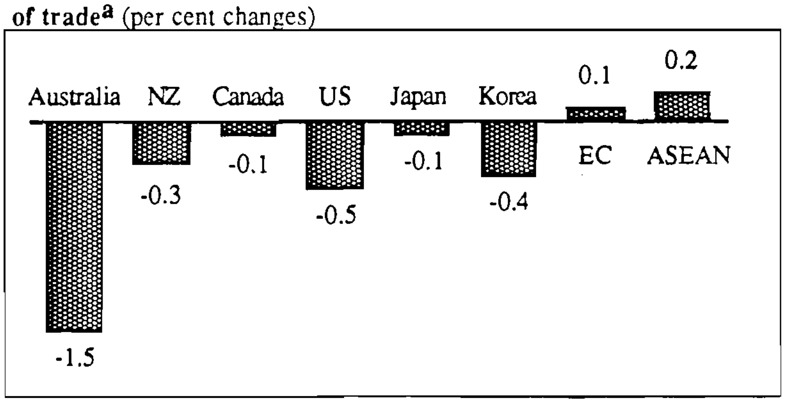
[a] Calculated as the weighted average of percentage change in returns to land, labour, capital and indirect taxes.

Source: SALTER simulations

As Australia is an "energy exporter", it is surprising that it is seen to lose from a rise in the price of oil and gas. However, most of Australia's energy exports are in the form of coal. Higher Oil and gas prices would be expected to increase demand for coal, thus raising Australia's export revenue. However, the SALTER model does not allow for substitution amongst energy sources. Thus a major way Australia might have benefited from increased Oil and gas prices was not accounted for.

In the simulation tax rates were held constant and government expenditure was fully indexed to the consumer price index. With the economy-wide reduction in activity, tax revenue fell and nominal expenditure rose, leading to a large increase in the public sector borrowing requirement. Consequently relatively large deteriorations in the balance of trade were observed (Figure 1.4) which were required to finance the large drops in national savings.

Figure 1.4: **Effect of higher Oil and gas prices on the balance of trade[a]** (per cent changes)



[a] Calculated as the percentage change in the ratio of the balance of trade to net domestic product.

Source: SALTER simulation results.

The simulation results highlight the need for economies to be flexible if they are to minimise (maximise) the economic cost (gain) of adverse (beneficial) international events. To demonstrate this the Oil and gas price shock was re-run assuming that wages adjust to clear labour markets in each country. With flexible real wages, net Oil and gas exporting countries (ASEAN and Canada) expanded output and real consumption. The net Oil and gas importers still lost from higher Oil and gas prices but the magnitude of the reductions in real consumption were much less.

IMPLICATIONS FOR FURTHER WORK

Several problems with the existing model specification were made apparent in the simulations. To accurately assess the implications of rice assistance it will be important to separate rice milling out of the other food products industry. As rice is an important output and consumption good in ASEAN economies this work is considered essential before more ambitious simulations are undertaken. The model results also display linearisation errors but non-linear solution of the model could not be obtained due to software problems. These are currently being corrected.

The simulation involving an increase in the price of Oil and gas has shown that the current model specification makes the analysis of shocks involving highly homogeneous products difficult. This problem might be remedied by modifying the basic structure of the model and could be undertaken in the near future.

2 THE SALTER MODEL STRUCTURE

The SALTER model is a computable general equilibrium model in the tradition of Whalley's (1985) models of world trade. Other models of this type include the WALRAS model used to analyse the economic implications of reducing agricultural assistance in member countries of the Organisation for Economic Cooperation and Development (Burniaux *et al*, 1990), and the Michigan model of North South trade relations between developed and developing countries (Deardorff and Stern, 1986). Like the SALTER, these models are all composed of regional submodels that describe to a varying degree of detail the economic activities of domestic producers, consumers, governments and so on. The regional submodels are then linked through international trade flows to form a general equilibrium model in which prices and quantities supplied and demanded are determined simultaneously in all domestic and international commodity and primary factor markets.

Regions and commodities

The SALTER model consists of 8 countries or groups of countries (Box 2.1) which together accounted for about 80 per cent of world Gross Domestic Product in 1987. The world's major market orientated economies — Japan, the United States and the European Community — are explicitly modelled. The rapidly growing regions of Asia are represented through the inclusion of the ASEAN region as an aggregate and the Republic of Korea. The close economic ties Australia has with New Zealand are captured through the inclusion of these two economies.

Box 2.1: **Regions explicitly modelled in the SALTER model**

Australia	
New-Zealand	
Japan	
European Community	(United Kingdom, France, Federal Republic of Germany, Italy, Belgium, Netherlands, Luxemburg, Denmark, Ireland, Greece, Spain, Portugal)
United States	
Canada	
ASEAN members	(Indonesia, Thailand, Singapore, Malaysia and the Philippines)
South Korea	

Source: SALTER database.

Countries not explicitly modelled are included in the Rest-of-the-World aggregate which is treated as a trading block. The Rest-of-the-World component of the model thus does not include explicit equations to describe producer and consumer behaviour. Rather this information is condensed into a set of trade elasticities which describe how trade in the Rest-of-the-World responds to movements in its trade prices relative to those of its partners.

In each country in the model 34 commodities and industries are distinguished (Box 2.2). This amount of detail was considered necessary if the model was to be capable of analysing issues of concern to Australia and its trading partners. The model thus explicitly recognises the production of key agricultural commodities of importance to the ASEAN region such as paddy rice and non-grain crops but still includes Australia's major resource based exports — wool, wheat and coal. Labour intensive manufacturing industries such as spinning dying and made up goods, wearing apparel, leather fur and their products, are separately identified as are the resource based activities of lumber and wood products and pulp paper and printing. The heavy manufacturing industries which have formed the basis of the rapid growth of several European economies, Japan and Korea are also recognised.

Box 2.2: **Industries and commodities in the SALTER model**

No.	*Description*	*No.*	*Description*
1	Paddy rice	18	Leather, fur and their products
2	Non-grain crops	19	Lumber and wood products
3	Wheat	20	Pulp, paper and printing
4	Grains, other than wheat and rice	21	Chemicals, rubber and plastic
5	Wool	22	Petroleum and coal products
6	Other livestock products	23	Non-metallic mineral products
7	Forestry	24	Primary iron and steel
8	Fishing	25	Other metals and products
9	Coal	26	Transport industries
10	Oil and gas	27	Other machinery and equipment
11	Other minerals	28	Other manufacturing
12	Meat products	29	Electricity, gas and water
13	Milk products	30	Construction
14	Other food products	31	Trade and transport
15	Beverages and tobacco	32	Other services (private)
16	Spinning, dyeing, made-up goods	33	Other services (government)
17	Wearing apparel	34	Other services (ownership of dwellings)

Source: SALTER database.

Overview of the model's economic structure

The SALTER model of the world economy can be thought of as a series of regional models linked together through trade. Each regional model can be further thought of as consisting of four blocks:

- a government block which keeps track of government revenues and expenditures;
- a macro-economic block which keeps track of national accounting aggregates;
- a production block describing how each industry produces its output and the costs of these outputs; and
- a final demand block which determines how consumers allocate their budget among alternative consumer goods, the government allocates its revenues among commodity purchases, investment expenditures are allocated to commodity purchases, and export demands are satisfied.

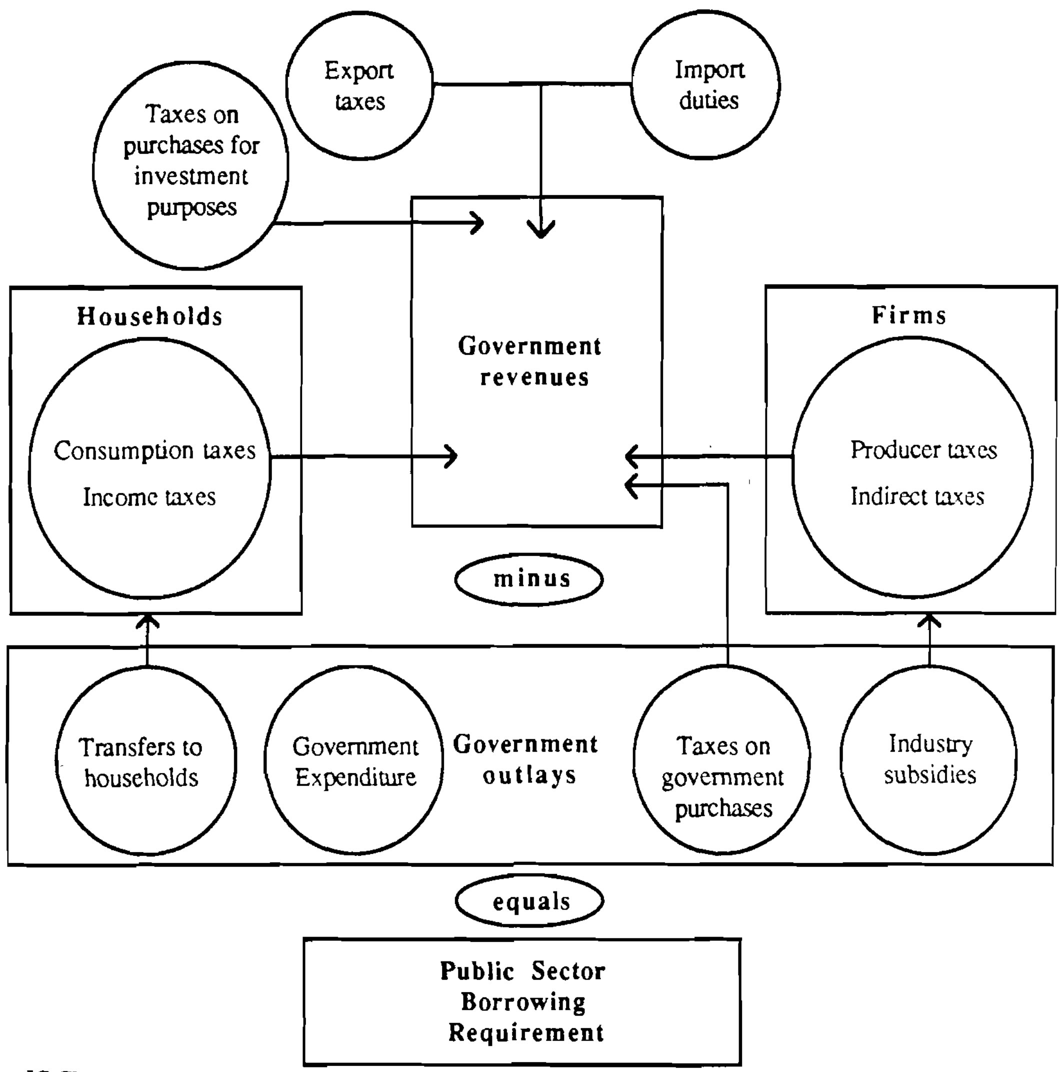
The interactions between various economic agents in the model give rise to commodity flows and income transfers that are a function of each modelled region's characteristics. These characteristics are based on different endowments in primary factors and different production technologies. In addition to these productive characteristics regions differ according to consumers' tastes and preferences as well as the structure of government and investment demands.

The government sector

A number of income transfers occur between the private and government sectors (Box 2.3). The government collects taxes from households in the form of income taxes and taxes on consumer purchases. In return, it redistributes income by distributing transfers to households. *Ad valorem* taxes are levied on all other purchases of commodities, that is, on purchases by producers and the government, and for investment purposes. In each region, governments also collect taxes on international trade, as duties may be imposed on imports, and taxes may affect exports. In addition to transfers to households, total government outlays include the provision of subsidies to selected industries and the purchase of commodities.

The difference between total outlays and the government's revenues obtained through taxes constitutes the public sector's borrowing requirement. This is the amount the government must borrow in order to cover the difference between its outlays and revenues.

Box 2.3: **Fiscal flows in the SALTER model**



Source: IC Chart.

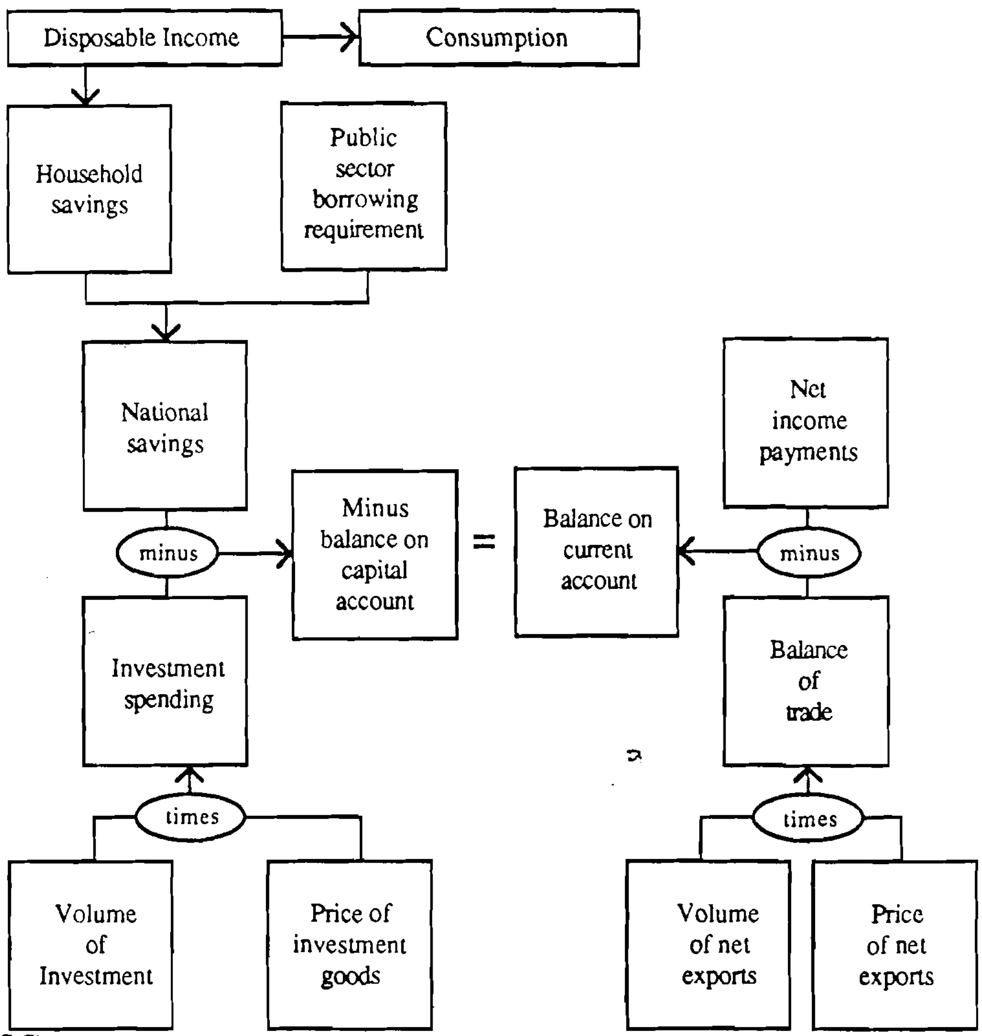
The external environment in the SALTER model

The external and internal macroeconomic constraints imposed on the model are depicted in Box 2.4. As currently specified the model takes no account of net income payments paid overseas. Thus in the model the balance on the current account consists solely of movements in the balance of trade which is influenced by movements in both the volume of net exports (exports less imports) and the price of net exports.

The balance on the capital account is equal to national saving minus gross investment. Investment spending is influenced mainly by movements in the price of investment goods as gross investment is held fixed in the current range of simulations. This is to ensure that gross investment maintains a fixed relation to the gross capital stocks of the economy which are also held fixed.

Movements in national savings consists of movements in household savings plus movements in the public sector borrowing requirement. In most medium-term simulations the public sector borrowing requirement is held fixed and household savings are assumed to be a fixed proportion of household disposable income. Under these assumptions movements in the balance on the capital account are largely driven by movements in disposable income and hence household saving.

Box 2.4: **National accounting identities embodied in the SALTER model**



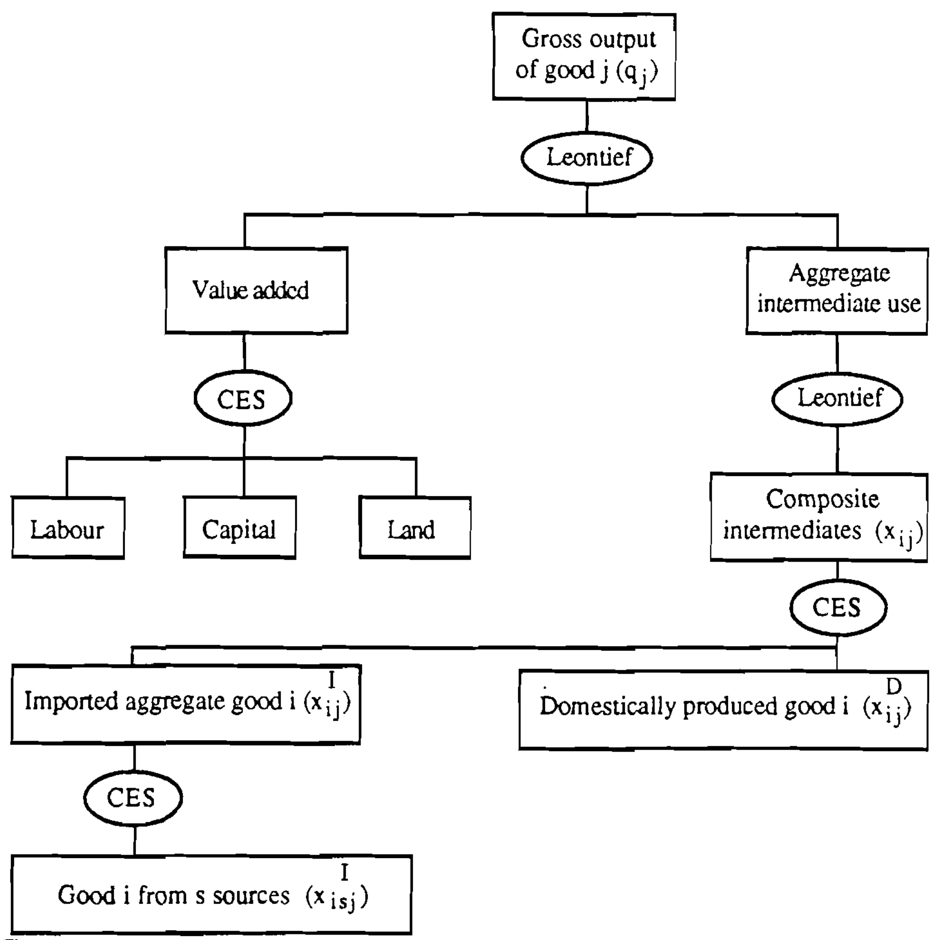
Source: IC Chart.

Production

Production activities in each region are structured around single-output industries. These industries are listed in Box 2.2. Six industries produce agricultural commodities, and there are five natural resource based industries. Food processing is disaggregated into 4 industries, while the textile sector is composed of three industries. The other industries compose the industrial manufacturing and services sectors.

The structure of input demand for each industry is described in Box 2.5. A representative firm in each region is assumed to combine a bundle of intermediate inputs with a fixed proportion of primary factors in order to produce one of the outputs listed in Box 2.2. Components of value added — labour, capital and land — are combined using a constant elasticity of substitution technology. The intermediate input aggregate is formed in fixed proportions of intermediate

Box 2.5: **Structure of production in a single-output industry of the SALTER model**



Source: IC Chart.

composite commodities. Demands for intermediate inputs are disaggregated into demand for domestic and imported commodities and demand for imports is itself disaggregated into demand for imports from different regions.

The choice between imports and domestically produced commodities and among imports is made assuming that producers minimise the cost of the bundle of intermediate commodities needed in production. The cost minimising opportunities are described by constant elasticity of substitution functions.

Technological change variables can be used to reflect productivity improvements in the use of intermediate inputs or primary factors due to technological or institutional change.

Final Demands

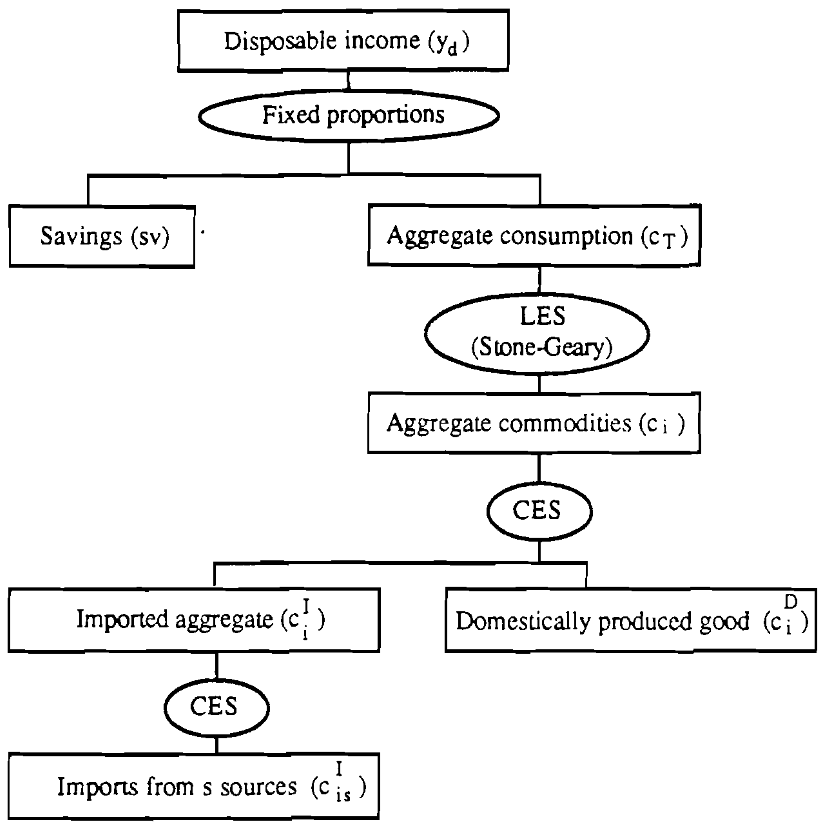
There are four components of final demand in each region modelled:

1. consumer demand;
2. government demand;
3. demand for investment ; and
4. export demand.

The structure of consumer demand is illustrated in Box 2.6. In each region, a single representative consumer is assumed to maximise utility from the consumption of goods and services and savings. In the short run, nominal disposable income is assumed to be devoted in fixed proportions to savings or consumption expenditures. Consumption expenditures in turn are composed of composite goods using the assumptions underlying a linear expenditure system (see Phlips, 1974, for an exposition of this expenditure system). The goods available for consumption are composites of domestic and imported commodities from various sources.

Consumer goods imported from different regions are assumed to be imperfect substitutes for the domestically produced good and imperfect substitutes for each other. This results in the double level of aggregation using constant elasticity of substitution functions similar to the choices available to producers. Thus, consumer demand for aggregate commodities is assumed to be a function of consumer prices, and aggregate consumption expenditure, and are ruled by the own-price and cross-price elasticities of the commodity and its elasticity to aggregate consumption expenditures.

Box 2.6: **Structure of consumer expenditure and savings in the SALTER model**



Source: IC Chart.

Demands for commodities by the government and for investment purposes follow the same basic structure as consumer and intermediate demands. However, commodity demands by the public sector are assumed to be a fixed proportion of real government spending on commodities. Investment demand for each composite commodity is a fixed proportion of aggregate real investment which is held fixed in most simulations.

For each modelled region, demands for exports are satisfied with domestically produced commodities. The demand for exports in one region is composed of the sum of import demands for commodities from this region by other modelled regions and the Rest-of-the-World. It is therefore sensitive to relative export prices which are related to the prices paid by different users in the other regions and the Rest-of-the-World.

Trade links between regional models

The eight regional sub-models are linked through commodity flows between each other and with the Rest-of-the-World of the world. These commodity flows are the imports and exports of commodities shown in Box 2.2. Following Armington (1969a, 1969b), domestic and imported commodities are assumed to be imperfect substitutes for each other. In furthering the practical applications of his model, Armington assumes the elasticity of substitution between domestic commodities and imports from different sources to be constant, constraining the elasticity of substitution between domestic and imported commodities. By contrast, a nested constant elasticity of substitution structure is assumed in the SALTER model, allowing the user to specify substitution parameters between imported and domestic commodities and among imports from different sources independently: each composite commodity is a constant elasticity of substitution function of domestic and imported commodities. Imports of each commodity are further disaggregated according to the source or region from which they are imported, and can be substituted at a constant rate. This latter nesting structure allows for different rates of substitution between imports and domestic commodities and among imports from different sources. This aggregation structure applies to both demands for intermediate inputs and final demands.

The international trade component of the model is completed by specifying a Rest-of-the-World aggregate which determines import demands, but has no consumption or production structure. Thus only the aggregate excess demands and excess supplies of the countries included in the Rest-of-the-World are represented in the SALTER model.

Economic environments

It is possible to specify three broad economic environments based on the ability of decision-makers to adapt their resources in response to the simulated policy changes. In a short-run environment, adaptations that could be made within a 1-2 year time frame are assumed to be possible. In a medium-run environment, adaptations over a 5 year period are assumed to be made by decision makers, while a long-run environment would produce results of simulated changes 10 years hence. The SALTER model is in this sense not a dynamic model in that it does not show how these changes occur. It is a comparative static model in which a new equilibrium resulting from adaptations to new conditions can be compared to the initial equilibrium.

Adaptations in the short run

In a typical short-run closure it is assumed that producers have insufficient time to adjust capital stocks in each industry. Thus movements in the profitability of employing capital are reflected in movements in its rental price rather than adjustments in industry aggregate capital demands.

In the short-run it is assumed that labour supply exceeds labour demand and that the resulting pool of unemployed workers can be hired at the going wage rate. Thus wages are indexed to the consumer price index and the rate of unemployment adjusts to equate labour demand to labour supply at the real wage rate determined in the model.

An important component of the short-run closure of the model is the specification of public sector borrowing requirements. The government is assumed to face two choices: it can either allow taxes to vary and maintain the public sector borrowing requirements fixed. Alternatively, it may hold income tax rates constant and allow the public sector borrowing requirement to vary.

Over the short-run, households are assumed to allocate disposable income in fixed proportions between consumption and savings. Since aggregate investment is set exogenously a change in the level of savings implies a change in the trade balance. Therefore, the trade balance is specified as endogenous.

Adaptations in the medium run

Over the medium-run, producers are assumed to be able to adjust their capital stock, but the national capital stock is assumed to be fixed. Consumers are assumed to vary the proportion of their income allocated to consumption and savings, and the ratio of the balance of trade to domestic product is held fixed. This reflects forward-looking behaviour by households who expect the present trade deficits to reduce future spending power. In the medium run, labour markets are assumed to clear. Money wages can vary independently of the consumer price index and labour demand equals labour supply.

The government's behaviour is also affected by the time horizon considered in the model. In the medium run, the government is assumed to increase its expenditures and transfers to households in line with increases in aggregate income.

Further, the government's borrowing requirement is assumed to be held fixed. This is done by assuming the government budget deficit is held constant. In order to maintain a constant budgetary balance, changes in expenditures are assumed to be counterbalanced by a change in the marginal income tax rate. Thus with increased expenditure, a corresponding increase in the marginal tax rate results in higher government revenues and a constant budgetary balance.

Adaptations in the long run

In the long run, a closure similar to the medium-run closure can be used to model consumers' behaviour, the decisions of government, and labour supply, but the supply of capital is now allowed to adjust to changing conditions. In addition to the ability of industries to change the size of their capital stock, it is now assumed that there is an international market for capital. This implies linking the availability of capital with the supply of savings, and allowing capital to be traded internationally. It is envisioned to expand the SALTER model to include international capital flows and an endogenous supply of capital. At this stage of the model's development, this facility is not available, and a full long-term closure cannot be implemented.

Solving the linear system of equations

The SALTER model is specified in terms of the percentage change in its variables. Although the underlying relationships are highly non-linear, it is assumed that percentage changes can be a good approximation of the true outcome of a policy change - provided the policy change is small. Where the policy change being simulated is large the Euler solution procedure can also be used. The procedure solves the model in a series of small steps and can reduce linearisation errors.

In general equilibrium models, the number of variables typically exceeds the number of equations specified. Variables include instruments through which shocks can be applied to the model, that is, exogenous variables, as well as variables whose behaviour is to be observed, the endogenous variables.

The SALTER model structure consists of 270 698 variables and 245 831 equations. In order to solve this linear system, the number of endogenous variables must equal the number of equations. The set of variables is therefore partitioned into an exogenous sub-set and an endogenous sub-set. This partitioning, known as the closure of the model, is linked to the economic environments the simulated policy changes are assumed to take place in.

The exogenous variables include policy instruments such as taxes and subsidies, or variables that are assumed to be predetermined. These variables are set to a chosen value by the user. A list of typical exogenous variables for the medium-run closure is provided in Table 2.1. Of the

270 698 variables in the model 24 867 variables are exogenous. This results in 245 831 endogenous variables, the same number as equations specified in Table A1. The system of equations can therefore theoretically be solved.

However, solving such a large linear system requires a substantial amount of computational resources. By condensing variables out, the linear system to be solved can be made smaller. Condensation involves replacing variables of relatively minor importance by their algebraic expression, thus reducing the number of endogenous variables to be solved for and the number of equations simultaneously (Codsi and Pearson, 1988). A list of the variables substituted by their algebraic expression is provided in Table 2.2. There is a total of 236 980 condensed variables which reduce the linear system of equations by the same number of variables and equations. After condensation, the system used for simulations is actually composed of 8 851 endogenous variables and equations.

As mentioned earlier the SALTER model is solved in percentage changes and this solution is an approximation to the true solution. The accuracy of the approximation depends on the degree of non-linearity of the model in the neighbourhood of the initial equilibrium and the size of the policy shock inflicted on the system. Keller (1980) indicates "that static general equilibrium systems are only moderately non-linear" when compared with dynamic systems. Linearisation errors limit the magnitude of changes that can be simulated, but Keller suggests that a 10 per cent change in taxes does not impair the accuracy of the linearised model.

When policy changes being simulated are large, the Euler solution procedure can be used to obtain an accurate solution of the model. The Euler procedure involves dividing a large policy change into a number of small changes in order to reduce the linearisation error. A first simulation is performed using a fraction of the large change. This results in a certain number of linear changes in the endogenous variables. These changes are applied to the original data to obtain a new, updated dataset upon which a second simulation is performed applying a small policy shock to obtain new linear responses with respect to the data resulting from the previous simulation. This process is repeated until the entire large change has been performed through the small changes.

Table 2.1 : **Typical list of exogenous variables for the SALTER model in the medium-run simulations**

Variable	Range	Number	Description
e^s	s=1...,S+1	S+1	Exchange rate.
p^z_{Ei}	i=1...,I z=S+1	I	Export price of commodity i (fob) from the Rest-of-the-World.
g^z	z=1...,S	S	Real government purchases of commodities.
em^z_1	z=1...,S	S	Employment rate.
f^z_{Sk}	k=2,3 z=1...,S	S	Aggregate supply of capital and land.
inv^z_R	z=1...,S	S	Real aggregate investment.
d^z_{is}	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Power of the duty applied to imported commodity i from source s in all uses.
t^{Dz}_{Ci}	i=1...,I z=1...,S	IS	Power of the *ad valorem* tax applied to the consumption of domestic commodity i.
t^{Iz}_{Ci}	i=1...,I z=1...,S	IS	Power of the *ad valorem* tax applied to the consumption of imported commodity i.
t^{Dz}_{ij}	i=1...,I j=1...,J z=1...,S	IJS	Power of the *ad valorem* tax applied to domestic commodity i purchased by industry j.
t^{Iz}_{ij}	i=1...,I j=1...,J z=1...,S	IJS	Power of the *ad valorem* tax applied to imported commodity i purchased by industry j.
t^{Dz}_{Gi}	i=1...,I z=1...,S	IS	Power of the *ad valorem* tax applied to domestic commodity i purchased by the government.
t^{Iz}_{Gi}	i=1...,I z=1...,S	IS	Power of the *ad valorem* tax applied to imported commodity i purchased by the government.
t^{Dz}_{Ki}	i=1...,I z=1...,S	IS	Power of the *ad valorem* investment tax applied to domestic commodity i.
t^{Iz}_{Ki}	i=1...,I z=1...,S	IS	Power of the *ad valorem* investment tax applied to imported commodity i.
s^z_{Qj}	j=1...,J z=1...,S	JS	Power of the non-commodity subsidy rate allocated to industry j.
t^z_{Ei}	i=1...,I z=1...,S	IS	Power of the *ad valorem* export tax applied to commodity i.

(Continued on next page)

Table 2.1 : **Typical list of exogenous variables for the SALTER model in the medium-run simulations** (continued)

Variable	Range	Number	Description
φ^{z}_{2j}	j=1...J z=1...,S	JS	Industry-specific differential returns to capital in industry j.
a^{z}_{j}	j=1...J z=1...,S	JS	Ouput-augmenting technical change in industry j.
a^{z}_{Xj}	j=1...J z=1...,S	JS	Aggregate intermediate input - augmenting technical change in industry j.
a^{z}_{kj}	j=1...J k=1...,K z=1...,S	JKS	Primary factor k - augmenting technical change in industry j.
h^{z}_{D}	z=1...,S	S	Demographic index.
r^{z}_{1}	z=1...,S	S	Ratio of government to household expenditure.
r^{z}_{2}	z=1...,S	S	Ratio of net factor income to government transfers
r^{z}_{4}	z=1...,S	S	Ratio of the trade balance to NDP.

Total exogenous variables: IS(S+1) + 2IJS + JKS + 11IS + I + 10S + 1

Table 2.2 : **List of variables condensed out of the equation system**

Variable	Range	Number	Description
c^{Dz}_{i}	i=1...,I z=1...,S	IS	Consumer demand for domestic commodities.
c^{Iz}_{i}	i=1...,I z=1...,S	IS	Consumer demand for aggregate imported commodity.
c^{Iz}_{is}	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Consumer demand for imported commodity i.
exp^{z}_{si}	i=1...,I s=1...,S+1 z=1...,S+1	$I(S+1)^2$	Export demand for commodity i by region s from region z.
gov^{Dz}_{i}	i=1...,I z=1...,S	IS	Government demand for domestic commodity i.
gov^{Iz}_{i}	i=1...,I z=1...,S	IS	Government demand for aggregate imported commodity i.

(Continued on next page)

Table 2.2 : **List of variables condensed out of the equation system** (continued)

Variable	**Range**	**Number**	**Description**
gov^{Iz}_{is}	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Government demand for imported commodity i.
inv^{Dz}_{i}	i=1...,I z=1...,S	IS	Investment use of domestic commodity i.
inv^{Iz}_{i}	i=1...,I z=1...,S	IS	Investment use of imported aggregate commodity i.
inv^{Iz}_{is}	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Investment use of imported commodity i.
x^{Dz}_{ij}	i=1...,I j=1...,J z=1...,S	IJS	Demand by industry j for domestic commodity i.
x^{Iz}_{ij}	i=1...,S j=1...,J z=1...,S	IJS	Demand by commodity j for imported aggregate commodity i.
x^{Iz}_{isj}	i=1...,I j=1...,J s=1...,S+1 z=1...,S	IJS(S+1)	Demand by industry j for imported aggregate commodity i from source s.
p^{z}_{Ci}	i=1...,I z=1...,S	IS	Consumer price of commodity i.
p^{Dz}_{Ci}	i=1...,I z=1...,S	IS	Consumer price of domestic commodity i.
p^{Iz}_{Ci}	i=1...,I z=1...,S	IS	Consumer price index of imported aggregate commodity i.
p^{Iz}_{Cis}	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Consumer price of imported commodity i from source s.
p^{Dz}_{Pij}	i=1...,I j=1...,J z=1...,S	IJS	Price of domestic commodity i paid by industry j.
p^{Iz}_{Pij}	i=1...,I j=1...,J z=1...,S	IJS	Price of imported aggregate commodity i paid by industry j.
p^{Iz}_{Pisj}	i=1...,I j=1...,J s=1...,S+1 z=1...,S	IJS(S+1)	Price of imported commodity i from source s paid by industry j.

(Continued on next page)

Table 2.2 : **List of variables condensed out of the equation system** (continued)

Variable	**Range**	**Number**	**Description**
p^{z}_{Pij}	i=1...,I j=1...,J z=1...,S	IJS	Producer price of commodity i.
p^{Dz}_{Gi}	i=1...,I z=1...,S	IS	Price of domestic commodity i purchased by the government.
p^{Iz}_{Gi}	i=1...,I z=1...,S	IS	Price of imported aggregate commodity i purchased by the government.
p^{Iz}_{Gis}	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Price of imported commodity i from source s purchased by the government.
p^{z}_{Gi}	i=1...,I z=1...,S	IS	Price of commodity i purchased by the government.
p^{Dz}_{Ki}	i=1...,I z=1...,S	IS	Price of domestic commodity i used in investment.
p^{Iz}_{Ki}	i=1...,I z=1...,S	IS	Price index of imported aggregate commodity i used in investment.
p^{Iz}_{Kis}	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Price of imported commodity i from source s used in investment.
p^{z}_{Ki}	i=1...,I z=1...,S	IS	Price of commodity i used in investment.
p^{Wz}_{is}	i=1...,I z=1...,S+1 s=1...,S+1	$I(S+1)^2$	Foreign currency landed duty-free price of imported commodities by source.
exp^{z}_{si}	i=1...,I s=1...,S+1 z=1...,S+1	$I(S+1)^2$	Export demand for commodities by destination.

Total condensed variables: $6IS(S+1) + 2IJS(S+1) + 2I(S+1)^2 + 5IJS + 15IS$

3 THE BENCHMARK DATA SET

The initial equilibrium data set for the SALTER model was built from basic input-output tables and fiscal information supplied by the different countries modelled or from secondary data sources. In addition to country-specific information international trade flow data are also necessary to specify the SALTER model.

Sources for each input-output data set are found in Table 3.1 along with the year to which they apply. Data sources are heterogeneous, based on varying commodity classifications, and apply to a variety of different years. However, the benchmark data set must present a picture of a homogeneous system being modelled at a point in time. The reference time period chosen for the SALTER model is 1988.

Table 3.1: **Origin of the input-output data used to build the equilibrium database**

	Year	*Source*	*Original commodity disaggregation*
Australia	1981	Industry Commission	109
New Zealand	1985	Government of New Zealand	34
ASEAN	1975	IDE (1982)	56
South Korea	1985	Government of Korea	403
Japan	1985	MITI (1989)	163
EC	1980	Commission of the European Communities	44
Canada	1987	Statistics Canada	593
US	1985	MITI (1989)	163

Because the available Input-Output tables are not available for a common year it was necessary to update them so that they reflect conditions in the model's base year, 1988. In addition, examination of the trade data implied by these tables indicated that the implied trade flows were inconsistent. For example one region's value of imports of a commodity at the importing region's border did not equal the partner regions' value of exports at those region's borders of that commodity plus freight and insurance. Also the input-output databases contain changes in stocks. These were assumed to represent temporary disequilibrium in supply and demand and it was therefore considered necessary to remove stock changes from the database.

The model's database was therefore constructed in several steps including:

1. development of concordances to map the industry structure in the various input-output tables to the industry structure of the SALTER model and the construction of the input-output database according to these concordances;

2. construction of a trade flow database in which trade in each commodity between partner countries is consistent;

3. removal of changes in stocks from the databases; and

4. updating the regional databases to 1988 and incorporating the trade flow database.

Development of input-output data for the SALTER level of aggregation

Raw input-output data are supplied in a variety of forms and commodity disaggregations. The first step in making the diverse databases compatible is to convert them to the 34-commodity classification used in the SALTER model. This involves aggregating some commodities and disaggregating others, based on external information. The concordances used to map the industry specification in the various input-output databases into the SALTER model's 34 sectors are available on request.

Development of the trade flow database

The trade database was constructed from data provided by Reuters. The data set is compiled by the Statistical Office of the United Nations and reflect the trade flows that occurred during 1988. These data had to be adjusted to fit the commodity classification used in the SALTER model. They also were made to balance so that the fob value of exports from all regions and the rest of the world to a given region add up to the cif value less freight costs of imports into that region.

Removing changes in stocks from the input output database

National accounting systems typically account for changes in stocks. As indicated above, this form of final demand is not required in the SALTER model. An update procedure (UPDATE1) was used to eliminate the changes in stocks in those databases containing them. The UPDATE1 procedure involves using a single-country version of the SALTER model which includes a set of variables and equations to describe changes in stocks, assuming fixed proportions in production and consumption activities. The equations and variables added for this purpose are found in Appendix B. For UPDATE1, the behavioural parameter settings and the closure are adjusted, so as effectively to reduce the model to a Leontief input-output model. The usual model structure is not appropriate, because it is designed to represent changes between equilibria, whereas the elimination of changes in stocks represents a change from disequilibrium to equilibrium. The Leontief structure used in this update holds prices and industry cost structures constant, and holds final demands fixed, both in aggregate and for individual commodities. The model is run with the following parameter settings:

1. factor substitution elasticities equal zero, enforcing Leontief relations between primary factors;
2. the price elasticities of consumer demand are made very small thus the consumption of each commodity is made a fixed proportion of aggregate consumption expenditure;
3. import demand elasticities by the rest of the world are set equal to zero, thus the pattern of imports by the rest of the world is held constant; and
4. import substitution elasticities equal zero, effectively eliminating the reactions of imports to price changes and maintaining fixed proportions between import sources.

To remove changes in stocks from the database, the medium-run closure (see Chapter 3) is modified as follows:

1. aggregate real changes in stocks are endogenous;
2. aggregate employment of primary factors are endogenous and returns to primary factors are exogenous;
3. the consumption to saving ratio is endogenous and aggregate real consumption exogenous;
4. real government transfers are endogenous and the ratio of transfer payment to real factor income exogenous;
5. the real government budget deficit is endogenous and the marginal tax rate exogenous.

The variables for changes in stocks are set exogenously to -100 per cent. Thus, at the end of the first update procedure a database is obtained for each modelled region that does not include changes in stocks and reflects the changes in production and consumption structure implied by allocating the changes in stocks to the various components of demand.

Incorporating the trade data

The trade component of most regional databases consists of import and export flows for each commodity, undifferentiated as to their origin. The trade pattern they reflect is that prevailing in their respective years. However, the trade pattern they should reflect is that of the trade database for the reference year of 1988.

The second update procedure (UPDATE2) is designed to modify the databases obtained earlier so they reflect the structure of trade in 1988. To facilitate this, variables are introduced into the model to define the ratio of imports and exports of each commodity to net domestic product (ndp) (see Appendix B). This constitutes a set of target ratios for 1988. The difference between the initial trade ratios and the target trade ratios for 1988 is the amount of the shocks that must be applied to the initial trade ratios.

Changes in trade ratios represent changes in prices or relative volumes, and may arise from changes in either domestic or foreign demand and supply. For UPDATE2, they are assumed to represent volume rather than price changes; this appears to agree broadly with actual medium-run trade changes for most broad commodity categories (with the notable exception of oil). The source of change in the trade ratios is assumed to be changed in foreign demand and supply. The closure is therefore modified, so that import prices and export demand shift terms are endogenous. The equation system is altered by adding equations defining the import and export to ndp ratios (see Appendix B); these variables are made exogenous.

Further changes are required to the medium-run closure, to generate a solvable equation system. Merely exogenising the trade ratios and endogenising import prices and export demand shift terms would lead to a singular system. In effect, we would be trying to hit 2T targets (where T denotes the number of tradeable goods) - the trade ratios - with 2T instruments - the import prices and export demand shift terms. Usually this is possible, but in this case it is not, because raising all the instrument variables by the same percentage would merely raise the domestic price level, without changing any real variables, in particular, without changing any of the trade ratios. So the 2T price instruments span at most (2T+1) dimensions of variation in the trade ratios. The complementary problem is that merely specifying the trade ratios leaves the general level of trade prices undetermined.

To fix the general price level, the ndp deflator is made exogenous. To allow all the trade ratio targets to be hit, the saving shift term is made endogenous. A change in the saving ratio represents a change in external balance, which is required if the trade ratio changes for individual commodities imply in aggregate a change in the trade balance. This gives a set of (2T+1) instruments - import prices, export demand shift terms, and the saving ratio - sufficient for hitting the (2T+1) targets - the trade ratios and the ndp deflator.

With the usual behavioural parameter settings, the required changes in trade volumes may be very great for some commodities, because some domestic demand elasticities are liable to be close to unity (so that the effects of price and volume changes on trade values almost offset each other). The usual settings are therefore unsuitable for UPDATE2. But the Leontief structure used for UPDATE1 is also unsuitable, because it involves fixed ratios between imported inputs and domestic activity levels, and so prevents the necessary changes in import usage.

For UPDATE2 therefore, the behavioural parameters are changed so as to greatly increase the substitution effects of price changes. In a model with no income effects, increasing all price elasticities of demand and supply by a common factor would have the effect of leaving quantity responses to any real shock unchanged, while diminishing all price responses by the same common factor. In the SALTER model, magnifying all substitution effects enables the required changes in trade values to be achieved by quantity responses, with only minute price changes. The new parameter settings are therefore:

1. factor substitution elasticities are made large so that the allocation of factors responds to the shocks applied instead of their prices;
2. the Frisch parameter is made to be small, making consumer demands very elastic;
3. import demand elasticities by the rest of the world are large, again making this demand for commodities elastic; and
4. import substitution elasticities are large, reflecting large own- and cross-price elasticities for all imports.

The model closure reflecting the medium-term conditions discussed in Chapter 2 is adapted by making:

1. the savings shift term endogenous and the ndp deflator exogenous; and
2. real government expenditure endogenous and the ratio of private to public expenditure constant.

Applying the shocks to the trade ratios in this environment produces a database for each region with a trade pattern which reflects 1988 trade flows and the production structure characterising the original database.

Updating ndp

In the following step (UPDATE3), the regional databases are updated to 1988 ndp levels and converted to US dollars. This is simply done by scaling all aggregates in a regional database by the difference between the ndp level of the database with the appropriate trade structure resulting from the UPDATE2 procedure and the target (1988) level of ndp. This results in aggregate commodity trade flows that match exactly the flows of the 1988 trade database and reflects production and consumption levels assumed to prevail in 1988. Thus the balanced trade database providing the corresponding information on all bilateral trade flows can be aggregated with the balanced regional databases, and all regional and trade databases are in balance. This yields a balanced equilibrium database composed of production and consumption activities in eight regions, and trade flows among these regions and with the rest of the world.

Having reviewed the process by which the database for the SALTER model was developed, it is more appropriate to consider some of the structure and characteristics of the economies modelled that are expected to play an important role in determining results in simulations.

Relative size and characteristics of modelled economies

The regional disaggregation in the SALTER model results in a group of large economies (Japan, the EC, and the US) making up for 90 per cent of the ndp explicitly accounted for in the SALTER model (Table 3.2). Among the smaller economies, New Zealand accounts for only 0.3 per cent of total ndp accounted for, and the other regions account for 1-4 per cent each.

Table 3.2: **Net domestic product of economies modelled: 1988**

Country	*ndp (million US$)*	*Per cent of ndp of modelled economies*
Australia[a]	224 881	1.9
New Zealand[a]	38 501	0.3
Canada[a]	429 047	3.6
US[a]	4 228 343	35.4
Japan[a]	2 442 349	20.4
Korea[a]	159 173	1.3
EC[a]	4 210 764	35.2
ASEAN[b]	216 930	1.8

Sources: [a]OECD (1990), [b]United Nations (1990).

The large economies are expected to determine much of the global results in the SALTER model, and smaller economies such as the ASEAN region are expected to be affected by policy changes made in the larger countries. But policy changes in smaller countries are not expected to significantly affect large countries. Net production in the modelled regions accounts for about three fourths of net world production. The importance of the rest of the world production is therefore limited, and the effect of a policy change in any one country within the rest of the world is not expected to significantly effect the economies represented in the SALTER model.

The factoral distribution of income in each region is found in Table 3.3. The share of labour is around 70-80 per cent in most countries except in the EC and the ASEAN countries. In these 2 regions, the income allocated to land is highest (6 and 11 per cent), reflecting the relatively large size of the agricultural sector in these economies and in the case of the EC, the high support provided the agricultural sector.

Table 3.3: **Share of primary factors in domestic factor income: 1988** (per cent)

Country	*Labour*	*Capital*	*Land*	*Total*
Australia	79	19	2	100
New Zealand	73	23	4	100
Canada	75	24	1	100
US	79	20	1	100
Japan	72	27	1	100
Korea	80	19	1	100
EC	62	32	6	100
ASEAN	50	39	11	100

Source: SALTER database.

Production and trade structure

The structure of trade and production is reviewed in the remainder of this chapter. The analysis will refer to the industry groupings described in Box 3.1.

Structure of production

The structure of production by broad industry group in each of the modelled economies is found in Table 3.4. Relative to other productive activities, agriculture is largest in the ASEAN region where it constitutes 20 per cent of aggregate production. In New Zealand and the EC, this sector accounts for 9 per cent of production, while it accounts for a maximum of 6 per cent of production in the other regions of the SALTER model. Resources (that is, forestry, fishing and mining) account for about 12 per cent of production in ASEAN, making this region very reliant on primary products.

Manufacturing accounts for a large portion of production in the EC (42 per cent), 25-30 per cent in most other countries, but only 22 per cent of gross production in the ASEAN countries. The services industries represent typically more than 50 per cent of gross output, except in the EC and ASEAN countries where they account for about 40 per cent of output.

Box 3.1: **Industry groupings**

Agriculture	**Manufacturing, non-metallic**
1 Paddy rice	16 Spinning, weaving, dyeing, made-up goods
2 Non-grain crops	17 Wearing apparel
3 Wheat	18 Leather, fur and their products
4 Grains, other than wheat and rice	19 Lumber and wood products
5 Wool	20 Pulp, paper and printing
6 Other livestock products	21 Chemicals, rubber and plastic
Resources	22 Petroleum and coal products
7 Forestry	23 Non-metallic mineral products
8 Fishing	**Manufacturing, metallic**
9 Coal	24 Primary iron and steel
10 Oil and Gas	25 Other metals and products
11 Other minerals	26 Transport industries
Food	27 Other machinery and equipment
12 Meat products	28 Other manufacturing
13 Milk products	**Services**
14 Other food products	29 Electricity, gas and water
15 Beverages and tobacco	30 Construction
	31 Trade and transport
	32 Other services (private)
	33 Other services (government)
	34 Other services (ownership of dwellings)

Source: SALTER database.

Table 3.4: **Share of sectors in gross aggregate production[a]: 1988 (per cent)**

	Australia	*New Zealand*	*Canada*	*US*	*Japan*	*Korea*	*EC*	*ASEAN*
Agriculture	6	9	3	4	3	3	9	20
Resources	7	4	4	4	6	5	7	12
Food	3	6	3	4	4	3	4	7
Non-metal manufactures	13	15	14	15	13	12	22	12
Metal manufactures	15	14	17	14	13	14	20	10
Services	56	52	58	59	60	63	39	38
Total	100	100	100	100	100	100	100	100

[a] Calculated as the share of each sector's costs in the total costs of gross production.

Source: SALTER database.

Production costs

The structure of production costs in each modelled region is found in Table 3.5. Overall, labour accounts for the largest portion of costs in Korea where returns to this factor account for 36 per cent of aggregate production costs. Labour costs are relatively low in the EC and ASEAN countries, as they account for less than 20 per cent of production costs.

Table 3.5: **Share of costs in gross aggregate production: 1988** (per cent)

Commodity aggregates and country	*Intermediate inputs* *Domestic*	*Imports*	*Labour*	*Capital*	*Land*	*Total*
Australia	42	7	33	17	1	100
New Zealand	48	9	25	17	1	100
Canada	44	5	29	20	2	100
US	43	6	33	18	..	100
Japan	46	7	26	21	..	100
Korea	41	3	36	19	..	100
EC	48	14	18	19	2	100
ASEAN	35	10	19	32	4	100

.. Less than 0.5 per cent.
ROW: Rest-of-the-World.

Source: SALTER database.

Returns to land are relatively small, accounting for less than 1 per cent of costs in most countries, but 2 and 4 per cent in the EC and ASEAN regions respectively. This reflects the importance of agriculture in the larger ASEAN countries and the rents accruing to this factor in Europe through the Common Agricultural Policy. In other sectors, returns to land are aggregated with those of capital; this results in the relatively high returns to capital in the Resources Sector.

The overall share of intermediate inputs in costs accounts for nearly 50 per cent or more of costs in all economies and is highest in the EC (62 per cent). Imports usually play a relatively minor role in production, accounting for less than 15 per cent of intermediate use in all regions but the EC and ASEAN, where they account for 22 per cent of total intermediate use.

Global trade structure

The main international commodity flows are outlined in Table 3.6. This table contains the shares of aggregate imports by origin and exports by destination for each modelled region. Australia's main suppliers are the US, Japan, the EC and the rest of the world, each accounting for about 20 per cent of aggregate imports. The data show the importance of Australia in New Zealand imports (34 per cent), the importance Japan plays in supplying the Korean economy (30 per cent of Korea's imports), and the close economic ties between Canada and the US. The strong links of the EC with economies not explicitly modelled here, such as the preferential agreements with the European Free Trade Area (EFTA) and African nations are evidenced by the large share of the rest of the world as a source of imports. Finally the import structure of ASEAN countries shows the strong economic links between the US and the Philippines, and the influence of Japan, Korea and Australia in this region's trade.

On the export side, the main trade links observed in the import structure are largely reinforced as the main import sources for the regions described above also provide the markets for the exporting regions.

Table 3.6: **Major trade flows in the SALTER model: 1988**

a) imports by sources in aggregate imports (per cent of aggregate regional imports)

	Exports from									
Importer	*Australia*	*New Zealand*	*Canada*	*US*	*Japan*	*Korea*	*EC*	*ASEAN*	*ROW*	*Total*
Australia	-	3	3	19	21	3	23	6	22	100
New Zealand	34	-	2	14	13	2	16	4	16	100
Canada	1	..	-	66	6	2	11	1	12	100
US	1	..	19	-	19	4	15	6	34	100
Japan	9	1	4	20	-	5	12	14	35	100
Korea	6	..	2	20	30	-	10	7	25	100
EC	2	..	2	10	9	1	-	4	73	100
ASEAN	5	1	1	19	26	3	17	-	28	100
ROW	2	..	2	16	11	2	63	3	-	100

b) exports by destination in aggregate exports (per cent of aggregate regional exports)

	Exports to									
Exporter	*Australia*	*New Zealand*	*Canada*	*US*	*Japan*	*Korea*	*EC*	*ASEAN*	*ROW*	*Total*
Australia	-	4	2	9	25	5	13	9	34	100
New Zealand	20	-	2	11	14	2	15	6	30	100
Canada	1	..	-	72	5	1	7	1	12	100
US.	3	...	21	-	11	3	16	6	39	100
Japan	5	..	2	32	-	5	15	10	32	100
Korea	3	..	3	34	16	-	12	7	24	100
EC	2	..	2	12	3	1	-	3	77	100
ASEAN	4	..	1	26	23	4	16	-	26	100
ROW	2	..	2	24	10	2	54	5	-	100

.. Less than 0.5 per cent.

Source: SALTER database.

The export structure by broad commodity groups of each region is summarised in Table 3.7. Agriculture constitutes a significant part of export earnings for Australia and New Zealand (18 per cent and 21 per cent of each country's exports), and resources are most important for Australia (26 per cent of exports), Canada (13 per cent) and ASEAN countries (15 per cent). Processed food products represent over one third of New Zealand's export earnings, and account for less than 15 per cent of earnings in other regions.

For most regions in the model, manufactures represent 80-90 per cent of export earnings; this is the case for Canada, the US, Korea and the EC, while in Japan, practically all exports are manufactured products, with most of the exports coming from the industries in the Manufacturing, metallic group.

Table 3.7: **Share of each industry group in aggregate exports: 1988** (per cent)

	Agriculture	*Resources*	*Processed Foods*	*Manufacturing nonmetallic*	*Manufacturing metallic*	*Total*
Australia	18	26	13	9	33	100
New Zealand	21	6	37	20	16	100
Canada	5	13	4	27	52	100
US	6	3	7	20	63	100
Japan	..	..	..	10	89	100
Korea	1	2	2	42	53	100
EC	2	3	6	27	62	100
ASEAN	9	15	11	27	38	100

.. Less than 0.5 per cent.

Source: SALTER database.

This structure of exports does not account for the relative size of exports by each region, but confirms some of the conclusions reached in analysing the production costs above: primary products are major export earners for Australia and New Zealand. As a low cost producer of processed food in the South Pacific region, New Zealand earns a substantial amount of its earnings from this type of export. Although the US is a major exporter of agricultural products (its exports of these commodities are nearly equal to the sum of EC and Australian exports), these products are dwarfed by the importance of manufactured commodity exports. A similar situation characterises the EC, while Japan and Korea are even more heavily specialised in manufactured products, indicating a significant advantage in these countries' costs in producing these commodities.

The prominence of large countries in exports by broad commodity groups is shown in Table 3.8. The modelled regions account for 66 per cent of world agricultural exports, 40 per

Table 3.8: **Share of each country in exports by commodity: 1988** (per cent)

	Agriculture	*Resources*	*Processed Foods*	*Manufacturing nonmetallic*	*Manufacturing metallic*
Australia	19	21	9	2	2
New Zealand	3	1	4	1	..
Canada	10	19	4	9	6
US	35	14	26	19	21
Japan	..	1	1	8	25
Korea	1	1	1	6	3
EC	17	21	41	48	38
ASEAN	15	20	13	8	4
Total	100	100	100	100	100

.. Less than 0.5 per cent.

Source: SALTER database.

cent of resource exports, 72 per cent of exports of processed foods and around 75 per cent of exports of manufactured goods. Among the trade flows between modelled regions, the US accounts for 35 per cent of agricultural exports and 14 per cent of exports in resource products, while Australia and the EC each account for around 20 per cent of these exports. The structure of world exports confirms the small role played in these markets by Korea and Japan, but ASEAN countries and Canada make a significant contribution to the trade in primary products. The large exporters of food products are the US and the EC, and these regions are also major players in the manufactured goods markets. In summary, the structure of exports is in large part related to the production capacity of the regions modelled.

Trade margins and the trade database

The trade data used to model the international trade flows in the SALTER model stem from the Statistical Office of the United Nations. These data are compiled from reports of imports and exports provided by each government and are notoriously inconsistent, but Tsigas *et al* (1990) have devised a method by which the database can be made to balance. The method of these authors relies heavily on the fact that each trade flow is reported twice and by different reporters. It entails estimating systematic biases in the reported imports and exports.

The first step involves identifying a pair of unbiased reporting countries. The US are found to be a good reporter of exports, while Japan is found to be reporting imports most accurately (Table 3.9). The reporting biases of other regions are estimated relative to these two countries' assumed correct reports. Values in excess of 1.0 reflect a region's tendency to underreport a particular trade flow, and is the factor by which its reported trade flows must be adjusted for them to match a balanced trade database. The converse interpretation applies for values less than

Table 3.9: Estimated trade reporting biases for eight regions

	Bias estimates	
Country	*Export bias*	*Import bias*
Korea	0.82946	1.06444
ASEAN	1.18071	1.39461
EC	1.01623	0.93874
Australia	1.06618	1.05109
New Zealand	1.07635	1.00420
Japan	1.00241	1
US	1	1.03823
Canada	0.92944	1.03083

Source: Adapted from Tsigas *et al* (1990)

1.0. These consistent bias estimates are used to adjust the trade flows reported in the original trade database.

Trade margins are defined as the ratio of cif import values to fob export values for broad commodity groups and trade routes. Estimates for these trade margins are found in Table 3.10. Bulky products of relatively low specific value have high margins associated with them. It is hypothesized that high margins for high valued items (such as the High technology category) result from high insurance costs.

Table 3.10: **Estimated trade margins (imports cif/exports fob)**

a) Means by commodity

Commodity	*Geometric mean*	*Commodity*	*Geometric mean*
Rice	1.06372	Other agricultural products	1.19449
Other tropical crops	1.09448	Forestry	1.38798
Wheat	1.17492	Mining	1.30026
Other grains	1.17492	Basic intermediate goods	1.14689
Dairy products	1.22683	Intermediate manufacturing	1.16892
Meats and live animals	1.20681	Light industry	1.06551
Nonedible crops and livestock	1.09128	Finished capital goods	1.05059
Alcohol, beverages and tobacco	1.09448	High technology commodities	1.24711
Fish	1.18174		

b) Means by route

	Korea	*ASEAN*	*EC*	*Australia*	*New Zealand*	*Japan*	*US*	*Canada*
Korea	-	1.130	1.177	1.212	1.212	1.292	1.326	1.155
ASEAN		-	1.308	1.022	1.022	1.197	1.239	1.388
EC			-	1.151	1.217	1.210	1.048	1.097
Australia				-	1.051	1.118	1.317	1.191
New Zealand					-	1.097	1.214	1.191
Japan				Symmetric		-	1.109	1.201
US							-	1.131
Canada								-

Source: Adapted from Tsigas *et al* (1990).

These commodity and route specific trade margins are used to generate a set of cif/fob margins for the SALTER commodity classification transported between the regions defined in the model. First, the trade margins in Table 3.10 are used to generate a set of trading route by commodity specific cif/fob ratios. The original 17 commodity and 28 trade-route margins are made to match the 34 commodity specification of the trade database used in the SALTER model (trade routes with the rest of the world are assumed to be the same as those representative of ASEAN). This yields a set of 34 by 28 or 952 cif/fob margins each of which describes the cost of transporting (freight and insurance) a commodity from one region to another. Thus a complete set of trade margins for the SALTER model is obtained. These ratios are then applied to the exports of the trade database to obtain a first estimate of the cif value of imports. The RAS method is then applied to obtain a balanced trade data set where reporting biases have been adjusted for and imports and exports are balanced. A more detailed description of the procedure followed is available in Appendix B.

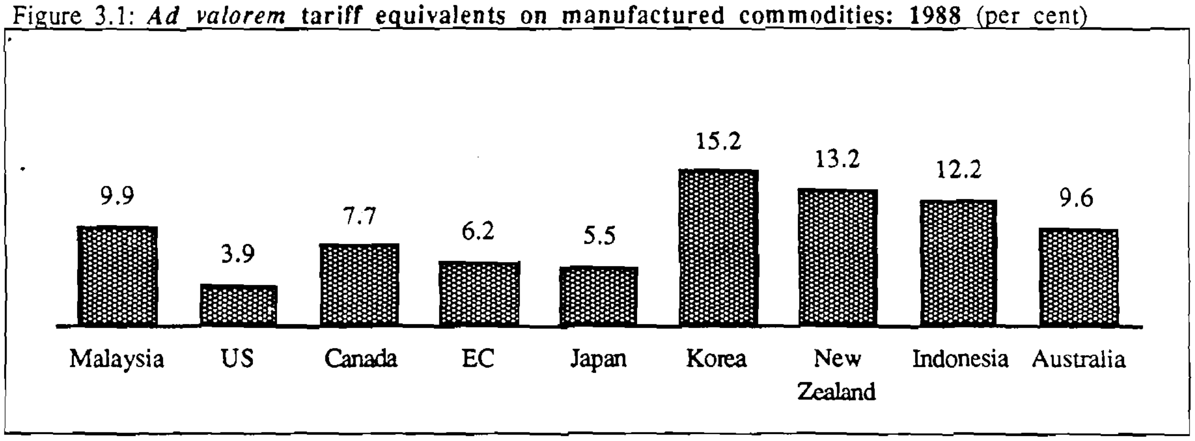
Protection database

Basic national accounts only provide the user with tax aggregates and government revenues. This is hardly useful to model the specific policies that protect and subsidise, or handicap a particular sector in a region. A database of industry protection was compiled for the SALTER model; it is composed of tariff and non-tariff assistance expressed in *ad valorem* equivalents.

Tariff assistance

Tariff assistance has fallen from around 40 per cent in the 1940s to much lower levels today (Figure 3.1). Tariff assistance provided manufactures is lowest in Europe and North America and is highest in Australia, New Zealand and Asian economies, other than Japan.

Figure 3.1: ***Ad valorem* tariff equivalents on manufactured commodities: 1988** (per cent)



Source: SALTER database

While tariffs provided manufactures are relatively low, each country has pockets of industry with relatively high tariffs. These are generally the Beverages, Tobacco, Textiles, Wearing apparel, Leather products and footwear sectors. In most countries assistance provided these sectors is two to three times the manufacturing industry average (Table 3.11). Several Asian economies also provide relatively high levels of assistance to the non-metallic minerals industries.

Table 3.11: **Weighted tariff protection for selected countries: 1988** (per cent)

	US[a]	Canada[b]	EC[a]	Japan[a]	Korea[a]	New Zealand[b]	Malaysia[b,c]	Indonesia[a,c]
Food, beverages & tobacco	3.5	7.6	14.5	16.2	17.0	19.4	11.1	9.6
Textiles & leather	14.9	20.4	10.7	11.3	13.1	15.0	24.7	30.3
Wood, cork, & products	2.7	7.0	3.4	3.5	14.4	17.2	25.7	41.3
Paper & printing	0.6	5.2	5.1	0.8	4.7	11.9	6.1	6.8
Chemicals, petrol, coal	3.4	8.2	5.0	4.0	11.6	7.9	10.3	6.5
Non-metallic minerals	7.3	8.2	6.5	3.0	15.2	15.1	24.7	12.3
Basic metal industries	2.5	4.4	2.3	5.2	7.7	8.7	5.7	6.8
Metal products, machinery	3.4	7.1	6.0	1.3	12.9	14.5	9.1	14.7
Other manufacturing	4.0	6.9	2.4	1.5	12.3	20.3	10.5	35.0
Overall average	4.5	7.8	6.2	5.5	11.9	13.2	9.9	12.2

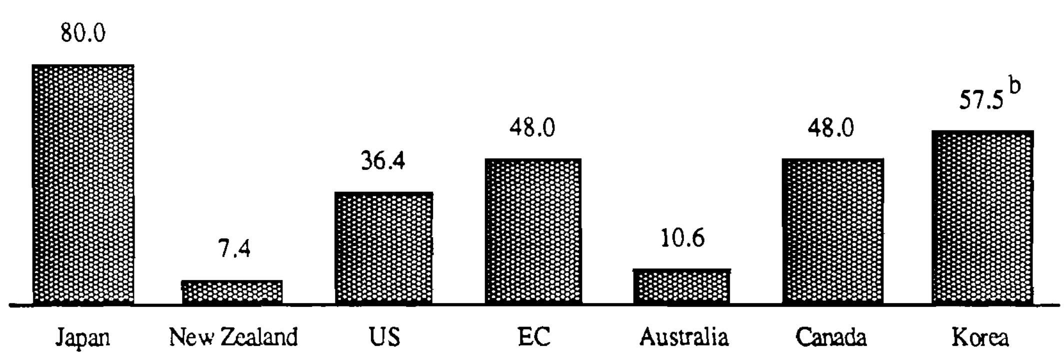
[a] Data relate to 1989. [b] Data relate to 1988. [c] Included as members of ASEAN.

Source: SALTER database.

Agricultural assistance

Agricultural producers in Europe, North America and several Asian economies are very heavily assisted. As shown in Figure 3.2, farmers in OECD countries (excluding Australia and New Zealand) derive nearly half of their income or more through assistance of one form or another. Similarly Korean farmers are heavily reliant on assistance as a source of farm income.

Figure 3.2: **Proportion of agricultural receipts derived from assistance[a] in selected OECD countries and Korea: 1988** (per cent)



[a] Calculated as the weighted average Producer Subsidy Equivalent for rice, wheat, coarse grains, sugar, beef, wool, milk, pork, poultry and eggs, [b] data relate to 1986.

Source: OECD (1990), USDA (1988).

Producer Subsidy Equivalents calculated by the OECD and the USDA were used to derive estimates of the policy instruments for use in the SALTER model. Four measures were calculated:

- the implicit tax applying to imported commodities;
- the implicit export tax applying to exported commodities;
- the rate of subsidy applying to the production of commodities; and
- the per unit consumer subsidy.

The implicit tax on imports and the equivalent export subsidy were derived by calculating per unit support derived from market price support and expressing this as a percentage of the world price for each commodity. The world price for each commodity was calculated by deducting from the per unit producer prices per unit assistance derived through market price support mechanisms.

Assistance other than market price support was treated as production subsidies. These include direct payments to farmers, and assistance which affects the cost of inputs. For each commodity the monetary value of this assistance was added together and then divided by the quantity provided of the commodity to derive the per unit production subsidy. The per unit subsidy was converted to its *ad valorem* equivalent by dividing it by the world price for each commodity.

The estimates of policy instruments derived from this process are detailed in Table 3.12. The most striking feature of this table is the very high levels of import tax on Japanese agricultural imports. Import taxes in the European Communities are also substantial but well below those appearing in Japan and Korea.

Non-tariff barriers

While the decline in tariff assistance is a major success of the GATT the proliferation of non-tariff barriers constitute its major failure. Non-tariff barriers had their origins in the 1955 'waiver' provided the United States which allowed it to use quantitative controls to facilitate domestic pricing policies. The discriminatory restraints imposed on Japanese textile exports under the Short-Term Arrangement on Cotton Textiles 1961 were also a significant weakening of the GATT discipline. Thus these decisions provided the means to implement discriminatory trade policies within GATT rules (Stoeckel *et al*, 1990).

Table 3.12: **Estimates of policy instruments provided the agricultural sector and related sectors: 1988** (per cent)

Sector	Australia Export tax	Australia Import tax	Australia Production subsidy	Australia Subsidy on food consumption	Canada Export tax	Canada Import tax	Canada Production subsidy	Canada Subsidy on food consumption
Paddy rice	7.76	7.76	20.37	0.00	0.00	0.00	0.00	0.00
Non-grain	0.71	0.71	0.61	0.00	1.37	1.37	3.13	0.00
Wheat	0.00	0.00	10.82	0.00	19.65	19.65	52.36	0.00
Other grain crops	0.00	0.00	8.19	0.00	14.43	14.43	17.64	0.00
Wool	0.00	0.00	3.95	0.00	0.00	0.00	0.00	0.00
Livestock & prods	0.46	0.46	7.66	0.00	2.07	2.07	31.72	0.00
Dairy products	39.41	39.41	0.00	0.00	127.86	127.86	0.00	0.00
Meat products	0.00	0.00	0.00	0.00	25.22	25.22	0.00	0.00
Other food	0.35	0.35	0.24	0.00	0.01	0.01	0.02	0.00

Sector	EC Export tax	EC Import tax	EC Production subsidy	EC Subsidy on food consumption	Japan Export tax	Japan Import tax	Japan Production subsidy	Japan Subsidy on food consumption
Paddy rice	83.17	83.17	11.77	3.73	388.12	388.12	86.64	3.51
Non-grain	3.18	3.18	1.43	0.00	1.13	1.13	0.93	0.00
Wheat	33.19	33.19	7.07	1.07	494.98	494.98	133.40	0.00
Other grain crops	45.93	45.93	3.41	4.55	624.78	624.78	185.12	0.00
Wool	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Livestock & prods	2.15	2.15	14.52	0.00	5.49	5.49	12.88	0.00
Dairy products	130.49	130.49	0.00	17.91	395.09	395.09	0.00	3.73
Meat products	56.16	56.16	0.00	0.00	99.81	99.81	0.00	0.00
Other food	1.33	1.33	-0.10	0.07	0.25	0.25	0.05	-0.23

Sector	New Zealand Export tax	New Zealand Import tax	New Zealand Production subsidy	New Zealand Subsidy on food consumption	Rep. of Korea Export tax	Rep. of Korea Import tax	Rep. of Korea Production subsidy	Rep. of Korea Subsidy on food consumption
Paddy rice	0.00	0.00	0.00	0.00	241.51	241.51	20.19	0.00
Non-grain	0.00	0.00	0.00	0.00	2.74	2.74	0.13	0.00
Wheat	0.00	0.00	15.44	0.00	146.50	146.50	3.33	0.00
Other grain crops	0.00	0.00	2.98	0.00	242.98	242.98	11.97	0.00
Wool	0.00	0.00	5.49	0.00	0.00	0.00	0.00	0.00
Livestock & prods	2.44	2.44	5.47	0.00	-0.09	-0.09	5.37	0.00
Dairy products	0.00	0.00	0.00	0.00	64.87	64.87	0.00	0.00
Meat products	1.12	1.12	0.00	0.00	6.60	6.60	0.00	0.00
Other food	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sector	US Export tax	US Import tax	US Production subsidy	US Subsidy on food consumption	ASEAN Export tax	ASEAN Import tax	ASEAN Production subsidy	ASEAN Subsidy on food consumption
Paddy rice	0.00	0.00	97.22	3.78	n.a.	n.a.	n.a.	n.a.
Non-grain	0.00	0.00	3.64	0.00	n.a.	n.a.	n.a.	n.a.
Wheat	8.97	8.97	43.43	1.46	n.a.	n.a.	n.a.	n.a.
Other grain crops	0.00	0.00	52.76	0.05	n.a.	n.a.	n.a.	n.a.
Wool	4.08	4.08	36.72	0.00	n.a.	n.a.	n.a.	n.a.
Livestock & prods	0.43	0.43	10.99	0.07	n.a.	n.a.	n.a.	n.a.
Dairy products	86.68	86.68	0.00	9.88	n.a.	n.a.	n.a.	n.a.
Meat products	24.22	24.22	0.00	0.68	n.a.	n.a.	n.a.	n.a.
Other food	0.56	0.56	0.09	0.00	n.a.	n.a.	n.a.	n.a.

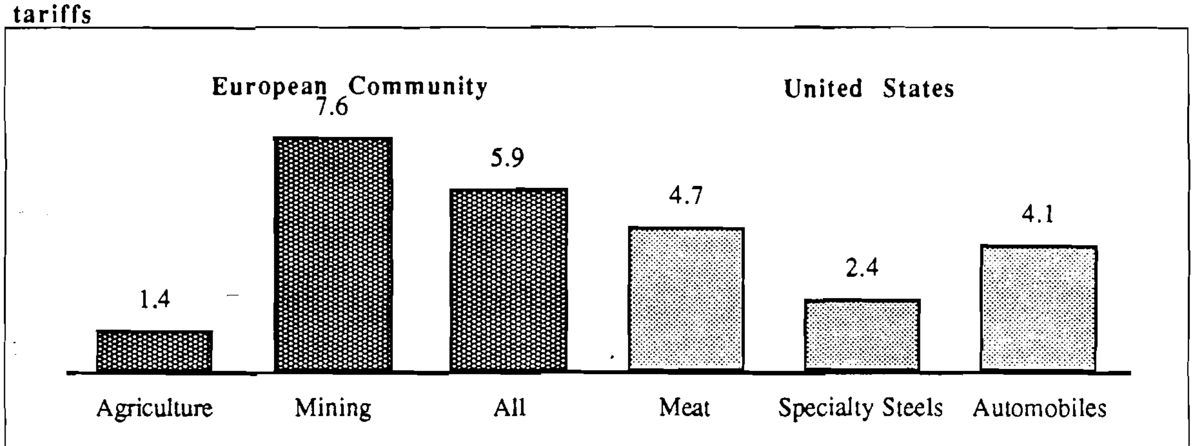
na: Not calculated.

Source: OECD (1990a), USDA (1988), SALTER database.

With the opportunities provided by the 1955 and 1961 exemptions non-tariff barriers proliferated. A recent study (Laird and Yeates, 1988), for example, found that the share of the major developed countries trade affected by non-tariff measure almost doubled from the levels prevailing twenty years earlier.

While it is clear that non-tariff barriers have become the preferred protective device, quantifying their impact is very difficult. This is their main appeal! Nevertheless, the few studies that are available suggest that non-tariff barriers provide well in excess of double the protection provided by tariffs (Figure 3.3).

Figure 3.3: **Ratio of the tariff equivalent of all border assistance to that provided through tariffs**



[a] Calculated as the ratio of the tariff equivalent for all border assistance to the tariff.

Source: Derived from Stoeckel *et al* (1990).

At this stage in the development of the SALTER model, assistance provided through quantitative controls has only been incorporated into the database for the agricultural sector.

4 PARAMETER SETTINGS IN THE SALTER MODEL

In addition to input-output and national accounts data, the SALTER model requires the specification of a number of behavioural parameters. These parameters describe cost minimising opportunities available to producers, utility maximising opportunities available to consumers in each modelled region and import demand behaviour by the rest of the world. The parameters necessary for the numerical specification of the SALTER model are listed and described in Table 4.1. A total number of $I^2 + 10I + 1$ (where I is the number of commodities in the model) or 1496 parameters are required to specify economic behaviour in each modelled country. An additional 2I or 68 parameters are required to describe imports by the rest of the world. Other parameters such as the marginal tax rate and the rate of capital depreciation must also be specified. This chapter provides the rationale behind the choice of parameters in the SALTER model.

As seen in Chapter 2, the length of the planning period may affect the choices available to producers and consumers. To allow for this, the SALTER model can be used in either a short-run (1–2 years) or a medium-term (3–5 years) mode, and behavioural parameters for alternate planning horizons are supplied. Little information is available on the relation between medium- and short-run parameters, and estimates presented here are by necessity largely the result of synthetic procedures and value judgements.

Since a whole system is being modelled, it would be desirable to estimate a consistent set of parameters. However, this is impractical due to the large number of parameters to estimate and the lack of reliable data (Mansur and Whalley, 1984). Modellers have in general relied on previous research to obtain parameter values that are then calibrated to fit the initial equilibrium data set. In the remainder of this chapter, relevant econometric evidence and practices followed by general equilibrium modellers are reviewed before sets of parameter values to be used in the numerical specification of the SALTER model are chosen. This review is based in part on a recent survey of parameter specification in a number of general equilibrium models (Adams *et al*, 1990).

Table 4.1 : **Behavioural parameters in the SALTER model**

Parameter	Description	Range	Number
σ_j^z	Elasticity of substitution between primary factors in industry j.	j=1...,J z=1...,S	JS
η_i^z	Elasticity of substitution in production between domestic commodity i and imported aggregate commodity i.	i=1...,I z=1...,S	IS
β_i^z	Elasticity of substitution in private consumption between domestic commodity i and imported aggregate commodity i.	i=1...,I z=1...,S	IS
β_{Gi}^z	Elasticity of substitution in government consumption between domestic commodity i and imported aggregate commodity i.	i=1...,I z=1...,S	IS
β_{Ki}^z	Elasticity of substitution in investment demand between domestic commodity i and imported aggregate commodity i.	i=1...,I z=1...,S	IS
η_i^{Iz}	Elasticity of substitution in production between commodities imported from different sources.	i=1...,I z=1...,S	IS
β_i^{Iz}	Elasticity of substitution in private consumption between commodities imported from different sources.	i=1...,I z=1...,S	IS
β_{Gi}^{Iz}	Elasticity of substitution in government consumption between commodities imported from different sources.	i=1...,I z=1...,S	IS
β_{Ki}^{Iz}	Elasticity of substitution in investment demand between commodities imported from different sources.	i=1...,I z=1...,S	IS
β_i^{IS+1}	Elasticity of substitution in aggregate demand by the rest of the world between commodities imported from different sources.	i=1...,I	I
ε_i	Price elasticity of demand by the rest of the world for commodity i.	i=1...,I	I
μ_i^z	Elasticity of demand for commodity i with respect to aggregate consumption expenditure.	i=1...,I z=1...,S	IS
λ_{ih}^z	Price-elasticity of demand in consumption for composite commodity i with respect to the price of commodity h.	i=1...,I h=1...,J z=1...,S	I^2S
χ_l^z	Elasticity of labour supply to after-tax wages.	z=1...,S	S

Total parameters: $I^2S + 10IS + 2I + S$.

Elasticities of substitution among primary factors

The SALTER model's production structure assumes producers substitute among primary factors (labour, capital and land) to form a value-added aggregate (land is assumed to be used only in the agricultural sectors). This aggregate is combined in fixed proportions with aggregate intermediate inputs to form gross output. The substitution among primary factors is ruled by a constant elasticity of substitution function in which the only parameter to be specified is the (constant) elasticity of substitution (σ^z_j). An estimate of this parameter is required for each industry j in the S modelled countries. This represents 272 parameters.

Econometric evidence

Caddy (1976) reviewed 21 cross-sectional and 13 time-series studies of empirical estimates of primary factors of substitution elasticities covering a variety of industries. The estimates reviewed are the product of estimating a production function directly or equations derived from the first-order conditions assuming the producer maximises profits.

Estimates of substitution elasticities are found to vary dramatically depending on the level of aggregation, the particular functional form or parameter restrictions imposed, and whether the estimation is based on cross-sectional or time-series data. There are many potential biases and little is known on their magnitude or direction.

In general, cross-sectional estimates tend to be larger than those obtained in time-series analyses. Cross-section studies typically cover a wide variety of economic circumstances found by individual firms. The variation in these circumstances is typically larger than the year-to-year variations observed in the data used in time-series studies. Because elasticities of substitution derived from cross-section studies have been estimated using data with greater variation, they are more likely to produce estimates of long-run substitution possibilities. The time-series estimates provided by Caddy are thus typically lower than the cross-section estimates of primary factor substitution, reflecting relatively short-run substitution opportunities.

Quantitative restrictions such as supply management policies affect the estimates of substitutability between inputs as they limit firms' access to specific inputs. For example, land-set-aside programs in the US are expected to reduce farmers' ability to use this input and thus bias estimates of substitution possibilities in agriculture that would be available when such programs are not in effect (Burniaux *et al*, 1988).

Rimmer (1990) has estimated elasticities of substitution between labour and capital using a cost function approach. The estimation procedure was adapted for each broad industry group to account for estimation problems or an industry's peculiarity (for example, performance in agriculture can be heavily influenced by weather conditions). The time-series estimation based on Australian data from 1962 to 1985 accounts for different wage regimes. Values estimated by Rimmer for the more recent periods are compared in Table 4.2 with those synthesised by Whalley (1985) from Caddy's (1976) compilation.

The values obtained by Rimmer are similar to those used by Whalley in spite of their very different origin. They show that substitution opportunities are highest in services industries, but lower in manufacturing and agriculture. The lower value for agriculture may reflect the relative importance of, and lack of substitutes for land in agricultural production in which substitution possibilities for this factor have largely been exhausted. The low value obtained by Rimmer for manufacturing may reflect the high degree of aggregation and heterogeneity of this sector.

Previous modelling practice

In their search for parameter values, researchers have also supplemented the econometric estimates reviewed above with their own judgements about the value parameters should have. For example, Mercenier and Waelbroeck (1986) believe efforts in estimating parameters are inconclusive and incorporate subjective estimates formulated by World Bank staff, advocating that the end user of their model might have a preferred set of parameter values.

It is typical in general equilibrium models to apply the same elasticities of substitution among primary factors for all countries involved (for example, Whalley, 1985; Burniaux *et al*, 1990). This may seem reasonable when the countries modelled are similar, but substitution opportunities may be affected by the technologies used. Early econometric studies suggest some differences exist in the substitution opportunities of developed and developing economies (Fuchs, 1963). It is expected that the largest differences between technologies that might affect substitution elasticities will arise from differences in the degree of development of a country.

Table 4.2: **Elasticities of substitution between capital and labour in various industries obtained from two studies**

	Whalley	*Rimmer*
Agriculture	0.6	0.4
Mining	0.8	0.8
Manufacturing	0.6 – 0.9	0.5
Construction	0.9	1.0
Services	1.0[a]	0.9
Electricity, Gas & Water	1.0[a]	0.9
Transport & Communications	1.0[a]	1.2
Retail and distribution	na	0.9

na not available.

[a] Values assumed by Whalley (1985).

Sources: Whalley (1985) and Rimmer (1990).

While a large part of industrial and extractive production processes might be assumed relatively homogeneous across countries, this may not be the case for agricultural industries as technologies in this sector may vary widely from industrialised to developing countries. Yotopoulos and Nugent (1976) indicate that several studies (including Arrow *et al*, 1961) find larger opportunities for substitution in agriculture than in manufacturing, but claim that modern technology tends to decrease substitution opportunities. This would point to the need to specify larger elasticities of substitution in agriculture in lesser developed countries, specifically the ASEAN members included in the SALTER model. However, the lack of reliable estimates makes it difficult to use differentiated sets of elasticities and the common practice of imposing a single set of substitution elasticities on all modelled countries is followed in specifying production parameters in the SALTER model.

Preferred parameter values

The elasticities of substitution among primary factors selected for the SALTER model are presented in Table 4.3. They are based on Rimmer's (1990) estimates except for manufacturing. Since the industry specification in SALTER is more disaggregated, the synthetic estimates of Whalley (1985) are used for the manufacturing industries.

In the short-run, there are less opportunities to adjust the mix of primary factors in response to relative changes in their prices. To reflect this, short-run elasticities of substitution are assumed to be lower than those affecting decisions in the medium term.

Caddy (1976) indicates that time-series elasticities are centred around 0.5, while cross-sectional estimates are centred around 1.0. Dixon *et al.* (1982) agree that the 'cross-sectional estimates should be interpreted as applying to an adjustment period considerably longer than one or two years' (p. 189-90). Assuming that cross-sectional estimates apply to a ten-year period, and the short term (2 years) and long term (10 years) values of the parameters change linearly, the doubling in the central values observed by Caddy implies a rate of change of 12 per cent per year. Thus, the medium term (5 years) estimates in Table 4.3 are obtained by increasing the short term (2 years) estimates by 40 per cent.

Trade elasticities in the SALTER model

In the SALTER model, it is assumed that domestically produced and imported commodities are imperfect substitutes for each other and that imports from different origins are likewise only partial substitutes. This applies to all categories of aggregate demand, that is intermediate industry demands, consumer demands, as well as government and investment demand in the explicitly modelled regions. In addition, demands for imports by the rest of the world are specified for each commodity.

Given this specification, three sets of trade elasticities are required to model international trade

Table 4.3: **Elasticities of substitution between primary factors assumed in the SALTER model**

No.	*SALTER commodities*	*Short run*	*Medium run*[a]
	Agriculture and primary non-extractive industries		
1	Paddy rice	0.40	0.56
2	Non-grain crops	0.40	0.56
3	Wheat	0.40	0.56
4	Grains, other than wheat and rice	0.40	0.56
5	Wool	0.40	0.56
6	Other livestock products	0.40	0.56
7	Forestry	0.40	0.56
8	Fishing	0.40	0.56
	Mining industries		
9	Coal	0.80	1.12
10	Oil and gas	0.80	1.12
11	Other minerals	0.80	1.12
	Food processing industries		
12	Meat products	0.80	1.12
13	Milk products	0.80	1.12
14	Other food products	0.80	1.12
15	Beverages and tobacco	0.80	1.12
	Textile industries		
16	Spinning, weaving, dyeing, made-up goods	0.90	1.26
17	Wearing apparel	0.90	1.26
18	Leather, fur and their products	0.80	1.26
19	Lumber and wood products	0.90	1.26
20	Pulp, paper and printing	0.80	1.26
21	Chemicals, rubber and plastic	0.90	1.26
22	Petroleum and coal products	0.90	1.26
23	Non-metallic mineral products	0.90	1.26
24	Primary iron and steel	0.90	1.26
25	Other metals and products	0.80	1.26
26	Transport industries	0.90	1.26
27	Other machinery and equipment	0.90	1.26
28	Other manufacturing	0.90	1.26
	Services		
29	Electricity, gas and water	0.90	1.26
30	Construction	1.00	1.40
31	Trade and transport	1.20	1.68
32	Other services (private)	0.90	1.26
33	Other services (government)	0.90	1.26
34	Other services (ownership of dwellings)	0.90	1.26

[a] Calculated as 40 per cent larger than the short term values.

Source: SALTER database.

in the SALTER model. These sets include:

1. elasticities of substitution between domestic and imported commodities (4IS or 1088 parameters);
2. elasticities of substitution between imports from different sources (4IS + I or 1122 parameters); and
3. import demand elasticities by the rest of the world (I, or 34 parameters).

The numerical specification of these 3 sets of parameters is the object of the following sections.

Substitution between domestic and imported commodities

Import price elasticities available from the literature are usually not differentiated by use. They are estimated for aggregate commodity imports or total imports (Stern *et al*, 1976). The builders of the ORANI model of the Australian economy point out that most of Australia's major imports are used predominantly by one end-user, and thus justify using the same substitution parameter for all end-uses (Dixon *et al*, 1982). Assuming that the share of imports in each user's demand is not too different, the substitution elasticity estimated by commodity but for all uses can be applied uniformly across users (that is, demand for intermediate inputs, consumer, investment, and government demands). These two assumptions are used in specifying the import-domestic substitution parameters for the SALTER model. If the shares of imports in each use are actually similar, this results in similar price elasticities of demand for imports and domestic products by all end-users.

Econometric evidence

Common sources for assigning values to the substitution elasticity between imports and domestic products are the Stern *et al* (1976) survey of about 130 estimations of import and export elasticities for a variety of countries, and the Alaouze (1977) and Alaouze *et al* (1977) studies of substitution elasticities between domestic and imported commodities in Australia. The import price elasticities reviewed by Stern *et al* (1976) are either for:

1. aggregate imports for a number of countries, or
2. large but disaggregated commodity group imports (usually for a single country).

Burniaux *et al* (1988) expect that disaggregated price elasticities are higher than estimates at more aggregate levels owing to greater substitution possibilities among homogeneous products.

As a consequence, agricultural product estimates are expected to be higher than estimates of manufactures; this is however not borne out by empirical results. Quantitative trade restrictions are presumed to affect the estimates of import price elasticities, and therefore opportunities for substitution.

Stern *et al* (1976) indicate that import price elasticities are centred around 1.0 while export price elasticities are slightly higher, around 1.25. However, a number of researchers (for example, Orcutt, 1950; and Kemp, 1962) have argued that biases toward unity are inherent to the estimation procedure used in many cases.

Alaouze *et al* (1977) provide estimates of substitution elasticities for 32 commodities imported into Australia. They use a 'rapid adjustment model' to estimate immediate response to price changes and a 'partial adjustment model' to account for lags in changing the relative shares of imports and domestic products as a result of a change in relative import prices. Elasticities for a number of time frames are obtained with the partial adjustment model. Alaouze (1977, p. 12) indicates:

> the infinite period elasticity obtained from the partial adjustment model is taken as an unbiased estimate of the long-run elasticity of substitution and the three period elasticity as the approximate estimate of the annual response.

The difference between the two estimates varies from nearly zero for beer and soap (small value consumables) to about 150 per cent of the short term value for underwear and refrigerators. Intermediate inputs such as raw textiles have relatively low differences in substitution elasticities, while in more processed textile products (for example, apparel) the differences are larger. The smallest differences between the 1-year and the infinite period estimates are found in inputs used by the construction industry, indicating that all adjustments to price changes are made by buyers of such products within the year. Simple averages of the percentage difference between long and short-run elasticities for broad commodity groups are shown in Table 4.4, indicating significant differences among groups in their ability to adjust to changing conditions.

Previous modelling practice

Modellers have often used the link between compensated price elasticities and substitution elasticities to specify the latter. Mansur and Whalley (1984) detail the assumptions and approximations involved. Basically, expansion effects are assumed to be small, and imports are assumed to be a relatively small proportion of total use. In this case, substitution elasticities can be approximated by uncompensated price elasticities. Models may require the specification of import price elasticities and expansion (income) elasticities or a set of substitution elasticities from which price elasticities can be derived.

Table 4.4: **Average long-run and short-run elasticities of substitution between domestic and imported products for broad commodity groups**

Commodity group	*ASIC*[a]	*Short-run elasticities*	*Long-run elasticities*
Food	2132, 2140	1.4	1.4
Beverages	2192	2.2	2.2
Textiles	2314, 2315, 2317, 2318, 2331	1.1	1.4
Apparel	2411, 2423, 2424, 2425, 2426	2.2	4.0
Pulp and paper	2611	0.8	1.1
Chemicals	2711, 2713, 3432	1.2	1.2
Construction	3324, 2821, 2831, 2835, 2914	1.2	1.2
Vehicles	3211, 3212	3.2	5.5
Manufactured products	2927, 2725, 2522, 3322, 3323, 3325	1.4	1.9

[a] Australian Standard Industrial Classification.

Source: Adapted from Alaouze *et al* (1977).

Using the Stern *et al* (1976) review, Whalley (1985) indicates that estimates of price elasticities of import demand for aggregate commodity groups and aggregate imports have a central tendency around unity for a number of countries. Whalley specifically uses import-price elasticities to specify substitution elasticities between domestic and imported commodities in both his 4-region and his 7-region models. This practice results in relatively low substitution elasticities, centred around unity.

Burniaux *et al* (1988) argue that 'implicit estimates of import elasticities derived from domestic demand and supply elasticities give much higher values than direct estimates based on time-series analysis', and consequently in the WALRAS model price elasticities are increased substantially to reflect long-run substitution opportunities among disaggregated commodity groups. The values used in specifying the WALRAS model are significantly higher than the price elasticities of aggregate imports used in Whalley's (1985) models. Values range between 5 and 7, and are different by country although no justification is given to support this pattern.

Rejecting the low results found in direct econometric estimation is a common practice. Abbott (1986) lists a number of potential sources of bias which include the standard problems encountered in econometrics (for example, specification error, identification error, aggregation, and so on). He advocates a synthetic approach to 'estimate' parameters based on previous research and the use of components in the behaviour of trade patterns. That is, rather than estimating a relatively simple econometric trade model, behavioural parameter estimates are derived from the trade behaviour of different components resulting in the net trade flows (that is, adjustments in domestic production and use, price transmissions, and stocks). Abbott shows that such synthetic estimates for wheat and coarse grains tend to provide larger estimates than those directly estimated econometrically. The synthetic estimates of substitution elasticities reported in this study range between 1.0 and 4.7, depending on the importing country. These are significantly higher than the values obtained through direct estimation which Abbott cites (all are less than 1.0) and other econometric estimates reviewed above.

The foregoing example illustrates the fact that evidence other than strict econometric estimates may prove useful in setting parameter values. This approach based on heterogeneous sources is used in the next section to choose the elasticities of substitution between imported and domestic commodities in the SALTER model.

Preferred parameter values

Because of the inter-country linkages in the SALTER model, the import-substitution elasticities in each region of the model help to determine not only the elasticity of demand for imports by the region, but also the elasticity of demand for exports by other regions.

For a small country supplying only a small share of its trading partners' imports of any particular commodity, the export demand elasticity for this commodity is approximately equal to the elasticity of substitution between imports from different sources in the partner's country. This is because the expansion effects in importing countries of changes in a small country's export price are negligible, while the elasticity of a small country's market share is approximately equal to the substitution elasticity among imports (Box 4.1). Furthermore, as described below, we have chosen to set elasticities of substitution between imports from different sources at twice the values of the corresponding domestic-import substitution elasticities. So the export demand elasticity for a small country is approximately twice the domestic-import substitution elasticity.

Thus, if we chose import-domestic substitution elasticities centering around unity, as proposed by Whalley (1985) then we would obtain export demand elasticities for small countries of about 2.0. In this case, even small countries would exercise a high degree of market power in international markets, and could greatly improve their terms of trade by taxing exports. With export demand elasticities of about 2.0, the optimal export tax rate would be about 100 per cent.

We find this account of the international trading environment facing small countries hard to believe. But if we reject it, then we must also reject the underlying import-import substitution elasticities. To do this, we must either set import-import substitution elasticities almost an order of magnitude higher than the domestic-import substitution elasticities, or set domestic-import substitution elasticities considerably higher than most econometric estimates. As explained below, we take the latter course.

Our preferred values for the domestic-import substitution elasticities represent a compromise between the econometric estimates on import substitution elasticities, and our prior beliefs concerning export demand elasticities.

For the econometric evidence on domestic-import substitution elasticities, we take the estimates of Alaouze *et al* (1977) as representative. We accept the evidence from Corado and de Melo (1983) discussed below, that import-import substitution elasticities are typically about twice as great as domestic-import substitution elasticities — we have no evidence suggesting that they are much more than twice as great. We postulate a typical value for the export demand elasticity facing a small country of about ten, similar to the apparent aggregate export demand elasticity facing Australia in long-run ORANI simulations. By the previous argument, this implies a typical value for domestic-import substitution elasticities of about 5.0; whereas the Alaouze *et al*

Box 4.1: **Relation between import substitution and export demand elasticities**

This box provides a simplified explanation of the relation between import substitution elasticities and export demand elasticities facing small countries in SALTER.

Consider a small country exporting a good with a single use to a single destination. Let p_1^I denote (the percentage change in) the price of imports from the small country, and p_2^I the price of imports from other sources. Then we may define an import price index,

$$p^I = S_1^I p_1^I + S_2^I p_2^I,$$

where S_s^I denotes the share of source s in the value of imports, s = 1,2. Let p^D denote the price of domestically produced goods of the same description. Then we may define a price index for all goods of this description,

$$p = S^D p^D + S^I p^I,$$

where S^D denotes the share of domestic products, and S^I, the share of imports, in total purchases of these goods.

Imports from all sources are assumed to be combined in a CES aggregation function to form a composite imported variety. Then demand for imports from the small country,

$$x_1^I = x^I - \sigma^I (p_1^I - p^I),$$

where x^I denotes demand for the composite imported variety, and σ^I the elasticity of substitution between imports from different sources. Similarly, the domestically produced and the composite imported variety are assumed to be combined in another CES function to form a

(Continued on next page)

estimates fall mostly in the range 1.0 to 2.0 (Table 4.4).

To derive our preferred values, we use a loss-function minimisation approach to set the medium-run elasticities between the values in Table 4.4 and the value of 5.0 implied by our prior beliefs on the elasticity of export demand. The problem consists of determining the value of a parameter based on the information found in the econometric estimate and the prior value above. The loss function is defined so as to be increasing in the difference between the preferred value of the parameter and the econometric estimate on the one hand, and the prior value of 5.0 on the other. When such a function is minimised with respect to the preferred value, we obtain a preferred estimate which takes into account the information contained in both the econometric estimate and the prior value. For the particular loss function chosen, this approach generates preferred values equal to the harmonic mean of the econometric estimate and the prior value of 5.0. The medium-run elasticities in Table 4.5 are determined according to this method.

The short-run elasticities are derived from the medium-run elasticities applying the ratios of the preferred values to the econometric estimates chosen for the medium-run to the short-run

Box 4.1 (continued)

composite good. Then demand for the composite variety is:

$$x^I = x - \sigma(p^I - p),$$

where x denotes demand for the composite good, and σ the elasticity of substitution between the domestically produced and the composite imported variety.

Finally, demand for the composite good depends on its price,

$$x = -\eta p,$$

where η denotes the absolute magnitude of the demand elasticities (assumed negative).

Combining these relations, we obtain the demand for imports from the small country

$$x_1^I = -\sigma^I(p_1^I - p^I) - \sigma(p^I - p) - \eta p$$
$$= -(S_2^I\sigma^I + S_1^I S^D\sigma + S_1^I S^I\eta)p_1^I + S_2^I(\sigma^I - S_1^I S^D\sigma - S^I\eta)p_2^I + S^D(\sigma - \eta)p^D.$$

Then the own-price elasticity of demand for imports from the small country,

$$\eta_1^I = -(S_2^I\sigma^I + S_1^I S^D\sigma + S_1^I S^I\eta).$$

This expresses the elasticity as the sum of the three effects: one representing substitution between imports from different sources, the second, substitution between imports and domestic products, and the third, variation in usage of the composite good.

The statement that the first exporting country is small may be interpreted as meaning that its share of the import market, S_1^I, is approximately equal to zero. Then the expression for the own-price demand elasticity reduces to:

(Continued on next page)

estimates found in Table 4.3, assuming that the long-run estimates apply to the definition of the medium-run in the SALTER model (5 years).

Following Deardorff and Stern (1986), the same elasticities of substitution are applied to all regions in the model. Differences in import sensitivity to price changes between the regions modelled are assumed to be captured by:

1. regional differences in production and final demand structure, that is, the differences in share parameters; and
2. regional differences in consumer demand parameters.

Similarly, assuming the proportion of imports in the use of a commodity by all users is similar, the parameters for aggregate imports of that commodity are applied to all user classes.

The elasticity of substitution among imports from different sources

The nested structure used to model imports from different sources is a common feature in trade models. This requires the specification of substitution elasticities among imports from different

Box 4.1 (continued)

$$\eta_1^I = -\sigma^I.$$

So under the model's assumptions, variation in the price of imports from a small country affects demand for those imports, only through substitution for imports from other sources; and the import demand elasticity is equal in magnitude to the elasticity of substitution between imports from different sources.

From the assumption that the small country exports the good to just one destination, where the good has just one use, we may identify the export demand elasticity with the import demand elasticity, and conclude that the export demand elasticity is equal in magnitude to the import-import substitution elasticity.

There are several reasons why this conclusion may not hold exactly in the actual model. First, even for small exporters, market shares are not exactly zero. Second, exports are generally sold into several markets. Then even if the substitution elasticity is the same in all individual markets, the aggregate substitution elasticity is in general smaller. Finally, import demand elasticities are defined with respect to purchasers' prices, but export demand elasticities with respect to f.o.b. prices. Trade and transport margins tend to make export demand elasticities lower than import demand elasticities.

Even where all these effects are present, the elasticities of substitution between imports from different sources are likely to give a good indication of the export demand elasticities facing small exporting countries.

sources. In the SALTER model, these parameters can be specified for each of four end-users and commodity import (I) in each country. This represents a total of 4IS or 1088 parameters.

Corado and de Melo (1983) estimate elasticities of substitution between imports from the EC and non-EC countries for Portugal. Their estimates range from a theoretically inconsistent -0.7 for mining and petroleum products to 3.3 for metal products. In general, they observe that the elasticity of substitution estimates among imports are larger than elasticities of substitution between imports and domestic products. The simple average of their estimates of substitution

Table 4.5: **Elasticities of substitution between imported and domestic commodities assumed in the SALTER model**

No.	*SALTER commodities*	*Broad categories for correspondence with Table 4.4*	*Short run*	*Medium run*
1	Paddy rice	Food	2.2	2.2
2	Non-grain crops	Food	2.2	2.2
3	Wheat	Food	2.2	2.2
4	Grains, other than wheat and rice	Food	2.2	2.2
5	Wool	Textiles	1.8	2.2
6	Other livestock products	Manufactures	2.2	2.8
7	Forestry	Manufactures	2.2	2.8
8	Fishing	Manufactures	2.2	2.8
9	Coal	Manufactures	2.2	2.8
10	Oil and gas	Manufactures	2.2	2.8
11	Other minerals	Manufactures	2.2	2.8
12	Meat products	Food	2.2	2.2
13	Milk products	Food	2.2	2.2
14	Other food products	Food	2.2	2.2
15	Beverages and tobacco	Beverages	3.1	3.1
16	Spinning, weaving, dyeing, made-up goods	Textiles	1.8	2.2
17	Wearing apparel	Apparel	3.1	4.4
18	Leather, fur and their products	Apparel	3.1	4.4
19	Lumber and wood products	Manufactures	2.2	2.8
20	Pulp, paper and printing	Pulp and paper	1.4	1.8
21	Chemicals, rubber and plastic	Chemicals	1.9	1.9
22	Petroleum and coal products	Chemicals	1.9	1.9
23	Non-metallic mineral products	Manufactures	2.2	2.8
24	Primary iron and steel	Manufactures	2.2	2.8
25	Other metals and products	Manufactures	2.2	2.8
26	Transport industries	Vehicles	3.0	5.2
27	Other machinery and equipment	Manufactures	2.2	2.8
28	Other manufacturing	Manufactures	2.2	2.8
29	Electricity, gas and water	Manufactures	2.2	2.8
30	Construction	Construction	1.9	1.9
31	Trade and transport	Construction	1.9	1.9
32	Other services (private)	Construction	1.9	1.9
33	Other services (government)	Construction	1.9	1.9
34	Other services (ownership of dwellings)	Construction	1.9	1.9

Source: SALTER database.

between imports and domestic commodities is about 0.8, while that of substitution among imports is 1.5. The authors find their estimates to be reasonable and in broad agreement with estimates for substitution elasticities for aggregate imports found by Hickman and Lau (1974).

Within the SALTER research program, substitution elasticities for New Zealand imports from different sources were estimated. Import sources are divided into 5 groups: Australia, the EC, North America (Canada and the US), selected Asian countries (Japan, Malaysia, Indonesia, Thailand and Singapore) and the rest of the world. Share equations derived from a cost function were estimated for 18 of the 34 commodity classifications in the SALTER model. From the parameters obtained, estimates of substitution elasticities are calculated. These estimates are found in Table 4.6 where they are compared with the estimates obtained for Portuguese imports by Corado and de Melo (1983).

In general, estimates from Appendix D are smaller than the Portuguese estimates. The simple average of the New Zealand estimates (1.3) represents 70 per cent of the average of the estimates for Portugal (1.8) reported in Table 4.6. In both studies, the authors tend to think of these estimates as applying to the short term, reflecting the fact that existing contracts make it difficult for importers to adapt their sources for imports very quickly in response to relative price changes.

Table 4.6: **Import substitution elasticities from two studies**

Commodities	*Appendix D*	*Corado and de Melo*
Non-grain crops	0.99	1.67
Other minerals	1.81	-0.66
Meat products	1.31	1.50
Other food products	2.02	0.64
Beverages & tobacco	0.46	3.02
Textiles	0.96	1.09
Wearing apparel	0.55	1.18
Leather fur and their products	1.05	1.57
Lumber & wood products	0.94	2.85
Pulp, paper and printing	2.18	0.75
Chemicals, plastics and rubber	1.44	0.99
Petroleum and coal products	3.15	0.14
Non-metallic mineral products	1.08	0.66
Primary iron and steel	1.61	1.89
Other metal and metal products	1.06	3.27
Transport equipment	0.52	2.58
Other machinery and equipment	1.32	na
Other manufacturing	0.63	1.20

na: Not available.

Sources: Corado and de Melo (1983); Appendix D.

Previous modelling practice

Burniaux *et al* (1990) assume fixed proportions between imports from different sources (substitution elasticity equals 0) but Whalley (1985) and Harrison *et al* (1989) assume a constant elasticity of substitution form, allowing imports to shift in reaction to relative price changes. Whalley (1985) sets these elasticities to 1.5 and Harrison *et al* (1989) set them at 2.0 for all commodities in all countries.

Preferred parameter values

The elasticities of substitution among imports specified in the SALTER model are calculated by multiplying the elasticities of substitution between domestic and imported products by a factor of 2.0, the approximate ratio of the average elasticities of substitution among imports and the average elasticities between domestic and imported commodities obtained by Corado and de Melo (1983). Two main reasons have guided this choice:

1. there is a lot more information about substitution between domestic and imported products; this led to the choice of parameters in Table 4.5; and
2. it is important for modelling purposes (and expected on theoretical grounds) that substitution elasticities in the lower nests (import-import substitution) are higher than those in higher level nests (import-domestic substitution)..

The resulting elasticities of substitution among import sources are found in Table 4.7. Preferred values for this parameter range from 2.8 to 10.4.

Import elasticities by the rest of the world

A rest of the world aggregate is often used in general equilibrium single- and multi-country models to account for the trade flows that do not occur between explicitly modelled regions. In SALTER, the net import demands from the rest of the world are a function of world prices relative to costs at the rest of the world border. The rest of the world is therefore assumed to choose between importing or using internally supplied commodities. An import price elasticity is specified for each commodity.

Given the heterogeneity of the regions included in the rest of the world, it is difficult to specify its behaviour. The WALRAS and ORANI models specify large export demand elasticities of the order of -10 to -20. This is reasonable when a single country is modelled and facing demand for its exports by the rest of the world. However, the SALTER model explicitly accounts for a large part of world production, and countries in the rest of the world will presumably not be able to switch demand for products very easily. In this respect, Whalley's (1985) models are similar to the SALTER model. These models used the average price elasticities in the modelled regions as the import price elasticities for the rest of the world.

Table 4.7: **Elasticities of substitution among imports from different sources assumed in the SALTER model**

No.	*SALTER commodities*	*Broad categories for correspondence with Table 4.4*	*Short run*	*Medium run*
1	Paddy rice	Food	4.4	4.4
2	Non-grain crops	Food	4.4	4.4
3	Wheat	Food	4.4	4.4
4	Grains, other than wheat and rice	Food	4.4	4.4
5	Wool	Textiles	3.6	4.4
6	Other livestock products	Manufactures	4.4	5.6
7	Forestry	Manufactures	4.4	5.6
8	Fishing	Manufactures	4.4	5.6
9	Coal	Manufactures	4.4	5.6
10	Oil and gas	Manufactures	4.4	5.6
11	Other minerals	Manufactures	4.4	5.6
12	Meat products	Food	4.4	4.4
13	Milk products	Food	4.4	4.4
14	Other food products	Food	4.4	4.4
15	Beverages and tobacco	Beverages	6.2	6.2
16	Spinning, weaving, dyeing, made-up goods	Textiles	3.6	4.4
17	Wearing apparel	Apparel	6.2	8.8
18	Leather, fur and their products	Apparel	6.2	8.8
19	Lumber and wood products	Manufactures	4.4	5.6
20	Pulp, paper and printing	Pulp and paper	2.8	3.6
21	Chemicals, rubber and plastic	Chemicals	3.8	3.8
22	Petroleum and coal products	Chemicals	3.8	3.8
23	Non-metallic mineral products	Manufactures	4.4	5.6
24	Primary iron and steel	Manufactures	4.4	5.6
25	Other metals and products	Manufactures	4.4	5.6
26	Transport industries	Vehicles	6.0	10.4
27	Other machinery and equipment	Manufactures	4.4	5.6
28	Other manufacturing	Manufactures	4.4	5.6
29	Electricity, gas and water	Manufactures	4.4	5.6
30	Construction	Construction	3.8	3.8
31	Trade and transport	Construction	3.8	3.8
32	Other services (private)	Construction	3.8	3.8
33	Other services (government)	Construction	3.8	3.8
34	Other services (ownership of dwellings)	Construction	3.8	3.8

Source: SALTER database.

In the SALTER model, we use the Mansur and Whalley (1984) argument that if the share of imports in the rest of the world's usage of a commodity is small, expansion effects are small and the price elasticity is approximately equal to the corresponding substitution elasticity. It is expected that production in the rest of the world provides for the bulk of most commodity uses. Hence, the share of imports in aggregation demand in the rest of the world is small, and the Mansur and Whalley (1984) argument is applied: the *elasticity of substitution* estimates in Table 4.5 are used to specify the import *price elasticities* for the rest of the world for both the short-run and the medium-run. The resulting price elasticities of imports by the rest of the world are therefore higher than the price elasticities in other regions in the model since the latter result from the product of the share of imports in aggregate use (which are less than or equal to 1.0) and the substitution elasticities specified in Table 4.5.

Consumer demand parameters

In the SALTER model, the demand for intermediate inputs is determined by the production structure. Government and investment demands for commodities are determined as fixed proportions of real aggregate levels of government expenditure and investment. Consumer demands, are determined assuming a representative consumer maximises a separable utility function subject to a budget constraint. The consumer is assumed to allocate a fixed proportion of disposable income to consumption expenditure; this is his budget allowance. The allocation among different commodities is assumed to be described by a linear expenditure system.

Reducing the number of parameters to specify

Expenditure systems are notorious for requiring a large number of parameters to characterise them. In the SALTER model, relations between expenditure and price elasticities are used to minimise the number of parameters needed to specify each region's consumer expenditure system.

The homogeneity and adding-up restrictions of the linear expenditure system imply that price and expenditure elasticities in the system are not independent. Frisch (1959) shows that if preferences are independent the price elasticities can be obtained by:

(4.1) $$\lambda_{ij} = -S_{Cj}\mu_i\left(1+\frac{\mu_j}{\bar{\omega}}\right)+\delta_{ij}\frac{\mu_i}{\bar{\omega}}$$

where

λ_{ij} is the elasticity of commodity i with respect to price j,

μ_i is the expenditure elasticity of commodity i

S_{Cj} is the average budget share of commodity j,

$\tilde{\omega}$ is the 'Frisch parameter', the reciprocal of the marginal utility of income, or the money flexibility, and

δ_{ij} is the Kronecker delta and is equal to zero when $i \neq j$, and unity when $i = j$.

Hence the I^2 or 1156 own- and cross-price elasticities for each country can be determined from a set of expenditure elasticities compatible with the benchmark equilibrium database share parameters obtained from the database and the Frisch parameter. This greatly reduces the number of parameters that must be specified and guarantees consistency between parameters and the database.

The SALTER commodity disaggregation is finer than the disaggregation typically used in estimating such systems. When estimating consumer demand systems, researchers typically assume preference independence. This allows them to specify a separable and additive utility function in which it is assumed that consumers' aggregate utility is the sum of the levels of utility derived from the consumption of broad commodity aggregates. But the assumption of additive preferences is only appropriate when commodity groups are broadly defined (Peter, 1990). Hence, estimates of consumer demand price and expenditure elasticities are typically available for a small number of broadly defined commodity groups. When the commodity disaggregation is finer, the estimates from the more aggregate consumption studies must be allocated to the disaggregated commodity specification.

Tulpulé and Powell (1978) show how estimates for expenditure elasticities derived from a small system (8 commodities) can be expanded to a larger system (109 commodities) using external information on expenditure elasticities and the equilibrium database. Tulpulé and Powell (1978) show that the expenditure elasticity for commodity i can be obtained by:

(4.2) $$\mu_i = \sum_{j=1}^{J} \frac{C_{ij}}{C_i} \mu_j^{o}$$

where

μ_i is the expenditure elasticity of commodity i,

C_{ij} is the level of commodity i in aggregate commodity group j,

C_i is the aggregate consumption of commodity i, and

μ_j^{o} is the expenditure elasticity of commodity group j.

In the SALTER model, each disaggregated commodity is assumed to be part of a single group of commodities. In this case, the consumption of commodity i (C_i) is equal to the consumption of commodity i from group j (C_{ij}), and the share parameter equals1. The disaggregated expenditure elasticity μ_i is therefore equal to the expenditure elasticity that applied to the aggregate commodity group, μ^o_j.

Econometric evidence and previous modelling practice

In surveying the econometric literature of income elasticities for specifying the WALRAS model, Burniaux *et al* (1990) produced the synthetic estimates shown in Table 4.8. Using estimates from Weisskoff (1971) and Lluch *et al* (1977), Mercenier and Waelbroeck (1986) produced the expenditure elasticities reported in Table 4.9, differentiating between urban and rural consumer behaviour. Such differences are very small for most commodities and even values across regions do not seem to vary much except in the case of food for which estimates are, as expected, higher in less developed regions.

Table 4.8: **Income elasticities for the WALRAS model**

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

Source: Burniaux *et al* (1990).

Table 4.9: **Income elasticities used in the Varuna model**

	Food	*Agriculture non-food*	*Manufactured products*	*Energy*	*Services*
Rural Sector					
South Asia	0.730	0.731	0.950	1.122	1.125
East Asia	0.679	0.679	0.950	1.013	1.017
OECD	0.524	0.524	0.949	0.630	1.050
Urban Sector					
South Asia	0.736	0.738	0.949	1.163	1.164
East Asia	0.684	0.685	0.950	1.046	1.049
OECD	0.499	0.500	0.949	0.599	0.999

Source: Mercenier and Waelbroeck (1986).

More recently, Selvanathan (1988) has produced estimates for 18 developed countries based on a 10-commodity classification, which are in broad agreement with the Lluch *et al* (1977) results. In general, the tendency is for estimates for food to be lower than estimates for other items in consumers' budgets and estimates for services are higher. Estimates less than unity indicate the commodity is a 'necessity' (for example, food, beverages, clothing, housing) whereas expenditures above unity make a commodity a 'luxury' (for example, durables and recreation).

Yet another more recent collection of elasticities was derived by Theil *et al* (1989). These estimates result from the International Comparisons Project currently conducted by the United Nations Statistical Office. Consumption data for 51 countries in 1980 were fit to a Working model of consumption expenditure assuming preference independence. The estimates obtained reflect expectations about the sensitivity of 'necessity' and 'luxury' goods to income changes relative to the initial level of income. By pooling the data across countries, the estimates obtained are consistent across countries.

Table 4.10: Expenditure elasticities used in the SALTER model

Commodities	*US*[a]	*EC*[b]	*Japan*	*Korea*	*ASEAN*[c]
Food	0.14	0.35	0.39	0.64	0.69
Beverages	1.02	1.02	1.02	1.02	1.02
Clothing	0.96	0.96	0.96	0.96	0.96
Gross rent, fuel	1.12	1.13	1.13	1.15	1.16
Durables	1.16	1.18	1.18	1.22	1.25
Medical care	1.24	1.27	1.27	1.39	1.50
Transport	1.24	1.27	1.27	1.38	1.48
Recreation	1.26	1.30	1.30	1.45	1.60
Education	1.08	1.08	1.08	1.09	1.09
Miscellaneous	1.25	1.28	1.28	1.40	1.52

[a] Elasticities for Australia, New Zealand and Canada are assumed to be the same as the US. [b]Elasticities for the EC are calculated as the simple linear average of Portugal, Greece, Ireland, Spain, Italy, U.K., Netherlands, France, Denmark, Belgium, Luxembourg, and Germany. [c]elasticities for ASEAN are the simple linear average of elasticities for Indonesia and the Philippines

Source: Adapted from Theil *et al* (1989).

Consumption expenditure elasticities in the SALTER model

Instead of specifying a full set of own- and cross-price elasticities that would be consistent with the linear expenditure system, these parameters are derived from expenditure elasticities based on values provided by Theil *et al* (1989) and the flexibility of the marginal utility of money. This set of estimates is preferred because they present an internal consistency across countries and are based on relatively recent (1980) consumption information.

The 34 SALTER commodities are allocated among the 10 commodity groups in Table 4.10 for which expenditure elasticities are available. The correspondence between the 10- and 34-commodity classifications is shown in Table 4.11. Through the Tulpulé and Powell (1978) argument presented earlier, the expenditure elasticities in the 34-commodity classification correspond directly to those in the 10-commodity classification. The values for the ASEAN countries are the simple average of the values for the Philippines and Indonesia on the grounds that the most populated countries of this group are developing economies in which food constitutes a large share of consumers' budgets and food consumption is in large part rice-based. Values for the EC are the simple average of expenditure elasticities for EC members included in the Theil *et al* (1989) study. Expenditure elasticities for the US are applied to Canada, New Zealand and Australia. Thus for each modelled region, there is a set of 34 expenditure elasticities. These elasticities are further normalised using the benchmark data set.

Table 4.11: **Correspondence between the SALTER 34-commodity classification and a 10-commodity classification for allocating consumption expenditure elasticities**

No.	*34-commodity classification*	*10-commodity classification*
1	Paddy rice	Food
2	Non-grain crops	Food
3	Wheat	Food
4	Grains, other than wheat and rice	Food
5	Wool	Miscellaneous
6	Other livestock products	Miscellaneous
7	Forestry	Miscellaneous
8	Fishing	Miscellaneous
9	Coal	Miscellaneous
10	Oil and gas	Miscellaneous
11	Other minerals	Miscellaneous
12	Meat products	Food
13	Milk products	Food
14	Other food products	Food
15	Beverages and tobacco	Beverages
16	Spinning, weaving, dyeing, made-up goods	Miscellaneous
17	Wearing apparel	Clothing
18	Leather, fur and their products	Clothing
19	Lumber and wood products	Miscellaneous
20	Pulp, paper and printing	Miscellaneous
21	Chemicals, rubber and plastic	Miscellaneous
22	Petroleum and coal products	Miscellaneous
23	Non-metallic mineral products	Miscellaneous
24	Primary iron and steel	Miscellaneous
25	Other metals and products	Miscellaneous
26	Transport industries	Durables
27	Other machinery and equipment	Durables
28	Other manufacturing	Durables
29	Electricity, gas and water	Miscellaneous
30	Construction	Miscellaneous
31	Trade and transport	Transport

32	Other services (private)	Recreation
33	Other services (government)	Miscellaneous
34	Other services (ownership of dwellings)	Miscellaneous

Consumption price elasticities of demand in the SALTER model

Once normalised, the expenditure elasticities are used with the Frisch parameter to generate the own- and cross-price elasticities of demand in consumption using the method shown above. A complete set of demand parameters is therefore determined by specifying only I + 1 or 35 parameter values for each region modelled.

The ORANI model of the Australian economy uses a Frisch parameter value of -1.82 (Dixon *et al*, 1982), a weighted average of values obtained by Williams (1978) for different Australian consumer groups. Frisch (1959) had originally conjectured that higher (absolute) values of $\bar{\omega}$ would be characteristic of lower income consumers and $\bar{\omega}$ would decrease as a function of consumers' incomes. In testing this conjecture, Selvanathan (1988) concludes that:

1. the income flexibility $\bar{\omega}$ is not related to real income, and

2. estimates of the income flexibility for 18 countries are centred around -0.5, which results in an estimate for $\bar{\omega} = -2$, close to the value used in the ORANI model.

In these conclusions, based on a variety of developed countries' consumption, Selvanathan joins Theil (1987) who concludes on the basis of consumption patterns in 30 developed and developing countries that evidence in favour of the Frisch conjecture is not sufficient to support it.

Table 4.12: **Values assumed for the income flexibility in the SALTER model**

Country	*Income flexibility*
Australia	-1.46[a]
New Zealand	-2.51[a]
Canada	-1.95[a]
USA	-1.85[a]
Japan	-2.47[a]
Korea	-3.24[b]
EC	-2.07[a]
ASEAN	-5.25[c]

Sources: [a] Peter (1990). [b] Calculated according to Lluch *et al* (1977) and United Nations (1990). [c] Linear average of values for Singapore, Malaysia, Philippines and Indonesia from Peter (1990).

However, this evidence is largely based on the estimation of demand systems using data from developed, affluent countries. There may not be sufficient variation in the data in this respect to obtain significantly different estimates of the income flexibility. Peter (1990) suggests a set of values for $\tilde{\omega}$ based on a relationship between this parameter and per capita GNP derived by Lluch *et al* (1977). These values are found in Table 4.12 and used to generate the set of consumer price elasticities for each country. Thus a complete set of consumer demand elasticities is generated relatively economically.

The elasticity of labour supply

Changes in the labour supply may be specified as a linear function of changes in the real after-tax wage rate in the SALTER model. This requires the specification of an elasticity of labour supply to the real after-tax wage (χ_1^z) for each region modelled (8 parameters). The SALTER model includes western developed economies as well as developed economies such as Japan where a different work ethic has been observed, Korea a middle-income country (presumably with an oriental work ethic) and ASEAN members who in large part are developing, mainly agricultural economies. It is expected that labour supply elasticities differ in these different types of regions.

Recent studies of labour supply in developed countries have attempted to separate income from substitution effects and concentrate on either male or female labour supply (Pencavel, 1986). Also, most studies of male labour supply measure the response of the male working force to wage changes and do not account for labour participation rates. Studies of female labour supply are also available, but also tend to concentrate on the labour supply of particular groups.

Econometric evidence

In his recent review of econometric evidence in Anglo-saxon countries, Pencavel (1986) places the elasticity of male labour supply to wage increases at about -0.1. This means that as wages increase by 10 per cent, the labour supply of working males *decreases* by 1 per cent. This points to the existence of a backward-bending supply curve in which large income-effects reduce male workers' incentives to work as they devote more time to leisure.

In analysing women's decision to work and supply labour, Luskin (1990) suggests with Mroz (1988) that estimates are very low, centred around 0. The low estimates for women's labour obtained by Mroz (1987) are based on married white US women aged 30-60.

In both cases, income effects are argued to have a strong depressing effect on the amount of labour supplied. This income effect is expected to effect elasticity estimates at the relatively high levels of income and economic development observed in the US and the United Kingdom.

These studies do not address issues related to the participation decision of thw whole work force, or that of groups such as young women and the decision by elderly people to work or not. Mansur and Whalley (1984) indicate that 'estimates on this elasticity vary sharply according to the group involved, with prime-age males having low if not negative elasticities and secondary and older workers having higher elasticities (around 0.5)'.

Labour supply in agricultural developing economies

Due to its lower income level, labour supply the ASEAN region is expected not to be affected by the negative income effect observed in more developed countries. In a large part of the ASEAN region, a significant part of the labour force is found in agriculture. A significant part of this force is expected to work in a semi-subsistence setting in which consumption and production decisions are made simultaneously. Household models have been used to analyse farmers' allocation decisions. Singh *et al* (1986) provide a review of these models. By taking into account the effects of price changes on total farm income, household models yield elasticities that are significantly different from those obtained from demand and supply studies that are not integrated. In the case of labour supply elasticities, estimates obtained with the household model tend to be larger. Elasticities assuming constant profits simulate results from a non-integrated model. Such low estimates reflect the negative income effects usually observed in labour supply studies. However, farm income is composed of labour income, income from management and profits. The effects of higher labour income (wages) is to *decrease* profits. This negative effect on profits, and aggregate farm income results in a higher supply of labour than was estimated assuming constant profits. Thus the elasticity of labour supply in this framework is positive and of the order of 0.1 to 0.3 shown in Table 4.13.

Table 4.13: **Elasticities of labour supply to wages assuming constant and varying profits**

	Taiwan	*Malaysia*	*Korea*	*Thailand*
Constant profits	-0.12	-0.07	0.00	0.08
Varying profits	0.17	0.11	0.11	0.26

Source: Singh *et al* (1986).

Previous modelling practice

Labour supply elasticities are mostly found in tax models in relation to labour taxation effects. Fullerton *et al* (1980) and Ballard *et al* (1985) use an elasticity of 0.15 for the supply of labour by the whole workforce in the US This value is obtained as an average of male and female labour supply elasticities, weighted by the respective wage bill of each group. In an extension of the ORANI model of the Australian economy, the influence of wages on labour force participation is specified as slightly positive, and tempered by negative effects of non-labour income and unemployment (Dee, 1989).

Labour supply elasticities in the SALTER model

Based on the evidence mentioned above, Luskin (1990) suggests that a weighted average of male and female elasticities be used in the SALTER model. Assuming 60 per cent of the labour force is male, an elasticity of labour supply of -0.1 for man and 0.0 for women, this yields a value of $\chi_1^z = -0.06$ for the elasticity of aggregate labour supply. This figure is used for all western economies.

In the cases of Japan and Korea, little information is available. However casual observation indicates that recent affluence in these countries and increasing western culture influence may result in behaviour similar to that encountered in western societies. Therefore the same labour elasticity to wages is assumed as for western economies.

Luskin (1990) suggests that only pure wage effects should be reflected in the SALTER model parametrisation. Thus, based on estimates of the elasticity of labour supply to off-farm wages in Thailand and Malaysia, he suggests a value of zero, thus making the labour supply effectively exogenous.

5 MODEL APPLICATIONS

Two applications of the model are reported in this chapter. In the first application removal of 1988 levels of Japanese agricultural assistance is simulated in a medium-run economic environment. The second application examines the implications of recent oil price rises. Assuming that these are unlikely to be of a long-term duration, their effects are evaluated using the model in its short-term configuration.

Removal of Japanese agricultural assistance

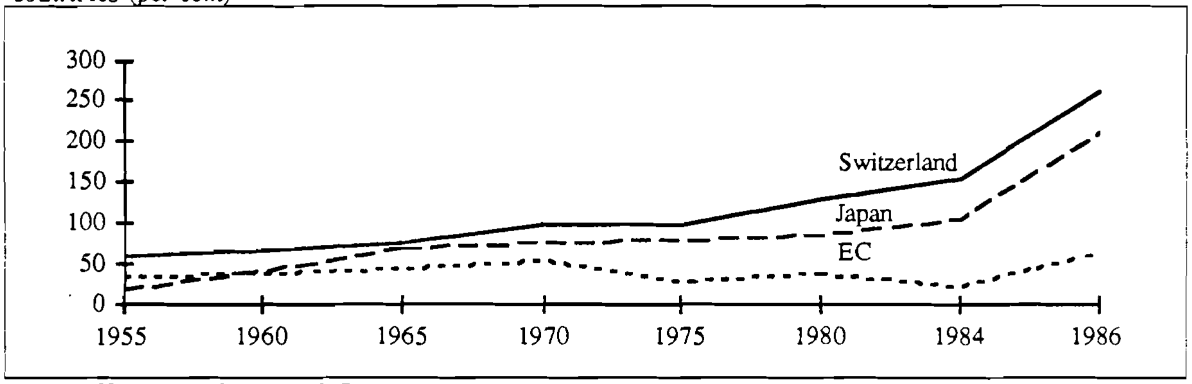
Background

Agriculture accounts for about 3 per cent of output of the Japanese economy, but 16 per cent of Japan's population occupied farm households in 1986 (ABARE, 1988). However, farms are very small and therefore cannot provide full-time employment opportunities for all members of farm households. Consequently, a large proportion of those who occupy farm households either work part time on the farm or have full-time jobs.

The small size of Japanese farms and the difficult terrain that many occupy have partly resulted in Japanese farms having cost structures in excess of those of their main competitors. This, and the intense competition the farm sector has faced from the rapid growth of the non-agricultural sector has placed enormous adjustment pressures on the Japanese agricultural sector since the last war. However, Japanese producers have been able to resist these pressures through their political influence (ABARE, 1988 p. S4). This is because farm families have a disproportionate share of elected representatives in the lower and upper houses of the Japanese parliament. They are able to exploit the political power this gives them, as nearly all farm families belong to the agricultural co-operative movement which has enabled the co-operatives to be a very effective lobbyists for Japanese farmers.

The success the Japanese agricultural sector has had in resisting the need for change is reflected in the lack of rationalisation of farm size. In 1950, for example, 73 per cent of Japanese farm families had less than 1 hectare of cultivated land, while in 1987 this proportion had only fallen to 68 per cent. But resisting the need for change has also needed ever-increasing levels of assistance to attain the policy objectives of secure and adequate food supplies, stable producer and consumer prices . . . and a "secure and equitable standard of living for farm households" (ABARE, 1988, p. 1). Hayami and Honma (1987), for example, estimate that the 1986 nominal rate of protection for a dozen major items produced by Japan's agricultural sector was more than 10 times their 1955 levels (Figure 5.1).

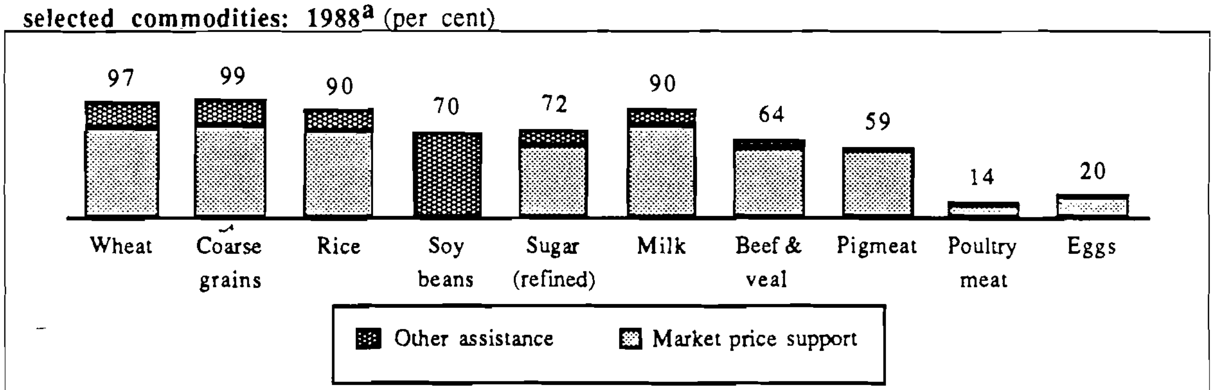
Figure 5.1: **Average nominal rates of protection of agriculture in selected industrialised countries** (per cent)



Source: Hayami and Honma (1987).

This escalation in protection has resulted in Japan having the second highest level of agricultural protection of all OECD countries. Only Switzerland is more heavily assisted (Figure 5.1). The Directorate for Food, Agriculture and Fisheries of the OECD provides the most comprehensive and up-to-date estimates of assistance provided the agricultural sector of OECD countries. Their estimates for 1988 indicate that assistance accounted for 80 per cent of revenue received by Japanese farms for 10 major items produced. Assistance is not uniform across products, with almost all income received by most grain producers being derived through assistance, while livestock products are less heavily assisted (Figure 5.2).

Figure 5.2: **Proportion of farm revenue obtained through assistance by Japanese farmers, selected commodities: 1988**[a] (per cent)



[a] Calculated as the producer subsidy equivalent of the respective products.

Source: OECD (1990).

Policy instruments used to protect Japanese farmers differ from product to product but market price support schemes play an important part in the overall assistance to Japanese farmers (see Figure 5.2). Thus the policies tend to contract domestic demand and expand supply, which reduces market opportunities for Japan's trading partners. The very high assistance Japanese farmers receive and the restrictions on market access that have been required to maintain these levels have created intense international pressure on Japan to open its agricultural markets to foreign competition. Policies applying to individual agricultural products are briefly outlined below. The discussion draws heavily on ABARE's recent assessment of Japanese agricultural policies (ABARE, 1988).

- *Rice*

The Japanese Food Agency, a quasi-government agency, purchases and sells all government marketed rice which accounts for about 60 per cent of Japan's rice crop. Since 1960 prices have been calculated using a production cost and income compensation approach, although in some years the Japanese Government has intervened to alter the price for rice that would have applied through strict application of the formulae. After purchasing the rice the Japanese Food Agency sells it to merchants at prices below the purchase price plus administration costs. This has required the injection of Government support into the operating budget of the Food Agency.

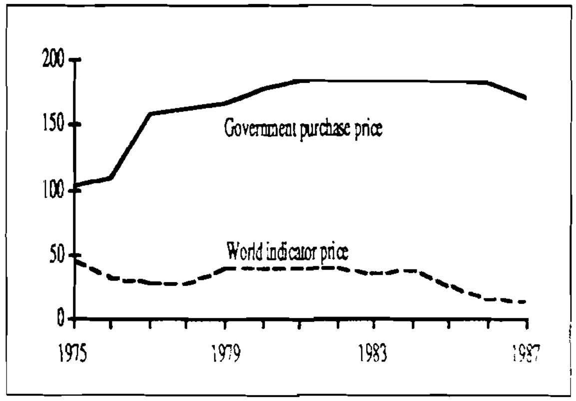
Setting prices mainly according to costs of production has resulted in domestic rice prices being well in excess of export parity. As indicated in Chapter 3 (Table 3.12) the producer price for rice is nearly 400 per cent above export parity levels. To maintain such a price differential, imports of rice are strictly controlled by the Food Agency. All rice imported into Japan must be sold to the Food Agency although since 1970 virtually no non-glutinous rice has been imported into Japan.

At prices prevailing for rice in Japan, supply exceeds demand. Surplus rice is stored by the Government, exported or sold for animal feed. In addition the Government has instituted policies to withdraw land from rice production. The latest program is called the Paddy Field Farming Establishment Program. In 1987 this program led to a 30 per cent reduction in the area of land devoted to rice growing and has contributed to significantly reduce government storage.

- *Wheat , barley and feedgrains*

In contrast to rice where Japan is self sufficient, Japanese farmers were able to satisfy only 14 per cent of domestic wheat requirements and 15 per cent of domestic barley requirements in 1985. Japan is thus a large importer of wheat and barley.

Figure 5.3: **Government purchase prices for wheat and world indicator wheat prices, 1975-1987 ('000 ¥/Tonne)**



Source: (ABARE) 1988, p. 125.

The Japanese Food Agency sets the purchase price for wheat and barley according to the costs of production of so called "core farmers". Setting purchase prices without regard to international price movements has resulted in the premium over world wheat prices received by Japanese wheat farmers rising from about 120 per cent in 1975 to a staggering 1010 per cent in 1987 (Figure 5.3). Consequently, as shown in Figure 5.2, Japanese wheat farmers' gross income is almost entirely derived through government handouts.

To maintain this price differential over world prices the Japanese Food Agency has monopoly control over wheat and barley imports. It sets annual import quotas based on expected demand and supply conditions. Once the quotas are set they are allocated to the co-operatives and general trading companies who arrange for the importation of the wheat and barley on behalf of the Food Agency.

The sale price of imported and domestically produced wheat and barley is determined by the Ministry of Agriculture, Forestry and Fisheries. Prices of domestically produced wheat sold to merchants and other users are generally about 30-50 per cent of the price paid to producers. In contrast imported wheat and barley is generally sold to users at prices more than 50 per cent above government purchase prices. The profits on sales of imported wheat and barley are used by the government to cover the loss made by the Food Agency when it sells wheat and barley at prices below that paid to farmers.

- *Milk and milk products*

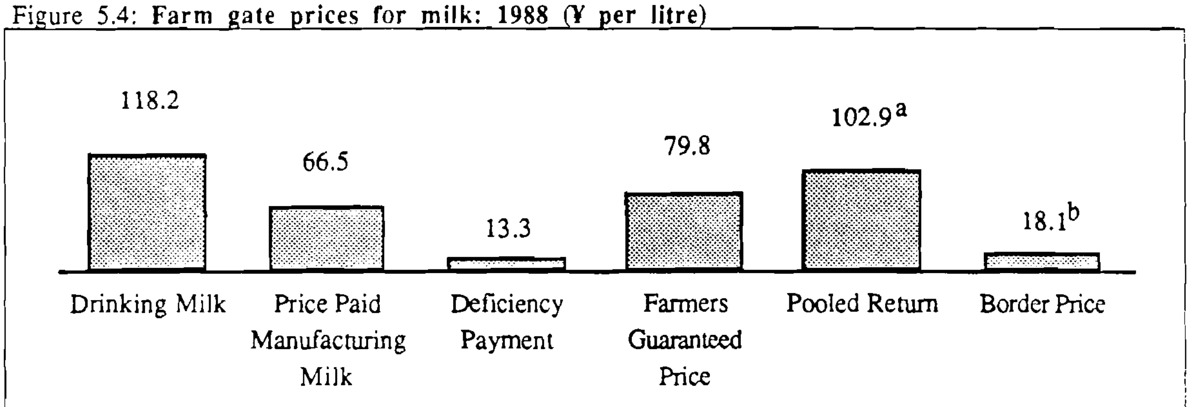
Production of milk is controlled by nation-wide quotas determined by the Central Council of Dairy Co-operatives, a national organisation which represents all prefectural co-operatives. Quotas are determined by forecasting total milk demand each year. Having calculated the relevant quota it is then allocated to each prefectural co-operative which then allocates a production quota to each farmer. Penalties are applied if farmers exceed their allocated quota.

The farm level price for drinking milk is determined by market conditions but the farm level price for manufacturing milk is administratively determined. The farm level price for manufacturing milk is known as the guaranteed price. It is calculated taking into account costs of production in Hakkaido where about 85 per cent of all manufacturing milk is produced. It also includes a deficiency payment or production subsidy paid directly to farmers by the government. The quantity of milk eligible for deficiency payments is however limited.

Revenues from the sale of drinking milk and manufacturing milk are pooled together at the prefecture level and farmers receive the pooled price. Because the share of drinking milk and manufacturing milk varies across prefectures so too does the pooled price received by farmers. This creates pressures for interprefectural trade in milk which has been controlled through voluntary agreements between co-operatives.

The farm level price supports are facilitated by protection provided manufactured milk products. The Livestock Industry Promotion Council (LIPC) sets stabilisation indicative prices for designated dairy products. These include butter, skim milk powder, sweetened condensed wholemilk and sweetened condensed skim milk. The stabilisation indicative prices minus an allowance for certain processing costs determine the standard transaction price which is paid by manufacturers for milk. The components of the pooled price for milk received by Japanese farmers are shown in Figure 5.4 where it can be seen that prices received for drinking milk and manufacturing milk are in excess of 4 times the border price for fluid milk in Japan.

Figure 5.4: **Farm gate prices for milk: 1988 (¥ per litre)**



[a] Calculated as 60 per cent of the drinking milk price plus 40 per cent of the farmers guaranteed price. [b] Calculated as the value of milk production minus market support payments all divided by the volume of production. The source of data was OECD (1990).

Source: ABARE (1988).

To maintain these returns, which are well above world parity levels, the LIPC undertakes direct market intervention to maintain prices at the determined levels. It also has monopoly control over imports of designated products. However, because prices for designated products are set so high, domestic demand is reduced and supply encouraged so that the LIPC has rarely been required to import designated dairy products.

Cheese is not a designated dairy product. Imports of processed cheese and natural cheese for direct consumption are subject to a tariff quota under which cheese in excess of quota is dutiable at 35 per cent. Imports of natural cheese for processing are also covered by tariff quota arrangements.

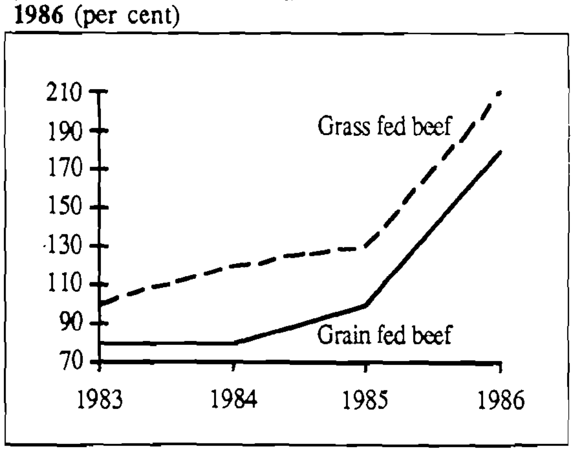
Cheese producers were required to purchase milk at the standard transaction price. However as the price of imported cheese fell, new arrangements were introduced in mid-1987 to enable manufacturers to purchase milk at prices below the standard transaction price.

- *Beef and veal*

Japan's beef industry will undergo significant change on 1 April 1991 when quotas on imported beef will be replaced by tariffs. An *ad valorem* tariff of 70 per cent will apply which will be phased down to 60 per cent in 1992 and to 50 per cent in 1993. Provision exists however, to increase these tariffs by 25 per cent if imports are expected to exceed 120 per cent of the previous year's imports or if they are likely to exceed the 1990 import quota compounded by 20 per cent for each year since 1990 (including the current year), whichever is the higher.

The proposed tariffs represent a substantial reduction on border assistance provided Japanese beef producers which has been estimated to be as high as 200 per cent in recent years (Figure 5.5). The replacement of quotas with *ad valorem* tariffs will thus force major changes in the operation of the price stabilisation scheme for beef operated by the LIPC. This is because the quotas have been used to achieve the very high prices implemented under the LIPC price stabilization scheme.

Figure 5.5: Nominal rates of protection for grain fed beef and grass fed beef: 1983-1986 (per cent)



Source: ABARE (1988 p. 191).

Under the stabilisation scheme run by the LIPC, price bands are established within which beef prices can fluctuate without the LIPC entering the market. These price bands are set by a formula which includes costs of production as a major element (ABARE, 1988, p. 170).

As is the case with other products, setting prices according to costs of production is only possible if competitive imports can be regulated. This has been achieved through the imposition of a global quota on beef imports into Japan which limited imports to about 40 per cent of the domestic market in 1987 (ABARE 1988 p. 198). The LIPC was allocated about 90 per cent of the global quota in 1988. While it allocates this quota in various ways, more recently the quota has been filled using the so-called "simultaneous buying and selling system". Under this system the LIPC sets the maximum price it would pay to importers for beef (the "buy in price") and also sets the minimum price it would accept from end users buying imported beef (the "sell out" price). It then allocates tenders starting with the highest sell-out price offered by an end user and continues allocating tenders until its quota is filled. Effectively by setting these prices the LIPC captures the quota rents created by the restriction on beef imports rather than letting importers or exporters capture them.

The quota rent the LIPC appropriates through these operations has been used to provide support to the dairy industry, which supplies feeder calves to the beef industry and has also been used to provide subsidies directly to beef producers. This form of support will cease after beef imports are liberalised unless direct government support is provided.

- *Sugar*

Sugar cane and sugar beet growing are a relatively small component of Japanese agricultural production. Together, in 1986 they accounted for about 2 per cent of the total cultivated area of Japanese farms. However, in the Okinawa prefecture 48 per cent of the cultivated land supplied 64 per cent of Japan's sugar cane. Similarly, 6 per cent of the cultivated area of Hakkaido was used to produce Japan's sugar beet crop. (ABARE, 1988, p. 201-202).

The Japanese Raw Silk and Sugar Price Stabilization Corporation, a quasi government agency, has a government sanctioned monopsony over domestically produced sugar. Prices for raw sugar are set to cover costs of production, provided millers have paid farmers at least the minimum producer prices for cane or beet.

The minimum producer price for cane and beet are calculated according to a formula which relates the prices of imports to agricultural costs of production and general consumer prices to the costs and prices that prevailed in 1950 and 1951.

Paying millers and farmers prices based on costs of production removes many of the incentives to cut costs. ABARE, for example, calculate that in 1987 the combined payment to cane growers and millers was ¥ 300,000/t of raw sugar or around US 91¢/lb - just over 12 times the world price for raw sugar. ABARE concluded "it is evident that sugar cane growing and milling in Japan are exceptionally costly by world standards". (ABARE, 1988, p. 207)

The prices paid for raw sugar are substantially above the resale price of the raw sugar paid by refineries. This is to enable millers to compete with inputs of raw sugar. The Corporation has thus run at a large deficit requiring large subsidies from budget allocations.

Summary of assistance measures

The diverse forms of interventions in the Japanese Agricultural Sector had to be reduced down to policy variables contained in the SALTER model to enable the removal of this assistance to be simulated. The assistance variables in the model include:

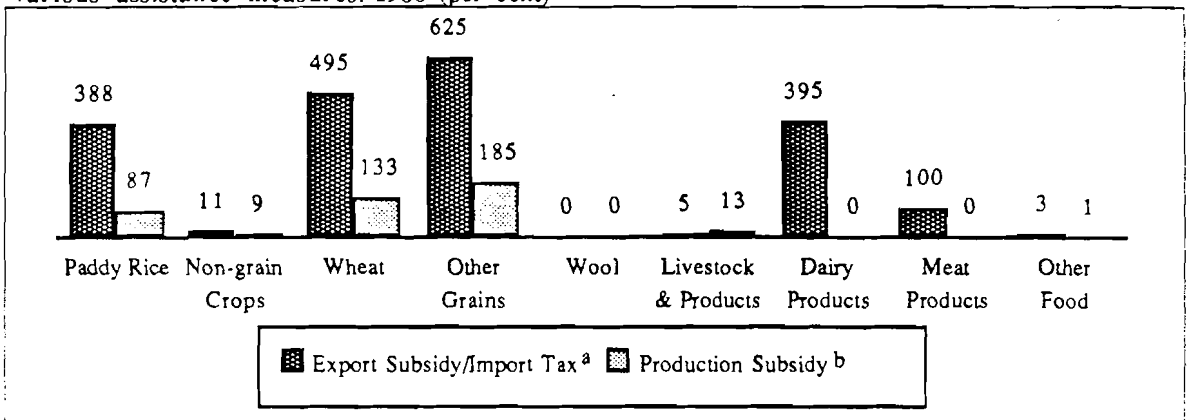
- subsidies paid to producers;
- export subsidies;
- taxes on imported commodities; and
- subsidies provided consumers.

The model also has the facility to alter factor endowments available to each industry. These can be used, for example, to model programs such as the paddy field farming establishment program which diverts land from rice growing to be used in the cultivation of other crops.

In Chapter 3 the OECD's calculations of Producer Subsidy Equivalents were used to calculate the implicit taxes and subsidies provided the agricultural sector of OECD countries. The estimates for Japan derived from this work are graphed in Figure 5.6, where it can be seen that Japanese agriculture is heavily assisted. Not only are there very high barriers to imports but production subsidies to many sectors are also substantial.

To simulate removal of this assistance it was first necessary to incorporate the assistance estimates depicted in Figure 5.6 into the model's database. This is necessary because many of the interventions in the Japanese agricultural sector are not explicitly recognised in the Japanese Input-Output table and a simulation of their removal would greatly understate the economic gains flowing from such a policy.

Figure 5.6: **Estimates of assistance provided Japanese agriculture and related industries by various assistance measures: 1988** (per cent)



[a] Calculated as per unit market price support expressed as a per cent of the world price. [b] Calculated as the per unit value of assistance other than market support all expressed as a per cent of world prices

Source: SALTER database.

The assistance estimates were incorporated into the Japanese database using the UPDATE1 procedure outlined in Chapter 3, but with stocks eliminated from the database. The cost and sales structure of the agricultural sector before and after the inclusion of the assistance estimates is depicted in Table 5.1 where it can be seen that the inclusion of these very high levels of assistance into the database did not alter significantly either the composition of the cost of agricultural commodities or their sales disposition.

Table 5.1: Cost **and sales structure in the Japanese agricultural sector before and after the inclusion of the assistance estimates into the Japanese database**

	(per cent of total cost) *Intermediate inputs* *Domestic*	*Imported*	*Labour*	*Capital*	*Land*	*Total*
Costs						
Before update	42	2	3	29	25	100
After update	42	4	2	28	24	100

	(per cent of total sales) *Intermediate inputs*	*Consumption*	*Investment*	*Government*	*Exports*	*Total*
Sales						
Before update	77	21	2	..	..	100
After update	75	23	2	..	..	100

.. Less than 0.5 per cent.

Source: SALTER database.

Ideally it would have been desirable to update the agricultural assistance database for all SALTER countries. This would enable more accurate estimates to be obtained of the economic implications of the policy changes being simulated. However, the agricultural policies of the United States and the European Community largely operate by insulating producers from world price movements. These policies can be approximated in the closure of the model. For example, import taxes on agricultural commodities and export subsidies can be made endogenous and the quantity of imports and exports of agricultural commodities exogenised. This closure insulates the agricultural sector from world price movements but allows the budgetary implications of these policies to be captured.

Model closure and results

An important part of the use of the SALTER model is the specification of the economic environment in which the simulations are carried out. This specification is known as the 'closure' of the model and alternate closures were outlined in Chapter 2. In this application of the model a medium-run economic environment is used. This represents a time period long enough for primary factors to be reallocated between industries, but not long enough for aggregate factor endowments to change considerably.

The main features of this closure are as follows:

- the employment rate in each economy is fixed, and the wage rate varies so that the aggregate quantity of labour demanded grows at the same rate as the quantity supplied;
- the aggregate capital stock in each economy is fixed, and the rental price of capital varies so that the aggregate quantity of capital demanded remains equal to the available stock;
- capital usage by individual industries varies, so as to maintain fixed relative rates of return across industries;
- aggregate real investment in each economy is fixed;
- in each economy, household savings vary so as to maintain a fixed ratio between the balance of trade and net domestic product;
- in each economy, real aggregate government consumption, and transfer payments move in line with movement in real net domestic product;
- in each economy, the marginal income tax rate varies, so as to maintain a fixed real government budget deficit;
- currency exchange rates are fixed; and
- fob prices of exports from the Rest-of-the-World are fixed.

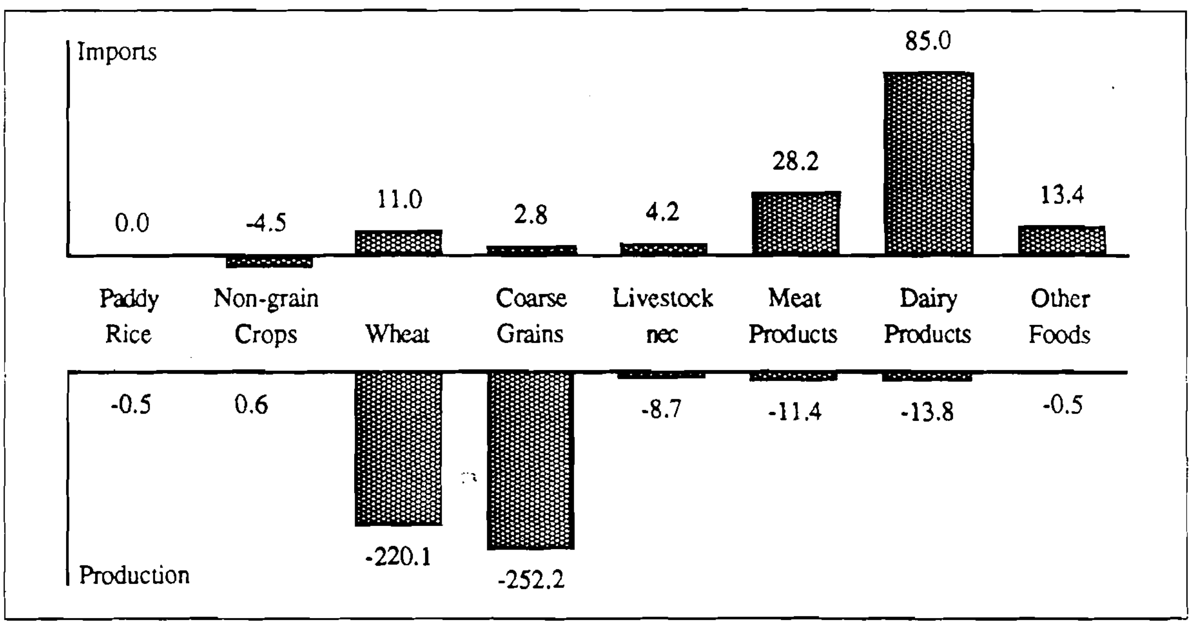
The initial impact of the assistance reductions on import prices and domestic prices of agricultural and related commodities are given in Table 5.2 where it can be seen that removal of import barriers led to a substantial drop in the price of imported agricultural commodities. Removing production subsidies would raise the cost of domestically produced agricultural commodities. Thus, overall, the initial effect of the assistance reductions was to raise domestic prices relative to import prices inducing a substantial substitution of the imported product for the domestically produced product. These substitution effects would then lead to reduced production of the domestic product. They are largely responsible for the production declines shown in Figure 5.7 and the increase in imports of most agricultural commodities.

Table 5.2: **Initial impact of the assistance reductions on prices of imported commodities and prices of domestically produced commodities** (per cent change)

Commodity	*Landed duty paid price of imports*	*Ex-factory price of domestically produced goods*
Paddy rice	-80	22
Non-grain crops	-1	1
Wheat	-83	29
Coarse grains	-86	34
Wool	0	0
Other livestock products	-5	4
Meat products	-50	0
Dairy products	-80	0
Other food products	-15	0

Source: SALTER simulation results.

Figure 5.7: **Estimated effects on the Japanese agricultural sector and imports of agricultural commoditites of removal of Japanese agricultural assistance** (per cent change)



Source: SALTER simulation results.

As shown in Figure 5.7, removing Japanese agricultural assistance led to a large expansion in imports of agricultural commodities other than non-grain crops. According to the model results, liberalisation would lead to all Japanese grown wheat and coarse grains being replaced by imports. Liberalisation in meat products and dairy products would open up large market opportunities for exporting countries with imports of these products expanding by 28 per cent and 85 per cent respectively.

The model results indicate that overall Japanese agriculture would not suffer large output declines following assistance removal. This is mainly because two of Japan's major agricultural sectors, Paddy rice and Non-grain crops, are not affected significantly by reduced protection. These results result from the aggregation together of highly assisted and lowly assisted industries. For example, the industry Non-grain crops consists of highly assisted sectors such as sugar growing but is dominated by crops such as fruit and vegetables for which assistance estimates were not available. Such crops were assumed to receive no assistance. Thus overall this sector is calculated to receive little assistance and therefore producer prices did not fall significantly when assistance was removed.

Paddy rice is very heavily assisted but most of this assistance is initially provided to the rice milling sector which is part of the Other food products industry. When assistance provided milled rice is averaged over all commodities contained in the Other food products industry the sector as a whole was calculated to be relatively lightly assisted. Thus, as can be seen in Table 5.2 import prices for other food products fell by only 15 per cent when assistance was removed.

Paddy rice also receives very high budgetary support and it would be expected that when this assistance is removed, the production of paddy rice would contract significantly. However, the demand for rice is very price inelastic and increasing costs of production does little to reduce demand. In addition, much of the initial increase in the price of rice caused by removal of the producer subsidy was offset by falling land prices. On net, rice prices only rose by 18 per cent thus creating only marginal declines in demand for rice.

Note also that the model results clearly display linearisation errors in some cases. The maximum reduction in wheat and coarse grain output that can occur is 100 per cent. Thus the production drops for wheat and coarse grains output are too large although as these sectors are a relatively small component of the total agricultural sector, these errors are unlikely to have significantly impacted on the overall model results.

Table 5.3: **Changes in real farm income and income earned in food processing industries**[a] (per cent change)

Industry	*Income*
Paddy rice	-28.3
Non-grain crops	-5.2
Wheat	-240.1
Coarse grains	-263.7
Wool	0.0
Other livestock	-31.5
Agriculture	-21.8
Meat products	-13.3
Dairy products	-14.9
Other food products	-0.7
Beverages & tobacco	0.7
Food	-3.7

[a] Calculated as the weighted average of returns to land, labour, capital (net of depreciation) and indirect taxes.

Source: SALTER simulation results

Because a large proportion of Japan's agricultural sector is little affected by the assistance reductions, farm income falls by 22 per cent (Table 5.3). Income earned from livestock activities falls by about twice as much as income in the farm sector as a whole as these activities suffer more import competition. Reflecting the intense import competition the grains sector would face plus the linearisation errors referred to above, income earned from grain farming was simulated to fall dramatically in the simulations.

Returning to a discussion of the overall results for the agricultural sector, no country is seen to gain a competitive edge in supplying the Japanese market after liberalisation. Imports of agricultural and related commodities were simulated to change by the same percentage as imports of each commodity in aggregate (Table 5.4). This suggests that very little substitution amongst imports from different sources occurred in the simulation as the relative cost of producing and transporting commodities to Japan from different countries was simulated to have changed little.

Table 5.4: **Effects of agricultural liberalisation in Japan on imports of agricultural commodities from SALTER countries** (per cent change)

	Commodity	*Australia*	*New Zealand*	*Canada*	*US*	*Korea*	*EC*	*ASEAN*	*All imports*
1	Paddy rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	Non-grain crops	-5.7	-5.3	-4.8	-4.9	-4.8	-4.2	-4.8	-4.5
3	Wheat	9.5	0.0	11.3	11.3	0.0	0.0	0.0	11.0
4	Coarse grains	1.0	2.0	2.7	2.7	0.0	3.2	2.7	2.8
5	Wool	-0.1	1.0	0.0	1.8	1.8	2.2	1.3	0.5
6	Other livestock	2.3	3.1	4.1	4.3	4.5	4.8	0.0	4.2
12	Meat	27.3	27.6	28.3	28.3	28.5	28.7	28.2	28.2
13	Dairy	83.9	84.1	85.0	85.0	0.0	85.3	84.8	85.0
14	Other food products	12.6	12.8	13.4	13.3	13.2	13.5	13.0	13.4

Source: SALTER simulation results.

Imports of Non-grain crops were simulated to fall from all countries and wool imports from Australia were also simulated to fall. Production of Non-grain crops in Japan was simulated to expand following assistance removal. This sector receives little assistance, thus the output reducing effect of lower assistance was more than made up for by the drop in land prices in Japan that followed when the very high assistance provided the rest of the agricultural sector was reduced. The fall in the price of non-grain crops in Japan led to substitution away from imported like items.

The decline in imports of wool from Australia also reflects substitution away from a commodity whose price rose. Reducing assistance in Japan raised nominal factor returns in Australia driving up Australian woolgrowers' costs of production relative to costs of production in other countries. Australian wool became less competitive with other wool hence exports of Australian wool to Japan fell.

Table 5.5: **Macroeconomic effects of agricultural trade liberalisation in Japanese agriculture: Japan** (per cent change)

Variable	
Real ndp	0.21
Real consumption	0.51
Real disposable incomes	0.45
Real household savings	-1.01
Real wage rate	1.35
ndp price index	-0.90
Real balance of trade	-0.03[a]

[a] change in trade balance as a per cent of base period ndp.

Source: SALTER simulation results.

Turning to a discussion of the macroeconomic results, the very large reductions in assistance afforded the agricultural and food processing sectors significantly reduced prices received by Japanese manufactures. Basic, or ex-factory, prices for meat products, milk products and other food products were simulated to fall by 9.2 per cent, 6.5 per cent and 8.0 per cent respectively. These price drops directly and indirectly lowered the production costs of almost all commodities in Japan. While these price reductions were small, they were sufficient to encourage exports of several manufactured commodities and also led to reduced imports of many manufactured commodities. These effects were sufficiently strong to offset the trade imbalance caused by the large influx of agricultural imports following removal of Japanese agricultural assistance. Thus, in the simulation results only a small decline in Japan's balance of trade was observed (Table 5.5).

Most sectors of the Japanese economy benefited from the direct and indirect effects of cheaper agricultural imports, (apart from agriculture and food processing) and gross output of other sectors expanded. These effects were however small (Table 5.6).

The decline in the agricultural and food processing sectors released resources for use in other sectors of the economy. However, as the total stock of resources is largely fixed, they can only generate increased output if they are used more efficiently. As shown in Table 5.5, the reallocation of resources did expand the output of the economy. Real net domestic product was simulated to rise by 0.2 per cent. Resources released from the agricultural sector thus generate greater wealth in non-agricultural uses.

Table 5.6: **Impact on volume of output of removing Japanese agricultural assistance** (per cent change)

Sector	Gross output[a]
Agriculture	-3.6
Resources	0.1
Food processing	-1.8
Manufacturing, non-metallic	0.3
Manufacturing, metallic	0.1
Services	0.1

[a] Calculated as the weighted average of movements in factor income, intermediate usage and commodity taxes.

Source: SALTER simulation results.

Resources released from the agricultural sector enable output of other sectors of the Japanese economy to expand after liberalisation, other than the food processing sector. This increased demand for resources led to rises in rates of return on capital and also led to significant wage rises which leads to increased demand for leisure by Japanese workers. Thus the benefits of increased labour demand following liberalisation are taken out in terms of a 0.03 per cent drop in employment and corresponding increase in time devoted to leisure activities.

Table 5.7: **Effects of liberalisation in Japanese agriculture on the components of Japanese real aggregate disposable income** (per cent change)

Labour income	1.4
Capital income	1.3
Land income	-8.6
Net factor income	1.2
Tax rate	1.5
Real disposable income	0.4

Source: SALTER simulation results.

The strong growth in the demand for labour is also reflected in strong demand for capital. But because the economy-wide stock of capital is held fixed, this increased demand is reflected in higher real rentals accruing to capital (Table 5.7). In contrast, the decline in the agricultural sector leads to a fall in the real land rental. Overall however, returns to factors of production rise significantly, raising real net factor income by 1.2 per cent, which after allowing for a 1.5 per cent increase in marginal tax rates, gives a 0.4 per cent rise in real disposable income. This is close to the observed rise in real consumption of 0.5 per cent (Table 5.5).

With factors of production largely fixed, growth in the economy is reflected in higher rentals accruing to capital and higher wage rates. The increased income these generate plus reduced savings enabled real consumption to expand significantly more than output.

The effects of Japanese agricultural liberalisation on other countries are detailed in Table 5.8 where it can be seen that they would provide small positive gains in real consumption for most countries.

In Australia, Japanese agricultural liberalisation was simulated to lead to an initial movement into external surplus corrected by a rise in the price level, contractions in non-agricultural exports and expansion in imports. The real wage rate rose by 0.03 per cent and the ndp price index by 0.19, with a slight rise in real ndp. The export price index rises by 0.2 per cent, while the import price index rises slightly by 0.01 per cent, so the terms of trade improve by 0.19 per cent, implying an income gain of US$133 million. The volume of non-agricultural exports contracts by -0.63; this is largely offset by the expansion in agricultural exports, so that the aggregate export volume contracts by only 0.02 per cent. The volume of imports expands by 0.17.

The effect on the EC of the reduction in Japanese agricultural and processed food assistance is minor. Most of the EC's trade is with the Rest-of-the-World (77 per cent of exports, and 73 per cent of imports); therefore, changes in the other regions in the model do not effect the EC greatly.

The rise in demand for US agricultural and processed food exports to Japan led to a rise in the US price level, a fall in other exports and an increase in imports. The effects are similar to those

Table 5.8: **Sectoral and macroeconomic effects on other countries of removal of Japanese agricultural assistance** (per cent change)

	Australia	*New Zealand*	*Canada*	*US*	*Korea*	*EC*	*ASEAN*
Sectoral outputs							
Agriculture	0.50	0.16	0.20	0.36	0.11	0.05	0.07
Resources	-0.37	-0.30	-0.02	-0.01	-0.01	..	-0.13
Food	1.10	0.73	0.26	0.30	0.24	0.06	0.47
Manufacturing non-metallic	-0.12	-0.18	-0.03	-0.03	-0.28	-0.02	-0.15
Manufacturing metallic	-0.32	-0.12	-0.08	-0.06	0.08	..	-0.12
Services	0.01	-0.02	..	..	0.01	..	..s
Macroeconomic variable							
Volume of exports	-0.02	-0.03	-0.01	0.06	-0.03	..	-0.05
Volume of imports	0.17	0.09	..	0.10	-0.06	..	..
Real ndp	..	..	..	..	..	..	..
Real consumption	0.05	0.04	..	0.01	-0.02	..	0.02
CPI	0.15	0.12	0.04	0.04	..	..	0.07
Terms of trade	0.19	0.13	0.01	0.06	-0.03	..	0.05
Nominal household savings	0.11	0.11	0.03	0.03	-0.02	..	0.06
Nominal land rental	1.37	0.80	0.55	0.60	0.45	0.12	0.25
Nominal capital rental	0.14	0.11	0.04	0.05	-0.02	0.01	0.07
Money wage rate	0.17	0.12	0.03	0.04	-0.07	..	0.07
Real disposable income	0.05	0.03	..	0.01	-0.01	..	0.02
Nominal balance of trade	..	0.01	..	..	..	..	..

.. *between -.005 to .005.*
Source: SALTER simulation results.

for Australia, except smaller, as exports of agricultural and processed foods constitute less of total production than in Australia. For this reason, the export price index rises less than Australia's, and consequently volumes of exports increase (compared to Australia's fall). However, because of the stronger improvement in its terms of trade Australia is able to increase real consumption considerably, whereas the increase in consumption in the US leads to a slight deterioration in its real balance of trade. Changes in the real balance of trade are determined by the closure, which requires the ratio of the balance of trade to nominal ndp to remain constant. As the US initially had a deficit in its balance of trade, a small increase in ndp leads to a small increase in its trade deficit.

Korea suffers as a result of reduced demand for exports. Korea benefits from increased demand from Japan for other processed foods, but suffers as the decline in the other highly protected agricultural industries reduces the cost of land so that Japanese production of non-grain crops increases, reducing demand for Korea's exports of non-grain crops, a major Korean export. In addition the costs of the Japanese Leather and fur products industry are significantly reduced as the cost of imported livestock and meat products fall. Leather and fur products are a large export industry for Korea, and it suffers from the increased Japanese competition. As a result of the reduction in demand for its exports, Korea undergoes an internal deflation and suffers a further terms-of-trade loss as export prices decline.

New Zealand's story is similar to Australia's, except that the changes are not as great because Japan is a less important market for New Zealand exports. Australia is New Zealand's major trading partner, and to some extent shares Australia fortunes.

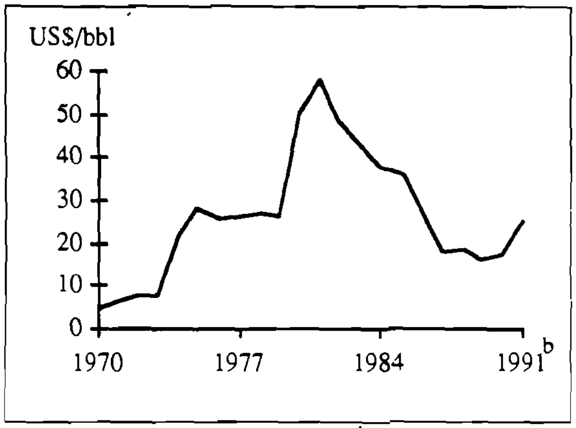
Overall, the effects on third countries of the reduction in Japanese assistance to its agricultural and food processing industries is related to the effect on the demands for their exports. Countries facing a contraction in export demand must undergo an internal deflation and endure a further terms-of-trade loss in order to restore external balance; countries facing an expansion in export demand can expand without worrying too much about inflationary pressures and enjoy a terms-of-trade improvement. The effects are small because the Japanese market is a relatively small outlet for exports of agricultural commodities from other countries.

Implications of higher prices for oil and gas

Background

After Iraq's invasion of Kuwait on August 2, oil prices rose sharply as a result of both the United Nations embargo on 4.3 million barrels a day of Iraq's and Kuwait's exports and fears that Saudi Arabian oil exports could be disrupted in the event of war. So far, however, these fears have proven to be unfounded and oil prices had fallen to US$24 per barrel by January 25.

Figure 5.8: **Real world oil prices**[a] (1990 US$)



[a] World trade weighted crude oil prices. [b] First six months of 1990-91.

Source: Adapted from information supplied by ABARE.

The current oil crisis differs significantly from those of the 1970s when developed economies were even more reliant on oil than they are now. At that time the Organisation of Petroleum Exporting Countries (OPEC) cut supply, driving real world oil prices to an all time record of US$60 per barrel compared to todays of US$24 per barrel (Figure 5.8). In contrast to the 70s oil crisis, todays oil prices have not risen to previous levels because major producers have increased oil production. Increased production by Saudi Arabia, Venezuela, the United Arab Emirates and the UK have ensured that by the end of 1990 nearly all the oil previously exported from Iraq and Kuwait had been replaced. Oil has also been released from the US strategic reserve.

Table 5.9: **Crude petroleum production in key countries and regions** (per cent)

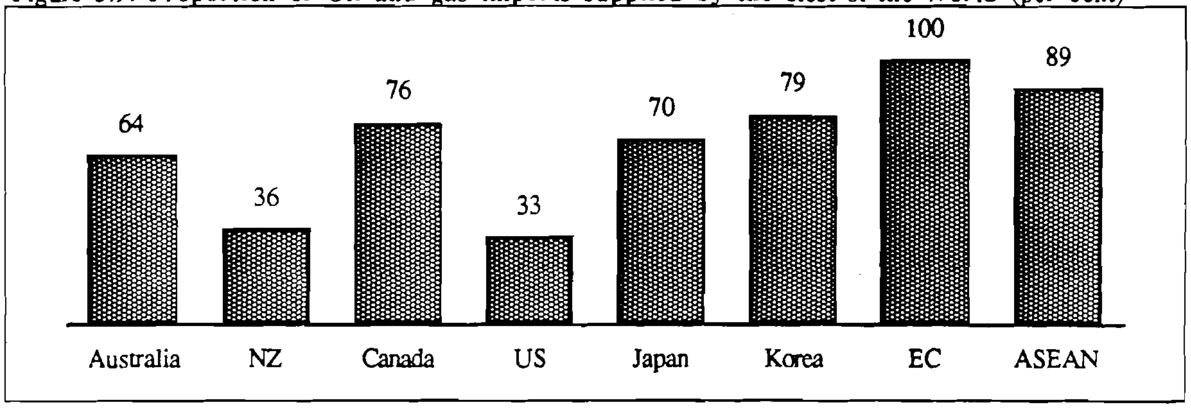
Country/Region	*Share of world production 1986*	*Share of market economies exports 1987*
USSR	22.1	na
Middle East	21.7	35.2
• Saudi Arabia	8.6	15.7
• Iraq and Kuwait	5.5	11.4
• Iran	3.4	8.0
US	15.4	..
Latin America	11.2	10.1
EC (mainly UK)	5.2	9.9
China	4.7	na
ASEAN	3.4	6.1
Australia	0.9	..

na Not applicable as the country is not a market economy.
.. less than 0.05 per cent.
World production: 2.8 billion metric tonnes, world exports $US 118 billion.

Sources: United Nations (1988, 1989).

The fact that crude oil prices are above pre-invasion levels despite world production being maintained, reflects concern about the potential effect of a long-term conflict in the Persian Gulf region on the security of supply from this important producing region. The current conflict in the Gulf might reduce world oil production by nearly 22 per cent, and exports to market economies by 35 per cent (Table 5.9). This has led to added pressure on demand as stocks were built up in the period following the initial invasion.

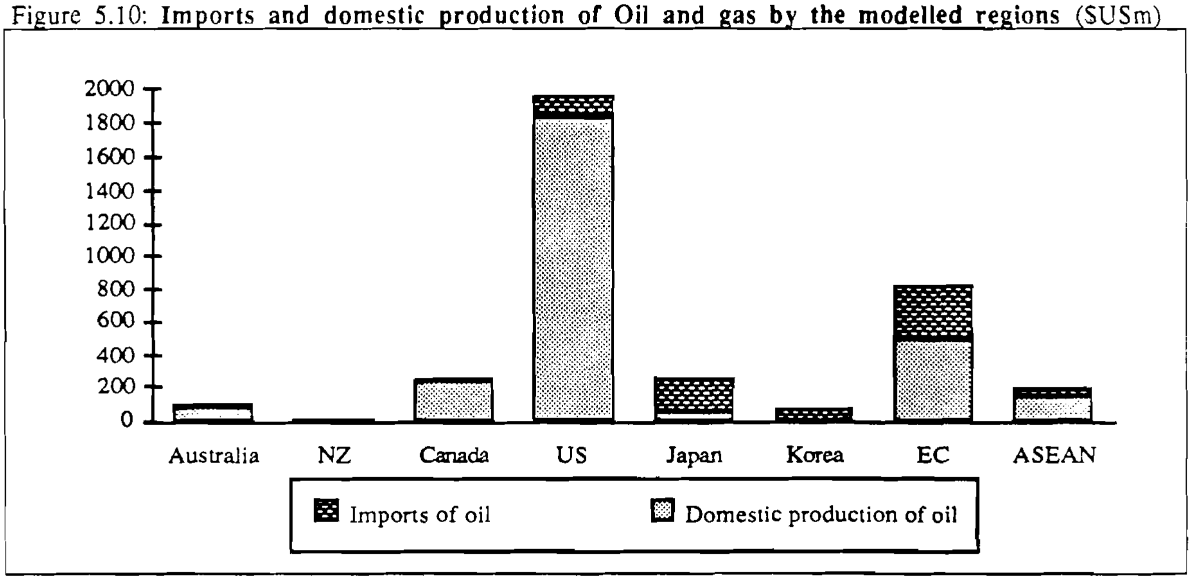
Figure 5.9: **Proportion of Oil and gas imports supplied by the Rest-of-the-World** (per cent)



Source: SALTER database.

If the Middle East was to cease oil production it would initially affect some countries more than others. As shown in Figure 5.9 all modelled countries, except New Zealand and the US, source more than 50 per cent of their crude oil imports from the Rest-of-the-World which includes the Middle East. Japan, Korea and the EC are predominantly dependent on the Middle East for oil.

Figure 5.10: **Imports and domestic production of Oil and gas by the modelled regions** (SUSm)

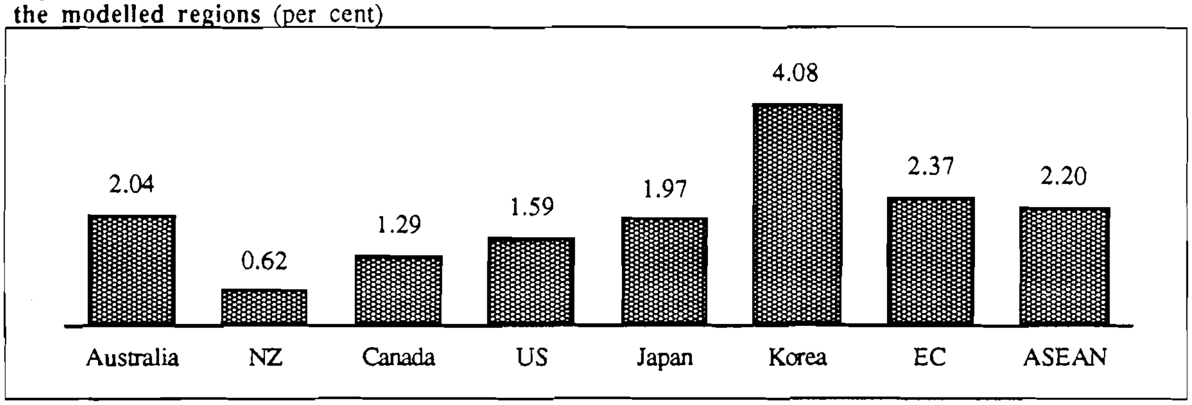


Source: SALTER database.

These countries also source a significant share of their oil and gas requirements from imports (Figure 5.10). Thus their competitive position would be particularly sensitive in the short-run to a rise in the price of Middle East oil. This is because they would not be able to substitute other oil for the higher priced Middle East oil without incurring cost penalties as they adjust their refining operations to different grades of crude oil.

Countries less reliant on Middle East oil would also be disadvantaged as higher Middle East oil prices would be reflected in the price of oil produced in other regions. Thus all countries would face higher oil and gas prices and these would, in the first instance, raise their cost structures as fuel costs are a significant component of industry costs in most countries (Figure 5.11).

Figure 5.11: **Share of intermediate usage of Petroleum and coal products in total costs for the modelled regions** (per cent)



Source: SALTER database.

The assumed economic environment

To provide an indication of the effects of oil price rises on the world economy, recent oil price rises were taken to illustrate the fluctuations that can occur in the oil market. For example, the recent increase in the price of oil from $US16 per barrel in June 1990 to $US26 per barrel on January 2, 1991 corresponds approximately to a 60 per cent price increase. Since the rest of the world region has a significant oil processing capacity, it is assumed that the 60 per cent increase in the price of crude oil also results in a 20 per cent increase in the price of Petroleum and coal products exported by the Rest-of-the-World. Because the SALTER model includes gas production with oil production, the 60 per cent price rise was assumed to apply to both gas and oil.

For modelling purposes, it was assumed that the higher oil and gas prices would be maintained for about two years and their economic effects were evaluated in the model's short-run economic environment. This environment is designed to represent how the economy would respond about 2 years after the oil price rise. The principal features of the short-run economic environment are:

- the capital stock in each industry is assumed to be fixed, and the rental price of capital in each industry is left to vary independently;
- the real wage rate is fixed and the rate of employment is free to adjust as employers can obtain the amount of labour they want to employ at the going real wage rate;
- aggregate real investment is fixed in each economy;
- nominal household savings and consumption expenditure are a fixed proportion of nominal disposable income;
- real government expenditure and transfers are fixed in each economy;
- exchange rates are fixed; and
- fob prices of exports from the Rest-of-the-World are fixed except for Oil and gas and Petroleum and coal products.

Model results

The model results are best interpreted in two stages. The first examines what happened in the oil market while the second traces through the ramifications of oil market changes for competitiveness and trade flows.

The oil market

The model treats oil from different sources as distinct, though highly substitutable commodities. An increase in the price of oil from the rest of the world increases the demand for oil produced in other regions, with the volume responses governed by short-run supply elasticities in the light of the assumed fixed capital stocks in each industry. The constraints on production lead to the biggest response being in the form of price increases rather than increased volumes of production. Table 5.10 illustrates the responses in the oil producing regions modelled.

Because oil is not treated as a homogenous good in the model, price responses vary between regions. Changes in relative prices of oil, combined with the assumed high degree of substitutability lead to large changes in the net flow of oil between regions. However, these

Table 5.10: **Impact of Rest-of-the-World Oil and gas price rises on Oil and gas production and prices in oil-producing SALTER countries**

	Short-run oil and gas supply elasticities[a]	*Per cent change in*[b] *Domestic oil and gas price*	*Oil and gas production*
Australia	1.73	51.8	5.7
Canada	4.55	44.2	13.3
United States	2.89	37.9	7.1
EC	1.27	46.6	3.8
ASEAN	0.10	55.4	0.4

Source: [a] SALTER database, [b] SALTER simulation results.

large volume changes are not sufficient to bring about a uniform change in the price of oil across regions.

This simulated response does not appear to accord with the observed response in the oil market to price shocks. When events which affect the supply and demand for oil occur, the generated changes in the price of oils from different regions is very uniform. The relative homogeneity of oil and the sophistication characterising the markets in which it is traded tend to produce uniform responses in oil prices around the world.

The reason the model does not closely reflect this uniformity in price response lies in the embedded structure of the demand and supply responses and in part to the numerical techniques used to solve the model. The structure is chosen to model all commodities in the same way, but with varying elasticities of demand, supply and substitution. To model a very homogenous commodity requires high degrees of substitution. This generates almost uniform price responses between regions, but even small numerical discrepancies when coupled with the high substitution parameters bring about significant changes in the volume of trade (Table 5.11). Thus it is difficult to select parameters which generate both uniform prices and small changes in net trade. However, the model could usefully be extended to better model the world wide market for some very homogenous commodities such as Oil and gas.

Table 5.11: **Domestic and imported demands for Oil and gas** (per cent changes)

	Domestic sales	*Imports*
Australia	-11.1	-205.0
New Zealand	-25.0	91.7
Canada	-36.0	255.2
US	4.2	-143.4
Japan	5.0	46.9
Korea	0.0	50.4
EC	-39.4	106.1
ASEAN	-117.2	140.3

Source: SALTER simulation results.

For the reasons just discussed, the model results relating to the production and trade in oil and gas are probably unreliable. However, the Oil and gas industry accounts for under 3 per cent of output of all modelled economies (other than ASEAN). Thus unreliable Oil and gas results will not greatly impact on the overall results. The model is therefore considered to be providing valid insights of the economic effects of the higher oil prices indicated in Table 5.10.

Non-oil markets

The effect of the higher oil and gas prices on particular industries in a given country depends, in part, on how important oil and petroleum products are in costs of production in that country, relative to what they are in other countries and the relative importance of oil intensive sectors in total output of the economy. As shown in Table 5.12, the Resources and Manufacturing non-metallic sectors are the most intensive users of oil, gas and petroleum products although the Agricultural and Services sectors also use significant quantities of these inputs. Australian exports are comprised mainly of agricultural commodities, resources and food. Australian production of these commodities is relatively energy intensive, thus Australian exports of these commodities would be sensitive to higher oil and gas prices.

Table 5.12: **Share of Oil and gas and Petroleum and coal products in total costs of aggregate sectors by SALTER country** (per cent)

	Agriculture	*Resources (excl. oil)*	*Food*	*Manufacturing non-metallic (excl. petroleum)*	*Manufacturing metallic*	*Services*
Australia	2.8	3.5	0.9	2.0	2.1	2.3
New Zealand	0.5	2.1	0.2	0.2	0.3	0.9
Canada	4.2	3.1	0.6	2.6	1.0	1.4
US	3.8	3.1	0.4	3.7	0.6	2.5
Japan	1.4	7.7	0.6	4.3	1.1	2.1
Korea	0.5	6.3	1.0	4.0	2.8	5.2
EC	2.6	3.7	1.2	2.6	1.4	1.8
ASEAN	0.4	4.5	0.6	1.7	1.6	3.3

Source: SALTER database.

But the simulated effects on industry outputs of the oil and gas price rises is influenced as much by indirect effects as they are by the direct effects of higher oil prices. In particular, real disposable income fell in all countries. This fall was largely responsible for reduced consumption of most commodities in most countries. This can be seen in Table 5.13 where consumption of domestic commodities across countries moves very much in line with movements in real disposable income. The exceptions are Agricultural and Food commodities, whose expenditure elasticities are very low in the SALTER model, and Oil and gas and Petroleum and coal products where consumption changes are dominated by the large price changes observed in the simulation results.

The declines in consumption dominated changes in other uses so that the simulated changes in gross output across countries (Table 5.14) are very similar to the observed changes in consumption. The major exceptions are the Oil and gas industry and the Petroleum and coal products industry where exports from most countries were simulated to expand, offsetting, in

Table 5.13: **Effects of simulated Oil and gas price rises on consumption by SALTER country** (per cent changes)

	Oil and gas	*Petroleum and coal products*	*Agric.*	*Resources (excl. oil)*	*Food*	*Manuf. non-metallic (excl. petroleum)*	*Manuf. metallic*	*Services*	*Real disposable income*
Australia	-44.41	-41.36	-1.55	-6.11	-1.35	-3.65	-4.02	-3.44	-3.37
New Zealand	-25.83	-15.00	-0.17	-0.54	-0.22	-0.71	-0.87	-0.72	-0.81
Canada	-23.67	-17.23	0.46	0.28	0.09	-0.24	0.13	-0.39	-0.61
US	0.00	-14.35	-0.08	-0.19	-0.16	-1.18	-0.81	-1.18	-1.37
Japan	-22.81	-7.26	-0.09	-1.08	-0.35	-1.03	-1.13	-0.88	-0.89
Korea	0.00	-12.86	-1.67	-4.55	-2.20	-4.63	-4.78	-4.25	-3.91
EC	-26.84	-9.81	-0.76	-1.47	-0.64	-1.45	-1.80	-1.47	-1.52
ASEAN	0.00	-5.89	0.12	0.05	-0.02	-0.12	-0.12	-0.21	-0.15

Source: SALTER simulation results.

the case of the Oil and gas industry, the observed consumption declines. Thus gross output of Oil and gas rose in all countries.

Table 5.14: **Changes in gross output by aggregate sector by SALTER country** (per cent changes)

	Oil and gas	*Petroleum and coal products*	*Agric.*	*Resources (excl. oil)*	*Food*	*Manuf. non-metallic (excl. petroleum)*	*Manuf. metallic*	*Services*
Australia	5.68	-62.88	-1.34	-2.09	-1.49	-3.07	-2.86	-2.06
New Zealand	4.31	-15.93	-0.13	-0.90	-0.10	-0.31	-0.30	-0.39
Canada	13.29	-32.70	-0.67	-2.64	-0.92	-2.94	-4.21	-0.98
US	7.11	-11.83	-0.89	-3.46	-1.00	-2.71	-2.91	-1.28
Japan	39.28	-0.12	-0.05	-0.37	-0.25	-0.48	0.10	-0.38
Korea	0.00	-1.49	-0.26	-0.63	-0.98	-0.13	0.64	-1.04
EC	3.82	1.40	-0.41	-1.06	-0.56	-1.10	-0.66	-0.83
ASEAN	0.40	-52.73	-0.13	-0.34	-0.18	-0.90	-1.02	-0.52

Source: SALTER simulation results.

Macro-economic effects

Turning to a discussion of the macro-economic results, the oil and gas price rise results in a worsening in the terms of trade for most oil importing regions, and an improvement for oil exporting regions. Terms of trade deteriorate for Korea, Japan, the EC and New Zealand, but improve for the ASEAN countries, Canada, Australia and the United States.

Deterioration in a region's terms of trade means that the commodities on which it spends its income become more expensive relative to the commodities it earns income by producing. So, if it continued to produce and purchase the same quantities as initially, its consumption expenditure would rise more than its income, and the region as a whole would move into external deficit. But in the SALTER model's short-run economic environment the household sector is assumed to reduce its consumption, so as to maintain fixed ratios between consumption spending, saving, and disposable income. Thus, in regions simulated to suffer a deterioration in their terms of trade, the simulation shows household consumption declining, in response to declining household disposable income (Table 5.15).

In most countries, production costs increase significantly, and although weaker consumption reduces aggregate demand, consumer prices increase. With fixed real wages, this results in higher money wages, which result in significant employment decreases. The increased share of labour, as well as oil and other intermediate inputs in production costs reduce returns to capital and land. Reduced returns to capital and land and a reduced wage bill reduce factor income and lead to reduced disposable income and consumption.

The effects of a terms of trade decline on export volumes vary across regions. In Korea and Japan, the decline in household consumption and the resulting reduction in costs of inputs into trade-exposed industries are so great that export competitiveness improves overall, despite the

Table 5.15: **Simulated effects of high Oil and gas prices on selected macro-economic variables** (per cent changes)

	Australia	*New Zealand*	*Canada*	*US*	*Japan*	*Korea*	*EC*	*ASEAN*
Real ndp	-4.07	-0.48	-1.39	-1.56	-0.33	-0.93	-1.17	-0.93
Real consumption	-3.37	-0.81	-0.61	-1.37	-0.89	-3.91	-1.52	-0.15
Consumer price index	0.66	1.01	3.40	2.95	0.24	-1.99	0.35	1.11
Price index for ndp	0.99	0.75	4.23	3.08	-0.05	-4.14	0.07	2.18
Export price index	2.71	0.97	5.01	2.87	0.78	0.29	1.21	5.56
Import price index	2.34	2.31	2.28	2.34	5.24	7.00	3.29	3.06
Terms of trade	0.36	-1.34	2.73	0.53	-4.46	-6.70	-2.09	2.50
Volume of exports	-9.51	-0.20	-0.92	-7.57	1.32	4.06	3.74	2.29
Volume of imports	-2.83	-0.37	2.28	-1.63	-1.36	-1.15	2.76	4.00
Labour employment	-3.27	-0.74	-2.11	-2.06	-0.45	-1.55	-1.14	-2.45
Nominal household savings	-2.71	0.20	2.79	1.58	-0.65	-5.90	-1.18	0.96
Nominal land rental	-5.28	-1.47	-6.43	-7.65	-4.22	-7.58	-3.60	-0.87
Money wage rate	0.66	1.01	3.40	2.95	0.24	-1.99	0.35	1.11
Real disposable income	-3.37	-0.81	-0.61	-1.37	-0.89	-3.91	-1.52	-0.15
Nominal balance of trade (USS m)	-4 427	-96	-249	-22 315	-2 035	-763	969	348
Change in the balance of trade to ndp ratio	-1.49	-0.27	-0.11	-0.48	-0.07	-0.41	0.06	0.16
Nominal PSBR[a] (USS m)	3 688	60	381	21 070	887	953	12 582	-503
Change in PSBR to ndp ratio	-1.14	-0.15	-0.07	-0.46	-0.02	0.11	-0.32	0.13
Net investment (US$ m)	406	67	1 062	2 052	521	19	-6 351	-126
Private savings (USS m)	-337	17	1 209	772	-545	207	7 126	-281

[a] PSBR public sector borrowing requirement.

Source: SALTER simulation results.

deterioration in the terms of trade; hence export volumes expand.

Terms of trade improve in Australia, Canada, US and ASEAN. However in all of these countries, both output and real consumption decline. In these countries the rise in oil and gas prices feeds through into costs of production raising the price of exports. With fob export prices fixed in the Rest-of-the-World this leads to a substitution away from exports whose prices had risen. Thus the terms of trade improvement in these countries is driven by cost-push inflationary factors rather than increased demand for exports.

Given that Australia is an 'energy exporter' it is surprising that Australia fares so poorly in the simulation. There are basically two reasons for this result. First, higher oil prices would be expected to lead to increased demand for other energy sources such as coal. As these substitution possibilities are not accounted for in the model, a major way Australia would benefit from higher oil prices was not accounted for. Second, Australia's petroleum and coal products industry has very little value added in the official input output table. Thus higher oil and gas prices are almost fully passed on into higher petroleum prices. A given increase in oil and gas prices thus generates a bigger increase in the price of Australian petroleum than in other countries. Oil and gas price rises are thus more inflationary in Australia and with wages fully indexed to the consumer price index in the short-run closure of the SALTER model, this inflationary pressure significantly raised the cost of Australian exports relative to exports from other sources. Thus output declined significantly driving down factor returns in Australia and hence real consumption.

In all countries higher oil and gas prices initially raised consumer prices. Because nominal wages are fully indexed to the consumer price index this created a wage-price spiral leading to significantly higher consumer prices in all countries other than Korea. In Korea, as outlined above, declining consumer demand depressed factor returns, offsetting the effects on the consumer price index of higher oil prices. Thus the consumer price index fell in Korea.

Domestic savings are simulated to fall in all countries other than ASEAN and the EC. This was largely caused by increased public sector borrowing. The blow-out in the public sector borrowing requirement was both expenditure and revenue driven. Expenditures rise as government are assumed to maintain their real spending, and thus when the consumer price index increases, nominal spending also rises. At the same time revenue fell largely because the output of all economies declined. With nominal spending rising and revenue falling, the public sector borrowing requirement rose in all countries other than ASEAN. In most cases the increase in the public sector borrowing requirement was largely matched by a deterioration in the balance of trade so that increased public borrowing was financed through an expansion in each country's trade deficit (or contraction of their surplus). The exception was the EC where the increased public sector borrowing of US$12.6 billion was largely funded through increased private savings of US$7 billion and a cut in net investment of US$6 billion.

The simulation results highlight the need for economies to be flexible if they are to minimise the economic cost of adverse international events. To demonstrate this the oil and gas price shocks was re-run assuming flexible labour markets in all countries but with all other features of the previously described economic environment unchanged. The results of this simulation are summarised in Table 5.16.

Table 5.16: **Estimated macro-economic effects of higher oil and gas prices; assuming flexible labour markets**

	Australia	*New Zealand*	*Canada*	*US*	*Japan*	*Korea*	*EC*	*ASEAN*
Real ndp	-1.38	-0.06	0.11	0.06	0.01	0.03	0.02	0.20
Real consumption	-1.59	-0.38	0.74	-0.36	-0.71	-3.39	-0.61	0.71
Price index for NDP	-2.22	-0.54	2.74	0.30	-1.55	-5.75	-1.00	0.63
Terms of trade	-0.47	-0.65	3.06	-1.01	-4.86	-6.97	-2.59	2.60
Volume of exports	-3.58	0.93	1.90	-0.24	2.98	6.36	5.80	4.17
Volume of imports	-2.77	0.50	3.69	-2.82	-1.21	-0.27	2.98	4.96
Labour employment	0.17	0.05	0.11	0.11	0.03	0.13	0.05	0.00
Money wage rate	-4.72	-1.19	0.20	-1.22	-1.68	-5.33	-1.47	-2.99
Real disposable income	-1.59	-0.38	0.74	-0.36	-0.71	-3.39	-0.61	0.71

Source: SALTER simulation results.

Terms of trade fell for all oil and gas net importers and they rose for the oil net exporters (Canada and ASEAN). Real consumption fell in countries in which the terms of trade fell and were simulated to rise in the oil and gas exporting countries. Employment increased in all countries although not significantly in ASEAN. With employment rising and capital and land fixed output of all economies would have increased marginally. Thus the major adverse effect of higher oil and gas prices for net importing countries was simulated to be reduced real consumption. This was largely brought about by lower wages.

It is also clear from these results that the assumptions made regarding the labour market are a crucial determinant of the overall results. Some attention should be given to determining the most operable labour market treatment for particular countries.

In summary there are two critical assumptions driving the model results. First, the assumption of fixed real wages is largely responsible for the setting of a wage-price spiral in most countries increasing fob export prices relative to fob export prices in the Rest-of-the-World. Second, real government expenditure was held constant as were tax rates. This created a blow-out in the public sector borrowing requirement which in most countries was financed through a deterioration in the balance of trade.

APPENDIX A: DETAILED MODEL STRUCTURE

This appendix provides a description of the SALTER equation system. The system of equations is found in Table A1, while Tables A2 and A3 provide detailed descriptions of variables and parameters, respectively.

Unless specified otherwise, items described in the tables are indexed by country z=1...,S. In the interest of conciseness, the regional reference is omitted in the descriptions of equations, variables and parameters. The model structure is the same for all S regions modelled explicitly. References to the rest of the world (region S+1) are specifically mentioned.

All lower case variables represent percentage changes in the corresponding price or quantity index. Upper case symbols correspond to the actual levels of a quantity and are described in the parameter list as levels in parentheses.

In general, geographical references are confined to superscripts. Most variables and parameters are specific to one of the S modelled countries and are superscripted z (z=1...,S). Other possible superscripts are D ('domestically produced' - or shortened to 'domestic'), I ('imported'), W ('world') and S+1 ('rest of the world').

Subscripts generally specify the commodity (i), factor of production (k) and/or industry (j) characterising the main symbol. Since commodities are differentiated by country of origin (source), thus making them products with 'different' characteristics, this particular geographical reference is included in the form of a subscript.

Uppercase subscripts indicate a particular use in final demand or another macro-economic aggregate, that is, C ('consumption'), G ('government consumption'), K ('investment demand'), E ('export demand') and Q ('aggregate supply').

The equation system consists of 9 types of equations which describe the structure of each modelled region and international trade flows:

1. The production structure which reflects the structure of input use by enterprises assuming they maximise profits,
2. The consumer demand system in which a single aggregate consumer is assumed in each modelled country to maximise utility from the consumption of goods and services purchased from the productive sector,

3. The government activities sector which consists of the fiscal activities of collecting commodity and income taxes and distributing subsidies, the government's purchase of commodities for providing public goods, and the distribution of direct transfers to households,

4. Other final demands: investment, exports and changes in stocks, the latter category expected to be eliminated in future implementations of the model,

5. Market clearing conditions whereby quantities domestically supplied are required to equal the sum of all uses,

6. Price transmission and aggregation equations where the relations between prices and taxes are defined,

7. Zero profit conditions which are based on the assumption of perfect competition within each modelled region,

8. Income aggregations in which macro-economic measures of economic performance are defined,

9. Trade aggregations and balance equations through which the system of trade flows among modelled countries and with the rest of the world is closed.

The model includes a number of variables that are not strictly needed to describe the structure of the model. They are however helpful in explaining simulation results and are included in the computer code. They are therefore included here as part of a complete documentation of the computer code.

The production structure

Intermediate inputs

The production decisions faced by producers are specified in equations 1.1 to 1.4. Output of each industry in each country is produced using a bundle of intermediate inputs and a bundle of primary factors of production. These bundles are used in fixed proportions but within bundles substitution amongst the components of the bundle is possible. Given a level of output, producers are assumed to minimise the cost of putting together the bundles of primary factors and intermediate inputs.

The cost-minimising choices for intermediate inputs are described in equations 1.1 to 1.3. These equations specify derived demands in each industry j for domestically produced and imported intermediate inputs of type i (variables x_{ij}^{Dz} and x_{ij}^{Iz} respectively).

Because intermediate inputs are used in fixed proportions the demand for both domestic and imported intermediate inputs moves directly in line with movements in industry output. Thus an increase in industry output (q_j^z) results in equations 1.1 and 1.2 in a proportional increase in x_{ij}^{Dz} and x_{ij}^{Iz}. In addition producers substitute between domestically produced and imported intermediate inputs in response to movements in the relative prices of these inputs. These effects are captured by the second terms of equations 1.1 and 1.2. These terms are the linearised demand equations for intermediate inputs conditional on the level of output, derived from a constant elasticity of substitution production function assuming producers minimise costs at each level of output.

In these equations the extent of substitution between domestic and imported intermediate inputs is determined by the CES substitution parameter η_i^z multiplied by the difference between the price of the commodity specified by origin (domestic or imported) in the left hand side and the weighted average price of commodity aggregate i used by industry j regardless of its domestic or imported origin.

In equations 1.3 the aggregate demand for imported intermediate inputs is broken down into imports from all source countries. The change in demand for imported intermediate inputs by source is related to the change in demand for aggregate imported intermediate inputs, but this effect is tempered by the possibility of substitution among intermediate inputs from different sources. Thus equation 1.3 contains the aggregate intermediate input demand as its first term. In addition substitution amongst intermediate inputs is allowed for in the second right hand term of equation 1.3. These terms are the linearised imported intermediate demand equations conditional on the level of import demand for intermediates derived from a CES production function. As previously outlined these equations express conditional input demand as a function of the degree of substitutability of imports from different sources (captured by the term η_i^{Iz}), and the difference between prices of imports from one source and a weighted average of import prices from all sources.

Primary factors

The SALTER model assumes producers have access to three primary factors of production: land (used only in the agricultural sector), labour and capital. Primary factor demands are determined by equation 1.4. Changes in primary factor demands are proportional to output unless the relative prices of primary factors change. Equation 1.4 includes industry output (q_j^z) to capture output expansion effects, while substitution effects amongst primary factors are captured by the second right hand side term in the equation. These terms are the linearised form of the conditional input demand equations for primary factors derived from a CES production function. The scope for substitution amongst primary factors is determined by the substitution parameter (σ_j^z) and by how much the price of individual primary factors move relative to the average price of all primary factors as a whole.

Industry demands for each primary factor are aggregated across industries in equations 1.5 to obtain the economy-wide demand for the three primary factors. Since the aggregate supplies of capital and land are fixed, the change in the aggregate demand (f_{Dk}^z) is equal to the aggregate supply of these factors. In the case of labour however, changes in the rate of employment are allowed for, and a separate variable is included for labour supply (f_{S1}^z). Equation 1.6 relates the labour supply (f_{S1}^z) to the real after tax wage rate (the term in square brackets).

The equations explaining the production structure (1.1 to 1.4) are a set of conditional input demands. They are conditional on the level of output and result from solving the producers' cost minimisation problem. Changes in the level of output (q_j^z) are determined in the market clearing equations 5.1. In order for markets to clear, the change in output is required to equal the sum of changes in all domestic demands and export demand.

Technical change

Technical change is allowed to affect the efficiency of:

1. intermediate inputs as a whole;
2. individual components of value-added; and
3. all inputs to production as a whole.

Technical change is modelled through variables a_{tj} where t indicates the type of technical change and j indicates the industry in which technical change occurs. Setting variables $a_{Xj}^z = -1$ (t = X for intermediate inputs) results in a 1% decrease of the requirements for all intermediate inputs (whether domestic or imported). Similarly, setting $a_j^z = -1$ results in a 1 per cent decrease in the use of intermediate inputs and primary factors.

Technical change is also assumed to affect the use of individual primary factors. As seen in equation 1.4, a technical change improving the efficiency of primary factor k by 1 per cent results in a decrease in its use of:

(A.1) $$1-\sigma_j^z(1-S_{kj}^z)$$

According to expression (A.1), as efficiency in a primary input's use is increased, resources are shifted out of its use and into the use of other primary factors according to the rate at which the factors substitute for each other.

The consumer demand system

The representative consumer is assumed to face a multi-level decision process. In the first stage of the process, according to the prices of consumer commodities, consumers decide upon the consumption of each commodity which maximises their utility from spending income available for consumption. The utility function is assumed to result in a linear expenditure system. Thus a change in the consumer demand for commodity i is a linear function of the prices of all commodities purchased (p_{Ch}^z), and aggregate consumption expenditure (c_T^z).

Having decided how much of each commodity to consume, the second stage of the consumer's decision process involves a choice about how much of each commodity should be sourced from imports and how much from domestically produced goods. To solve this problem the representative consumer is assumed to minimise the cost of combining imported and domestic goods to achieve the aggregate level of demand determined at Stage 1 in the decision process. The cost-minimising opportunities available to the consumer are represented by the parameters of a constant elasticity of substitution function. Thus in equations 2.2 and 2.3 demands for domestic and imported commodities are a function of the aggregate consumer demand for each commodity (c_i^z) determined at Stage 1 in the decision process. In addition, substitution between domestic and imported commodities is allowed for in equations 2.2 and 2.3.

Stage 3 of the representative consumer's decision process involves minimising the cost of acquiring the bundle of imported commodities determined in Stage 2 of the decision process. The cost minimising opportunities available to the consumers are represented by a constant elasticity of substitution function. Imports from each source are a function of the aggregate level of imports decided upon at Stage 2 in the decision process (ie. c_i^{Iz}) and of movements in relative prices. To capture these substitution effects, in equation 2.4 the difference in the percentage change of import prices from different sources is multiplied by the compensated price elasticity of demand for imported commodities (ie. β_i^{1z}) to determine the percentage change in the compensated demand for imported consumer goods from different sources.

An important component of the household's decision process revolves around the amount of income to save. In equation 2.5 changes in private savings sv^z are linked to changes in consumption c_T^z. However, there may be simulations which require this link to be broken. To allow for this, equation 2.5 also includes a saving shift term (h_c^z). Endogenising this term would allow private savings to move independently of changes in consumption.

Equation 2.6 defines disposable income (y_d^z) as a weighted average of the percentage change in private expenditure (c_T^z) and private savings (sv^z). The percentage changes in these variables are weighted by their respective shares in the base value of disposable income. In equation 2.7, the change in real consumer expenditure is defined as the difference between changes in nominal expenditure and the consumer price index.

The government activities

The government's activities are composed of a fiscal and a public expenditure aspect. Fiscal duties include the collection of commodity taxes, indirect taxes, and income taxes, thus providing revenues to purchase commodities from the private sector.

Equation 3.1 defines real government expenditure (g^z) as the ratio between nominal expenditure (z_G^z) and the price index of government purchases. The government allocates in equation 3.2 a fixed proportion of its real budget (g^z) to each commodity (gov_i^z), thereby assuming that the composition of government expenditure does not vary. In this first stage in which government demand for a commodity (gov_i^z) is determined, prices are not taken into account. Having decided on the allocation of its resources among different commodities, the goverment minimises the cost of acquiring each commodity by purchasing it domestically or importing it from different sources. This process is similar to the one conducted by consumers and producers. Different preferences for domestic and imported commodities can however be specified as different values of the elasticity of substitution for the various end users.

Prices of domestic commodities relative to imports are important in the second stage of government decision-making, where a constant elasticity of substitution function rules the choice between domestic and imported commodities. In this stage, government preferences are modelled in the elasticity of substitution between domestic and imported commodities (β_{Gi}^z). Subject to these preferences and the relative prices of domestic and imported commodities, the government minimises the cost of acquiring the amount of each commodity required to satisfy the proportions specified in the database. Changes in demands for domestic commodities (gov_i^{Dz}) and imports (gov_i^{Iz}) are specified in equations 3.3 and 3.4 as functions of changes in the aggregate level of commodity i demanded by the government (gov_i^z), the elasticity of substitution (β_{Gi}^z) and changes in the price of the domestic commodity and the average price of imported commodities.

In a third stage of the decision process, the government minimises the cost of imports subject to the aggregate level of imports determined in stage 2, the prices of imports from different sources, and the degree to which imports from different sources can be substituted. A constant elasticity of substitution (β_{Gi}^{Iz}) is used to model the degree of substitutability among sources of imports. The change in quantity imported from a particular source is therefore modelled in equation 3.5 as a function of changes in the aggregate demand for imports of the commodity (gov_i^{Iz}), the elasticity of substitution (β_{Gi}^{Iz}), and the difference between changes in the price of the commodity (p_{Gis}^{Iz}) and the average price of imports (p_{Gi}^{Iz}).

Fiscal duties of the government include raising taxes and distributing subsidies to industries and transfers to households. Taxes can be levied at each level of economic activity. Import duties, taxes on domestic and imported commodities, and export taxes are specific to the commodity and the use to which it is put. The contribution of different commodity taxes to government revenues is described in equations 3.6 to 3.13. The contribution of a tax on a particular commodity i to aggregate government revenue (r_G^z) in percentage change is usually expressed as:

(A.2) $$r_{Gi} = \frac{T_i P_i X_i}{R_G}\left[x_i + p_i + \left(\frac{1+T_i}{T_i}\right)t_i\right]$$

where

T_i	is the *ad valorem* tax rate applied to commodity i,
P_i	is the price of commodity i,
X_i	is the demand for commodity i,
R_G	is the sum of aggregate government revenues,
r_{Gi}	is the contribution of taxes on commodity i to aggregate government revenues,
t_i	is the percentage change in the power of tax T_i, and

x_i, p_i are the percentage change variables corresponding to the level variables defined above.

According to equation A.2, the change in government receipts from a tax is equal to the share of revenues from this tax in aggregate government revenue multiplied by the sum of the effects on each component of revenue stemming from the tax, that is, changes induced in the volume of transactions (x_i), the price of the commodity (p_i), on the exogenous change if the power of the tax rate (t_i).

When the tax rate $T_i = 0$, the expression in A.2 is undefined. Distributing the $T_i P_i X_i$ term, the equation was therefore rewritten as:

$$r_{Gi} = \frac{1}{R_G}\left[t_i\left(P_i X_i + T_i\right) + T_i P_i X_i\left(x_i + p_i\right)\right] \qquad \text{(A.3)}$$

The coefficient on t_i is the value of after-tax expenditure on commodity i, and the coefficient on x_i and p_i is aggregate tax revenues from taxing commodity transaction i. The change in the contribution of a commodity tax to aggregate government revenue is therefore composed of an exogenous effect due to a change in the particular tax (t_i) and an endogenous effect due to changes in the tax base ($x_i + p_i$). This principle was applied when deriving equations 3.6 - 3.12 which describe the contribution of each tax to revenues from commodity taxes.

The contribution of income taxes to government revenues is found in equation 3.13, while the aggregate contribution of all components of government revenue from commodity taxes is described in equation 3.14. In equation 3.13, the change in the contribution of income taxes to government revenue (r^z_{GY}) is a function of changes in the marginal income tax rate (t^z_Y) and taxable income (y^z), a marginal tax parameter (R^z_Y) and an indexation scheme that determines the minimum taxable income. R^z_Y is defined as the marginal tax rate multiplied by the household income level. The last two terms in equation 3.13 are used to index the minimum taxable income to income or the consumer price index. When $h^z_{T1} = 1$ and $R^z_{T2} = 0$, the intercept of the linear income tax schedule (R^z_T), is tied to the consumer price index. Conversely when $h^z_{T1} = 0$ and $h^z_{T2} = 1$, parameter R^z_T and the minimum taxable income is tied to income.

Changes in aggregate government revenue from commodity taxes are defined in 3.14 as the sum of changes in the contribution of each tax. Changes in aggregate government revenue are defined as the sum of changes in government revenues from income taxes from commodity taxes. Real transfers to households are calculated by deflating transfers by the consumer price index. In equation 3.16 changes in real transfers are found to be equal to changes in nominal transfers less the consumer price index.

The budget deficit is found in equations 3.17. This variable (bd^z) is expressed in terms of changes in the levels because it can be positive or negative, and would affect the sign of a variable defined in terms of relative changes if it was expressed in terms of relative changes. The nominal change in the budget deficit is defined as the difference between the change in the level of revenues ($R^z_G\, r^z_G$) and total government outlays, composed of transfers to households ($T^z_G\, t^z_G$) and public expenditures on commodities ($Z^z_G\, z^z_G$).

Equations 3.18, 3.19 and 3.20 specify ratios that may be used to specify different types of model closures. The change in the first ratio is equal to the difference between private and public expenditures. The second ratio is defined as the ratio of aggregate factor income to government transfer payments to households. The third ratio is defined as the ratio between the get deficit and ndp. These ratios may be fixed to maintain constant relative growth among the variables they include.

The other final demands

Other final demands are composed of investment and export demands. The exogenous level of real investment (inv^z_R) determines in 4.1 the nominal level of investment (inv^z_N) through a capital price index (pci^z). The disaggregation between domestic and imported commodities by source follows the two-stage, constant elasticity of substitution structure described above for input and consumer demands. Parameters β^z_{Ki} and β^{Iz}_{Ki} are the elasticities of substitution between domestic and imported commodities and among imported commodities of different sources used in investment. They are used in equations 4.2 to 4.4 to determine investment demand for each commodity.

Capital depreciation is defined in equation 4.5 as a function of gross investment or changes in the value of the capital stock. This is expressed in nominal terms by multiplying the capital stock by the price index of investment goods (pci^z). Since full employment is assumed, the capital stock is indicated equivalently by the aggregate demand for capital (f^z_{Dz}).

The following equations relate to export demand. Equation 4.6. shows that a given region's export of a commodity is equivalent to the corresponding region's imports of that commodity. Changes in aggregate export demand for a particular region's commodity are the weighted sum of the changes in demands from all other regions and the rest of the world (4.7). Equation 4.8 expresses the change in commodity i exports from region z at fob prices as the sum of changes in the price of exports and export volumes to all destinations. In equation 4.9, changes in the fob value of exports by region z are calculated as the sum of changes in prices and volume of exports to a given destination.

The market clearing conditions

In these conditions, changes in domestic production of each commodity (q^z_j) is required to equal the weighted sum of changes in all demands for the commodity: demand for intermediate inputs and for investment purposes, consumer, export and government demands and demands for changes in stocks. The weights S^{Dz}_{QXij}, S^{Dz}_{QKi}, S^{Dz}_{QCi}, S^{Dz}_{QEi}, S^{Dz}_{QGi} are the respective shares of each demand component in the aggregate demand for commodity i.

Equilibrium in the labour market is expressed in (5.2) in terms of an exogenous rate of employment (em^z_l). In other factor markets (land and capital) full employment is assumed to prevail according to equation 5.3.

The price transmission and aggregation equations

The equations in Part 6 show the relation between prices of individual commodities from each source, taxes and price indices of commodity aggregates. *Ad valorem* commodity taxes can be applied upon entry in an economy in the form of a duty specific to the source of a commodity (d^z_{is}), or once inside an economy in the form of taxes according to the commodity, whether domestic or imported, and according to the use it is to be put to (ie. $t^{Iz}_{ij}, t^{Dz}_{ij}, t^{Iz}_{Ci}, t^{Dz}_{Ci}, t^{Iz}_{Gi}, t^{Dz}_{Gi}, t^{Iz}_{Ki}, t^{Dz}_{Ki}, t^{Iz}_{Si}, t^{Dz}_{Si}$). Exports may also be taxed using t^z_{Ei}. All these variables are defined in terms of powers of the tax (that is, one plus the tax rate). This system of taxes allows the user to modify the wedges between prices at different stages of the exchange process.

Price indices are available for the major macro-economic aggregates: consumption (6.10), government expenditures on commodities (zpi^z) in 6.15, investment (pci^z) in 6.20, exports (epi^z) in 6.22 and imports (ipi^z) in 6.23, as well as gdp (gpi^z) in 6.27 and ndp (npi^z_E) in 6.28. They are weighted averages of the prices of commodities composing the aggregates where the weights are the shares of each commodity in the aggregate corresponding to the price index calculated. The large number of price indices calculated here reflect the number of decision-makers modelled as they face different prices in their choices since their consumption bundles may be very different. Thus the price indices faced by the investor in his decision-making are different than those faced by consumers or the government.

The ndp deflator is calculated by using the expenditure definition of ndp. Thus a change in the ndp deflator (npi^z_E) is equal to the weighted sum of the changes in price indices of consumption, net investment, government expenditure on commodities, and net exports. The price index of exports is evaluated at free on board prices, while that of imports is made of landed, duty free prices. The import and export price indices enable the user to easily assess the terms of trade effects of a policy change.

In equation 6.24, the change in the foreign-currency landed duty-free price of an import is composed of the change in the free on board export price of the commodity expressed in the currency of the importing country ($p^s_{Ei} - e^s$) and the change in the price of freight (p_T), weighted by the respective shares of these items (S^{Wz}_{Vis} and S^{Wz}_{Fis}) in the landed duty free value of the commodity. The price of freight is defined in equation 6.25 as a weighted average of the prices of transport services provided by each region and the rest of the world (p^s_{EJ}), adjusted to a common currency by the exchange rate (e^s).

In equation 6.29, the wage rate can be indexed to the consumer price index (when the second term is exogenously set to zero and the coefficient on the consumer price index is set to the level of indexation desired), or set exogenously (by endogenising h^z_{W2}). Equation 6.30 allows the user to set industry-specific differentials in the changes in returns to primary factors. These differential rates of change are implemented by specifying $\varphi^z_{kj} \neq 0$. Such differentials may be induced by sectoral policies that are not explicitly modelled in SALTER, but affect industries' allocation decisions. In SALTER, such differentials are only applied to returns to capital: wages and returns to land are assumed unique in any of the modelled countries.

The zero profit conditions

In equation 7.1, the price of each industry's output (p^{Dz}_j) is required to equal the sum of its costs less any industry-specific subsidies it may benefit from. Technical changes are directly reflected in decreased output prices according to its share in the composition of output. This results from the assumption of perfect competitiveness in all industries. The percentage change in the price of output j is therefore the weighted sum of the percentage changes in the prices paid by producers for intermediate inputs (p^{Dz}_{Pij} and p^{Iz}_{Pij}) and primary inputs (w^z_{kj}), and the cost savings induced by productivity improvements modelled through technical change variables a^z_j, a^z_{Xj} and a^z_{kj}, less changes in the rates of subsidies received by the industry (s^z_{Qj}). The weights used in calculating per cent changes in output prices are the shares of each component of cost in industry j's total costs.

The income aggregations

In this section, different measures of income are defined. Aggregate factor income is defined as the sum of income accruing to labour, capital and land, less depreciation. In equation 8.1, change in aggregate factor income is defined as the share-weighted sum of changes in each factor's income net of capital depreciation where the weights are the ratio of each factor's income and depreciation to aggregate factor income. Aggregate private income is defined as the sum of aggregate factor income and transfers from the government. The change in private income is calculated in equation 8.2 as the weighted sum of the changes in nominal factor income (y^z_F) and government transfers to households (t^z_G). The weights are shares of factor income and transfers in the database value of household income.

Disposable income is equal to private income less income taxes, where the income tax rate may be indexed to the consumer price index or to income. In equation 8.3, changes in disposable income are affected by changes in private household income and changes in the income tax schedule. The first two terms of equation 8.3 can be written:

$$\text{(A.4)} \qquad \left(R^z_{YYD} - R^z_{YD}\right)y^z - R^z_{YD}t^z_Y = \frac{\left(1-T^z_Y\right)Y^z}{Y^z_d}y^z - \frac{T^z_Y Y^z}{Y^z_d}t^z_Y$$

$$= \frac{Y^z y^z}{Y^z_d} - \frac{T^z_Y Y^z y^z}{Y^z_d} - \frac{T^z_Y Y^z t^z_Y}{Y^z_d}$$

where upper case variables (Y^z, Y^z_d and T^z_y) are defined as the level of the corresponding lower case variables. The change in disposable income ($Y^z_d y^z_d$) is therefore seen to be composed of the change in income ($Y^z y^z$), less the changes in the total tax bill due to the endogenous change in income ($T^z_Y Y^z y^z$) and the change in the marginal tax rate. The last two terms in equation 8.3 are used to index the marginal tax rate to the consumer price index or to aggregate private income in the same way as explained for equation 3.13. Disposable income (y^z_d) is deflated by the consumer price index in 8.4 to yield real disposable income (y^z_{dR}).

Abstracting from depreciation, ndp from the expenditure side is the sum of domestic and foreign expenditures on domestic commodities (Rivera-Batiz and Rivera-Batiz, 1985). As such, it is the sum of domestic absorption net of imports (part of foreign production), and exports (foreign purchases of domestic commodities). Since ndp is valued at purchasers' prices (Horridge, 1985), it includes commodity taxes and duties which are merely transfers within the country which applies them. All shares of non-traded components of the ndp equation are therefore calculated at purchasers' prices, including all applicable taxes. Export taxes are included in the value of exports used in calculating their share in ndp. Conversely, for the share of imports in ndp, the duty applied to imports is not included in the value of imports used to calculate the ratio of imports to ndp. The change in ndp calculated from the expenditure side is calculated in equation 8.5. It is the weighted sum of percentage changes of each of the components of ndp as described above. The weights applied are the levels of each component divided by the level of ndp in the database.

Net domestic product measured from the disposition side is calculated as the sum of the allocation of private and public income between consumption and savings, where transfers from the government to households are subtracted to avoid double-counting. The change in ndp from the disposition side is equal in equation 8.6 to the sum of changes in private and public consumption, changes in savings, less changes in transfers from the government to households. Both definitions of ndp should result in the same changes being observed if the initial data base was balanced. Real ndp is obtained by deflating nominal ndp by its corresponding price index (npi^z) in equation 8.7.

The change in gdp at factor cost is calculated in equation 8.8 by adding all changes to gross returns to primary factors according to their weight in gdp. The difference between gdp and net factor income is made up of depreciation. Since the stock of capital is fixed, any difference between changes in the two aggregates is accounted for by changes in the average price of capital goods. In equation 8.8, changes in real gdp are obtained by subtracting the change in the gdp price index from the change in the nominal measure of gdp.

The trade aggregations and balance

In these equations, the links between the modelled regions and with the rest of the world are specified. In the SALTER model, regional sub-models are linked simultaneously to each other and to the Rest-of-the-World through explicitly modelled trade flows.

The first two equations in this section represent trade between the modelled regions and the rest of the world. In equation 9.1, import demand for each commodity from the rest of the world (imp_i^{S+1}) is determined by the cost of importing a commodity (p_i^{WS+1}) relative to its cost in the rest of the world as expressed by its export price (p_{Ei}^{S+1}), and the rest of the world price elasticity of demand for imports of commodity i (ε_i).

In 9.2 the Rest-of-the-World allocates its imports from different regions according to an elasticity of substitution (β_i^{IS+1}) and the price of a commodity supplied by a particular region (p_{is}^{WS+1}) compared to its average border price (p_i^{WS+1}). This allocation process is similar to the last stage of decisions made by consumers in the explicitly modelled countries, but is made at the more aggregate level of total imports for the Rest-of-the-World because this part of the world is not modelled in as much detail.

The corresponding import demand for commodities specified by source is required to equal the sum of uses of the commodity in each modelled region. The change in import demand for each commodity by source (imp_{is}^z) is specified in equation 9.3 as the sum of changes in intermediate and final demands for the imported commodity specified by source.

The aggregate landed duty free value of imports into a region is the sum of all imports multiplied by their landed duty free prices. In equation 9.4, the change in the landed duty free value of imports (imp^z) is calculated by adding changes in the landed duty free value of imports of each commodity i from all sources s. The change in the value of imports may result both from a change in the landed duty free price (p_{is}^{Wz}) and a change in the volume imported (imp_{is}^z). These percentage changes are weighted by the share of the landed, duty free value of each import in the aggregate landed duty free value of imports (S_{Mis}^z).

Equation 9.5 describes the value of imports into region z from region s. The change in this value is the weighted sum of changes in the foreign currency, landed, duty free prices and changes in the volume of commodities imported from region s. Aggregate imports are calculated in equation 9.6 as as the value of the sum of all imports into region z. The change in real imports is obtained in equation 9.7 by deflating the value of aggregate imports (imp_T^z) by the price index of imports.

Similar aggregates are available for exports. In equation 9.8, changes in aggregate exports are obtained as a weighted sum of price and volume changes in each commodity's exports, while in equation 9.9, real exports are obtained by deflating the aggregate value of exports (exp_T^z) by the export price index (exp^z).

The nominal trade balance is calculated as the difference between aggregate exports values at fob prices and imports before duty is applied. Changes in the nominal trade balance are calculated in equation 9.10. Because the trade balance may be positive or negative, it is defined in terms of the change in its level instead of the usual percentage change. The nominal trade balance is obtained in 9.10 by the difference between aggregate exports and aggregate imports valued at landed duty-free prices but adjusted to the local currency value by the exchange rate.

The ratio of the trade balance to ndp is used to specify particular closures. In equation 9.11, the change in this ratio (r_4^z) is equal to the difference in the percentage change in the trade balance and ndp.

TABLE A1 : Equations for the SALTER model

No.	Equation	Range	Number	Description
1.	**Production Structure**			
1.1	$x_{ij}^{Dz} = q_j^z - \eta_i^z\left[p_{Pij}^{Dz} - p_{Pij}^z\right] + a_j^z + a_{Xj}^z$	i=1...,I j=1...,J z=1...,S	IJS	Intermediate demand for domestic commodities.
1.2	$x_{ij}^{Iz} = q_j^z - \eta_i^z\left[p_{Pij}^{Iz} - p_{Pij}^z\right] + a_j^z + a_{Xj}^z$	i=1...,I j=1...,J z=1...,S	IJS	Intermediate demand for imported commodities.
1.3	$x_{isj}^{Iz} = x_{ij}^{Iz} - \eta_i^{Iz}\left[p_{Pisj}^{Iz} - p_{Pij}^{Iz}\right]$	i=1...,I j=1...,J s=1...,S+1 z=1...,S	IJS(S+1)	Intermediate demand for imported commodities by source.
1.4	$f_{kj}^z = q_j^z - \sigma_j^z\left[w_{kj}^z - \sum_{m=1}^{K} S_{mj}^z\, w_{mj}^z\right] + a_j^z + a_{kj}^z - \sigma_j^z\left[a_{kj}^z - \sum_{m=1}^{K} S_{mj}^z a_{mj}^z\right]$	j=1...,J k=1...,K z=1...,S	JKS	Industry demands for primary factors.
1.5	$f_{Dk}^z = \sum_{j=1}^{J} S_{Dkj}^z\, f_{kj}^z$	k=1...,K z=1...,S	KS	Supply of primary factors.
1.6	$f_{S1}^z = \chi_1^z\left[w_1^z - cpi^z - \left(\frac{T_Y^z}{1 - T_Y^z}\right)t_Y^z\right] + h_D^z$	z=1...,S	S	Labour supply.
2.	**Consumer demand system**			
2.1	$c_i^z = \sum_{h=1}^{I} \lambda_{ih}^z p_{Ch}^z + \mu_i^z c_T^z$	i=1...,I z=1...,S	IS	Commodity demand for consumption.
2.2	$c_i^{Dz} = c_i^z - \beta_i^z\left(p_{Ci}^{Dz} - p_{Ci}^z\right)$	i=1...,I z=1...,S	IS	Demand for domestic commodities.
2.3	$c_i^{Iz} = c_i^z - \beta_i^z\left(p_{Ci}^{Iz} - p_{Ci}^z\right)$	i=1...,I z=1...,S	IS	Demand for imported aggregate commodities.
2.4	$c_{is}^{Iz} = c_i^{Iz} - \beta_i^{Iz}\left(p_{Cis}^{Iz} - p_{Ci}^{Iz}\right)$	i=1...,I s=1...,S+1 z=1...S	IS(S+1)	Demand for imported commodities by source.

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TABLE A1 : **Equations for the SALTER model** (continued)

No.	Equation	Range	Number	Description
2.5	$c_T^z = sv^z + h_c^z$	z=1...,S	S	Supply of private savings.
2.6	$y_d^z = S_{YS}^z sv^z + S_{YC}^z c_T^z$	z=1...,S	S	Total disposable income.
2.7	$c_{TR}^z = c_T^z - cpi^z$	z=1...,S	S	Real aggregate consumption
3.	**Government activities**			
3.1	$g^z = z_G^z - zpi^z$	z=1...,S	S	Real government purchases of commodities.
3.3	$gov_i^{Dz} = g_i^z - \beta_{Gi}^z\left(p_{Gi}^{Dz} - p_{Gi}^z\right)$	i=1...,I z=1...,S	IS	Government demand for domestic commodities.
3.4	$gov_i^{Iz} = g_i^z - \beta_{Gi}^z\left(p_{Gi}^{Iz} - p_{Gi}^z\right)$	i=1...,I z=1...,S	IS	Government demand for imported aggregate commodities.
3.5	$gov_{is}^{Iz} = g_i^{Iz} - \beta_{Gi}^{Iz}\left(p_{Gis}^{Iz} - p_{Gi}^{Iz}\right)$	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Government demand for imported commodities by source.
3.6	$r_{GX}^z = \frac{1}{R_G^z}\left[\sum_{j=1}^{J}\sum_{i=1}^{I}\left[E_{ij}^{Dz}t_{ij}^{Dz} + T_{ij}^{Dz}\left(x_{ij}^{Dz} + p_i^{Dz}\right)\right] + \sum_{j=1}^{J}\sum_{i=1}^{I}\sum_{s=1}^{S+1}\left[E_{isj}^{Iz}t_{ij}^{Iz} + T_{ij}^{Iz}\left(x_{isj}^{Iz} + p_{is}^{Iz}\right)\right]\right]$	z=1...,S	S	Contribution of taxes on intermediate commodity use to aggregate government revenue.
3.7	$r_{GC}^z = \frac{1}{R_G^z}\left[\sum_{i=1}^{I}\left[E_{Ci}^{Dz}t_{Ci}^{Dz} + T_{Ci}^{Dz}\left(c_i^{Dz} + p_i^{Dz}\right)\right] + \sum_{i=1}^{I}\sum_{s=1}^{S+1}\left[E_{Cis}^{Iz}t_{Ci}^{Iz} + T_{Ci}^{Iz}\left(c_{is}^{Iz} + p_{is}^{Iz}\right)\right]\right]$	z=1...,S	S	Contribution of consumption taxes to aggregate government revenue.
3.8	$r_{GG}^z = \frac{1}{R_G^z}\left[\sum_{i=1}^{I}\left[E_{Gi}^{Dz}t_{Gi}^{Dz} + T_{Gi}^{Dz}\left(gov_i^{Dz} + p_i^{Dz}\right)\right] + \sum_{i=1}^{I}\sum_{s=1}^{S+1}\left[E_{Gis}^{Is}t_{Gi}^{Iz} + T_{Gi}^{Iz}\left(gov_{is}^{Iz} + p_{is}^{Iz}\right)\right]\right]$	z=1...,S	S	Contribution of taxes on government commodity purchases to aggregate government revenue.

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TABLE A1 : Equations for the SALTER model (continued)

No.	Equation	Range	Number	Description
3.9	$r^z_{GK} = \frac{1}{R^z_G}\left[\sum_{i=1}^{I}\left[E^{Dz}_{Ki}t^{Dz}_{Ki} + T^{Dz}_{Ki}\left(inv^{Dz}_i + p^{Dz}_i\right)\right] + \sum_{i=1}^{I}\sum_{s=1}^{S+1}\left[E^{Is}_{Kis}t^{Iz}_{Ki} + T^{Iz}_{Ki}\left(inv^{Iz}_{is} + p^{Iz}_{is}\right)\right]\right]$	z=1...,S	S	Contribution of investment taxes to aggregate government revenue.
3.10	$r^z_{GI} = \frac{1}{R^z_G}\left[\sum_{j=1}^{J}\left[E^z_{Qj}s^z_{Qj} + S^z_{Qj}\left(q^z_j + p^{Dz}_j\right)\right]\right]$	z=1...,S	S	Contribution of indirect taxes net of industry subsidies to aggregate government revenue.
3.11	$r^z_{GE} = \frac{1}{R^z_G}\sum_{i=1}^{I}\left[E^z_{Ei}t^z_{Ei} + T^z_{Ei}\left(exp^z_i + p^{Dz}_i\right)\right]$	z=1...,S	S	Contribution of export taxes to aggregate government revenue.
3.12	$r^z_{GD} = \frac{1}{R^z_G}\sum_{i=1}^{I}\sum_{s=1}^{S+1}\left[E^z_{Mis}d^z_{is} + D^z_{is}\left(imp^z_{is} + p^{Wz}_{is} + e^z\right)\right]$	z=1...,S	S	Contribution of import duties to aggregate government revenue.
3.13	$r^z_{GY} = R^z_Y\left(t^z_Y + y^z\right) + h^z_{T1}R^z_T cpi^z + h^z_{T2}R^z_T y^z$	z=1...,S	S	Income tax revenue.
3.14	$r^z_{GT} = r^z_{GC} + r^z_{GX} + r^z_{GG} + r^z_{GK} + r^z_{GI} + r^z_{GE} + r^z_{GD}$	z=1...,S	S	Commodity tax revenue.
3.15	$r^z_G = S^z_{GY}r^z_{GY} + S^z_{GT}r^z_{GT}$	z=1...,S	S	Aggregate government revenue
3.16	$t^z_{GR} = t^z_G - cpi^z$	z=1...,S	S	Real transfers to households.
3.17	$100\ bd^z = R^z_G r^z_G - \left(Z^z_G z^z_G + T^z_G t^z_G\right)$	z=1...,S	S	Government budget deficit.
3.18	$r^z_1 = c^z_T - z^z_G$	z=1...,S	S	Ratio of government expenditure to household expenditure.
3.19	$r^z_2 = y^z_F - t^z_G$	z=1...,S	S	Ratio of net factor income to transfer payments to households.
3.20	$r^z_3 = \frac{100\ bd^z - BD^z\ ndp^z_E}{NDP^z_E}$	z=1...,S	S	Ratio of the budget deficit to ndp.

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TABLE A1 : **Equations for the SALTER model** (continued)

No.	Equation	Range	Number	Description
4.	**Other final demands: investment and export demands**			
4.1	$inv_N^z = inv_R^z + pci^z$	z=1...,S	S	Aggregate real investment.
4.2	$inv_i^{Dz} = inv_{TR}^z - \beta_{Ki}^z\left(p_{Ki}^{Dz} - p_{Ki}^z\right)$	i=1...,I z=1...,S	IS	Investment demand for domestic commodities.
4.3	$inv_i^{Iz} = inv_{TR}^z - \beta_{Ki}^z\left(p_{Ki}^{Iz} - p_{Ki}^z\right)$	i=1...,I z=1...,S	IS	Investment demand for imported commodity aggregates.
4.4	$inv_{is}^{Iz} = inv_i^{Iz} - \beta_{Ki}^{Iz}\left(p_{Kis}^{Iz} - p_{Ki}^{Iz}\right)$	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Investment demand for imported commodities by source.
4.5	$dep^z = f_{D2}^z + pci^z$	z=1...,S	S	Depreciation of the capital stock.
4.6	$exp_{si}^z = imp_{iz}^s$	i=1...,I s=1...,S+1 z=1...,S+1	$I(S+1)^2$	Export demand for commodities by destination.
4.8	$expi_i^z = \sum_{s=1}^{S+1} S_{EIsi}^z(p_{Ei}^z + exp_{si}^z)$	i=1...,I z=1...,S	IS	Aggregate exports at fob prices.
4.9	$exps_s^z = \sum_{i=1}^{I} S_{ESsi}^z(p_{Ei}^z + exp_{si}^z)$	s=1...,S+1 z=1...,S+1	$(S+1)^2$	Aggregate exports at fob prices by source and destination.
4.10	$exp_i^z = \sum_{s=1}^{S+1} S_{Esi}^z\, exp_{si}^z$	i=1...,I z=1...,S+1	I(S+1)	Commodity exports.
5.	**Market clearing conditions**			
5.1	$q_i^z = \sum_{j=1}^{J} S_{QXij}^{Dz}\, x_{ij}^{Dz} + S_{QKi}^{Dz}\, inv_i^{Dz} + S_{QCi}^{Dz}\, c_i^{Dz} + S_{QEi}^{Dz}\, exp_i^z + S_{QGi}^{Dz}\, gov_i^{Dz}$	i=1...,J z=1...,S	JS	Market clearing condition for domestic commodities.
5.2	$em_1^z = f_{S1}^z - f_{D1}^z$	z=1...,S	S	Labour employment rate.

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TABLE A1 : **Equations for the SALTER model** (continued)

No.	Equation	Range	Number	Description
6.	**Price transmission and aggregations**			
6.1	$p_{is}^{Iz} = p_{is}^{Wz} + e^z + d_{is}^z$	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Border price of imported commodities by source (cif).
6.2	$p_{Pisj}^{Iz} = p_{is}^{Iz} + t_{ij}^{Iz}$	i=1...,I j=1...,J s=1...,S+1 z=1...,S	IJS(S+1)	Producer price of imported intermediate commodities.
6.3	$p_{Pij}^{Dz} = p_{i}^{Dz} + t_{ij}^{Dz}$	i=1...,I j=1...,J z=1...,S	IJS	Producer price of domestic intermediate commodities.
6.4	$p_{Pij}^{Iz} = \sum_{s=1}^{S=1} S_{Pisj}^{Iz} p_{Pisj}^{Iz}$	i=1...,I j=1...,J z=1...,S	IJS	Producer price of incorporated commodities.
6.5	$p_{Pij}^{z} = S_{Pij}^{Dz} p_{Pij}^{Dz} + S_{Pij}^{Iz} p_{Pij}^{Iz}$	i=1...,I j=1...,J z=1...,S	IJS	Producer price of commodity i.
6.6	$p_{Cis}^{Iz} = p_{is}^{Iz} + t_{Ci}^{Iz}$	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Consumer price of imported commodities by source.
6.7	$p_{Ci}^{Dz} = p_{i}^{Dz} + t_{Ci}^{Dz}$	i=1...,I z=1...,S	IS	Consumer price of domestic commodities.
6.8	$p_{Ci}^{Iz} = \sum_{s=1}^{S+1} S_{Cis}^{Iz} p_{Cis}^{Iz}$	i=1...,I z=1...,S	IS	Consumer price of imported aggregate commodities.
6.9	$p_{Ci}^{z} = S_{Ci}^{Iz} p_{Ci}^{Iz} + S_{Ci}^{Dz} p_{Ci}^{Dz}$	i=1...,I z=1...,S	IS	Price paid by consumers for commodity i.
6.10	$cpi^z = \sum_{i=1}^{I} S_{Ci}^{Dz} p_{Ci}^{Dz} + \sum_{i=1}^{I} S_{Ci}^{Iz} p_{Ci}^{Iz}$	z=1...,S	S	Consumer price index.
6.11	$p_{Gis}^{Iz} = p_{is}^{Iz} + t_{Gi}^{Iz}$	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Price paid by the government for commodities by source.
6.12	$p_{Gi}^{Dz} = p_{i}^{Dz} + t_{Gi}^{Dz}$	i=1...,I z=1...,S	IS	Price paid by the government for domestic commodities.

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TABLE A1 : **Equations for the SALTER model** (continued)

No.	Equation	Range	Number	Description
6.13	$p^{Iz}_{Gi} = \sum_{s=1}^{S+1} S^{Iz}_{Gis}\, p^{Iz}_{Gis}$	i=1...,I z=1...,S	IS	Price paid by the government for aggregate imported commodities.
6.14	$p^{z}_{Gi} = S^{Iz}_{Gi} p^{Iz}_{Gi} + S^{Dz}_{Gi} p^{Dz}_{Gi}$	i=1...,I z=1...,S	IS	Price paid by the government for aggregate commodities.
6.15	$zpi^{z} = \sum_{i=1}^{I} S^{z}_{Gi}\, p^{z}_{Gi}$	z=1...,S	S	Price index for government purchases.
6.16	$p^{Iz}_{Kis} = p^{Iz}_{is} + t^{Iz}_{Ki}$	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Price in investment of imported commodities by source.
6.17	$p^{Dz}_{Ki} = p^{Dz}_{i} + t^{Dz}_{Ki}$	i=1...,I z=1...,S	IS	Price in investment of domestic commodities.
6.18	$p^{Iz}_{Ki} = \sum_{s=1}^{S+1} S^{Iz}_{Kis} p^{Iz}_{Kis}$	i=1...,I z=1...,S	IS	Price in investment of imported commodities.
6.19	$p^{z}_{Ki} = S^{Iz}_{Ki} p^{Iz}_{Ki} + S^{Dz}_{Ki} p^{Dz}_{Ki}$	i=1...,I z=1...,S	IS	Price in investment of aggregate commodities.
6.20	$pci^{z} = \sum_{i=1}^{I} S^{Dz}_{KTi} p^{Dz}_{Ki} + \sum_{i=1}^{I} S^{Iz}_{KTi} p^{Iz}_{Ki}$	z=1...,S	S	Purchase price of capital.
6.21	$p^{z}_{Ei} = p^{Dz}_{i} + t^{z}_{Ei}$	i=1...,I z=1...,S	IS	Export price (fob).
6.22	$epi^{z} = \sum_{i=1}^{I} S^{z}_{Ei} p^{z}_{Ei}$	z=1...,S	S	Price index of exports (fob).
6.23	$ipi^{z} = \sum_{i=1}^{I} \sum_{s=1}^{S+1} S^{z}_{Mis} p^{Wz}_{is}$	z=1...,S	S	Domestic currency price index of imports (cif).
6.24	$p^{Wz}_{is} = S^{Wz}_{Vis}\left(p^{s}_{Ei} - e^{s}\right) + S^{Wz}_{Fis}\, p_{T}$	i=1...,I s=1...,S+1 z=1...,S+1	$I(S+1)^2$	Foreign currency landed duty-free price of imported commodities by source.
6.25	$p_{T} = \sum_{s=1}^{S+1} S_{Fs}\left(p^{s}_{EJ} - e^{s}\right)$		1	Price of international freight.

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TABLE A1 : Equations for the SALTER model (continued)

No.	Equation	Range	Number	Description
6.26	$p_i^{WS+1} = \sum_{s=1}^{S+1} S_{is}^{WS+1} p_{is}^{WS+1}$	i=1...,I	I	Landed duty-free price of aggregate commodities imported by the Rest-of-the-World.
6.27	$gpi^z = \sum_{k\neq 2} S_{GDPk}^z w_k + \sum_{j=1}^{J} S_{GDP2j}^z w_{2j}^z$	z=1...,S	S	GDP deflator at factor cost.
6.28	$npi_E^z = S_{NC}^z cpi^z + \left(S_{NK}^z - S_{ND}^z\right) kpi^z + S_{NZ}^z zpi^z + S_{NE}^z epi^z - S_{NI}^z \left(e^z + ipi^z\right)$	z=1...,S	S	Price index for net domestic product from the expenditure side.
6.29	$w_1^z = h_{W1}^z cpi^z + h_{W2}^z$	z=1...,S	S	Wage indexation.
6.30	$w_{2j}^z = w_2^z + \varphi_{2j}^z$	j=1...,J z=1...,S	JS	Industry-specific returns to capital.
7.	**Zero profit conditions**			
7.1	$p_j^{Dz} = s_{Qj}^z + \sum_{i=1}^{I} H_{ij}^{Dz} p_{Pij}^{Dz} + \sum_{i=1}^{I} H_{ij}^{Iz} p_{Pij}^{Iz} + \sum_{k=1}^{K} H_{kj}^z w_{kj}^z + a_j^z + a_{Xj}^z + \sum_{k=1}^{K} H_{kj}^z a_{kj}^z$	j=1...,J z=1...,S	JS	Zero profit condition for each industry.
8.	**Income aggregations**			
8.1	$y_F^z = \sum_{k\neq 2} S_{Yk}^z (w_k^z + f_{Dk}^z) + \sum_{j=1}^{J} S_{Y2j}^z (w_{2j}^z + f_{2j}^z) - S_{YD}^z dep^z$	z=1...,S	S	Aggregate net primary factor income.
8.2	$y^z = S_{YF}^z y_F^z + S_{YT} t_G^z$	z=1...,S	S	Aggregate private income.
8.3	$y_d^z = \left(R_{YYD}^z - R_{YD}^z\right) y^z - R_{YD}^z t_Y^z - h_{T1}^z R_{TYD}^z cpi^z - h_{T2}^z R_{TYD}^z y^z$	z=1...,S	S	Aggregate household disposable income.

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TABLE A1 : **Equations for the SALTER model** (continued)

No.	Equation	Range	Number	Description
8.4	$y^z_{dR} = y^z_d - cpi^z$	z=1...,S	S	Real aggregate household disposable income.
8.5	$ndp^z_E = S^z_{NC}\, c_T + S^z_{NK}\, inv^z_T - S^z_{ND}\, dep^z + S^z_{NZ}\, z^z_G + S^z_{NE}\, exp^z_T - S^z_{NI}\left(e^z + imp^z\right)$	z=1...,S	S	Net domestic product from the expenditure side.
8.6	$ndp^z_D = S^z_{NC}\, c^z_T + S^z_{NS}\, sv^z + S^z_{NR}\, r^z_G - S^z_{NT}\, t^z_G$	z=1...,S	S	Net domestic product from the disposition side.
8.7	$ndp^z_{ER} = ndp^z_E - npi^z_E$	z=1...,S	S	Real net domestic product from the expenditure side.
8.8	$gdp^z_F = \sum_{k\neq 2} S^z_{GDPk}(w^z_k + f^z_{Dk}) + \sum_{j=1}^{J} S^z_{GDP2j}(w^z_{2j} + f^z_{2j})$	z=1...,S	S	Gross domestic product at factor cost.
8.9	$gdp^z_{FR} = gdp^z_F - gpi^z$	z=1...,S	S	Real gross domestic product at factor cost.
9.	**Trade aggregations and balance**			
9.1	$imp^{S+1}_i = \varepsilon_i\left(p^{WS+1}_i - p^{S+1}_{Ei} - e^{S+1}\right)$	i=1...,I	I	Demand by the Rest-of-the-World for composite commodities.
9.2	$imp^{S+1}_{is} = imp^{S+1}_i - \beta^{IS+1}_i\left(p^{WS+1}_{is} - p^{WS+1}_i\right)$	i=1...,I s=1...,S+1	I(S+1)	Demand by the Rest-of-the-World for commodities by source.
9.3	$imp^z_{is} = \sum_{j=1}^{J} S^{Iz}_{MXisj}\, x^{Iz}_{isj} + S^{Iz}_{MKis}\, inv^{Iz}_{is} + S^{Iz}_{MCis}\, c^{Iz}_{is} + S^{Iz}_{MGis}\, gov^{Iz}_{is}$	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Imports of commodities by source.
9.4	$imp^z_i = \sum_{s=1}^{S} S^z_{Mis}\left(p^{Wz}_{is} + imp^z_{is}\right)$	i=1...,I z=1...,S	IS	Aggregate imports by commodity at foreign currency, landed duty-free prices.

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TABLE A1 : Equations for the SALTER model (continued)

No.	Equation	Range	Number	Description
9.5	$imps_s^z = \sum_{i=1}^{I} S_{MSis}^z (p_{is}^{Wz} + imp_{is}^z)$	s=1...,S+1 z=1...,S+1	$(S+1)^2$	Aggregate imports by source and destination valued at foreign currency, landed duty-free prices.
9.6	$imp_T^z = \sum_{i=1}^{I} \sum_{s=1}^{S+1} S_{MTis}^z (p_{is}^{Wz} + imp_{is}^z)$	z=1...,S	S	Aggregate imports at foreign currency landed duty free prices.
9.7	$imp_{TR}^z = imp_T^z - ipi^z$	z=1...,S	S	Real aggregate imports.
9.8	$exp_T^z = \sum_{i=1}^{I} S_{ETi}^z (p_{Ei}^z + exp_i^z)$	z=1...,S	S	Aggregate exports at fob prices.
9.9	$exp_{TR}^z = exp_T{}^z - epi^z$	z=1...,S	S	Real aggregate exports.
9.10	$100\ tb^z = EXP^z\ exp^z - IMP^z\left(e^z + imp^z\right)$	z=1...,S	S	Balance of trade at current domestic prices.
9.11	$r_4^z = \left(\dfrac{100tb^z - TB^z ndp_E^z}{NDP_E^z}\right)$	z=1...,S	S	Ratio of the trade balance to ndp.

TABLE A2 : List of variables for the SALTER model

Variable	Range	Number	Description
a	**Disaggregated quantities**		
c_i^z	i=1...,I z=1...,S	IS	Consumer demand for aggregate commodity i.
c_i^{Dz}	i=1...,I z=1...,S	IS	Consumer demand for domestic commodity i.
c_i^{Iz}	i=1...,I z=1...,S	IS	Consumer demand for imported aggregate commodity i.
c_{is}^{Iz}	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Consumer demand for imported aggregate commodity from source s.
exp_i^z	i=1...,I z=1...,S+1	I(S+1)	Aggregate exports of commodity i.
exp_{si}^z	i=1...,I s=1...,S+1 z=1...,S+1	$I(S+1)^2$	Export demand for commodity i by region s.
$expi_i^z$	i=1...,I z=1...,S	IS	Aggregate exports by commodity at fob prices.
$exps_s^z$	s=1...,S+1 z=1...,S+1	$(S+1)^2$	Aggregate exports by source and destination at fob prices.
f_{kj}^z	j=1...,J k=1...,K z=1...,S	JKS	Demand by industry j for primary factor k.
gov_i^{Dz}	i=1...,I z=1...,S	IS	Government demand for domestic commodity i.
gov_i^{Iz}	i=1...,I z=1...,S	IS	Government demand for aggregate imported commodity i.
gov_{is}^{Iz}	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Government demand for imported commodity i from source s.
imp_i^{S+1}	i=1...,I	I	Aggregate imports of commodity i by the rest of the world.
imp_{is}^z	i=1...,I s=1...,S+1 z=1...,S+1	$I(S+1)^2$	Imports of commodity i from source s.
$imps_s^z$	s=1...,S+1 z=1...,S+1	$(S+1)^2$	Aggregate imports at foreign currency by source and destination at landed duty free prices.

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TABLE A2 : Equations for the SALTER model (continued)

Variable	Range	Number	Description
inv_i^z	i=1...,I z=1...,S	IS	Investment use of aggregate commodity i.
inv_i^{Dz}	i=1...,I z=1...,S	IS	Investment use of domestic commodity i.
inv_i^{Iz}	i=1...,I z=1...,S	IS	Investment use of imported aggregate commodity i.
inv_{is}^{Iz}	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Investment use of imported commodity i.
q_j^z	j=1...,J z=1...,S	JS	Supply of commodity j.
x_{ij}^{Dz}	i=1...,I j=1...,J z=1...,S	IJS	Demand by industry j for domestic commodity i.
x_{ij}^{Iz}	i=1...,S j=1...,J z=1...,S	IJS	Demand by commodity j for imported aggregate commodity i.
x_{isj}^{Iz}	i=1...,I j=1...,J s=1...,S+1 z=1...,S	IJS(S+1)	Demand by industry j for imported aggregate commodity i from source s.
b Prices and price indices			
cpi^z	z=1...,S	S	Consumer price index.
e^s	s=1...,S+1	S+1	Exchange rate.
epi^z	z=1...,S	S	Export price index (fob).
gpi^z	z=1...,S	S	Gross domestic product price deflator at factor cost.
ipi^z	z=1...,S	S	Price index of imports (cif).
pci^z	z=1...,S	S	Price index of capital.
npi_E^z	z=1...,S	S	Price index for net domestic product from the expenditure side.
p_i^{Dz}	i=1...,I z=1...,S	IS	Basic price of domestic commodity i.

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TABLE A2 : Equations for the SALTER model (continued)

Variable	Range	Number	Description
p_{is}^{Wz}	i=1...,I s=1...,S+1 z=1...,S	$I(S+1)^2$	Foreign currency landed duty-free price of imported commodity i from source s.
p_i^{WS+1}	i=1...,I	I	Average foreign currency landed duty-free price of imports into the rest of the world.
p_{is}^{Iz}	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Border price of commodity i from source s (cif).
p_{Ci}^{z}	i=1...,I z=1...,S	IS	Consumer price index of commodity i.
p_{Ci}^{Dz}	i=1...,I z=1...,S	IS	Consumer price of domestic commodity i.
p_{Ci}^{Iz}	i=1...,I z=1...,S	IS	Consumer price index of imported aggregate commodity i.
p_{Cis}^{Iz}	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Consumer price of imported commodity i from source s.
p_{Pij}^{z}	i=1...,I j=1...,J z=1...,S	IJS	Price of aggregate commodity i paid by industry j.
p_{Pij}^{Dz}	i=1...,I j=1...,J z=1...,S	IJS	Price of domestic commodity i paid by industry j.
p_{Pij}^{Iz}	i=1...,I j=1...,J z=1...,S	IJS	Index of price paid by industry j for aggregate imported commodity i.
p_{Pisj}^{Iz}	i=1...,I j=1...,J s=1...,S+1 z=1...,S	IJS(S+1)	Price of imported commodity i from source s paid by industry j.
p_{Gi}^{z}	i=1...,I z=1...,S	IS	Price of commodity i to the government.
p_{Gi}^{Dz}	i=1...,I z=1...,S	IS	Price of domestic commodity i purchased by the government.
p_{Gi}^{Iz}	i=1...,I z=1...,S	IS	Price of imported aggregate commodity i purchased by the government.

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TABLE A2 : Equations for the SALTER model (continued)

Variable	Range	Number	Description
p^{Iz}_{Gis}	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Price of imported commodity i from source s purchased by the government.
p^{z}_{Ki}	i=1...,I z=1...,S	IS	Price of commodity i used in investment.
p^{Dz}_{Ki}	i=1...,I z=1...,S	IS	Price of domestic commodity i used in investment.
p^{Iz}_{Ki}	i=1...,I z=1...,S	IS	Price index of imported aggregate commodity i used in investment.
p^{Iz}_{Kis}	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Price of imported commodity i from source s used in investment.
p^{z}_{Ei}	i=1...,I z=1...,S+1	I(S+1)	Export price of commodity i (fob).
p_T		1	Price of freight.
w^z_k	k=1...,K z=1...,S	KS	Basic returns to primary factors.
w^z_{kj}	j=1...,J k=1...,K z=1...,S	JKS	Price paid by industry j for primary factor k.
zpi^z	z=1...,S	S	Price index for government expenditure.
c Macro-economic aggregates			
bd^z	z=1...,S	S	Government budget deficit.
c^z_T	z=1...,S	S	Aggregate consumer demand.
c^z_{TR}	z=1...,S	S	Real aggregate consumption.
dep^z	z=1...,S	S	Depreciation of capital.
em^z_1	z=1...,S	S	Rate of employment.
exp^z_T	z=1...,S	S	Aggregate exports at fob prices.
exp^z_{TR}	z=1...,S	S	Real aggregate exports.

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TABLE A2 : **Equations for the SALTER model** (continued)

Variable	Range	Number	Description
f^z_{Dk}	k=1...,K z=1...,S	KS	Aggregate demand for of primary factor k.
f^z_{S1}	z=1...,S	S	Aggregate labour supply.
g^z	z=1...,S	S	Real government spending on commodities.
imp^z_T	z=1...,S	S	Aggregate imports at foreign currency landed duty free prices.
imp^z_{TR}	z=1...,S	S	Real aggregate imports.
inv^z_R	z=1...,S	S	Aggregate real investment.
ndp^z_E	z=1...,S	S	Net domestic product from the expenditure side.
ndp^z_{ER}	z=1...,S	S	Real net domestic product from the expenditure side.
ndp^z_D	z=1...,S	S	Net domestic product from the disposition side
r^z_G	z=1...,S	S	Government revenue net of non-commodity subsidies.
r^z_{GI}	z=1...,S	S	Contribution of subsidies net of indirect taxes to aggregate government revenue.
r^z_{GX}	z=1...,S	S	Contribution of taxes on intermediate commodity use to aggregate revenue from commodity taxes.
r^z_{GC}	z=1...,S	S	Contribution of consumption taxes to aggregate revenue from commodity taxes.
r^z_{GG}	z=1...,S	S	Contribution of taxes on government commodity purchases to aggregate revenue from commodity taxes.
r^z_{GK}	z=1...,S	S	Contribution of investment taxes to aggregate revenue from commodity taxes.
r^z_{GE}	z=1...,S	S	Contribution of export taxes to aggregate revenue from commodity taxes.
r^z_{GD}	z=1...,S	S	Contribution of import duties to aggregate revenue from commodity taxes.
r^z_{GY}	z=1...,S	S	Contribution of income taxes to government revenue.

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TABLE A2 : Equations for the SALTER model (continued)

Variable	Range	Number	Description
r^z_{GT}	z=1...,S	S	Aggregate commodity tax revenues.
sv^z	z=1...,S	S	Private savings supply.
tb^z	z=1...,S	S	Balance of trade at current domestic prices.
y^z_F	z=1...,S	S	Aggregate primary factor income.
y^z	z=1...,S	S	Aggregate private income.
y^z_d	z=1...,S	S	Aggregate household disposable income.
y^z_{dR}	z=1...,S	S	Real aggregate household disposable income.
z^z_G	z=1...,S	S	Government spending (nominal).
d Policy instruments			
d^z_{is}	i=1...,I s=1...,S+1 z=1...,S	IS(S+1)	Power of the duty applied to imported commodity i from source s in all uses.
t^{Dz}_{Ci}	i=1...,I z=1...,S	IS	Power of the *ad valorem* tax applied to the consumption of domestic commodity i.
t^{Iz}_{Ci}	i=1...,I z=1...,S	IS	Power of the *ad valorem* tax applied to the consumption of imported commodity i.
t^{Dz}_{ij}	i=1...,I j=1...,J z=1...,S	IJS	Power of the *ad valorem* tax applied to domestic commodity i purchased by industry j.
t^{Iz}_{ij}	i=1...,I j=1...,J z=1...,S	IJS	Power of the *ad valorem* tax applied to imported commodity i purchased by industry j.
t^{Dz}_{Gi}	i=1...,I z=1...,S	IS	Power of the *ad valorem* tax applied to domestic commodity i purchased by the government.
t^{Iz}_{Gi}	i=1...,I z=1...,S	IS	Power of the *ad valorem* tax applied to imported commodity i purchased by the government.
t^{Dz}_{Ki}	i=1...,I z=1...,S	IS	Power of the *ad valorem* investment tax applied to domestic commodity i.
t^{Iz}_{Ki}	i=1...,I z=1...,S	IS	Power of the *ad valorem* investment tax applied to imported commodity i.

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TABLE A2 : Equations for the SALTER model (continued)

Variable	Range	Number	Description
s^z_{Qj}	j=1...,J z=1...,S	JS	Subsidies net of indirect taxes allocated to industry j.
t^z_Y	z=1...,S	S	Marginal income tax.
t^z_G	z=1...,S	S	Government transfer payments to private households.
t^z_{GR}	z=1...,S	S	Real government transfers to private households.
t^z_{Ei}	i=1...,I z=1...,S	IS	Power of the *Ad valorem* export tax applied to commodity i.
e	**Modelling instruments**		
φ^z_{2j}	j=1...,J z=1...,S	JS	Industry specific differential for returns to capital in industry j.
a^z_j	j=1...,J z=1...,S	JS	Ouput augmenting technical change in industry.j
a^z_{Xj}	j=1...,J z=1...,S	JS	Aggregate intermediate input - augmenting technical change in industry.j
a^z_{kj}	j=1...,J k=1...,K z=1...,S	JKS	Primary factor k - augmenting technical change in industry j.
h^z_D	z=1...,S	S	Demographic index.
h^z_{W2}	z=1...,S	S	Variable used to disconnect wages from the consumer price index.
h^z_c	z=1...,S	S	Variable used to make savings exogenous.
r^z_1	z=1...,S	S	Ratio of government expenditure to household expenditure.
r^z_2	z=1...,S	S	Ratio of net factor income to government transfer payment to households.
r^z_3	z=1...,S	S	Ratio of the budget deficit to NDP.
r^z_4	z=1...,S	S	Ratio of the trade balance to NDP.

TABLE A3 : Parameters for the SALTER model

Equation	Parameter	Description
1.1,1.2	η_i^z	Elasticity of substitution in production between domestic commodity i and imported aggregate commodity i.
1.3	η_i^{Iz}	Elasticity of substitution in production between commodities imported from different sources.
1.4	σ_j^z	Elasticity of substitution between primary factors in industry j.
	S_{mj}^z	Share of primary factor m used by industry j.
1.5	S_{Dkj}^z	Share of industry j's use of primary factor k in the aggregate use of factor k.
1.6	χ_l^z	Elasticity of labour supply to after-tax wages.
	T_Y^z	Marginal income tax (level).
2.1	λ_{ih}^z	Elasticity of demand in consumption for commodity i with respect to the price of commodity h.
	μ_i^z	Elasticity of demand for commodity i with respect to aggregate consumption expenditure.
2.2,2.3	β_i^z	Elasticity of substitution in private consumption between domestic commodity i and imported aggregate commodity i.
2.4	β_i^{Iz}	Elasticity of substitution in private consumption between commodities imported from different sources.
2.6	S_{YS}^z	Share of savings in private disposable income.
	S_{YC}^z	Share of aggregate consumption in private disposable income.
3.3,3.4	β_{Gi}^z	Elasticity of substitution in government consumption between domestic commodity i and imported aggregate commodity i.
3.5	β_{Gi}^{Iz}	Elasticity of substitution in government consumption between commodities imported from different sources.
3.6-3.13	R_G^z	Aggregate government revenue (level).
3.6	E_{ij}^{Dz}	Post-tax expenditure in intermediate use on domestic commodity i (level)
	T_{ij}^{Dz}	*Ad valorem* tax rate on intermediate use of imported commodity i (level).

(Continued on next page)

TABLE A3 : **Parameters for the SALTER model** (continued)

Equation	**Parameter**	**Description**
	E^{Iz}_{isj}	Post-tax expenditure in intermediate use on commodity i imported from source s (level).
	T^{Iz}_{ij}	*Ad valorem* tax rate on intermediate use of imported commodity i (level).
3.7	E^{Dz}_{Ci}	Post-tax consumption expenditure on domestic commodity i (level).
	T^{Dz}_{Ci}	*Ad valorem* tax rate on consumption of imported commodity i (level).
	E^{Iz}_{Cis}	Post-tax consumption expenditure on commodity i imported from source s (level).
	T^{Iz}_{Ci}	*Ad valorem* tax rate on consumption of imported commodity i (level).
3.8	E^{Dz}_{Gi}	Post-tax government expenditure on domestic commodity i (level).
	T^{Dz}_{Gi}	*Ad valorem* tax rate on domestic commodity i purchased by the government (level).
	E^{Iz}_{Gis}	Post-tax government expenditure on commodity i imported from source s (level).
	T^{Iz}_{Gi}	*Ad valorem* tax rate on imported commodity i purchased by the government (level).
3.9	E^{Dz}_{Ki}	Post-tax investment expenditure on domestic commodity i (level).
	T^{Dz}_{Ki}	*Ad valorem* tax rate on domestic commodity i used in investment (level).
	E^{Iz}_{Kis}	Post-tax investment expenditure on commodity i imported from source s (level).
	T^{Iz}_{Ki}	*Ad valorem* tax rate on imported commodity i used in investment (level).
3.10	E^{z}_{Qj}	Total costs of industry j (level).
	S^{z}_{Qj}	Subsidies net of indirect taxes provided to industry j (level).
3.11	E^{z}_{Ei}	Post-tax value of exports of commodity i (level).
	T^{z}_{Ei}	*Ad valorem* export tax rate (level).

(Continued on next page)

TABLE A3 : **Parameters for the SALTER model** (continued)

Equation	Parameter	Description
3.12	E^{z}_{Mis}	Post-duty value of imports of commodity i from source s (level).
	D^{z}_{is}	*Ad valorem* duty imposed on imported commodity i from source s.
3.13	R^{z}_{Y}	Marginal tax rate multiplied by household income.
	R^{z}_{T}	Intercept of the linear income tax schedule.
	h^{z}_{T1}	Parameter indexing the intercept of the linear income tax schedule to the consumer price index.
	h^{z}_{T2}	Parameter indexing the intercept of the linear income tax schedule to private income.
3.15	S^{z}_{GY}	Share of income taxes in aggregate government revenue.
	S^{z}_{GT}	Share of commodity taxes in aggregate government revenue.
3.17	Z^{z}_{G}	Government spending (level)
	T^{z}_{G}	Transfer to private households (level).
3.20	BD^{z}	Government budget deficit (level).
	NDP^{z}_{E}	NDP calculated from the expenditure side (level).
4.2,4.3	β^{z}_{Ki}	Elasticity of substitution in investment demand between domestic commodity i and imported aggregate commodity i.
4.4	β^{Iz}_{Ki}	Elasticity of substitution in investment demand between commodities imported from different sources.
4.8	S^{z}_{EIsi}	Share of commodity i export from z to region s in total exports of commodity i from region z.
4.9	S^{z}_{ESsi}	Share of exports of commodity i with respect to exports from region z to region s.
4.10	S^{z}_{Esi}	Share of exports of commodity i to region s with respect to aggregate exports of commodity i.
5.1	S^{Dz}_{QXij}	Share of the intermediate usage by the j'th industry in aggregate demand for the i'th domestically produced commodity.
	S^{Dz}_{QKi}	Share of investment usage in aggregate demand for the i'th domestically produced commodity.

(Continued on next page)

TABLE A3 : **Parameters for the SALTER model** (continued)

Equation	**Parameter**	**Description**
	S^{Dz}_{QCi}	Share of consumption usage in aggregate demand for the i'th domestically produced commodity.
	S^{Dz}_{QEi}	Share of exports in aggregate demand for the i'th domestically produced commodity.
	S^{Dz}_{QGi}	Share of government usage in aggregate demand for the i'th domestically produced commodity.
6.4	S^{Iz}_{Pisj}	Share of imported commodity i from source s in the aggregate use of imports of commodity by industry j
6.5	S^{Dz}_{Pij}	Share of domestic commodity i in the aggregate use of commodity i by industry j.
	S^{Iz}_{Pij}	Share of imported commodity i in the aggregate use of commodity i by industry j.
6.8	S^{Iz}_{Cis}	Share of imported commodity i from source s in consumer demand for aggregate imported commodity i in consumer demand.
6.9, 6.10	S^{Dz}_{Ci}	Share of domestic commodity i in consumer demand for aggregate commodity i.
	S^{Iz}_{Ci}	Share of imported commodity aggregate i in consumer demand for aggregate commodity i.
6.13	S^{Iz}_{Gis}	Share of imported commodity i from source s in government consumption with respect to aggregate imported commodity i in government consumption.
6.14	S^{Dz}_{Gi}	Share of domestic commodity i in government consumption of aggregate commodity i.
	S^{Iz}_{Gi}	Share of imported aggregate commodity i in government consumption of aggregate commodity i.
6.15	S^{z}_{Gi}	Share of aggregate commodity i in aggregate government purchases of commodities.
6.18	S^{Iz}_{Kis}	Share of imported commodity i from sources in investment use of imported commodity i.
6.19	S^{Dz}_{Ki}	Share of domestic commodity i in investment use of aggregate commodity i.
	S^{Iz}_{Ki}	Share of imported commodity i in investment use of aggregate commodity i.
6.20	S^{Dz}_{KTi}	Share of domestic commodity i in aggregate investment expenditure on domestic commodities.

(Continued on next page)

TABLE A3 : Parameters for the SALTER model (continued)

Equation	Parameter	Description
	S^{Iz}_{KTi}	Share of imported commodity i in aggregate investment expenditure on imported commodities.
6.22	S^{z}_{Ei}	Share of commodity i in aggregate exports.
6.23	S^{z}_{Mis}	Share of imported commodity i from source s in imports of aggregate commodity i.
6.24	S^{Wz}_{Vis}	Share of the fob value in the landed duty-free value of commodity i from source s.
	S^{Wz}_{Fis}	Share of the international freight cost in the landed duty-free value of commodity i from source s.
6.25	S_{Fs}	Share of international freight supplied by region in the total value of international freight.
6.26	S^{WS+1}_{is}	Share of imported commodity i from source s in imports of aggregate commodity i by the Rest-of-the-World.
6.27	S^{z}_{GDPk}	Share of primary factor k's income in gdp evaluated at factor cost.
	S^{z}_{GDP2j}	Share of capital in industry j in gdp evaluated at factor cost.
6.28	S^{z}_{NC}	Share of aggregate consumption in ndp.
	S^{z}_{NK}	Share of aggregate investment in ndp.
	S^{z}_{ND}	Share of capital depreciation in ndp.
	S^{z}_{NZ}	Share of government expenditure in ndp.
	S^{z}_{NE}	Share of exports in ndp.
	S^{z}_{NI}	Ratio of imports to ndp.
6.29	h^{z}_{W1}	Wage indexation parameter.
7.1	H^{Dz}_{ij}	Share of domestic intermediate commodity i in total costs of industry j.
	H^{Iz}_{ij}	Share of imported intermediate commodity aggregate i in total costs of industry j.
	H^{z}_{kj}	Share of primary factor k in total costs of industry j.

(Continued on next page)

TABLE A3 : Parameters for the SALTER model (continued)

Equation	Parameter	Description
8.1	S^z_{Yk}	Share of primary factor k's income in total primary factor income.
	S^z_{YD}	Ratio of depreciation to total factor income.
8.2	S^z_{YF}	Share of factor income in aggregate private income.
	S^z_{YT}	Share of government transfers in aggregate private income.
8.3	R^z_{YYD}	Ratio of aggregate household income to household disposable income.
	R^z_{YD}	Marginal tax rate multiplied by the ratio of aggregate household income to household disposable income.
	R^z_{TYD}	Ratio of the intercept in the linear personal income tax schedule to household disposable income.
	h^z_{T1}, h^z_{T2}	See equation 3.13.
8.5, 8.6	S^z_{NC}, S^z_{NK}, S^z_{ND}, S^z_{NZ}, S^z_{NE}, S^z_{NI}	See equation 6.28.
8.6	S^z_{NR}	Ratio of aggregate government revenues to ndp.
	S^z_{NT}	Ratio of government transfers to households to ndp.
8.8	S^z_{GDPk}, S^z_{GDP2j}	See equation 6.27.
	S^z_{NS}	Ratio of private savings to ndp.
9.1	ε_i	Price elasticity of demand by the Rest-of-the-World for commodity i.
9.2	β_i^{IS+1}	Elasticity of substitution in aggregate demand by the Rest-of-the-World between commodities imported from different sources.
9.3	S^{lz}_{MXisj}	Share of intermediate demand by industry j in imports of commodity i from source s.
	S^{lz}_{MKis}	Share of investment demand in imports of commodity i from source s.
	S^{lz}_{MCis}	Share of consumption demand in imports of commodity i from source s.

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TABLE A3 : **Parameters for the SALTER model** (continued)

Equation	Parameter	Description
	S^{iz}_{MGis}	Share of government demand in imports of commodity i from source s.
9.4	S^{z}_{Mis}	Share of imports of commodity i from source s in aggregate imports from source s.
9.5	S^{z}_{MSis}	Share of imports of commodity i by region z from region s with respect to aggregate imports by region z.
9.6	S^{z}_{MTis}	Share of imports of commodity i from region s in aggregate imports by region z.
9.8	S^{z}_{ETi}	Share of exports of commodity i from region z in aggregate exports of region z.
9.10	EXP^{z}	Domestic currency value of total exports (level).
	IMP^{z}	Domestic currency value of total imports (level).
9.11	TB^{z}	Domestic currency value of the trade balance (level).
	NDP^{z}_{E}	NDP calculated from the expenditure side (level).

APPENDIX B: UPDATING REGIONAL AND TRADE DATABASES

This appendix indicates the changes to the standard SALTER model structure needed to update the databases as indicated in Chapter 4. The equilibrium database is obtained from a variety of heterogeneous sources. These data are made compatible by using the UPDATE procedure, a large-change facility in GEMPACK (Pearson, 1990). In order for a regional database to be included in the equilibrium database, three modifications are performed:

1. changes in stocks are eliminated in each regional database;
2. the regional database is updated to reflect 1988 trade patterns; and
3. the regional database is scaled to reflect 1988 NDP levels.

The first two modifications involve small changes to the standard SALTER model structure that are outlined here.

Eliminating changes in stocks

To account for changes in stocks usually supplied by national accounts data, the single-country model version of the SALTER model includes the following additional equations:

(B.1) $sto_i^D = sto_R$

(B.2) $sto_{is}^I = sto_R$

where variables are expressed in percentage changes, and

sto_i^D is changes in the stock of domestic commodity i

sto_{is}^I is changes in the stock of commodity i imported from origin s, and

sto_R is aggregate real changes in stocks.

Relations B.1 and B.2 indicate a fixed proportion is assumed between aggregate and individual commodity changes in stocks. As outlined in Chapter 4, the SALTER model is used as a Leontief model where fixed proportions rule production and consumption relations.

Adapting the trade structure

The trade flows in each regional model must correspond to the flows reported for 1988. Trade data supplied by Reuters were used to build ratios of commodity imports and exports to NDP. In order to obtain the 1988 trade flow structure for each regional database, a simulation was conducted using the trade ratios as targets to modify the databases.

In order to run this simulation, variables for the trade ratios are defined for each regional model. The following equations define the corresponding percentage change variables and the demand for imports by the rest of the world:

$$r_{Mi} = \sum_{s=1}^{S+1} S_{is} imp_{is} - ndp_E$$

$$r_{Xi} = exp_i - ndp_E$$

$$imp_i^{S+1} = \varepsilon_i \left(p_i^{WS+1} - p_{Ei}^{S+1} \right) + h_{Ti}$$

where variables are expressed in percentage change terms, and:

r_M	is the ratio of commodity i imports to NDP,
r_X	is the ratio of commodity i exports to NDP,
S_{is}	is the share of commodity i from origin s in total imports of i,
imp_{is}	is imports of commodity i from source s,
ndp_E	is NDP measured from the expenditure side,
exp_i	is total exports of commodity i,
imp_i^{S+1}	is aggregate imports of commodity i by the rest of the world,
ε_i	is the price elasticity of demand for imports by the rest of the world,
p_i^{WS+1}	is the average foreign currency landed duty-free price of imports into the rest of the world,
p_{Ei}^{S+1}	is the export price of commodity i by the rest of the world, and
h_{Ti}	is a trade shift term used to cut the link between quantities imported by the rest of the world and prices.

In order to obtain the trade structure prevailing in 1988, the ratios r_{Mi} and r_{Xi} are exogenously set to the percentage difference between the regional database value and the corresponding value in the trade database for 1988.

Arriving at a balanced trade database

The database is to comprise data for exports f.o.b, trade margins, and imports c.i.f, by source, commodity and destination. The database is to be internally consistent, in that for each commodity and trade (i.e. source-destination ordered pair) exports f.o.b. and the trade margin sum to imports c.i.f values. Values are recorded in US dollars. The reference period is calendar 1988.

The proposed method of construction divides the work into three stages:

1. derivation of initial estimates of exports f.o.b. and imports c.i.f. by commodity and trade, for 1988;
2. determination of c.i.f/f.o.b ratios for each commodity and trade; and
3. reconciliation of export and import estimates.

Initial trade estimates are derived from the original trade data as follows:

1. data for periods other than 1988 are rescaled to 1988, scaling by the ratio of NDP in US dollars at current prices, in the original reference period, to NDP in 1988; and
2. all data are rescaled, using the reporting bias correction factors provided by Hertel and Tsigas (1990), counting Korea as an old NIC (newly industralised country), and ASEAN and rest of world as new NICs.

C.i.f/f.o.b ratios are determined as follows:

1. the judgementally adjusted commodity mean ratios provided by Hertel and Tsigas are scaled so that, weighting by the initial exports estimates, their mean is equal to the overall mean reported by Hertel and Tsigas; similarly the judgementally adjusted trade mean ratios are scaled to agree with the overall mean; and
2. the RAS method is used to determine a set of commodity- and trade-specific ratios consistent with the rescaled commodity and trade means, weighting by the initial exports estimates.

Since Hertel and Tsigas use geometric means, we also use geometric means in rescaling the commodity and trade means. Instead of the means themselves, we rescale their logarithms, so that the arithmetic means of the logarithms, weighted by export shares calculated from the initial export estimates, are equal to the logarithm of the predetermined overall mean. This ensures that the geometric mean of the means is equal to the overall mean.

Likewise, in applying the RAS method to derive commodity- and trade-specific ratios, we require the weighted geometric means across trades and across commodities to agree with the predetermined commodity and trade means. To achieve this, we define a two dimensional array, in which one dimension corresponds to commodities, and the other to trades. Each element of the matrix represents the logarithm of the c.i.f/f.o.b ratio, multiplied by the share of the commodity and trade in total exports. Row and column totals represent logarithms of commodity or trade means, multiplied by the share of the commodity or trade in total exports.

For the initial estimates in the RAS procedure, we use the rescaled commodity means.

Finally, the export and import estimates are reconciled as follows:

1. for each commodity, two two-dimensional arrays are constructed, in which one dimension represents source, and the other destination; in one array the elements represent exports f.o.b, by source and destination; in the other array, they represent imports c.i.f;

2. the imports matrix is revalued to f.o.b. prices, using the c.i.f/f.o.b. ratios determined in the previous stage;

3. an initial f.o.b. trade matrix is calculated, as the maximum of the exports f.o.b. and imports f.o.b. matrices;

4. an initial import-valuation trade matrix is calculated from the f.o.b. trade matrix and the c.i.f/f.o.b ratios, in which trade is shown either f.o.b. or c.i.f, depending on the reporting practice of the importing country;

5. all zeros in imports from or exports to the rest of the world are replaced by a small number (0.01); and

6. a variant of the RAS method is used to generate f.o.b. and import-valuation trade matrices, in which:

   a. source totals in the f.o.b. trade matrix agree with the initial exports estimates for each reporting region;

   b. destination totals in the import-valuation trade matrix agree with the initial imports estimates for each reporting region;

   c. c.i.f/f.o.b ratios agree with the ratios previously determined; and

7. from the final matrices generated by the RAS, and the previously determined c.i.f/f.o.b ratios, a matrix is constructed for each country, showing exports f.o.b, imports c.i.f, and trade margins on imports, by commodity and trading partner.

In the modified RAS procedure, the first step is to rescale the import-valuation matrix so that destination totals agree with the initial imports estimates; the second step, to compute a new f.o.b. trade matrix, using the predetermined c.i.f/f.o.b ratios; the third step, to rescale the new f.o.b. trade matrix so that source totals agree with the initial exports estimates; and the fourth step, to compute a new import-valuation matrix, using the predetermined c.i.f/f.o.b ratios. This four-step cycle is repeated until the conditions on source and destination totals are satisfied simultaneously.

The rest of the world is treated in a special way during the scaling involved in the modified RAS procedure. Suppose we are scaling across rows. Then the row corresponding to rest of world is not scaled. The elements in the column corresponding to the rest of the world are not scaled by the scaling factor for their respective row, but are replaced by the difference between the target row total and the sum of the scaled other elements in their row. It will be noted that intra rest of world trade is not determined by this procedure. It is merely set equal to a small number (0.01) and is determined elsewhere.

APPENDIX C: CONSUMER DEMAND ELASTICITIES

Consumer demand elasticities used in the SALTER model are listed in Tables C.1 and C.2.

Table C.1: **Expenditure elasticities used in the SALTER model**

SALTER commodity number	*Australia*	*New Zealand*	*Canada*	*U.S.A.*	*Japan*	*Korea*	*EC*	*ASEAN*
1	0.1293	0.1311	0.1237	0.1215	0.3408	0.5422	0.3077	0.5583
2	0.1293	0.1311	0.1237	0.1215	0.3408	0.5422	0.3077	0.5583
3	0.1293	0.1311	0.1237	0.1215	0.3408	0.5422	0.3077	0.5583
4	0.1293	0.1311	0.1237	0.1215	0.3408	0.5422	0.3077	0.5583
5	1.1543	1.1705	1.1047	1.0850	1.1184	1.1860	1.1251	1.2298
6	1.1543	1.1705	1.1047	1.0850	1.1184	1.1860	1.1251	1.2298
7	1.1543	1.1705	1.1047	1.0850	1.1184	1.1860	1.1251	1.2298
8	1.1543	1.1705	1.1047	1.0850	1.1184	1.1860	1.1251	1.2298
9	1.1543	1.1705	1.1047	1.0850	1.1184	1.1860	1.1251	1.2298
10	1.1543	1.1705	1.1047	1.0850	1.1184	1.1860	1.1251	1.2298
11	1.1543	1.1705	1.1047	1.0850	1.1184	1.1860	1.1251	1.2298
12	0.1293	0.1311	0.1237	0.1215	0.3408	0.5422	0.3077	0.5583
13	0.1293	0.1311	0.1237	0.1215	0.3408	0.5422	0.3077	0.5583
14	0.1293	0.1311	0.1237	0.1215	0.3408	0.5422	0.3077	0.5583
15	0.9419	0.9551	0.9014	0.8854	0.8912	0.8641	0.8966	0.8253
16	0.1293	0.1311	0.1237	0.1215	0.3408	0.5422	0.3077	0.5583
17	0.8865	0.8989	0.8484	0.8333	0.8388	0.8133	0.8438	0.7767
18	0.8865	0.8989	0.8484	0.8333	0.8388	0.8133	0.8438	0.7767
19	1.1543	1.1705	1.1047	1.0850	1.1184	1.1860	1.1251	1.2298
20	1.1543	1.1705	1.1047	1.0850	1.1184	1.1860	1.1251	1.2298
21	1.1543	1.1705	1.1047	1.0850	1.1184	1.1860	1.1251	1.2298
22	1.1543	1.1705	1.1047	1.0850	1.1184	1.1860	1.1251	1.2298
23	1.1543	1.1705	1.1047	1.0850	1.1184	1.1860	1.1251	1.2298
24	1.1543	1.1705	1.1047	1.0850	1.1184	1.1860	1.1251	1.2298
25	1.1543	1.1705	1.1047	1.0850	1.1184	1.1860	1.1251	1.2298
26	1.0712	1.0862	1.0252	1.0069	1.0310	1.0335	1.0372	1.0113
27	1.0712	1.0862	1.0252	1.0069	1.0310	1.0335	1.0372	1.0113
28	1.0712	1.0862	1.0252	1.0069	1.0310	1.0335	1.0372	1.0113
29	1.1543	1.1705	1.1047	1.0850	1.1184	1.1860	1.1251	1.2298
30	1.1543	1.1705	1.1047	1.0850	1.1184	1.1860	1.1251	1.2298
31	1.1450	1.1611	1.0959	1.0763	1.1096	1.1691	1.1163	1.1974
32	1.1635	1.1798	1.1136	1.0937	1.1359	1.2284	1.1427	1.2945
33	1.1543	1.1705	1.1047	1.0850	1.1184	1.1860	1.1251	1.2298
34	1.1543	1.1705	1.1047	1.0850	1.1184	1.1860	1.1251	1.2298

Their origin is outlined in Chapter 4. Price elasticities ar calculated using the Frisch parameter and the assumptions underlying the linear expenditure system. The cross-price elasticities (not reported here) generated by this system are all negative (the linear expenditure system does not allow for complementarity between commodities). In general, they are very small and the larger values do not exceed 30 per cent of the own-price elasticities.

Table C.2: **Own-price elasticities in the SALTER model**

SALTER Commodity number	*Australia*	*New Zealand*	*Canada*	*U.S.A.*	*Japan*	*Korea*	*EC*	*ASEAN*
1	-0.0885	-0.0522	-0.0635	-0.0657	-0.1380	-0.1673	-0.1486	-0.1064
2	-0.0893	-0.0540	-0.0641	-0.0663	-0.1419	-0.1993	-0.1504	-0.1434
3	-0.0885	-0.0525	-0.0638	-0.0657	-0.1380	-0.1673	-0.1489	-0.1063
4	-0.0886	-0.0527	-0.0636	-0.0657	-0.1380	-0.1675	-0.1488	-0.1142
5	-0.7906	-0.4680	-0.5665	-0.5865	-0.4528	-0.3661	-0.5436	-0.2342
6	-0.7914	-0.4733	-0.5683	-0.5872	-0.4537	-0.3707	-0.5486	-0.2449
7	-0.7906	-0.4667	-0.5674	-0.5866	-0.4528	-0.3677	-0.5438	-0.2391
8	-0.7911	-0.4684	-0.5666	-0.5866	-0.4556	-0.3796	-0.5443	-0.2650
9	-0.7906	-0.4703	-0.5666	-0.5866	-0.4528	-0.3661	-0.5444	-0.2362
10	-0.7907	-0.4664	-0.5683	-0.5865	-0.4528	-0.3661	-0.5446	-0.2342
11	-0.7906	-0.4663	-0.5671	-0.5866	-0.4528	-0.3661	-0.5436	-0.2348
12	-0.0930	-0.0551	-0.0660	-0.0674	-0.1415	-0.1806	-0.1582	-0.1186
13	-0.0905	-0.0549	-0.0655	-0.0667	-0.1398	-0.1740	-0.1526	-0.1105
14	-0.0946	-0.0588	-0.0678	-0.0700	-0.1645	-0.2156	-0.1606	-0.1604
15	-0.6616	-0.4025	-0.4720	-0.4851	-0.3758	-0.3010	-0.4512	-0.1878
16	-0.0897	-0.0543	-0.0640	-0.0662	-0.1399	-0.1717	-0.1556	-0.1174
17	-0.6158	-0.3801	-0.4441	-0.4600	-0.3562	-0.2700	-0.4144	-0.1690
18	-0.6099	-0.3662	-0.4381	-0.4529	-0.3431	-0.2523	-0.4129	-0.1529
19	-0.7935	-0.4750	-0.5715	-0.5895	-0.4548	-0.3686	-0.5513	-0.2393
20	-0.7932	-0.4783	-0.5737	-0.5921	-0.4569	-0.3730	-0.5502	-0.2451
21	-0.7952	-0.4883	-0.5746	-0.5942	-0.4614	-0.3984	-0.5551	-0.2635
22	-0.7917	-0.4737	-0.5733	-0.5969	-0.4590	-0.3839	-0.5495	-0.2405
23	-0.7911	-0.4682	-0.5678	-0.5870	-0.4539	-0.3675	-0.5454	-0.2383
24	-0.7906	-0.4664	-0.5667	-0.5865	-0.4528	-0.3661	-0.5443	-0.2343
25	-0.7918	-0.4713	-0.5697	-0.5877	-0.4554	-0.3684	-0.5468	-0.2446
26	-0.7461	-0.4569	-0.5405	-0.5596	-0.4266	-0.3260	-0.5152	-0.2187
27	-0.7458	-0.4543	-0.5392	-0.5546	-0.4310	-0.3424	-0.5123	-0.2402
28	-0.7388	-0.4377	-0.5295	-0.5489	-0.4236	-0.3254	-0.5057	-0.2073
29	-0.7954	-0.4801	-0.5827	-0.6032	-0.4715	-0.3806	-0.5532	-0.2440
30	-0.7906	-0.4670	-0.5672	-0.5865	-0.4528	-0.3661	-0.5481	-0.2368
31	-0.8419	-0.5930	-0.6704	-0.6831	-0.5843	-0.5011	-0.6399	-0.4254
32	-0.8246	-0.5714	-0.6901	-0.6820	-0.5891	-0.4572	-0.7043	-0.3477
33	-0.8138	-0.5042	-0.5954	-0.6490	-0.5147	-0.4648	-0.5581	-0.2816
34	-0.8308	-0.5431	-0.6386	-0.6537	-0.5451	-0.4235	-0.6007	-0.2835

APPENDIX D: THE ELASTICITY OF SUBSTITUTION BETWEEN IMPORTS FROM DIFFERENT SOURCES - ESTIMATES FOR NEW ZEALAND

Introduction

The demand for imported commodities in the SALTER model is determined by a two stage optimisation process. In the first stage the quantity which is to be sourced domestically and the aggregate level of imports is determined. In the second stage the composition of total imports by source is determined. The second stage assumes that the compensated, or Allen-Uzawa, elasticities of substitution are the same between all sources of imports (that is, a CES specification is assumed).

The purpose of this appendix is to form estimates of the partial elasticities of substitution between different import sources using monthly import data for New Zealand from five sources, collected between July 1982 and December 1987. The five sources are: Asia, Australia, the European Economic Community, North America, and Other Countries. The Asian region comprises Indonesia, Singapore, Thailand, Malaysia and Japan, while the North American region includes the US and Canada.

Estimates of the substitutability between imports from the different sources were derived by treating New Zealand as a single producer combining imports of intermediate inputs with other factors such as capital and labour to produce finished goods for sale to consumers and for export. The production function is assumed to be homothetically separable between imported intermediate inputs and all other inputs. This permits the input demand equations to be derived via the minimisation of total costs over the different sources for a given quantity of total imports, in isolation from all other input decisions.

The import demand equations for New Zealand were derived from a CES import cost function. The CES import cost function is obtained through the minimisation of total import costs subject to importing a given quantity determined by a CES import function.

Previous work

Burgess (1974a, 1974b) develops a framework for modelling import demand by taking a production theoretic approach to the demand for imports. The justification for modelling import demand in this way is that most import decisions are made by firms who combine the imported commodities with other factors to produce the completed good for sale to consumers. The firms production function is assumed to be weakly separable between total imported commodities and all other factors. The firm then chooses its level of import demand from each source so as to minimise its total cost of importing subject to meeting the level of total imports required for the production process. Burgess uses a translog cost function to approximate the total cost of importing from all the sources. The translog cost function was inappropriate for this study since it permitted the elasticity of substitution to vary between pairs of import sources, whereas this study requires the elasticity of substitution between pairs of sources be the same.

Corado and de Melo (1983) derived constant elasticities of substitution for 26 groups of commodities, using annual import data for Portugal between 1962 and 1978. The two sources of imports were the EC and non-EC countries. The elasticity of substitution was estimated by regressing the logarithm of the ratio of EC to non-EC import values against the logarithm of non-EC to EC import prices. Where it was significant the logarithm of national income for Portugal was also included. The coefficient on the price term provides the elasticity of substitution since differentiating the import value term with respect to the price term is the elasticity of substitution by definition.

Kohli and Morey (1990) estimate the elasticity of substitution for US imports of crude oil between 8 regions using demand equations derived from a constant elasticity of substitution cost function. The justification for imposing a constant elasticity of substitution between the sources is that if all the characteristics of crude oil are accounted for in the model then there will be no reason for US importers to prefer oil from one region over another region. The characteristics they included in their equations are: the specific gravity of the oil in each region, the sulphur content of the oil in each region, the shipping distance, the quantity of oil available in each region and the state of the political relationship between the US and the region. The authors make the same assumptions as Burgess in applying production theory to explain import demand behaviour.

A CES model of import demand

The demand for imports into New Zealand is modelled by assuming that New Zealand acts as a single producer minimising its total production costs by choosing the appropriate quantities of labour, capital and domestic or imported intermediate inputs. The production function is assumed to be homothetically separable between imported intermediate inputs and all other inputs and has constant returns to scale. This implies the producer minimises the total cost of importing over the different sources separately to the decisions concerning the level of aggregate imports and other inputs. Assuming all import decisions are made by producers is not unreasonable since even finished goods are not imported directly by consumers but have to go through distribution and retail channels before reaching the final consumer. The model is partial equilibrium in nature as all output and input prices are assumed to be exogenous. Since New Zealand is a small country in terms of international trade, its import decisions have negligible effects upon the world prices of the commodities it imports; consequently, import prices can reasonably be assumed exogenous.

This study is more specifically tailored to the parameter needs of the SALTER model. Within the SALTER model there are several effects that determine the level of commodity import demand by source. Firstly commodity demand is determined by the sum of consumer demand, intermediate usage, government demand and investment demand. Consumer demand is determined by a linear expenditure system whilst intermediate demand is determined by assuming firms have a Leontief technology. Government and investment demand both assume that imports are held in fixed proportions of their aggregates. In the next stage, the level of commodity demand that is to be satisfied domestically is determined while imports supply the remaining demand. This stage assumes a constant elasticity of substitution between demand for domestically produced and imported commodities. In the final stage, the model determines the level of commodities that will be imported from each of the five sources. The import substitution elasticities in SALTER for a particular commodity between the sources of imports is assumed to be the same, hence the need to estimate CES elasticities to be consistent with the specification of the model. The elasticity of substitution measures purely the effect of the responsiveness of the change in import mix as a consequence of a change in the price of one import in isolation of any expansion effect.

A change in the price of an imported commodity from one source will affect aggregate demand, total import demand and the level of demand for imports from each source. For example suppose the price of a commodity from one source fell, this would lower the aggregate import price for that commodity and thus in turn lower the price index of that commodity, increasing overall demand for that commodity by consumers and firms. In the SALTER model, there is both an expansion and a substitution effect at work in this case. Firstly the lower price index means that agents may increase their consumption of all commodities (as their budget now allows them to buy more of all products). Secondly, since one commodity is now cheaper relative to others, additional amounts of this commodity relative to others will now be consumed. This will raise demand for both the imported and domestically produced commodity, but there will be a change in preference for the imported commodity since it is relatively cheaper. In the final level the demand from all importing sources will increase but will favour the source which is now relatively cheaper.

For ease of exposition the import demand theory will be developed in terms of more familiar production input demand. It should be remembered that input prices are in fact imported prices inclusive of freight costs and duty. However, import duties will not affect the share of imports by source in total imports if the rate of duty on each source is the same *ad valorem* rate for all import sources.

A firm's cost function describes how a given level of output can be produced at least cost by employing a vector of inputs, x, given the vector of exogenously determined input prices ω. The cost function of a firm is linearly homogeneous, increasing, continuous and concave in input prices. Linear homogeneity requires that if all input prices are multiplied by the same non zero scalar then the firm's total costs must also increase by this amount. The intuition behind the concavity property is that increasing the price of one input will lead to higher costs but as the price continues to increase the firm substitutes towards other inputs, so that total cost increases but at a decreasing rate. Costs must increase in all input prices since if the firm were able to choose a cost minimising bundle that costs less as a consequence of the price of one input increasing it would have done so previously. Continuity of the cost function requires that for every positive input price there must exist a corresponding level of cost (see Varian 1984).

The cost function is obtained by minimising the firm's total costs subject to producing a given level of output q, to yield an equation which has as its arguments a vector of prices and output. Most empirical applications have also included a time trend to account for the effect of technological changes in total costs. The cost function may be represented as follows where Q(.) is the production function:

$$C(\omega,q) = \min_x \{\omega' x \text{ s.t. } q \in Q(x)\} \qquad \text{(D.1)}$$

where

$C(\omega,q)$ is the cost function with arguments ω, a vector of input prices with elements ω_i, i=1,...,n and q is the level of production; and

x is the vector of input quantities with elements x_i, i=1,...,n.

The firm's derived demand for inputs (x_i^*) may be obtained through Shephard's (1953) Lemma which states the first derivative of the cost function with respect to the ith input price provides the ith input demand equation as follows:

$$x_i^*(\omega,q) = \frac{\partial C(\omega,q)}{\partial \omega_i} \tag{D.2}$$

Rimmer (1990) derives a CES cost function for the two-input case (capital and labour). This cost function extends easily to one in which the number of inputs is greater than two and is given as follows:

$$C(\omega,q) = q\left\{\sum_{j=1}^{n}\left(\frac{\omega_j}{A_j b_j^{-1/\beta}}\right)^{\frac{\beta}{1+\beta}}\right\}^{\frac{1+\beta}{\beta}} \tag{D.3}$$

$$A_j = \exp\{\psi_j t\},\ \sum_{j=1}^{n} b_j = 1$$

where ψ_j, β, and b_j, are the parameters to be estimated. The elasticity of substitution (σ) is given as $\sigma = 1/(1+\beta)$.

Applying Shephard's Lemma to the cost function and multiplying both sides of the equation by ω_i / pq provides an expression for the share of input i in total costs:

$$S_i = \frac{\omega_i x_i}{pq} = \frac{\omega_i}{pq}\frac{\partial C}{\partial \omega_i}$$

In the case of the CES cost function (D.3) this share equals:

$$S_i = \frac{\omega_i}{p\left(A_i b_i^{\frac{-1}{\beta}}\right)}\left[\frac{\omega_i}{A_i b_i^{\frac{-1}{\beta}}}\right]^{\frac{-1}{1+\beta}}\left\{\sum_{j=1}^{n}\left(\frac{\omega_j}{A_j b_j^{\frac{-1}{\beta}}}\right)^{\frac{\beta}{1+\beta}}\right\}^{\frac{1}{\beta}} \tag{D.4}$$

Rearranging equation (D.3) we obtain:

$$\left(\frac{C}{q}\right)^{\frac{\beta}{1+\beta}} = \sum_{j=1}^{n}\left(\frac{\omega_j}{A_j b_j^{\frac{-1}{\beta}}}\right)^{\frac{\beta}{1+\beta}} \qquad (D.5)$$

Substituting this term into equation (D.4) simplifies the equation for the share of input i in the total cost of inputs:

$$S_i = \frac{\omega_i}{pA_i b_i^{\frac{-1}{\beta}}}\left(\frac{\omega_i}{A_i b_i^{\frac{-1}{\beta}}}\right)^{\frac{-1}{1+\beta}}\left(\frac{C}{q}\right)^{\frac{1}{1+\beta}} \qquad (D.6)$$

Further, by substituting into (D.6), the condition of perfect competition in the factor market (i.e. C=pq) provides a simple input share equation as follows:

$$S_i = b_i^{\frac{1}{1+\beta}}\left(\frac{\omega_i}{pA_i}\right)^{\frac{\beta}{1+\beta}} \qquad (D.7)$$

It should be noted at this point that as the model is in fact to be used to describe import behaviour decisions, the price faced by importers from source i is $\omega_i(1+\tau)$, where τ is the *ad valorem* rate of duty. Assuming the rate applied to imports from all sources is the same then the price index of imports from all sources is $p(1+\tau)$. So the share equation is more appropriately given as:

$$S_i = b_i^{\frac{1}{1+\beta}}\left(\frac{\omega_i(1+\tau)}{p(1+\tau)A_i}\right)^{\frac{\beta}{1+\beta}} \qquad (D.8)$$

However, it may be seen from the above that if the duty is *ad valorem* and applied without discrimination against any source then the duty will not affect the share of imports from each source. That is, the demand for inputs is assured to be homothetic.

Taking a logarithmic transformation of both sides of (D.7) and indexing it by time yields:

$$\ln(S_{it}) = \frac{1}{1+\beta}\ln(b_i) + \frac{\beta}{1+\beta}\left\{\ln\left(\frac{\omega_{it}}{p_t}\right) - \ln(A_{it})\right\} \qquad (D.9)$$

While equation (D.9) could form the basis of an estimating system it is important to recognise that firms will form expectations on import prices from different sources. Thus if equation (D.9) is taken as the expected level of imports from source i then the error in forecasting import shares in the previous period is given by:

$$\ln(S_{i,t-1}) - \frac{1}{1+\beta}\ln(b_i) - \frac{\beta}{1+\beta}\left\{\ln\left(\frac{\omega_{i,t-1}}{p_{t-1}}\right) - \ln(A_{i,t-1})\right\} \quad \text{(D.10)}$$

Substituting $A_{it} = \exp\{\psi_i t\}$ into (D.9) and taking first differences provides:

$$d\ln(S_{it}) = \frac{\beta}{1+\beta}\left(d\ln\left(\frac{\omega_{it}}{p_t}\right) - \psi_i\right) \quad \text{(D.11)}$$

It is assumed that producers adjust current ordering patterns in response to past ordering errors. We shall assume that firms adjust inventories (excess or short fall) by some proportion of the error in the previous period. Thus the model includes a proportional change in shares plus some proportion of previous error which is known as an error correction mechanism:

$$\begin{aligned} d\ln(S_{it}) = {} & \frac{\beta}{1+\beta}\left(d\ln\left(\frac{\omega_{it}}{p_t}\right) - \psi_i\right) + \\ & (\alpha_i - 1)\left(\ln(S_{i,t-1}) + c_i - \frac{\beta}{1+\beta}\left\{\ln\left(\frac{\omega_{i,t-1}}{p_{t-1}}\right) - \psi_i(t-1)\right\}\right) \end{aligned} \quad \text{(D.12)}$$

where $-1 < (\alpha_i - 1) < 0$ is expected and $c_i = -\frac{1}{1+\beta}\ln(b_i)$.

To implement this model describing import demand behaviour for New Zealand, the total cost function $C(\omega, q)$ will be assumed to represent the total cost of importing a particular commodity. This function is therefore the minimum cost of importing a quantity of imports q from different sources, where ω_i is the price of an import from source i. Equation (D.12) is the system of equations to be estimated for each commodity. Each equation relates the share of a particular commodity that is imported from each of the import sources to the price of that commodity from each source.

Data and estimation

The quantity and value of imports (including freight costs) were obtained from the New Zealand Department of Statistics (External Trade Section). Data were monthly for the period July 1982 to December 1987. Import data were provided at the 5 digit Standard International Trade Classification (SITC).

Price and quantity series were formed by taking a divisia index of the prices and quantities of the components of aggregate commodity groups (Diewert 1978). The divisia index formula was chosen to aggregate the various components of each commodity group, because it is a weighted average of past and current prices and values. Alternative indices such as Laspeyres and

Paasche, require base prices and thus do not take into account compositional changes in the share of each component within a commodity group.

The formula for the divisia index uses the logarithm of shares and prices. If either quantity or price is zero then the divisia index will be undefined. In order to remove the zeros from the data, the data were aggregated from the 5 digit SITC level to the 4 digit SITC level. In addition the data were aggregated from monthly data to quarterly data, to further remove the zeros.

The percentage of each commodity imported from the different sources and the total value of imports are presented in Tables D.1 and D.2 for the December quarters 1982 and 1987, respectively. The percentage of each source in total imports is provided in the final row, while the last column contains the percentage of each commodity in total imports.

There was little change in the composition of total imports over this period. Approximately one quarter of New Zealand's imports came from Asia. Australia is the second most important supplier of imports, supplying just over one fifth of New Zealand's imports. The most important commodity imported into New Zealand is Other Machinery and Equipment; its share of total imports increased over the five years from 21.6 per cent to 25.7 per cent. A significant shift is noticeable in the share of meat products by source between 1982 and 1987. In 1982 34.4 per cent were provided by Australia. However, by 1987 Australia was by far the most significant supplier providing 83.3 per cent of meat imports. Most of this increase occurred at the expense of meat imports from North America.

During the period of the study there was a movement towards freer trade between Australia and New Zealand that might be reflected in the level of imports from Australia increasing not through changes in prices and this may cause some bias of the estimates. The free trade agreement between New Zealand and Australia has become known as Closer Economic Relations (CER). CER was implemented in the beginning of the first quarter of 1983. The agreement resulted in immediate removal of some restrictions to imports to New Zealand, while other commodities had the restrictions removed gradually. Within each SALTER group different commodities were affected in different ways. Some were never affected by trade restrictions, others were to have restrictions phased out gradually, while the remainders had restrictions removed immediately. Because immediate removal only occurred for a few commodities, CER was not considered to have much impact on the estimated demand for imports from Australia. Any impact could be expected to be negligible and accounted for in the time trend for imports from Australia.

Table D.1: **Percentage of commodity import value by source December quarter 1982** (per cent)

Commodity	Sources: Asia	Australia	EC	Other Countries	North America	Proportion of commodity in imports
Non-grain crops	14.3	12.0	2.5	42.1	29.1	3.8
Other minerals	1.8	10.0	1.1	30.0	57.1	2.2
Meat products	16.5	34.4	3.8	10.3	35.1	0.4
Other food	15.4	19.3	10.6	40.1	14.6	4.8
Tobacco and beverages	0.5	28.5	40.1	26.0	4.9	1.3
Spinning, weaving, dyeing, and other made-up textile goods	21.0	9.6	16.9	38.5	14.1	8.4
Wearing apparel	7.6	9.2	8.2	69.8	5.2	0.4
Leather fur and their products	3.2	26.4	34.4	26.2	9.8	0.6
Lumber and wood products	4.5	24.1	30.8	30.6	10.0	0.3
Pulp, paper and printing	22.2	12.3	37.0	19.1	9.4	2.0
Chemicals, plastics and rubber	14.1	16.0	21.3	18.0	30.7	13.4
Petroleum and coal products	25.6	40.5	1.0	18.0	15.0	11.5
Non-metallic mineral products	16.4	25.5	38.2	6.6	13.2	1.7
Primary iron and steel	51.4	26.9	10.9	7.6	3.2	9.3
Other metal and metal products	16.6	42.4	11.4	8.9	10.6	6.6
Transport equipment	30.7	29.7	15.6	2.2	21.8	11.1
Other machinery and equipment	33.2	11.0	26.2	9.3	20.2	21.6
Other manufactures	15.6	12.5	16.4	38.8	16.6	0.7
Aggregate imports	25.3	22.4	16.5	17.1	18.7	100.0

Source: New Zealand Department of Statistics, External Trade Section.

Table D.2: **Percentage of commodity import value by source December quarter 1987** (per cent)

Commodity	Sources: Asia	Australia	EC	Other Countries	North America	Proportion of commodity in imports
Non-grain crops	11.7	22.8	3.2	35.0	27.3	2.7
Other minerals	5.4	13.3	7.7	38.0	35.5	0.9
Meat products	1.7	83.2	3.3	8.0	3.8	0.6
Other food	19.4	37.5	11.0	20.1	12.0	5.1
Tobacco and beverages	0.3	51.0	31.7	13.1	3.9	1.3
Spinning, weaving, dyeing, and other made-up textile goods	15.3	14.7	18.5	43.1	8.4	6.5
Wearing apparel	5.2	16.8	11.2	64.4	2.4	0.6
Leather fur and their products	3.7	30.0	21.7	37.4	7.2	0.7
Lumber and wood products	8.8	37.0	13.3	36.0	4.8	0.8
Pulp, paper and printing	17.1	11.0	36.5	17.8	17.6	2.8
Chemicals, plastics and rubber	13.9	17.9	23.0	18.6	26.6	10.1
Petroleum and coal products	3.8	32.3	1.6	52.4	10.0	3.5
Non-metallic mineral products	9.8	19.0	42.6	15.5	13.2	2.4
Primary iron and steel	54.8	16.5	10.5	10.2	8.0	7.8
Other metal and metal products	9.6	58.3	11.6	14.4	6.1	6.6
Transport equipment	23.6	23.7	23.0	4.0	25.9	21.1
Other machinery and equipment	37.5	10.4	23.2	16.3	12.6	25.7
Other manufactures	18.1	15.9	26.4	26.5	13.0	0.9
Aggregate imports	24.4	22.0	19.7	17.8	16.1	100.0

Source: New Zealand Department of Statistics, External Trade Section.

The set of equations given by (D.12) is assumed to have an additive error term which has an independent normal distribution with mean zero and unknown covariance matrix. Any variation in the share of imports from one source will impact on the share of imports from other sources, consequently it is assumed that the errors are not independent across the equations. Zellner's (1962) technique of seemingly unrelated regressions was adapted to the non-linear setting of the present estimation.

The system of equations (D.12) consists of import shares which add up to total imports of a commodity. Including all the shares would result in a singular covariance matrix. The share of

Table D.3: Estimated derived import demand equations by source

	Estimated coefficient:								
Source:	*Asia*			*Australia*			*EC*		
SALTER Commodity:	α_1	c_1	ψ_1	α_2	c_2	ψ_2	α_3	c_3	ψ_3
Non-grain crops	-0.00	1.75	2.23	-0.23	2.55	-8.47	-0.42	3.70	-2.34
	(-0.01)	(15.77)	(1.64)	(-1.24)	(17.75)	(-1.59)	(-2.67)	(45.97)	(-1.12)
Other minerals	-0.15	3.97	-0.02	0.32	3.03	0.06	0.06	4.74	0.15
	(-0.64)	(19.36)	(-1.08)	(1.69)	(7.58)	(1.52)	(0.29)	(19.45)	(4.20)
Meat products	0.06	1.32	-0.55	-0.04	1.26	0.32	-0.21	3.15	0.30
	(0.24)	(3.48)	(-0.79)	(-0.19)	(11.40)	(0.96)	(-1.21)	(9.15)	(0.85)
Other food	0.02	2.12	0.04	-0.00	1.52	0.03	0.30	1.90	-0.00
	(0.08)	(19.81)	(4.10)	(-0.03)	(10.50)	(2.95)	(1.72)	(11.13)	(-0.03)
Tobacco & beverages	0.28	4.46	0.14	0.09	1.72	-0.06	0.31	0.55	0.04
	(1.72)	(9.49)	(2.19)	(0.69)	(8.71)	(-2.24)	(2.60)	(4.45)	(2.24)
Spinning, weaving, dyeing other made-up textile goods	0.38	1.28	0.49	0.18	2.75	-0.53	0.38	1.76	-0.16
	(2.45)	(14.72)	(0.20)	(1.27)	(31.09)	(-0.20)	(2.54)	(24.64)	(-0.19)
Wearing apparel	-0.21	2.61	0.06	-0.58	2.91	-0.14	-0.03	2.34	-0.01
	(-1.35)	(15.59)	(1.21)	(-3.03)	(19.01)	(-2.50)	(-0.18)	(13.85)	(-0.55)
Leather, fur & their products	0.35	3.13	0.28	-0.22	1.56	0.19	-0.15	0.85	-0.68
	(1.80)	(12.56)	(0.55)	(-1.52)	(26.07)	(0.92)	(-1.26)	(13.76)	(-0.87)
Lumber & wood products	0.16	2.76	-0.40	0.10	1.44	-0.24	0.16	1.07	0.43
	(0.80)	(12.15)	(-0.44)	(0.55)	(15.23)	(-0.42)	(0.79)	(10.68)	(0.42)
Pulp, paper & printing	-0.19	1.30	-0.02	0.58	2.30	0.02	-0.18	1.09	0.00
	(-0.81)	(17.17)	(-1.82)	(2.92)	(8.48)	(1.30)	(-0.88)	(17.63)	(0.45)
Chemicals, plastics & rubber	0.35	2.06	0.04	0.18	1.94	0.01	0.05	1.45	0.03
	(1.52)	(21.65)	(2.26)	(0.80)	(30.56)	(0.89)	(0.24)	(40.68)	(3.61)
Petroleum & coal products	0.05	1.30	0.00	0.00	0.37	-0.03	0.53	3.63	-0.00
	(0.26)	(6.11)	(0.22)	(0.00)	(2.36)	(-5.71)	(2.63)	(3.39)	(-0.11)
Non-metallic mineral products	0.17	1.69	-0.19	-0.23	1.43	-0.08	0.35	1.06	0.12
	(0.93)	(9.88)	(-0.40)	(-1.31)	(35.29)	(-0.59)	(1.37)	(10.59)	(0.43)
Primary iron & steel	0.00	0.52	0.00	-0.08	1.33	-0.01	-0.12	2.32	0.01
	(-0.03)	(13.74)	(0.27)	(-0.55)	(20.68)	(-1.14)	(-0.86)	(28.03)	(1.42)
Other metals and metal products	0.36	1.78	-0.53	0.32	0.49	-0.01	0.25	2.11	-0.04
	(2.49)	(11.22)	(-0.30)	(2.41)	(9.98)	(-0.12)	(1.53)	(24.81)	(-0.17)
Transport equipment	0.62	1.04	0.09	0.46	2.51	-0.05	0.79	4.44	-0.21
	(3.14)	(2.89)	(1.76)	(2.67)	(8.39)	(-1.24)	(4.61)	(2.67)	(-1.28)
Other machinery & equipment	0.22	1.07	0.07	0.17	2.27	-0.03	0.11	1.21	-0.06
	(1.30)	(16.23)	(1.87)	(0.99)	(18.03)	(-0.72)	(0.63)	(15.88)	(-1.58)
Other manufactures	0.43	1.61	0.04	0.10	2.15	-0.08	0.07	1.52	-0.01
	(2.77)	(10.68)	(1.30)	(0.60)	(18.99)	(-3.54)	(0.47)	(11.00)	(-0.40)

Note: t-statistics are in parenthesis

imports from the US was eliminated from the estimated system to avoid this. Since the critical parameter to be estimated (the elasticity of substitution among imports) is constant across import sources, this does not affect the object of this research.

Results

For each of the 18 commodities considered, a system of 4 import share equations (D.12) was estimated. Each share is the share of imports from a particular source. As mentioned earlier, including all share equations in the system results in a singular system. Therefore the share of imports from North America was dropped from the estimating system. The resulting system of

Table D.3: Continued

			Summary statistics for estimated demand equations							
Other Countries			*Asia*		*Australia*		*EC*		*Other Countries*	
α_4	c_4	ψ_4	R^2	*DW*	R^2	*DW*	R^2	*DW*	R^2	*DW*
-0.18	0.77	0.86	0.47	1.86	0.45	1.54	0.64	1.75	0.55	1.62
(-1.18)	(17.79)	(1.17)								
0.17	1.23	-0.03	0.75	2.32	0.20	1.78	0.49	1.85	0.44	1.85
(0.87)	(6.28)	(-1.37)								
-0.11	2.30	-0.01	0.36	1.61	0.57	1.89	0.66	2.06	0.49	1.80
(-0.51)	(11.80)	(-0.11)								
-0.14	1.26	-0.04	0.59	1.62	0.74	2.00	0.44	2.20	0.70	2.28
(-0.88)	(11.65)	(-4.65)								
0.34	1.57	0.02	0.41	2.02	0.36	1.37	0.09	1.24	0.65	2.35
(2.40)	(9.06)	(0.64)								
0.32	1.03	-0.20	0.25	1.36	0.43	2.02	0.37	2.06	0.21	1.09
(2.48)	(28.39)	(-0.21)								
-0.34	0.33	0.01	0.40	1.56	0.68	1.20	0.53	2.39	0.86	2.59
(-2.57)	(13.15)	(1.66)								
-0.23	1.44	0.49	0.41	2.38	0.53	1.77	0.47	1.59	0.58	1.68
(-1.67)	(25.52)	(0.82)								
-0.27	1.61	-0.34	0.41	1.87	0.37	1.43	0.23	1.32	0.58	1.65
(-1.51)	(25.87)	(-0.42)								
-0.09	1.74	-0.02	0.58	2.34	0.56	2.45	0.68	1.57	0.54	1.84
(-0.35)	(17.65)	(-2.09)								
-0.03	1.68	-0.03	0.46	2.37	0.59	2.26	0.61	1.23	0.58	2.05
(-0.15)	(25.98)	(-2.64)								
0.23	1.85	-0.08	0.43	1.02	0.60	1.52	0.44	1.89	0.68	1.74
(1.15)	(2.71)	(-3.55)								
-0.03	2.83	0.28	0.34	1.56	0.58	1.76	0.37	2.16	0.40	1.63
(-0.13)	(20.35)	(0.42)								
0.32	3.47	-0.01	0.60	2.17	0.44	1.70	0.72	2.26	0.53	2.07
(1.70)	(11.48)	(-0.33)								
0.43	3.26	1.20	0.31	1.75	0.31	1.85	0.44	2.05	0.29	1.58
(2.50)	(20.53)	(0.30)								
-0.18	4.92	-0.19	0.72	2.03	0.66	2.28	0.87	2.80	0.60	2.05
(-1.06)	(19.58)	(-5.01)								
0.25	2.46	0.08	0.28	1.64	0.27	1.20	0.39	1.66	0.20	1.36
(1.24)	(21.92)	(1.48)								
0.10	1.19	-0.02	0.53	1.81	0.29	1.41	0.45	1.78	0.82	2.73
(0.57)	(12.63)	(-1.18)								

equations was estimated using Zellner's (1962) seemingly unrelated regression technique since variation in import shares from one source will impact on the shares of imported commodities from other sources; consequently it is expected that the errors are not independent across the equations. The estimation was performed using the non-linear regression algorithm within SHAZAM (White *et al* 1990). The elasticity of substitution was included in the estimation procedure by substituting $\beta=(1-\sigma)/\sigma$ in equations (D.12); thus the standard errors for the estimated elasticity of substitution are obtained directly.

Summary statistics and the estimated coefficients for each equation are provided in Table D.3, while Table D.4 contains the estimated elasticity of substitution and corresponding t-statistics. Table D.5 contains the own price elasticities of demand from each source, computed for all commodities using the estimated elasticity of substitution and the import shares for the December quarter 1987.

The single equation coefficients of determination (R^2) imply the model fitted the data well. In 40 out of 70 equations estimated, more than 50 per cent of the variation in the data is accounted for by the model proposed. Kohli and Morey (1990) estimated their CES import demand equations using the seemingly unrelated regression equations technique. The model proposed

Table D.4: Estimated CES elasticity of substitution between import sources

SALTER commodity	*Estimated elasticity of substitution:*	*SALTER commodity*	*Estimated elasticity SALTER commodity*
Non-grain crops	1.00 (283.37)	Paper, pulp & printing	2.18 (6.50)
Other minerals	1.81 (8.94)	Chemicals, plastics & rubber	1.44 (11.81)
Meat products	1.13 (7.58)	Petroleum & coal products	3.15 (9.99)
Other food products	2.02 (9.35)	Non-metallic mineral products	1.08 (5.79)
Tobacco & beverages	0.46 (7.37)	Primary, iron & steel	1.61 (7.40)
Spinning, weaving, dyeing and other made-up textiles goods	0.96 (4.36)	Other metal products	1.06 (7.40)
Wearing apparel	0.55 (2.61)	Transport equipment	0.52 (11.20)
Leather, fur & their products	1.05 (19.88)	Other machinery & equipment	1.23 (11.06)
Lumber and their products	0.94 (7.09)	Other manufactures	0.63 (5.35)

Note: t-statistics in parenthesis.

by Kohli and Morey provided a superior explanation of the data compared to our results, explaining almost all the variation of the data. It appears that the main difference between the model estimated here and that of Kohli and Morey is that their study provided additional variables to explain the difference in demand between the sources. Corado and de Melo (1983) estimate their model using OLS and obtain a similar range of coefficients of determination to those obtained in this appendix. Although the authors admit their data was of poor quality, their low R^2 were probably also due to the restrictive nature of their model.

Table D.5: **Estimated own price elasticities of demand for each import source, December quarter 1987**

	Sources				
Commodity	*Asia*	*Australia*	*EC*	*Other Countries*	*North America*
Non-grain crops	-0.88	-0.77	-0.97	-0.65	-0.73
Other minerals	-1.71	-1.57	-1.67	-1.12	-1.17
Meat products	-1.11	-0.19	-1.09	-1.04	-1.09
Other food	-1.63	-1.26	-1.80	-1.61	-1.78
Tobacco and beverages	-0.46	-0.23	-0.31	-0.40	-0.44
Spinning, weaving, dyeing and other made-up textile goods	-0.81	-0.82	-0.78	-0.55	-0.88
Wearing apparel	-0.52	-0.46	-0.49	-0.20	-0.54
Leather, fur and their products	-1.01	-0.74	-0.82	-0.66	-0.97
Lumber and wood products	-0.86	-0.59	-0.81	-0.60	-0.89
Pulp, paper and printing	-1.81	-1.94	-1.38	-1.79	-1.80
Chemicals, plastics and rubber	-1.24	-1.18	-1.11	-1.17	-1.06
Petroleum and coal products	-3.03	-2.13	-3.10	-1.50	-2.84
Non-metallic mineral products	-0.97	-0.87	-0.62	-0.91	-0.94
Primary iron and steel	-0.73	-1.34	-1.44	-1.45	-1.48
Other metal and metal products	-0.96	-0.44	-0.94	-0.91	-1.00
Transport equipment	-0.40	-0.40	-0.40	-0.50	-0.39
Other machinery and equipment	-0.77	-1.10	-0.94	-1.03	-1.08
Other manufactures	-0.52	-0.53	-0.46	-0.46	-0.55

A Wald test (Amemiya 1986) was performed on the overall significance of the system regression by testing the joint hypothesis that all coefficients with the exception of the constant (or intercept) term are zero. The Wald test has an asymptotic chi squared distribution with degrees of freedom equal to the number of coefficients being tested, which in this case is 9. For all estimated import demand equations the Wald statistic exceeded the 5 per cent critical value of 16.9 with the lowest test value being 37.2 for Wearing apparel.

The Durbin Watson statistics indicate serial correlation is not present in most equations estimated. A Durbin Watson test statistic close to 2 reflects the absence of serial correlation. With few exceptions most Durbin Watson statistics were between 1.5 and 2.5. It was therefore not considered necessary to re-estimate the demand equations with corrections for any bias in the standard errors of the coefficients that arise when the errors are serially correlated.

From equation D.7 it can be determined that a negative coefficient on the time trend ψ_i will result in the A_i term, which is an exponential function of time, decreasing during the period of the data. Since the A_i term appears in the denominator of the import share equation (D.7), a negative coefficient implies the share of imports from that source increases over time. Conversely a positive coefficient implies that the share falls over time. Individually the inclusion of the time trend appeared to make no significant contribution to the equations estimated with few of the coefficients being significantly different from zero at the 5 per cent level of significance.

Error correction terms α_i should fall between zero and one if forecasting errors are partially corrected for. If α_i equals zero then importers correct their errors instantaneously. If however α_i is less than zero then importers overcorrect their previous errors. An estimated α_i greater than one would be unreasonable as it would imply importers continually repeat their previous errors. This latter case does not appear in the results estimated.

Some of the estimated coefficients do however imply overcorrection by importers. In most cases however the α_i terms are not significantly different from zero, consequently we cannot reject the hypothesis that the error correction terms are not significantly different from negative one, which would indicate that in response to previous expectation errors, importers fully correct their error in the next period.

The estimated trend (ψ_i) coefficients indicate that there seems to have been some increase in the share of commodities imported from Australia at the expense of New Zealand's other Oceanic trading source Asia. For 12 of the estimated commodity import demand equations there was an increase in the share of imports from Australia while there was a fall in Asia's share of imports for 12 commodities, during the period of the data. There would therefore seem to be some evidence, however small, that there has been some increase in the demand for imports from Australia arising out of Closer Economic Relations between Australia and New Zealand. For EC and Other Countries the number of commodities for which demand for imports from these sources fell, was slightly outweighed by the number of commodities for which demand from these sources rose.

The term in (D.12) involving the coefficient b_i may alternatively be expressed as $C_i = \sigma \ln(b_i)$. Since the elasticity of substitution (σ) is positive for all commodities and the estimated constant is positive for all commodities and sources, then the coefficient b_i falls between zero and one in all cases. The effect of the constant term may best be interpreted from equation (D.9) with the demand share equations in logarithms. If the term in parenthesis is set to zero then the constant term represents some minimum level of import demand from each of the sources. That is the level that will always be imported regardless of what happens to prices. The estimated results indicate that for all imported commodities there will be some level of import demand by source that will be autonomous to the relative price levels. The inclusion of the constant term appears to be warranted since the corresponding t-statistic is relatively large, indicating it is significantly different from zero.

All elasticities of substitution are positive as expected, and are significantly different from zero at the 5 per cent level of significance, indicating that there is substitution between all sources. The large t-statistic implies that the coefficient is large relative to the standard error, therefore it is highly probable that the true elasticity of substitution falls within a very narrow interval around the estimated elasticity (assuming the model is correct). A negative elasticity of substitution would have implied complementarity between any pair of import sources for a similar commodity. It would be unreasonable to expect a rise in the price of a commodity from one source to be accompanied by an increase in demand when other sources may provide similar commodities at lower cost.

The estimated elasticity of substitution varies between 0.46 for Beverages and Tobacco and 3.15 for Petroleum and Coal Products. The magnitude reflects the degree with which the importing country may substitute between the different sources. A low value for the elasticity of substitution could be accounted for by the lack of homogeneity of the commodities comprising the SALTER commodity designation and the difference in quality of the commodity from each source. Quality may be the main reason for a relatively low elasticity of substitution for Lumber and Wood products, since the quality of wood depends upon the species of trees grown in each source. It would not be possible for New Zealand to obtain Australian Cedar or Tasmanian Huon Pine from Asia whereas Canadian Maple could not be imported from Australia. The estimate for Other Manufactures is relatively low since since this classification contains a wide variety of manufactures, that is the commodity designation is not very homogenous. Products within this designation range from buttons to jewellery to musical equipment. If some sources account for the bulk production of the individual goods then this will account for the low estimated elasticity of substitution since importers will not readily substitute between the different goods within the SALTER designation. The elasticity of substitution for Paper, Pulp and Printing is relatively large however, as this classification is relatively more homogeneous since it is less aggregated but more importantly there is less difference in quality between the sources of imports. New Zealand importers will therefore more readily switch between their sources of imported paper as the relative prices of paper imports vary.

The elasticity of substitution for US imports of crude oil estimated by Kohli and Morey of 3.37, with a t-statistic of 1091.14, is very close to the elasticity of substitution for Petroleum and Coal Products estimated by the model proposed here of 3.15. Corado and de Melo obtained an elasticity of substitution of 0.15, with a t-statistic of 0.19 significantly lower than the estimates obtained here and by Kohli and Morey. In addition a different aggregation for Corado and de Melo's commodity group, Petroleum and coal derivatives, may also explain some of the difference in the results of the two models.

The compensated demand elasticity measures the change in input demand once the income effect has been removed, that is, the compensated demand elasticity is measured with output held fixed and only the input combination allowed to vary. The compensated demand elasticity may be recovered from the elasticity of substitution between import sources i and j (σ_{ij}) by multiplying the elasticity of substitution by the share of imports from j. The matrix of compensated demand elasticities will therefore not be symmetric although the elasticity of substitution is constant. The own price elasticities may be obtained via the homogeneity property of the cost function which requires the compensated elasticity with respect to prices must sum to zero; alternatively the own price elasticity is equal to the negative of the sum of the compensated cross demand elasticities. Since the estimated elasticity of substitution is positive and the share of import values must sum to one then the cross compensated demand elasticities obtained from this model will all be positive. Through the homogeneity property, the derived own-elasticities of demand are therefore all negative as expected

Table D.5 contains the own price import demand elasticities computed from the elasticity of substitution and the import shares of the December quarter for 1987. The own price elasticities were typically between zero and negative one indicating the demand for imported commodities from most sources was inelastic, that is the responsiveness of import demand from each source to a change in price was low. The most elastic demand for imports was for imports of Petroleum and Coal Products from the EC with an own price elasticity of -3.10, the most inelastic response being for imports of Pulp Paper and Printing from Other Countries which had an own price elasticity of demand of -0.20.

Conclusions

This study has found that the elasticities of substitution between import sources to be lower than those being used in some multicountry general equilibrium models. For example the substitution elasticity between import sources vary around 5 within the WALRAS model (See OECD 1990). It is important however to recognise that the estimates reflect short run. Long run estimates are expected to be higher, as firms will substitute between sources more if they believe price changes are to be sustained.

Further work may be necessary to estimate long-run elasticities. One possible route is to have prices generated by some expectations mechanism. Other work that may be fruitful is restricting the error correction term to be more plausible, in our case the error correction term should be restricted from implying overcorrection. Further consideration should be given to the choice of lagged variables. It may be more appropriate to lag by four quarters, to remove changes between successive quarters caused by seasonal effects. An alternative is the introduction of seasonal dummy variables to remove the seasonal effect.

The model proposed here assumed that the *ad valorem* rate of duty was the same for each source. Further investigation should be undertaken to see if the assumption was valid and there have been no changes during the sample period on the duty applied from each source.

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