PROTECTIONISM AND AGRICULTURAL COMMODITY TRADE:

An investigation into world wheat trade

using spatial equilibrium modelling.

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ABSTRACT

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Protectionism and Agricultural Commodity Trade

This study has two main objectives. The first is to investigate the capacity and limits of spatial equilibrium modelling in the context of international agricultural commodity trade. The second is to identify protectionism and other factors distorting the pattern of trade in an international agricultural commodity market and to assess their relative importance. Wheat is chosen as the commodity of study.

It is shown how various distorting factors can be built into a basic model whose predictions as a result grow closer and closer to observed reality. The closeness of fit of the model to reality is measured by use of a simple statistic (called λ). Moreover, as the model is built up, the trade flow matrix shows where distortions lie, and what the success of particular model alterations are in capturing the nature of these distortions.

Protectionism is found to be the most significant cause of distortion in the international wheat market. In some cases, however, in particular the US Export Enhancement Program, it appears to be counter-distortionary i.e. redressing distortions on trade patterns caused by other protectionist policies. Also, the effects of including in the model countries additional to those in the basic model are analysed, and a comparison with the international soya market is made.

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CONTENTS

CHAPTER 1: INTRODUCTION

1. The world wheat market, like most international agricultural commodity markets, is a far cry from being perfectly competitive. Agriculture has historically been subject to government intervention, and when comparing international trade in agricultural commodities with that in other goods and services, the higher level of distortion caused by government policies is distinctly noticeable.

2. The term protectionism is used in a broad sense throughout this thesis to include all such government policies. Thus not only are tariffs and quotas defined as protectionist, but so are export subsidies, domestic price supports, export taxes and any other policy involving intervention in the international wheat market. Other factors of importance in shaping the international wheat market are the nature of imperfect competition in wheat trading, and product heterogeneity.

3. This study has two main objectives. The first is to investigate the capacity and limits of spatial equilibrium modelling in the context of international agricultural commodity trade. The second is to identify protectionism and other distortions from perfect competition in an international agricultural commodity market and assess their relative importance.

4. These two objectives have not been chosen arbitrarily. Econometric techniques are typically used to study external trade balances, but are not ideal for studying the patterns of international trade flows. Spatial equilibrium modelling, which specifically models trade flows, has not been so thoroughly investigated as a technique for measuring the effects of protectionism and other distortions on international trade as has econometrics (or for that matter general equilibrium modelling). This study does investigate this possibility, and highlights the advantages (and disadvantages) of using spatial equilibrium modelling. It is shown how various theoretically justified distortions can be built into a basic model

which as a result grows closer and closer to observed reality. The closeness of fit of the model to reality is measured by use of a simple statistic (called λ). Moreover, as the model is built up, the trade flow matrix shows where distortions lie, and what the success of particular model alterations are in capturing the nature of these distortions.

5. Wheat is chosen as the commodity of study due to its dominance in agricultural commodity trade, because there is an international wheat market, and because the wheat market is a good example of a market complicated by a number of different factors: protectionism, imperfect competition, product heterogeneity and product substitutability. However, the choice of only one commodity does not mean that the technique is restricted to the wheat market. On the contrary, as shown in chapter 14 (Extensions and a comparison: the case of soya) the technique can be used for other commodities. The virtue of the approach is its simplicity and flexibility to particular market conditions. Judgement based on detailed knowledge of the market is an essential part of the modelling process, for which there is no apology.

6. In line with this flexible non-mechanistic approach, part I sets the scene for subsequent modelling. Firstly, chapter 2 surveys agricultural commodity trade models. Chapters 3 to 6 then discuss the main distortionary features of the international wheat trade and their effects. With regard to protectionism chapter 3 discusses the effects of the European Community's Common Agricultural Policy (CAP) and other protectionism on developing countries, and chapter 4 surveys protectionist policies (particularly of the exporting countries) specific to the international wheat market. Moving to economic justifications of protectionism chapter 5 analyses the market power of nations in the wheat market, and also imperfect competition in the private trading sector. Chapter 6 discusses wheat heterogeneity.

7. The debate on the appropriate choice of methodology has been left until after part I, so as to be read in the context of the environment in which the choice of model was made. This is covered in chapter 7. The remainder of part II, chapters 8 to 13, documents the modelling carried out. A basic transportation model is presented in chapter 8. This is then adapted to

create partially non-linear and other price models in chapter 9, incorporating the effects of international price on wheat import demands. Protectionist policies are incorporated in chapter 10 and product heterogeneity and seasonality in chapter 11. In chapter 12 an approach to analysing strategic behaviour is discussed. Chapter 13 provides a synthesis of the model developed including an assessment of the relative importance of various market distortions in the international wheat trade.

8. Finally, Part III includes some examples of extensions to the modelling framework developed, and the main conclusions of the study. In chapter 14 the number of countries is extended, and also a comparison made of how the technique can be used to model the international soya market. Chapter 15 presents the main findings and conclusions.

9. A large proportion of the research time has been spent programming, including extending the range of uses of existing software. This is not dwelt on in the body of the thesis and so is worth mentioning here in a little detail. The principal computer software package used has been GAMS (General Algebraic Modeling System) developed by Anthony Brooke, David Kendrick and Alexander Meeraus. The linear solver GAMS/BDLMP and the non linear solver GAMS/MINOS were used. One feature of GAMS is the need to label each line of data input. With up to 3000 lines of data input in a single program this became a sufficient problem to warrant a fortran program produced to write this part of the GAMS program. Template programs (from which other programs could be written) were also produced and extensively used to reduce repetitive programming. An integer non-linear solver would have been of use in chapter 13 in developing discontinuous transport cost functions: although it was possible to call on GAMS/MINOS to model such a function, internal GAMS limits were reached in some cases. Also, several fortran programs were written to process data, including a massive 2300 line program to produce the 39 data sets introduced in chapter 8. The principal econometrics package used was David Hendry's PCGIVE, and Lotus-123 was used extensively to prepare data.

PART I

Trade models and trade distortions

CHAPTER 2: QUANTITATIVE COMMODITY TRADE MODELS

1. The scope of this chapter is to discuss quantitative agricultural commodity trade models. A particular purpose is to introduce some of the problems associated with these models, and to set the scene for the choice of methodology to be used later in the study. Most are partial price equilibrium models. General equilibrium models are also relevant but are not considered as the study is concerned with a single commodity without detailed secondary effects on other sectors. However, some results from general equilibrium models are discussed in chapter 3.

2. Commodity trade models are built to shed light on structure, to forecast, or to simulate the effects of possible policies. We start the discussion of available model types with a basic national structure. This provides a useful departure point for discussion of other model types. The models have different characteristics from which the modeller can choose, depending on his or her objectives and the nature of the commodity market.

3. Before outlining the model it is useful to state some general characteristics of agricultural commodity markets, as distinct from other commodity markets. These differences fundamentally affect the structure of agricultural commodity trade models. Firstly, transport costs are often important as they represent a significant proportion of c.i.f. import price. Secondly, there are in many cases large distortions from free trade caused by tariffs and other import barriers, internal support policies, and export subsidies. Thirdly, factors of production are immobile (land and agricultural labour), thus necessitating commodity trade as opposed to factor movements. Lastly, supply and demand characteristics differ widely from country to country.

Basic national model and import/export elasticities

4. Many commodity models have a similar basic structure, which is

described in equations (2.1) to (2.4) below. National demand and supply functions, together with inventory accumulation and domestic price expectations and formation, are modelled for a country or region under investigation.

$$D = f_1\ (D_{-1},\ p,\ p_l,\ p_s,\ Y,\ z_*) \tag{2.1}$$

$$S = f_2\ (S_{-1},\ p_l,\ z_*) \tag{2.2}$$

$$p = f_3\ (p_{-1},\ \Delta I,\ z_*) \tag{2.3}$$

$$I = I_{-1} + S + M - D - X \tag{2.4}$$

where

D = quantity demanded in current period
D_{-1} = quantity demanded in last period
p = price
p_l = lagged prices
p_s = prices of substitutes
Y = income
z_* = other explanatory and policy variables
S = quantity produced in current period
I = inventory at end of current period
M = imports
X = exports.

5. The model is in partial adjustment form in recognition of structural rigidities in supply and demand. It is noted that there is a delay in supply response (current price is omitted from the supply equation) typical for agricultural products. The greatest empirical weakness in this framework lies in the price determination (2.3) together with equation (2.4). Inventory data for virtually all commodities are inadequate and suffer from errors, and price expectations models are often inadequate. In particular, price formation is often inadequately modelled due to imperfect market structure

and/or government intervention. Theoretical weaknesses of determinacy (causality may be incorrectly assumed) may also pose a problem.

6. The policy variables in the literature are usually domestic, and trade flows often not determined by international conditions, with the balance of trade either exogenous or determined by additional econometric equations. The model, whilst a domestic one, can be extended to cover trade. To construct a world trade model several national models have to be linked, and to endogenize trade flows fully the following constraint is necessary:

$$\Sigma_{i=1}^{n} X = \Sigma_{j=1}^{m} M \tag{2.5}$$

where there are n exporting and m importing countries.

7. Equations (2.1) to (2.5) together provide the framework for modelling the quantities of a commodity in which countries trade, although not who trades with whom. This can be seen if equations (2.1) and (2.2) are substituted into equation (2.4), giving an identity in (M - X):

$$M - X = \Delta I + f_1(...) - f_2(...) \tag{2.6}$$

If a world price is included in the z_* term in equation (2.2) for a country, then that country's reactions are modelled as responding to world market conditions, and further relationships are required to determine the world price. Commonly, the (M - X) term in equation (2.6) is assumed determined by domestic variables (the right-hand term), without itself determining those domestic variables in any way. At the same time, in a large country, M and X affect international prices; but we shall ignore this possibility for the moment.

8. If it is not domestic aspects but international trade and the world price which are of most interest to the modeller, then what is required is the trade part of the model, rather than the set of domestic relations as described. Equations (2.1) to (2.4) may be considered unnecessary luxuries.

What is important is an explanation of import demands and export supplies.

9. Most commodity trade models which do model an international market rely on the existence of a world price for the commodity in question. The price is determined by the equilibrium of world export supply with world import demand. These in turn are normally modelled with the help of export supply and import demand elasticities of individual countries. Any market distortions are treated as part of national behaviour. In other words, a world price and perfect competition are still assumed to exist in the international trade part of the model. Trading nations' perceptions of other countries' reactions determine their own actions, and so are important. The reactions modelled should be as complete as practicable, taking into account any significant market distortions, institutional characteristics, and other relevant government and private behaviour affected by changes in the world price. This methodology allows analysis of the effects of distortions by comparing different simulations.

10. Assuming a world market clearing without distortions, the normal procedure for calculating countries' trading behaviour is, as stated above, via import and export elasticities. These can be either dependent variables from the domestic models, or estimated econometrically from historical data, and are often assumed fixed once estimated. However, econometric estimation from time series data must consist of more than simple regression of trade quantity on world price by ordinary least squares, as has been done in some cases - price and quantity are determined simultaneously. Also, it is important that other relevant variables be included.

11. In addition, in a celebrated article Orcutt (1950) adduced five reasons why estimated price coefficients may be biased towards zero. These factors were widely believed to lead to under-estimation of elasticities until Magee (1975) produced a list of eight reasons why the converse could be true, i.e

elasticities be over-estimated.[1]

12. In the standard framework outlined so far price elasticity estimates are essential. The equilibrium world market price and the quantities traded between each region in the model are determined simultaneously by the behaviour of all regions according to these elasticities. As the accuracy of elasticity estimations is often in doubt (which may significantly reduce the significance of model results), sensitivity analysis may be essential to gauge the importance of estimation errors.

Protectionism, Oligopoly, and foreign exchange shortages

13. Protectionism is defined as any government action designed to distort trade by affecting prices or quantities of imports or exports. The basic protectionist device is the tariff. In the equations presented above, prices have all been expressed in local currencies. To change these into a world price they are converted using exchange rates with the numéraire[2] currency,

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[1] Orcutt's list comprised simultaneity, random observation errors in the price indices, aggregation, timing (short-run elasticities are smaller than long-run elasticities), and quantum effects (elasticities are larger for large price changes than for small price changes). Magee's counter list consisted of non-price rationing, cross-price effects, structural effects, understated lags, inversely correlated measurement errors, aggregate prices in submarkets, positive component elasticities, and 'Orcuttization' (modellers over-estimating elasticities in order to counter under-estimation).

[2] A numéraire currency (say the US$) may also be a 'key' currency in either or both of two senses. Firstly, changes in US domestic variables such as US demand or labour costs may have a major effect on real world prices. This is the case when the US has a large domestic market for the good and/or is the residual supplier on the world market. Secondly, movements in nominal dollar exchange rates (brought about by factors entirely outside the market for the commodity in question) may cause a change in the real world price. In other words, nominal US exchange rate changes may not be accompanied by matching movements in the dollar price of the good. This is due to market imperfections, such as rule-of-thumb pricing in dollars. With rational expectations, perfect information, and zero transaction costs the real value of the good in foreign currency would be unaffected. However, there are serious measurement difficulties about determining whether a numéraire currency is or is not a key currency in this second sense. There are three reasons why the price of some commodity measured in a non-key

usually the US dollar. In the absence of protectionism we have simply:

$$p_j^w = (1/\epsilon).p_j^d, \tag{2.7}$$

where ϵ is the exchange rate in units of domestic currency per unit of the key currency.

14. Now equation (2.7) can be re-arranged and tariffs introduced as follows:

$$p_j^d = p_j^w.\epsilon.(1 + v_j) + s_j, \tag{2.8}$$

where v_j is an ad valorem and s_j a specific tariff. The argument is symmetric for export taxes.

15. Unfortunately, non-tariff barriers are normally more significant in agriculture than tariff barriers, and they are not as easily modelled, being often not directly sensitive to price variations. Considerable effort has been spent in trying to calculate tariff equivalents for non-tariff barriers (see Baldwin (1970)). If non-tariff barriers (as reflections of government policy) are indirectly sensitive to changes in prices then a tariff equivalent will be a function of price. However, unless the non-tariff barrier equivalent is **not** a function of price, the moment any exogenous non-tariff barrier in a model changes so does the tariff equivalent for that region, which in turn, depending on quantities traded, changes the measured

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numéraire currency (say again the US$) varies, and the relevance of each has to be assessed before the degree to which the numéraire is after all a key currency can be gauged. Firstly, factors affecting the commodity's real purchasing power in the world market may change; secondly, the US$ nominal exchange rate may vary; and thirdly, there may be world inflation. All three are liable to be difficult to measure. Typically, there are problems of the choice of weights for compiling appropriate index numbers. For example, national price indices have to be weighted to produce an average world index; bilateral foreign exchange rates have to be weighted in order to define the overall appreciation or depreciation of the numéraire currency. See chapter 4 for an example of how to transform price movements in current US$ to reflect movements in real purchasing power assuming the dollar to be **not** a key currency.

world price import demand elasticity. In fact, the effect of non-tariff barriers may be to insulate internal prices from world prices (if internal prices are kept higher than the world price then non-tariff barriers are decreasing functions of world price). In the extreme case of a state agency deciding on internal prices, or on the volume of trade, totally independently of world prices, a model which determines trade using prices and elasticities is completely inadequate in trying to explain the trade of that country. The Common Agricultural Policy of the European Community is a good example, where variable levies keep internal prices within certain limits regardless of global conditions. In other words the protectionist barrier (the variable levy) is itself perfectly responsive to world prices. A comparable effect is achieved when countries prefer (as many do) to set quotas instead of tariffs, so they can be sure of the amount imported regardless of the world price.

16. What motivates protectionist policies? And if protection is not determined by world price, can it still be endogenized in a trade model? In order to answer these questions it is necessary to understand in detail the motivations of the governments concerned.

17. One motivation is the setting of an optimal tariff: importing or exporting countries or trading blocs with enough market power are able to set optimal tariffs or export taxes (or equivalents) in order to decrease or increase respectively the world price of a traded good to their advantage. Secondly, imperfect competition may lead to protectionism in order to capture surplus profits. Thirdly, where externalities exist protectionism may be justified in order to modify private sector behaviour to take account of social costs and benefits.

18. A fourth explanation which seems plausible in many cases is that government policy is decided primarily on (political) income distribution considerations, rather than with reference to economic efficiency. Anderson (1978) and Brock and Magee (1978) have argued that policy is determined by demand from rent seekers (domestic producers and traders of the good) for protection in the face of foreign competition at home or abroad as against

government willingness to provide it.[3]

19. A fifth argument is that protectionism is applied by governments in order to encourage domestic production for strategic reasons. Winters (1988), comments in relation to the Common Agricultural Policy of the European Community, that this is largely a false justification for protectionism. Agricultural inputs (such as fertilizers and oil) are more susceptible to embargo than produce. Also, if an embargo is feared, stockpiling would be far cheaper. However, whether the argument is justified or not in the case of the CAP, it may still be a motivation for protectionism in many instances.

20. These arguments suggest that in some commodity markets domestic prices may be unresponsive to world price changes. Protectionism may be responsive to the world price if it takes the form of a tariff or a levy that varies with world price to maintain constant internal prices - in this case the responsiveness of the protectionism to world price is the cause of the lack of responsiveness of domestic prices to world price. Other barriers such as quotas may also be price responsive to some extent[4], but much protectionism is unresponsive to world price and primarily motivated by non-market considerations. The more significant are distortions caused by this type of protectionism in a market, the less easily a world price can be modelled, or government behaviour, or domestic prices, or trade. This is because this protectionism is exogenous to a price equilibrium model.

21. Similarly, distortions may occur if there is imperfect competition in

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[3] This is one case where symmetry between export taxes and tariffs breaks down. To be successful a lobby usually has to be organized and articulate, which requires strong commitment by those lobbying. This is often more easily attained by a set of producers of a particular good, than the consumer/taxpayer. This approach may explain why export taxes are less common than tariffs.

[4] If governments have clear unchanging objectives, perfect information, and are able to alter protectionist measures continuously, then virtually all protection is responsive to world price to some extent. In practice this is often not the case due to these assumptions being invalid (changing objectives, imperfect information, and especially non-continuous alteration of protectionist measures).

the world market for a commodity. This possibility, and further analysis of government motivations and behaviour, are discussed in chapter 5.

22. Distortions may also occur as a result of foreign exchange shortages faced by developing countries. Significant reductions in food imports of countries short of foreign exchange have been detected empirically in several cases. This has led Jabara and Thompson (1980) to argue that optimum risk-averse policy may be to distort domestic prices away from world market prices in order to save foreign exchange. Foreign exchange shortages do not only influence importers however. In the wheat market since 1985 foreign exchange shortages of importing countries have been countered increasingly competitively by exporters offering credit. This discriminates against those exporters themselves short of foreign exchange who cannot provide such credit.

Spatial equilibrium models

23. Spatial equilibrium models are those which model trade flows[5] as opposed to mere aggregate national export and import positions. To do this some technique has to be incorporated which will distinguish one flow from another. One approach is to apply market shares, which can be predicted from historical data, using either simple mechanical techniques to determine trends in market share changes or more sophisticated econometric techniques which include variables other than historical market shares. However, this methodology on its own fails to explain adequately the determinants of the historical patterns; and the assumption that patterns will continue as hitherto may in any case be misplaced. Accordingly, a detailed econometric analysis of trade flows using economic theory to select dependent variables could be more profitable. Alternatively, models can be used which focus on transport costs, and maximise the global gains from a given total trade using mathematical programming.

[5] A trade flow is here defined as a quantity traded over a period (normally a year), and specific to both its origin and destination countries.

24. International transport costs are added to the price received by the exporter to yield the price paid by the importer. With otherwise perfect competition it follows that every importer pays the same ex-transport (f.o.b.) price to each supplier, and every exporter receives the f.o.b. price. Thus, where all prices are denominated in a numéraire currency (normally US dollars) the following equality holds for all non-zero trade flows:

$$p_i + t_{ij} = p_j \tag{2.9}$$

(where t_{ij} is the transport cost from exporter i to importer j). If $p_i + t_{ij}$ is observed to be less than p_j then (assuming rising supply curves) this must be caused by a distortion away from perfect competition - i.e. super-normal profits. If $p_i + t_{ij}$ is greater than p_j then the trade flow is zero.

In addition, the following constraints are imposed:

$$\Sigma_{i=1}^{n} F_{ij} = M_j, \qquad j = 1,m \tag{2.10}$$

and

$$\Sigma_{j=1}^{m} F_{ij} = X_i, \qquad i = 1,n \tag{2.11}$$

where F_{ij} is the trade flow from i to j. In other words, the sum of flows from a country equals total exports and the sum of flows to a country total imports.

25. The assumption behind equation (2.9), that each importer pays the same for all imports and each exporter receives the same f.o.b. price for its exports, is often observed not to be true in practice. This is due to protectionism and other distortions, as well as the fact that there is only a restricted number of countries trading (exporting in particular). Exporters may in theory compete in international clearing houses, not conscious of the nationalities of the buyers; but whilst this is the case for many minerals

and metals, it is often not so in agricultural markets: exporters and their governments compete for specific markets against known competitors.

26. Having drawn attention to possible pitfalls in the assumption that countries pay and receive the same prices for all their transactions, we now turn to the analysis itself and examine the results which are obtainable. The modeller's objective is to find an equilibrium set of prices which ensures market clearing given a matrix of transport costs (made up of t_{ij} terms). If imports and exports are assumed price-responsive (under perfect competition) an equilibrium solution requires non-linear programming. This is because, if imports and exports are responsive to the world price, the cost minimization function which determines global spatial equilibrium includes in its argument the world price, and not simply transport costs. Samuelson (1952) showed that competitive spatial equilibrium is obtained by maximizing the area under all excess demand curves minus that under all excess supply curves minus total transport costs. Formally, this is expressed as:

$$maximixe\ \pi = \sum_{j=1}^{m} \int_0^{M_j} p_j^M(M_j)\, dM_j - \sum_{i=i}^{n} \int_0^{X_i} p_i^X(X_i)\, dX_i - \sum_{i=1}^{n} \sum_{j=1}^{m} t_{ij} F_{ij} \qquad (2.12)$$

subject to non-negativity constraints and equations (2.10) and (2.11).

27. This can be difficult and expensive to solve. The problem becomes easier if world price for each country is assumed to be a linear function of the quantity imported or exported for the country (after Takayama and Judge, 1964a, 1964b):

$$p_j^M = b_j + c_j M_j, \qquad p_i^X = b_i + c_i X_i \qquad (2.13)$$

Then, integrating (2.12) and disposing of integration constants[6], the maximand becomes a quadratic, and the resulting model is called a quadratic programming model:

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[6] For optimization purposes the integration constants can be ignored as their existence does not affect the outcome of the optimization.

$$\text{maximize } \pi = \Sigma_{j=1}^{m}(b_j M_j + c_j M_j^2) - \Sigma_{i=1}^{n}(b_i X_i + c_i X_i^2) - \Sigma_{i=1}^{n}\Sigma_{j=1}^{m} t_{ij} F_{ij} \qquad (2.14)$$

The parameters b_j, c_j, b_i, and c_i together capture countries' reactions to prices, including tariff changes, in more detail than simple constant elasticities. Furthermore, although integration constants were discarded in equation (2.14) after integration of equation (2.12), constants can be re-introduced to model non-price-responsive movements in behaviour.

28. A technical difficulty is that the number of non-zero trade flows calculated in the solution cannot mathematically exceed the number of constraints (n + m - 1 + any additional constraints imposed). This, however, is a difficulty only inasmuch as more trade flows are observed to be non-zero due to market distortions and behavioural characteristics than would occur without distortions. In the absence of distortions, assuming that transport costs between regions are all different, it follows that at least one flow (along the cheapest route) from an exporter to an importer will either equal the exporter's total exports, or equal the importer's total imports of the good. The next flow (along the second cheapest route) is determined taking into account the flow already established, and so on. In this way a maximum of n + m - 1 flows is attained. By the same token, it is the assumption of a non-distorted market which may lead to a difference between the expected number of trade flows in the market and the number actually observed. However, by including additional constraints which for instance restrict certain bilateral trade flows as lying within certain limits (i.e the flows are constrained to be non-zero), the potential number of trade flows is increased as the model incorporates these distortions.

29. Quadratic programming has been much used, but computational costs can rise with the number of regions included in the model; and the simple linear price relations (2.13) may be inadequate to model price and trade behaviour, in particular if inventories are significant. As price equations more complex than those presented in equation (2.13) are used computational costs again rise. Several techniques have been developed to solve such non-linear and

non-quadratic programming problems, and others developed as alternatives to quadratic programming. First, MacKinnon (1976) developed a fixed-point algorithm called the sandwich technique. Secondly, Holland and Pratt (1980) elaborated an iterative algorithm. Both of these have been used to model the world wheat market, which displays highly non-linear inventory demand functions. Thirdly, to reduce programme costs, a large non-linear model can be broken into several smaller ones and joined by a linear programme. Fourthly, assuming linear or log-linear demand and supply functions, reactive programming is a relatively cheap technique developed by Tramel (see King and Ho, 1972) as an alternative to quadratic programming. Lastly, as a further alternative to quadratic programming in large models, Duloy and Norton (1975) have shown how linear programming can be used to approximate more realistic but over-expensive alternatives.

30. So far, international prices have been of crucial importance to the models discussed. However, as has been mentioned, it is possible that domestic prices may be relatively unresponsive to world price changes (due to domestic price support policies), and that government policy may be the main determinant of internal prices, import demand, and export supply. In certain markets, therefore, balances of trade may have very little to do with world prices. However, trade flows can still be modelled even if trade balances are non-price-responsive.

31. The market share approach is one way of modelling such flows, as mentioned in paragraph 23. Alternatively, within the set of spatial equilibrium models, linear programming can be used. If imports and exports are not functions of world price in any region, then (implicitly) f.o.b. prices cannot be functions of M_j or X_i in any region. Then maximization of π in (2.12) is the same as minimization of just the third term, the first two terms being constant with respect to the pattern of flows. The problem becomes a simple 'transportation problem', where flows are determined solely on the basis of minimizing total transport costs.

We minimize $$T = \Sigma_{i=1}^{n}\Sigma_{j=1}^{m}t_{ij}F_{ij} \qquad (2.15)$$

subject to (2.10) and (2.11) and non-negativity constraints.

Nonspatial price equilibrium models

32. Nonspatial equilibrium models model total import and export positions of countries for the commodity in question, but not individual (disaggregated) trade flows. They can be considered a simplification of spatial equilibrium models, and they are cheaper and easier to formulate than spatial equilibrium models.

33. Nonspatial equilibrium models are normally formulated as a set of simultaneous equations (as opposed to a mathematical programming problem). The changes in imports and exports of countries are calculated from c.i.f. and f.o.b. prices respectively using import and export elasticities. For non-zero trade flows (as in the spatial models, such flows may number no more than $n + m - 1$, but unlike in the spatial models the specification of which potential flows are non-zero is already given) transport costs can be incorporated using equation (2.9). So in a simple model there may be $n + m - 1$ trade flows, n price-export-reaction functions, m price-import-reaction functions, and the constraint (2.5) that total imports equal total imports. This implies a total of $2(n + m)$ variables to be determined if import demands and export supplies are assumed functions of world price ($n + m$ prices, n export supplies, and m import demands).

34. The model does not specify which potential trade flows are non-zero. Three methods have been adopted to overcome this problem. Firstly and most simply, transport costs can be ignored altogether. The $n + m - 1$ price equations (2.9) then disappear, a uniform world market price is assumed and the model becomes dependent entirely on import demand and export supply functions (subject to (2.5)). Zwart and Meilke (1979) in a study of the world wheat market argue that this is justified on the grounds that transport costs can be considered a part of domestic production costs.

35. Secondly, Rojko et al (1978) used prior knowledge of the principal

trading routes to determine which t_{ij} values should be modelled as non-zero. This approach is obviously not appropriate when trying to predict changes in trade patterns unless there is strong reason to suppose that any change considered would not open up new flows.

36. Thirdly, all export prices can be linked to a single world price by differentials determined by transport costs to markets where more than one exporter exports, i.e. the f.o.b. price of a particular exporter is always a fixed percentage below or above that of another. Similarly, all importers can be assumed to pay a fixed differential from the world price. Now instead of n + m - 1 constraints (2.9) corresponding to actual flows, there are n + m - 1 equations of the type:

$$p_k = p_w + t_k \tag{2.16}$$

where p_k is a country's domestic port price, p_w is the world price (that of a numéraire country), and t_k is the transport differential (which is negative for exporters). In effect the model assumes all countries to be located on a line (although not necessarily a straight line) from which trade cannot deviate. However, the surface of the earth is not one-dimensional but two-dimensional.

37. Non-spatial models have certain advantages over spatial ones. Firstly the models are cheaper and easier to run and so for instance more domestic market details can be included within a given research budget. Secondly, the simultaneous equations solution method makes it easier to endogenize exchange rates, policy variables, and transport costs as it is not difficult for more equations specifying such constraints to be added.

38. Disadvantages, however, include the fact that the models are not very accurate if transport cost differences vary considerably between routes or vary over time, or if the set of non-zero trade flows changes. Finally, it is more difficult to introduce non-price-responsive variables.

Differentiated Product models

39. Differentiated product models were developed by Armington (1969). They differentiate products by place of production. This is justified where goods are not perfectly homogenous. In the case of commodities there may be physical differences in quality, or other types of differences perceived as important by the importer such as credit facilities offered, security of supply, or bilateral political relationships. To model this imperfect substitution in a general equilibrium framework would be hugely expensive if every country's production was viewed as an entirely separate good. Therefore, Armington assumes consumers to have weakly separable utility functions: that is, consumers maximize utility with respect to quantities of various broad categories of goods (subject to expenditure constraints), and then for each good maximize utility with respect to different varieties of the same good, subject to a total quantity constraint. In other words, importers choose first how much of each good they require, and secondly their sources.

40. Even assuming independence of want and a linearly homogenous utility function, in order to simplify demand equations to make them of practical use, some further restrictive assumptions are necessary. The second stage of the demand decision is fairly easy to model: the problem is a simple utility maximization problem given a budget constraint representing total expenditure on the good (weak separability is a necessary and sufficient condition for this second stage budgeting). Calculation of this total good expenditure at the first stage, however, is more problematic: one solution is to assume additive separability and Gorman polar form utility functions between goods. Within this framework, and for computational simplicity, Armington assumes constant elasticity of substitution (CES) across countries (varieties of good). The cross-price elasticities between different varieties can be calculated from the estimated price elasticity of substitution for the category of good, the estimated price elasticity of import demand, and import share.

41. One weakness of this model is that substitution elasticities between

varieties have to be constant and equal across countries. To increase flexibility Artus and Rhomberg (1973) generalise Armington's initial model by replacing the CES functions with constant-ratio-of-elasticities-of-substitution and homothetic (CRESH) functions. These functions enable proportionate changes in substitution elasticities to occur. Take the example of importer A importing x% more than before from B due to a solitary price reduction by B. Under the CES formulation the corresponding loss to other exporters is spread equally among them; whereas this is only one possibility using CRESH functions - it being possible to specify these proportions. Resnick and Truman (1973) achieved the same loosening effect as Artus and Rhomberg by specifying a multi-stage decision process.

42. The Armington assumption, as it is known, is most effective in multi-sectoral models and for broad product classifications. Grennes, Johnson, and Thursby (1977) used the assumption in a model of the world wheat market on the grounds that wheat is not a homogenous commodity, and that state trading, cross-hauling and imperfect competition result in there not being a single world price for wheat. However, their forecasts of changes in trade and prices have prediction errors mostly over 20%. This possibly stemmed from failing to use historical data to estimate substitution elasticities, and from use of the original Armington CES model as opposed to a more generalized specification.

43. There are also other types of model which differentiate products. Markov models assume that consumers tend to switch from goods whose prices are going up to those whose prices are going down. Then there are a whole variety of both econometric and market share models. Lastly, instead of (or in addition to) differentiating products, one can differentiate between characteristics of products. Lancaster's 1971 characteristics model and some subsequent developments are discussed in chapter 6.

Conclusion

44. The purpose of this opening chapter has been to introduce the main

types of agricultural single-commodity trade models. The chapter has concentrated on general methodologies and issues rather than any detailed analyses. Also, multi-commodity models have been excluded, as has a discussion of the strategic aspects of trade policy, which is reserved for chapter 5.

45. Most of the approaches discussed have been partial price equilibrium models. For the purpose of this study it is important firstly that even partial (as opposed to general) price equilibrium models tend to be costly in money and time to construct and estimate. Secondly, forms of government intervention which insulate national markets from world price movements, as well as other market distortions such as monopolistic or oligopolistic competition, may make the use of international prices as the main or only determinant of trade inappropriate.

CHAPTER 3: EFFECTS OF PROTECTIONISM ON DEVELOPING COUNTRIES

1. Chapter 2 concentrated on the theoretical and empirical properties and problems of various types of commodity trade model. This chapter investigates the international effects of protection, and in particular those of the Common Agricultural Policy of the European Community (CAP) on developing countries. This analysis is not restricted to wheat, whereas the content of subsequent chapters is largely wheat specific. The chapter is split into three sections: a section briefly outlining relevant general external impacts of protection, a description of the main external repercussions of the CAP, and lastly a review of the evidence presented in empirical studies addressing the effects of CAP protection on developing countries. The issue of the effect of the CAP in the case of wheat is revisited in chapters 10 and 13.

External Impacts of Protection

2. What are the (static) welfare changes to foreign countries when a single government introduces a policy which causes a move from free trade? We assume that countries are not 'small' in that the world price is affected by their actions, and that they have similar utility functions and demand patterns. Then, if only one country moves from free trade and that country is subsequently better off, then at least one other country must be worse off as total global welfare can not be exceeded by that attained under free trade (Samuelson, 1962). More generally, any set of distortions which makes the total welfare of the set of distorting countries better off must make the sum of other countries worse off.

3. Unfortunately, although the individual actions of distorting countries may be welfare maximizing[1], the combined actions of a set of distortion

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[1] This is not to say, however, that protectionist policies do maximize domestic welfare, at least in a narrow Paretian sense. Other objectives may include the need to raise revenue, income distribution objectives, or non-economic objectives relating to trade or domestic political necessity.

creating countries may make that set of countries worse off. If this is the case (as it often is in agricultural markets) then the total net welfare effect on the rest of the world is also ambiguous.

4. Empirical work is therefore necessary to determine the total net effects, as well as the effects on individual countries, although it may not be clear what counter-factuals should be used, nor (where suitable historical data are unavailable) what assumptions should be employed to calculate them. Additionally, even if the distorting countries jointly increase their net welfare, the assumptions that countries do not anticipate competitors' reactions and that demand patterns are identical are unrealistic. Also, the distribution of gains within a country may be assumed to affect the total welfare of the country.

5. There are, however, some effects of specific distortions that are normally observed. Here we consider tariffs, export subsidies, non-tariff barriers such as quotas and variable levies, and also export tariffs and equivalents. We continue for the moment to assume perfect competition and constant returns to scale. Government intervention which affects market power is considered in chapter 5.

6. Whenever a tariff, non-tariff barrier, or export tax or equivalent is binding, trade is reduced. If the imposing country has a comparative advantage and is reducing its exports; or if the country is protecting import substitutes when the rest of the world, as an aggregate, has a comparative advantage in the good; then there will be a reduction in the total gains from trade as world production becomes less efficient. Assuming this, in the case of a measure that alters domestic price, domestic loss consists of deadweight consumption and production losses[2] (fig.3.1). If the protection does not

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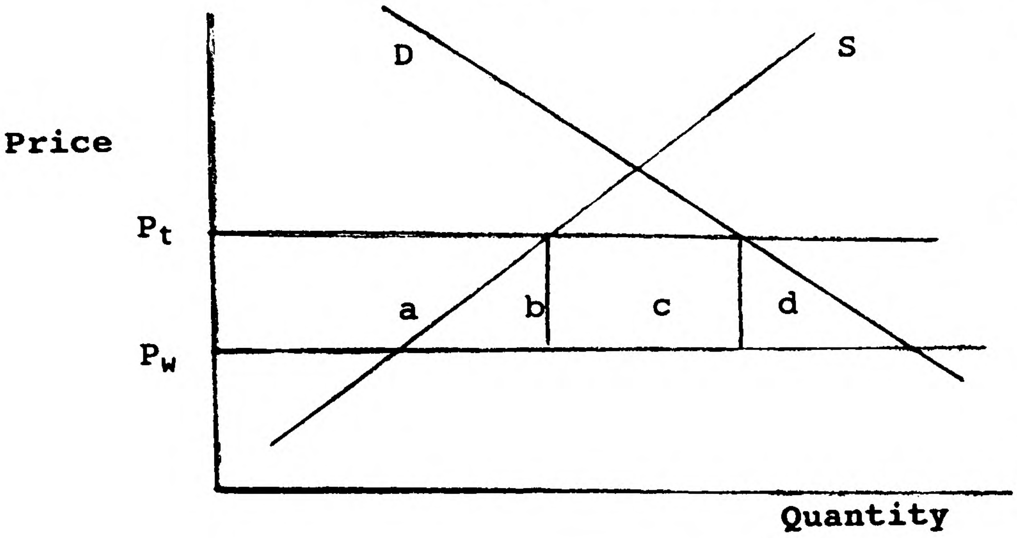
Moreover, whatever the objectives, government measures may be ill-defined to achieve them in practice.

[2] The case of an export tax is broadly symmetrical with that of a tariff. However, in the case of an export tax a deadweight consumption loss is said to occur whilst domestic prices go down. The loss stems from excessive domestic consumption of the good, and is borne by the consumer through higher taxes.

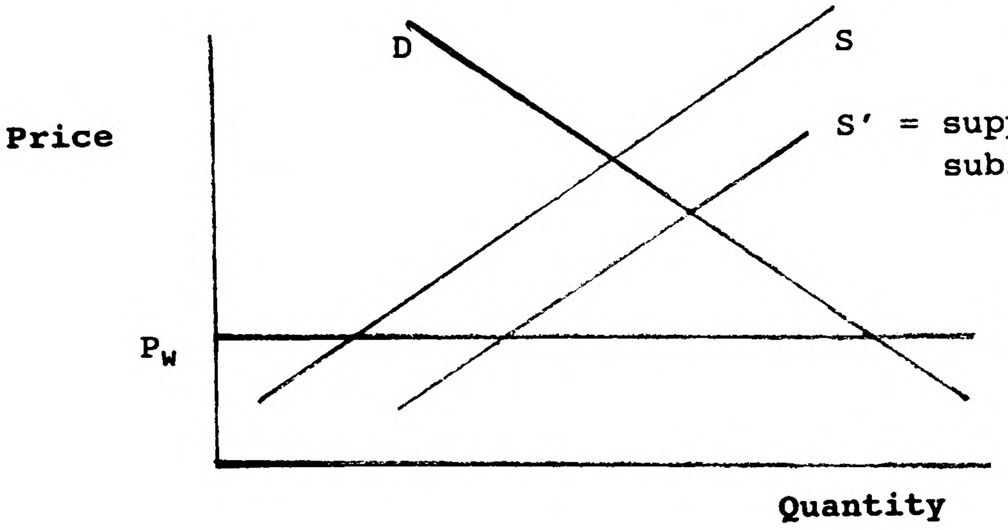
fig 3.1 The effect of a tariff



a+b+c+d = consumer surplus loss
a = producer surplus gain
b = deadweight production loss
c = tariff revenue
d = deadweight consumption loss
P_W= world price
P_t= domestic price with tariff

(At a given price Imports = Demand - Supply)

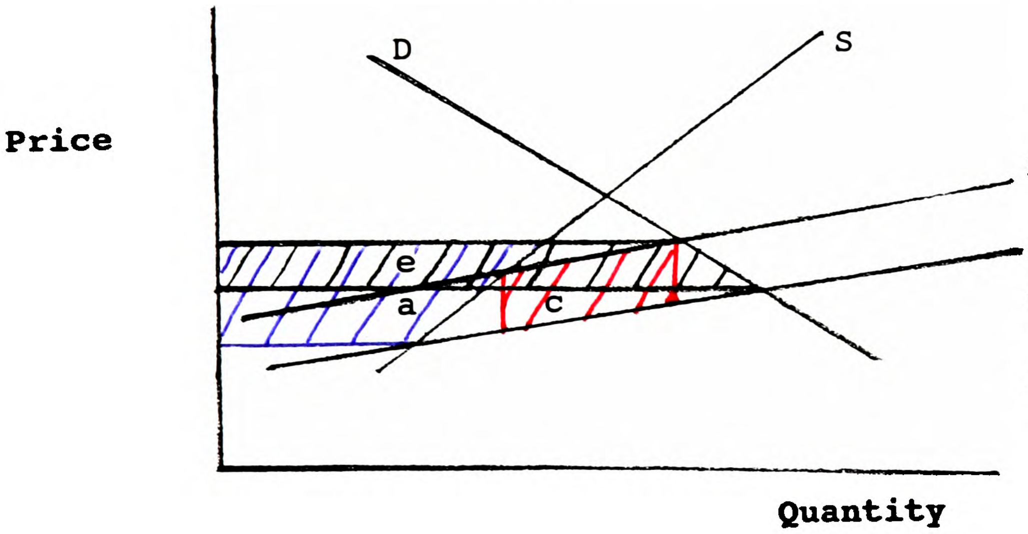
fig 3.2 The effect of a subsidy



S' = supply schedule with subsidy

Subsidy does not affect price but increases domestic production.

fig 3.3 The optimal tariff



S_W^t= World supply curve plus optimal tariff
S_W= World supply curve
e = consumer surplus loss
a + c ≥ e for net gain from tariff

alter domestic market prices there is no deadweight loss, but revenue needs to be raised to finance a subsidy (fig 3.2). Thirdly, if the country is large world price may be sufficiently changed to more than compensate for deadweight losses, hence the optimal tariff (fig 3.3). With a reduction in trade, deadweight production and consumption losses will be borne by the rest of the world. Thus foreign countries experience a shrinkage of trade and a detrimental change in price.

7. The external effect of a non-price-responsive import barrier, such as a quota, differs from that of a tariff in two respects. Firstly, although such a policy has a tariff equivalent, it is not a fixed equivalent; and it has the effect of magnifying instability in the world price of the commodity. This is because the fixity with respect to price of the import demand or export supply of the country in question reduces the corresponding global price elasticity of import demand or of export supply. Hence, when any destabilizing shock causes a movement in price it will be damped less than under free trade.

8. The second distinction concerns the allocation of quotas. If a quota system is implemented to reduce imports then the government has to decide how to allocate the quotas among the supplying countries[3]. Unless quotas are allocated in ascending order of production costs different firms will trade than if a tariff were imposed instead. If allocation is ad hoc or political then this is a gift to those exporters receiving them. The case is particularly clear-cut if quotas are transferable and so sellable. In this case those not in receipt of a quota are obviously worse off (possibly more than under a tariff), while those who are may be better off (depending on their increase in market share, if any). Alternatively the government may decide to auction quotas, merely providing itself with an income (as with a tariff), and increasing the price of imports by the unit cost of acquiring the quota. Export quotas are rarer than import quotas, but a symmetric argument could be put forward.

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[3] Unless there is state trading there will also be an internal allocation problem.

9. So far the effect of only a simple policy measure (tariff or quota) has been considered. However, to take the case of a tariff, the effective protective rate (EPR)[4] may not equal the tariff for two reasons. Firstly, so long as the product uses imported inputs the EPR is higher than the tariff even in the absence of distortions elsewhere. This is because the tariff depreciates the real exchange rate. Secondly, the EPR also takes into account any relevant effects caused by distortionary measures on other goods - tariffs (say) on input, output, complementary, or substitute goods affecting input costs and domestic demand for the finished product. A high tariff on an input may more than counteract a tariff on the output. Additionally, the effectiveness of a tariff depends on substitutes: a tariff on a good may fail to support a domestic industry if there is no tariff on a highly substitutable and competitively priced alternative. In agricultural markets these considerations are not as important as for manufactures, since there are less stages of processing. However, substitutes are important, and so are input prices where there is trade in intermediate goods (such as cattle feed and fertilizers).

The external consequences of the CAP

10. Article 39 of the Treaty of Rome defines the objectives of the European Community in the agricultural sector as being to improve agricultural productivity, provide fair agricultural incomes, stabilize internal markets, and ensure fair consumer prices. The set of policies which have evolved to promote these objectives are collectively known as the Common Agricultural Policy. In practice the effects have been to encourage agricultural production and stable prices rather than to ensure low prices for consumers or indeed lift the incomes of the poorest farmers. Political motivation prompted by strong agricultural lobbies has played a major part in moulding this emphasis. There was no explicit intention to damage agricultural exporters outside the Community, but there was the (inconsistent) intention

[4] The EPR of a good is defined: EPR = DVA-IVA/IVA where DVA = domestic value added (with protectionist measures), and IVA = international value added.

of making Europe more self-sufficient in agriculture.

11. The main part of the Common Agricultural Policy consists of pricing ("guarantee") policies[5]. The policies for each commodity covered by the CAP are similar, though not identical. In the case of wheat a summary of the main mechanisms is presented in chapter 4. In general, the policies for most protected products can be summarized as follows. Firstly there is a domestic price support measure (without some income-boosting measure many farmers would go out of business). An intervention price is set, below which official support buying occurs (leading to intervention stocks); and above this a target (sluice-gate) price above which prices cannot rise. Secondly, there are variable levies on competing imports which adjust daily so that the world price plus the levy (which may be negative) exactly equals the target price. Thirdly, when farmers over-produce, they can export their excess using export subsidies (restitutions) from the Commission to bring prices down to the world price. The Commission also pays traders to export intervention stocks. If the world price is above the internal price, then the Commission taxes exports to keep internal prices down to the target price, i.e. imposes a negative variable levy, as mentioned. This has happened for some products in some years.

12. Taking these three measures in turn, the external impacts can be summarized as follows. Internal price support can be expensive. Well over two-thirds of the Commission's budget is spent on the price policies of the CAP, and the major expenditure within this is the cost of intervention. This does not in itself constitute an external impact, but the scale of the expenditure is sufficient to be a significant drain on the resources of EC Member States. National income is lower than it would be without the CAP, and this reduces demand for imports of non-CAP products. Secondly, the variable levies reduce imports and therefore also the world price. Thirdly, restitutions, by enabling EC exports, have the same effect. The reduction in

[5] The other, smaller, part comprises finance under the Guidance Section of the European Agricultural Guidance and Guarantee Fund (EAGGF/FEOGA). This provides grants for farm, infrastructure, marketing, and processing improvements.

the world price harms exporters and benefits importers. Also, the nature of the CAP system is to reduce instability in prices within the EC at the expense of the rest of the world, where price instability increases.

13. The main commodities affected by the CAP include some for which there are high import barriers in the rest of the world and others which are substitutes for CAP protected products. Commodities can be categorized under the following three rough headings: substitutes for CAP-protected products (oilseeds, oilcake, manioc, and other cereal substitutes); those others where in aggregate developing countries are net exporters (sugar, citrus fruit, tomatoes, olive oil, and tobacco); and those where in aggregate developing countries are net importers (grains, meats, and dairy products). For products in the second category, EC protectionism makes developing countries unambiguously worse off, although in the case of sugar there is preferential access into the EC for some developing countries at above world price levels. Exports in this category account for less than 20 % of EC agricultural imports, but this figure would probably be significantly larger in the absence of protection. Products in the third category are more important in value terms, but the net effect of the CAP on developing countries as a group is not clear, as the terms of trade of importing developing countries are improved.

14. Concerning the first category above - substitutes, there is a set of important relationships between grains, cereal substitutes, livestock, and other products. Grains provide a major input into livestock production, but are replaceable with manioc (imported mainly from Thailand), maize gluten feed (a bi-product of beer making), cereal brans and other bi-products, as well as oilseeds and oilcake. The European Community agreed at the General Agreement on Tariffs and Trade (GATT) in the early 1960s when the CAP was being set up that no large external barriers to certain products (including manioc and oilseeds and oilcake) would be imposed. As a result, as internal grain prices have risen in the EC, so have imports of these products - although some developing countries, starting with Thailand in 1980, have been persuaded to sign voluntary export restraint agreements with the Commission. However, the benefit to developing country oilseed and oilcake producers is

partially offset by the fact that additional production of animal and dairy fats due to the CAP reduces demand for vegetable oils. Also, increased EC production of livestock reduces production elsewhere, and so also demand for feed inputs outside the EC - as production is cheaper outside the EC this may also lead to a reduction in global consumption of meat. Lastly, lower world grain prices have caused some shift in the United States into soybean production, which reduces world prices of oilseed and oilcake.

15. Another set of related products is imports of processed food. These, although not directly affected by the CAP, face significant Common External Tariffs (CETs), and in many cases high effective protective rates.

16. Lastly, there are long-run dynamic effects of CAP protection: with time European farmers become more efficient, possibly slightly lessening their lack of comparative advantage (depending on how other European producers are increasing efficiency). Developing countries with comparative advantages in CAP products may, on the other hand, try to shift production into other activities, and this may reduce their comparative advantage.

Empirical evidence

17. Several attempts have been made to measure the external impacts of the CAP. As indicated above, the net effects on developing countries are far from clear. Three main model types have been used: market share models, partial equilibrium models, and general equilibrium models.

18. Starting with market share models, the Commission to the European Communities (1982) examines historical data on market shares, and concludes that "...the inevitable repercussions of the CAP on non-member countries, and in particular on the developing countries...vary according to the product concerned and from country to country; nevertheless the impact is relatively limited." The Commission is of course a biased witness, and so this conclusion must be treated with care. The study largely bases this conclusion on the statistic that developing countries' shares of EC imports have not

shown any consistent trend (a fairly meaningless statistic on its own - the study does not indicate trade volume figures alongside these trade shares). Another market share study was carried out by Yeats (1981) who includes intra-EC trade in a study of primary food products, and concludes that between 1962 and 1979 developing countries lost export orders worth $3 billion. Yeats, however, assumes that all increased intra-EC trade is trade diversion rather than trade creation, which tends to overestimate this loss.

19. As mentioned in chapter 2, there are considerable doubts as to the relevance of such models. In particular it is impossible to present an adequate counter-factual to actual events. The assumption that market shares would not change but for the CAP is naive in a sector where protectionism and trade wars are the norm rather than the exception. Anyway, if the market shares being studied are those of EC imports, total size of EC imports is the first thing that should be looked at. Also, this approach can gauge the effect only on developing country exporters, not importers.

20. More popular than the market share approach has been the use of nonspatial partial equilibrium models, as defined in chapter 2. The most quoted study is that of Valdes and Zietz (1980). They model a 50% reduction in OECD agricultural protection, and estimate that the net income of developing country exporters would be $1 billion a year higher, and that of developing country importers $600 million a year less. However, many of the gains arise from increased income in food processing industries (in the case of the EC as a result of CET reductions more than from CAP reductions), and the gains in the temperate products sector are small. Also, as Matthews (1985a) points out, the study excludes dairy products, although developing countries are net importers of dairy products and would lose by an increase in price. The study further neglects the preferential import agreements that some developing countries have with OECD countries (such as EC sugar protocols). On the other hand, the study ignores the gains from liberalization of a reduction in OECD exports. Since the 1975-77 base period for the study the EC has become a net exporter in more products, and so this effect will have become more significant.

21. Matthews (1985b) investigates the static effects of abolishing the CAP completely, also using a nonspatial partial equilibrium model. The study concludes that a majority of developing countries would be worse of. This depends on the observation that a majority of developing countries are now net importers of CAP products. More specifically, most African and Asian countries would be worse off whereas many Latin American countries (which are net exporters of CAP products) would be better off. The reasons for this dependence on imports are given as an 'urban bias' in developing countries' policies, leading to a discrimination against agriculture; bias in favour of export crops and away from food self-sufficiency; and changes in tastes in food type and increases in import demand as developing country incomes rise. If developing countries were to change domestic policies to give greater incentives to agriculture then they would benefit more from a liberalization of the CAP; but this is considered unlikely. Any influence of the CAP in causing dependence on food imports is assumed insignificant.

22. There have been several studies of the effect of trade liberalization on specific commodities. Koester (1982) studied EC cereals liberalization, and concluded that welfare changes would be significant only in a few countries. Developing countries would be 0.4% of GNP worse off, not including the possible loss of food aid.

23. Roberts (1982) calculated direct costs of Community sugar policy to developing country sugar exporters as between $370 and $570 million a year, and the benefits to ACP[6] countries under the Sugar Protocol as $170 million a year. Koester and Schmitz (1982) also take into account the gains to developing country importers, and conclude that the policies together have a positive net effect on developing countries.

24. Von Massow (1984) calculates the effect of removing EC beef protection as benefiting Argentina, Brazil, and Uruguay by $330 million a year at the

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[6] African, Caribbean, and Pacific signatory countries to the Lomé Conventions. The ACP States (there are currently 69 under the fourth Lomé Convention) are the main recipients of EC development assistance.

expense of a loss to importers of $100 million.

25. All of these partial equilibrium models predict only slight changes from the liberalization of the CAP, and even the signs of the effects on groups of LDCs are debatable. There are several reasons why these results are unconvincing. Firstly, effects on products other than those specifically examined are ignored, as is the effect of a rise in income within the EC resulting from liberalization. Secondly, these models often ignore or make naive assumptions concerning third-country behaviour. In many of these markets the behaviour of the United States (which is prepared to enter into trade wars with the EC) and other countries is crucial to understanding the impact of a possible change in EC policy; studies that consider a reduction in OECD protection are probably more realistic than those modelling a reduction just in CAP protection. Thirdly, as mentioned in chapter 2, the models depend to a large extent on import demand and export supply elasticities, estimates of which may be inaccurate and biased.

26. Lastly, there are dynamic considerations to take into account. Static models cannot model the dynamic time-path of the effects of policy changes during transition. More seriously, there are aspects of dynamic behaviour in world markets which are affected by protection. One of these has already been mentioned: the price destabilizing effect of the CAP in the residual world market. At the same time, it is argued that a reduction in CAP protection may result in a freeing of agricultural investment capital which would flow into developing countries; and that a reduction of 'export pessimism' may occur, causing a shift in developing country policies towards the export sector, thus increasing overall economic wellbeing. However, these potential dynamic effects may be fairly small. A small change in world price may not be sufficient to change LDCs' domestic policies, and a change in attitude or 'export pessimism' may require more than a reduction in EC protection.

27. In order to gauge the effects of protection on other products, and on EC income, a general equilibrium framework is required. Several models have been developed which specifically model the effects on developing countries of CAP liberalization: by the FAO (1971), by the International Institute for

Applied Systems Analysis (IIASA) from 1976, by Burniaux and Waelbroeck (1985), and by Loo and Tower (1988). The latter two studies include the effects of cheaper relative prices of EC manufactures with respect to food. This results from the EC's need to import more food and become more competitive in manufactures to do so. The Burniaux and Waelbroeck study predicts an increase in real income for the set of developing countries of 2.9% by 1995. The significant gainers are not only Latin America and other net agricultural exporters, but also net importers of manufactures (including many African countries) who benefit from changed EC terms of trade. Loo and Tower assume that liberalization of agricultural trade will mean a 10% increase in prices. Overall this leads to a $26 billion a year increase in 1985 prices in income for developing countries: $4.1 billion from straightforward terms of trade effects, and the rest from increased production of agricultural products in developing countries and - because agriculture is relatively heavily taxed - increased government revenue spurring growth.

CHAPTER 4: THE WORLD WHEAT MARKET AND PROTECTIONISM

1. The purpose of this chapter is to describe, with particular reference to protectionist policies, the world wheat trade, which is dominated by five major exporters competing ever more vigorously for a seemingly non-expanding market. The price support mechanisms and export practices of these five major exporters (Argentina, Australia, Canada, the EC, and the United States) are covered at some length. Importers' behaviour is also analysed. The last section discusses rising protectionism in the 1980s and the Uraguay Round of GATT negotiations.

Export shares

2. The five major exporters account for over 90% of world wheat trade, and for more than one third of total production. Traditionally the United States has been the largest exporter, providing between 30% and 45% of the world total (see table 4.i). The EC is both a major importer and exporter, with an increasing share of world exports.

Table 4.i Export shares of world wheat and wheat flour (%)

Year	Arg	Aus	Can	EC	US	Total
80/1	4.1	11.8	18.1	14.6	44.8	93.4
81/2	4.3	11.3	17.7	13.9	49.0	96.1
82/3	7.8	8.8	22.0	15.3	40.9	94.9
83/4	9.6	11.6	21.1	14.9	38.2	95.4
84/5	7.7	14.7	18.6	16.9	35.7	93.6
85/6	7.5	19.5	20.3	17.2	28.4	93.6
86/7	5.0	16.9	23.5	17.2	30.7	93.2

World prices and export volume

3. World prices have fallen considerably since 1980 due to increased

competition from exporters (see table 4.ii and figure 4.1). The figures presented in table 4.ii are firstly presented in current US$ prices (figures from the International Wheat Council) and then transformed to represent changes in the real purchasing power of wheat. We assume that the US dollar is not a key currency in wheat in the second sense mentioned in chapter 2, footnote 2 (i.e. nominal dollar exchange rate changes do not affect the real price of wheat). In other words we assume a fairly well-developed world market. In order to measure changes in real purchasing power we need to deflate the dollar prices and adjust the figures for fluctuations in the dollar exchange rate. The adjusted data in table 4.ii and figure 4.1 have been deflated by a weighted average of developed world consumer price indices - not a US deflator - where the weights are taken from relative 1980 output. If US production and consumption were minimal, the US exchange rates used to transform the figures should be a weight of bilateral rates such that with real commodity prices constant and zero inflation, a percentage change in nominal dollar exchange rate is matched by the same percentage change in the dollar price of the commodity. The exchange rates used were calculated in the IMF Multilateral Exchange Rate Model. As US production and consumption comprise a significant proportion, ω_{US}, of world production and consumption, the changes in these exchange rates are then reduced by multiplying them by $(1-\omega_{US})$.

4. Using these adjusted figures, United States wheat prices declined from $178 per ton in 1980 to $98 in 1986, in Argentina from $181 to $80, Australia from $188 to $100, Canada from $189 to $107, and the EEC from $186 to $108. It is noteworthy that Argentinian prices have had to fall furthest, probably in large part because of competition from export credit terms which she cannot match. However, these falls in prices have not hitherto been accompanied by an increase in world demand. World trade (see table 4.iii) rose from 94 m. tons in 1980/81 to 103 m. tons in 1984/85, but then fell to 82 m. tons the following year before recovering slightly to 89 m. tons in 1986/87. Excluding exports to the USSR and China, which fluctuated considerably, trade rose from 65 m. tons in 1980/81 to 70 m. tons, but then declined to 64 m. tons in 1986/87.

5. It seems that import demand and export supply elasticities are, at least in the medium run, extremely variable. This can be seen by comparing the drop in world prices shown in the second set of columns in table 4.ii and figure 4.1 with the volume of trade shown in table 4.iii. There is a clear fall in wheat prices unaccompanied by any significant increase in world trade. Before reaching any conclusion about what this data may mean it is necessary to investigate the nature of the wheat market in more detail.

Table 4.ii Annual Average Wheat Export Prices
(US$/ton, followed by globally deflated 1980 US$/ton*)

Year	Arg		Aus		Can		EC		USA	
1980	181	181	188	188	189	189	186	186	178	178
1981	201	205	192	196	203	207	172	176	179	183
1982	178	183	149	153	181	186	155	160	148	152
1983	145	144	158	157	171	170	146	145	162	161
1984	132	136	144	148	170	175	122	125	153	157
1985	118	114	129	125	162	157	143	139	145	141
1986	99	80	124	100	133	107	134	108	122	98

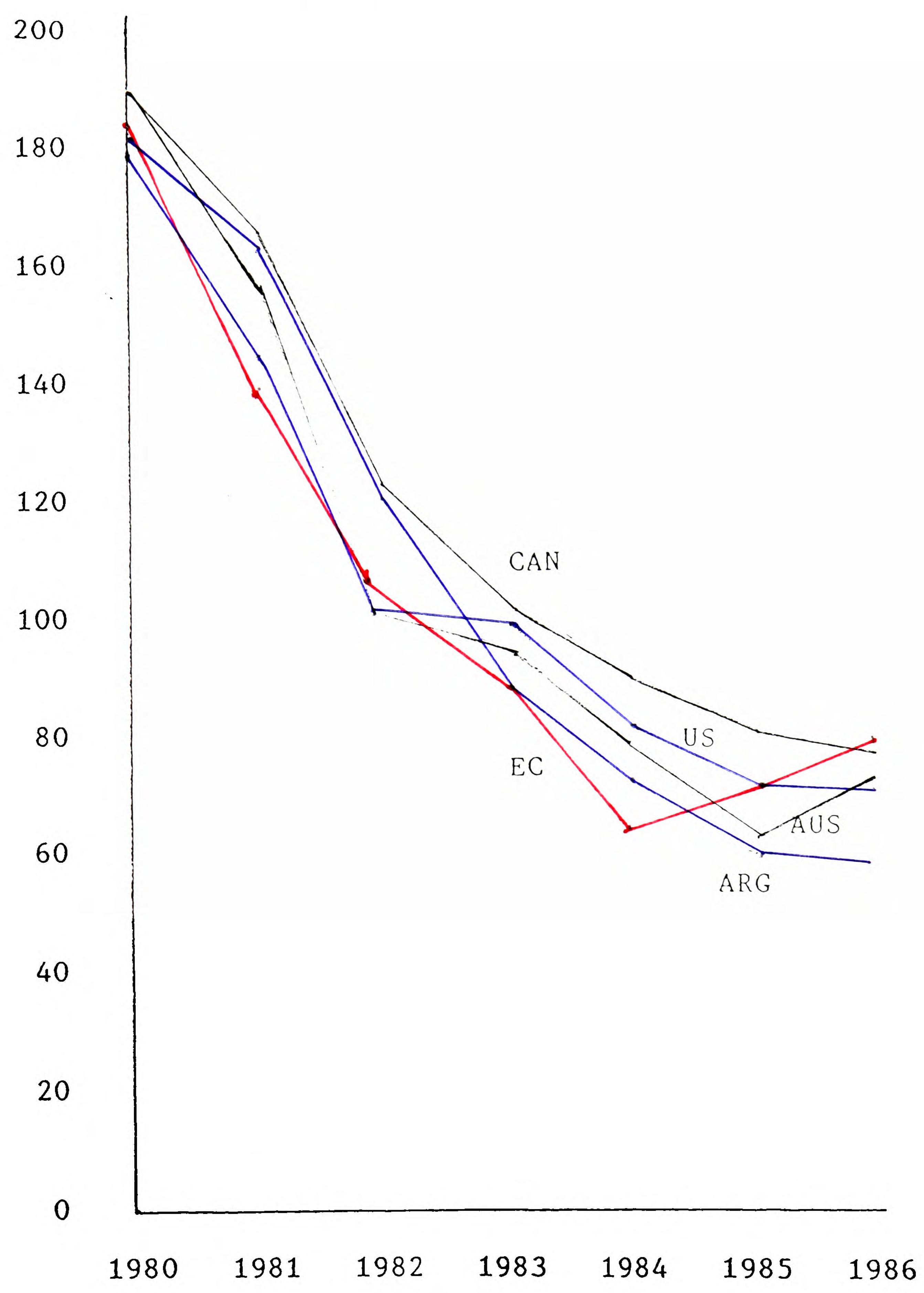
* deflated by weighted average of developed market economies' GNP deflators, times the nominal effective US$ exchange rate as calculated in the IMF Multilateral Exchange Rate Model adjusted for the US share in global production plus consumption.

Table 4.iii World wheat trade

Year	Million tons	Excluding USSR & China sales
80/81	94.0	65.0
81/82	100.7	67.5
82/83	96.1	63.0
83/84	100.3	69.7
84/85	102.9	67.2
85/86	82.0	58.6
86/87	88.8	64.0

6. The figures presented in table 4.ii do not take account of export subsidies. Until 1985 US export prices could be equated with the world price. Since 1985 the US Export Enhancement Programme (EEP) and other protectionist measures have altered world prices significantly by subsidizing exports - if

Fig 4.1 Annual Average Wheat Export Prices
(Globally deflated 1980 US$ per ton)



there is any easily-calculable representative world price at the present time it is the US export price adjusted by the EEP subsidies. However, EEP subsidies are geographically differentiated, and so no single world price can be said to exist. In 1988 the bad US harvest removed the US price even further from the status of world price as US sales dropped as a proportion of world sales.

7. The five major exporters have been increasing export subsidies in the latter half of the 80s, and world prices have decreased as a result. The United States EEP was a response to declining market shares (from 49% of world exports in 1981/82 to 28.4% in 1985/86). Canada and Australia must also be held partly responsible for the increase in protectionism, but more so the European Community, whose export subsidies are far higher than elsewhere. Not only does an increase in protectionism lead to lower prices, but lower prices lead to protectionism. For example, when the US and EC are increasing protection and prices of wheat decline, it is natural for Australia and Canada (who are more able to do so than Argentina) to take steps in turn to protect their farmers. However, only in the EC and the United States does intervention support occur in the average year.

8. Moreover, the EC is the only major exporter whose level of output seems quite independent of world market conditions. In Argentina and Australia at any rate a lower world price leads to substitution into other crops; in Canada the potential for substitution appears to be much less.

Price support and export policies

9. The main distortions in the wheat market caused by government behaviour can be categorized into three types: domestic price support, export policy, and impacts on the market structure. The first two of these are described below for the main exporters. The third is discussed in chapter 5.

ARGENTINA

10. All the large exporting countries maintain strong government control over their grain trade using a centralized body to coordinate support and export policy. In Argentina this is the Argentine Grain Board (**Junta Nacional de Granos**). However, in Argentina the Board does not significantly distort wheat prices. It acts primarily as an insurer for producers, guaranteeing the expected dollar f.o.b. price and therefore reducing the risks born by the producers. As wheat is an important foreign exchange earner the Board also makes available loans for agricultural inputs in order to encourage producers to plant. Lastly, the Board intervenes in the market as a competitor to private traders. Its main functions in this respect are ensuring that sufficient stocks exist for domestic consumption and fulfilling official export contracts.

11. Grain trading within the country is conducted in dollars in order to minimize the risk to producers, although payments are made in local currency at the current exchange rate. The guaranteed price is also in local currency, and so, being determined by the expected f.o.b. dollar price, changes nominally throughout the season.

12. Export prices are determined by the market: by individual buyers and sellers, or by the Board with reference to prevailing f.o.b. prices (when carrying out government contracts).

13. Perhaps the most important feature of the wheat sector has been an export tax on grain which has been a major source of government revenue for some years, reaching 24.7% of the price of grain exports in 1983. This was gradually reduced, and eliminated in December 1987. Together with most agricultural commodities, wheat is still subject to a tax of 1.5% to fund the National Agricultural Research Centre. In order to calculate the amount of tax payable an official **minimum export price** (MEP) is announced each day, although this is not necessarily the price at which transactions are actually made.

14. Being short of foreign exchange, Argentina makes export credit lines for wheat exports less available than her competitors. The Central Bank extends a limited number of credits to Latin American countries, but these are not linked to the development of markets or specifically to cereals, and no credit in recent years has exceeded twelve months. This has caused serious problems for Argentina who has had to reduce prices below that of her competitors in order to compete with the increased provision of credit to customers (particularly from the United States). Even offering exports at prices below that of competitors has often not been sufficient to make a sale, as many importers face serious foreign exchange shortages.

AUSTRALIA

15. As in Argentina, price intervention is slight in Australia. The **Australian Wheat Board (AWB)** protects producers from major year-to-year fluctuations in price, but there are no large direct export subsidies. Unlike Argentina, Australia does compete with the United States in offering increasingly generous export credit.

16. At present nearly all wheat is bought by the AWB from the producers (some stockfeed buyers are issued permits to buy directly from the farmers). Support is given to farmers by the AWB in the form of the **Guaranteed Minimum Price (GMP)** which is equal to 95% of the average of three prices, viz. the price expected in the coming year and that achieved in the worst two out of the last three years. This mechanism protects the farmer from very low prices in a particular year without affecting the price directly in most years. If the final average price for all the wheat sold by the AWB is below the GMP then the government finances the shortfall.

17. Barring a shortfall subsidized by the government, the entire costs (interest, credit, insurance, administration, and marketing) of the AWB are met by the producers themselves in the form of deductions from payments made to them by the AWB. There is an initial payment of 90% of the GMP (announced in October) made by the AWB to producers, followed by a second payment at the

end of the season (March) when the AWB is better able to estimate revenue from sales. A revised GMP is estimated and payments made to bring farmers' receipts up to the new GMP. Further payments are made if the AWB finally receives more than the revised GMP from the pool of wheat it is selling. Because selling the whole pool may take three or four years farmers may have to wait this long for final payment.

18. The price for domestic human consumption is fixed by the AWB at an average of export prices plus a margin which reflects the cost to producers of all the services provided by the AWB - i.e. producers can recoup from the consumer the costs they have to pay to the AWB. Thus indirectly it is the Australian consumer who pays for the services of the AWB. This is effectively an export subsidy, although not a large one.

19. Export prices are set by the AWB, largely reflecting world market conditions. There are several forms of contract pricing, the main ones being: in Australian dollars and in United States dollars. Various forms of deferred pricing are available. These various options are provided to the buyer in order to compete with United States exports. The final price is not subsidised (other than by the two methods already mentioned: the passing on of AWB's costs to Australian consumers, and government underwriting of the GMP). If export prices in different contracts vary, then this represents the difference in costs to AWB of providing the particular packages.

20. One service that the AWB can offer to buyers (and increasingly has done since 1982 largely to match competitors) is export credit. Up to three years' credit in traditional cash markets is now common. Export credit insurance (particularly vis-à-vis high-risk countries) may not be available commercially. In such cases the government may underwrite all or part of the risk, thus providing another effective export subsidy.

CANADA

21. The support and export systems in Canada are similar to those in Australia. There is a sole marketing agency for wheat grown in the Prairie

Provinces: the **Canadian Wheat Board (CWB)**. An **initial payment** is announced by the Board before sowing starts for each grade of wheat, and paid on delivery by the producer. This represents the guaranteed price. The wheat then enters a 'pool', as in Australia, and CWB sells the wheat to the domestic and export markets. If final net receipts are positive, a **final payment** is then made to the producer. Any deficit is paid by the government.

22. Wheat sold on the domestic market has to be sold within a specific price range by CWB (for example Can $220.46 - Can $404.18 per ton at Thunder Bay for No. 1 Canada Western Red Spring in 1988). Until recently wheat sold on the domestic market has been more expensive than that exported, i.e. there has been an effective export subsidy. However, since 1st August 1988 the government has based domestic prices on North American export prices and so this differential has been removed for the consumer. CWB's losses from this change in the two-tier pricing system are being borne not by the producers but by government subsidy; the price of exports not being affected.

23. There are several additional schemes to help the producer, some of them subsidised by the government. The **Western Grain Stabilization Programme** introduced in 1976 guarantees voluntarily subscribing producers that their cash flow in any year will not fall below the average for the previous five years. Producers are covered up to Can $60,000 on payment of a 1% levy on sales which is supplemented by a further 3% subsidy from the government. Also, in 1987/88 the government wrote off half the accumulated (Canadian $) debts of the Western Grain Stabilization Programme.

24. The **Advance Payments Programme** assists farmers by paying part of the **initial payment** before wheat is delivered. Since the CWB provides that export wheat is only delivered to ports as export markets are found, some farmers would otherwise have to borrow at commercial rates before delivery. The government pays for this programme (except for its administration costs, which are paid by producers).

25. The **Special Canadian Grains Programme** in December 1986 granted oilseed

and grain producers Can $1 bn. to help offset the impact of subsidies given to producers in competing countries. The programme was continued in 1987/88 to the tune of Can $1.1 bn.

26. Other forms of assistance include fuel tax rebate, farm review boards which help indebted farmers, government debt relief to the Farm Credit Corporation, and transport subsidies.

27. All these direct and indirect forms of subsidy assist farmers, thus facilitating lower export prices. However, apart from substantial and subsidised export credit facilities and the recent Special Canadian Grains Programme, export subsidies are not overt.

EUROPEAN COMMUNITY

28. The EC exports grain mainly in order to dispose of excess production. As the CAP has protected farmers, internal production has increased and the EC has exported more surplus. Partly as a result of this, two things have happened: world prices for grain have been falling since 1980, and since 1985 other exporters have retaliated with export subsidies and increased use of credit. In the case of the United States, the US Department of Agriculture has made it clear in numerous public statements that a major justification and need for the Export Enhancement Programme has been the increased use of restitutions by the EC.

29. As explained in the previous chapter (see especially paragraph 11), the basic support mechanism of the Common Agricultural Policy consists of the **intervention price** (guaranteed minimum price) combined with variable import levies to raise imports to the **target price** to prevent competition from imports (which are normally cheaper than European produce). If internal supply is greater than demand at the intervention price then either stocks are stored, alternative uses found, or the crop exported using **restitutions** (export subsidies).

30. The European Commission specifies **target prices** for wheat at various destinations which differ because of transport costs and **green exchange rates**. These green rates, which developed from 1969 onwards, are not equal to the normal exchange rates. The original (and remaining) rationale of the green rates was to protect the intervention system and so the CAP itself from unilateral movements in the exchange rates of Member States. Without separate green rates a depreciation of a Member State currency would lead to an imbalance between intervention prices paid in different countries. As a result, traders could buy the depreciating country's agricultural output for sale into intervention elsewhere, which could undermine the whole system. To avoid this green rates move separately from normal exchange rates.

31. Target prices may not be reached by the market. The intervention price is set below the target price to guarantee a certain producer income if prices are below the target price. If the intervention price is not reached for two consecutive weeks the Commission starts buying at the intervention price for at least three weeks (since 1987 at 94% of the intervention price in order to discourage over-production). If the market reaches the target price then allowing in imports ensures that the target price is not exceeded.

32. In order to keep out imports at lower prices, and yet ensure that prices do not exceed the targets, a **variable levy** is employed. The levy is varied every day, and is set to the difference between: (a) the world price and (b) the target price less transport costs from the entry port (ARA - Antwerp/Rotterdam/Amsterdam is the most important) to the specified destination.

33. When the CAP was initiated in 1962 Europe was a major net importer of wheat. Now, however, the guaranteed intervention prices and isolation from the world market result in excess supply (see table 4.iv). Internal competition drives the market price below the intervention price, and so the Commission buys the excess. Much of this is then exported with the aid of restitutions equal to the difference between the intervention and world

prices.

34. Restitutions are of two main types. Firstly there are **common refunds** which are published daily and apply to specified destinations. A trader wanting to export wheat obtained on the market can apply for a certificate for the quantity requested. Additionally, low common refunds apply to exports from intervention stocks. Traders bid for intervention stocks at about world market prices, taking into account the common refund that day. Secondly, the largest proportion of exports is bought on the internal market and subsidised by refunds tendered for by traders. These **free market tenders** are destination and quantity specific, and the resulting export must be carried out within a specified time. Thus the Commission can in theory control EC exports very effectively, although there have been cases of traders defrauding the Commission.

Table 4.iv: EC* Imports and Exports of wheat and wheat flour
(1000 metric tonnes wheat equivalent)

Year	Imports	Exports
1975/6	6679	7729
1976/7	4609	3912
1977/8	5630	4479
1978/9	4543	7349
1979/80	4478	10270
1980/1	4840	12683
1981/2	4755	13990
1982/3	3385	14085
1983/4	3429	15040
1984/5	2116	17234
1985/6	2042	14414

* includes Greece from 1980/1

35. Export credit is provided not by the Commission, but by the export credit agencies of the Member States. France is the largest EC wheat exporter, and export credit is often provided by COFACE (Compagnie Francaise d'Assurance du Commerce Exterieur) for up to six months. For the past few

years, due to competition, credit in traditional North African markets has been extended over two or three years. Similarly in the UK, the ECGD (Export Credits Guarantee Department) in 1984 extended cover for grain exports to up to two, and in some cases three, years.

36. Since 1984 there have been various attempts to reduce surpluses. A **coresponsibility levy** of 3% of the intervention price was introduced in 1986 which is paid by the first buyer, thus reducing the price. This is intended to reduce wheat production by encouraging farmers to substitute into other crops. In February 1988 stabilizers in the form of additional levies as well as set-aside provisions (which pay farmers to take land out of production) were agreed. Overproduction is the norm for many CAP products, not just wheat, and this is expensive and increasingly seen as politically undesirable. There are likely to be more measures to reduce production in the future.

UNITED STATES

37. In less than the last thirty years the agricultural sector of the USA has been transformed from a labour intensive industry of small farmers into a capital intensive export sector with concentrated ownership. In the early 1970s exports rose due to the devaluation of the dollar (with the break from fixed exchange rates), the Soviet decision to resume grain imports, and a drive for new developing country export markets (see Butler, 1986, chapter 2). In 1979 the dollar started appreciating, which damaged wheat exports. Surpluses grew, and in 1983 the US department of Agriculture (USDA) tried to take land out of production. Up to the early 1980s US wheat policy has been used as a political device (in relations with the Soviet bloc and with developing countries). Since the failed Soviet embargo (see below, paragraph 46), however, economic objectives have been to the fore, and the central problem that of a rise in protectionism. A potential trade war with the EC is looming, set against a background of the lack of agreement (at the time of writing) in the Uruguay GATT round (see paragraph 48 ff), and pressures to cut agricultural spending in order to reduce the US budget deficit.

38. The basic instruments of support are the **loan rate** and the **target price**, which are both available to all farmers who cooperate with wheat programmes, such as acreage reduction requirements. The loan rate, set by the Department of Agriculture, gives the farmer the option of a nine month loan from the Commodity Credit Corporation (CCC) using his crop as collateral. At the end of the nine months the farmer can either pay back the loan with interest, or give up his wheat. The target price is the price at which the government decides that it will sell, and is the final price received by participating farmers for their grain. Farmers receive a deficiency payment to make up their income which is equal either to the difference between the loan rate and the target price or to the difference between the market price and the target price, whichever is the less (if the first were always used farmers who have borrowed at the loan rate might pay back their loan in order sell at the market price if this is higher than the loan rate).

39. There are also several other schemes, including the **Farmer-Owned Reserve** programme which allows eligible farmers to receive a three-year loan with interest waived for the first year, and subsidised storage. Wheat may not be 'redeemed' from this storage programme until the market price is above a certain 'trigger' price. Prior to the harvest upper and lower quantity limits are set for this reserve.

40. There are various export subsidies, and aid programmes. Firstly, **Public Law 480** provides for food aid to developing countries. Secondly, the **GSM-102** and the **GSM-103** programmes administered by the General Sales Manager of the CCC have provided since 1979 export credit at commercial rates of interest for up to three years, and since 1985 export credit for periods of between three and ten years to developing countries. Thirdly, the **Targeted Export Assistance Programme** selectively subsidises exports where competitors are perceived by USDA to be using unfair trade practices. The budget for this was $110 m. in 1988, rising to $325 m. in 1989 and 1990.

41. Fourthly and most significantly, in May 1985 the **Export Enhancement Programme (EEP)** was initiated to counter unfair trade practices by

competitors. The EEP provides geographically differentiated export subsidies, and is operated in the form of government commodity stocks offered as bonuses to targeted countries if they import from the US. The bonuses (in kind) are given to traders intending to sell to these markets after competitive tendering for this business by the traders - i.e. the subsidy (in kind) indirectly lowers the cost to the importer. Up to mid 1988 over $1.3 bn. had been spent on common wheat exports under this programme, although other commodities are also covered by the EEP.

__Importers' behaviour__

42. The effects of government intervention on trade patterns in wheat are most evident on the side of exporters' support and export policies. However, there are also some observations to make concerning importers. The main importers and their purchases between 1978/9 and 1985/6 are listed in table 4.v.

43. Import demand is assumed in this study to be primarily determined by domestic variables (as opposed to international prices). This is due to the characteristics of the product as a largely non-substitutable staple food. Domestic demand may in some cases be fairly constant. In others there may be an upward trend as the incomes of consumers in developing countries rise and as tastes change in favour of wheat away from other staples. Assuming that this trend is gradual, however, most variation in import demand can be ascribed to fluctuations in domestic production of wheat. Domestic production fluctuates principally with weather. It is expected that countries with less variable domestic production or, more likely, less domestic production in proportion to domestic demand show less fluctuation in import demand. This is borne out by table 4.v. Also, domestic policies (as mentioned in chapter 3) may be significant. They may affect trends over longer periods than one year. In particular, the more domestic policies favour the agricultural sector, and so the greater the agricultural production, the larger the absolute fluctuations in domestic output.

44. From table 4.v, importers can be classified according to the constancy over time of their aggregate import demand. Egypt, Japan, Algeria, Cuba, Peru and Venezuela are countries where production invariably falls far short of demand. The import demands of these countries tend to fluctuate less than those of the USSR, China, Bangladesh, India, or Pakistan (and to a lesser extent Morocco, and also Brazil where such fluctuation, as mentioned, occurred after 1985/6) In these countries year-to-year changes in import demand are to a large extent determined by the success of domestic harvests. The demands of Iran and Iraq are affected by their war throughout the period, peaking in 1983-1985 at the height of hostilities but trailing off, earlier for Iran, as foreign exchange became shorter. Other countries show trends in demand: downwards for the EC (due to greater internal production), Mexico and (since 1983) Chile; and upwards for the rapidly growing South Korea.

Table 4.v: Imports of 19 main importers ('000 tonnes)

	78/9	79/80	80/1	81/2	82/3	83/4	84/5	85/6
USSR	5024	11686	14911	19645	20140	20560	28156	16465
China	8058	8680	13776	13223	12936	9786	7429	6821
Egypt	5441	5156	6755	6012	6188	7331	6819	6432
Japan	5584	5572	5930	5637	5597	5901	5748	5579
Brazil	3738	4717	3855	4589	3879	4320	4933	2494
EC	4543	4478	4840	4755	3385	3429	2116	2042
Korea (S)	1702	1814	2072	1907	1804	2510	3043	3028
Iraq	1467	2300	1366	1577	1900	2960	2836	1974
Algeria	1006	1986	1824	2294	2008	2365	2164	2498
Iran	1061	1187	1896	1377	1959	3639	2643	2076
Morocco	1422	1705	2076	2312	1388	2330	2718	1843
Bangladesh	1221	2172	659	1165	1564	1632	2189	1050
Cuba	1000	1300	1203	1437	1395	1741	1319	1433
India	311	222	384	2625	4342	2495	146	7
Pakistan	2025	610	238	416	417	431	1277	1890
Peru	755	947	853	924	942	927	979	937
Chile	948	909	1098	959	1137	1093	600	492
Venezuela	747	736	797	818	801	971	1100	934
Mexico	1057	1045	1209	898	124	512	449	69

45. The USSR is the largest wheat importer, importing an average of about 20% of world exports. Historically Russia had been a major wheat exporter,

but in the Brezhnev era in the second half of the 1960s and early 1970s there was a shift in domestic policy towards the consumer. This took the form of increased meat production, for which feed grains were required. Between 1968 and 1971 a 40% increase in the use of feed grains was experienced. This meant an increase in imports in the face of domestic production shortfalls, often exacerbated by variable growing conditions.

46. One event of interest is the US embargo between January 1980 and summer 1981 on grain sales to the USSR, ordered by President Carter after the Soviet invasion of Afganistan. Although the United States was the USSR's main supplier, the Soviets successfully managed to diversify their supplies; and in any case significant amounts of wheat escaped the embargo. Also it seems a sine qua non of an effective embargo that total US wheat exports should fall - this was not the case. The indication from this is that future unilateral embargo attempts are unlikely[1].

47. All the major exporters have made substantial exports to the USSR since 1983, with Canada and the EC replacing the USA and Argentina as the main suppliers (see table 4.vi). Australia and Canada are the main suppliers to China. Egyptis supplied mainly by the United States and Australia. The next largest market is Japan, who buys from the USA, Canada, and Australia in roughly the same proportions every year. Brazilian imports declined in 1985/6 and 1986/7 due to large domestic crops. The United States was the main exporter to suffer as a result, whilst the EC has been increasing its market share, also at US expense. On the other hand, US shares have risen in Algeria and Morocco, as a result of the EEP.

Increasing protectionism and GATT

48. Economists are famed for their ability to disagree with each other, yet

[1] The failure of the US embargo also supports Winters' (1988) argument (mentioned in paragraph 19 of chapter 2) that European self-sufficiency in food is unnecessary on strategic grounds.

Table 4.vi: Wheat imports by origin (%)

Exporter	USSR	China	Egypt	Japan	Braz	Korea	Alger	Moroc
Argentina								
78/9	-	11	-	-	25	-	-	3
79/80	17	5	-	-	32	-	-	-
80/1	20	1	-	-	-	-	-	-
81/2	16	2	-	-	7	-	4	-
82/3	21	15	-	-	-	-	-	-
83/4	19	11	1	-	18	-	-	-
84/5	15	9	-	-	13	-	-	-
85/6	4	9	-	-	35	2	-	-
86/7	3	11	-	-	35	2	-	-
Australia								
78/9	3	17	23	21	-	-	-	-
79/80	23	41	33	19	-	-	-	-
80/1	17	10	27	15	-	-	-	-
81/2	12	11	26	17	-	1	-	-
82/3	5	9	29	17	-	-	-	-
83/4	8	17	36	18	-	17	-	-
84/5	7	20	52	18	-	32	-	-
85/6	20	40	53	18	-	22	-	-
86/7	8	38	41	17	-	18	-	-
Canada								
78/9	38	39	3	22	28	2	34	1
79/80	15	30	1	23	22	-	25	13
80/81	30	21	-	25	37	1	41	1
81/2	24	23	6	24	26	-	26	1
82/3	35	33	-	24	38	3	24	-
83/4	29	39	12	24	35	-	35	-
84/5	27	37	10	24	24	-	22	-
85/6	29	38	12	23	23	14	24	-
86/7	37	41	4	24	31	28	20	-
EC								
78/9	-	-	27	-	7	-	13	63
79/80	6	1	31	-	-	-	28	60
80/1	5	4	35	-	-	-	18	66
81/2	9	1	17	-	3	-	32	50
82/3	17	11	17	-	4	-	34	22
83/4	21	1	21	-	-	2	45	19
84/5	22	1	-	-	1	-	52	44
85/6	32	4	1	-	2	4	20	43
86/7	37	8	3	-	14	5	9	1
USA								
78/9	59	32	35	57	39	98	48	16
79/80	34	22	35	58	46	99	34	28
80/1	20	63	37	59	63	99	28	33
81/2	35	64	50	60	65	99	36	48
82/3	15	32	50	59	58	97	30	77
83/4	22	32	29	58	48	81	18	81
84/5	22	33	38	58	62	68	25	56
85/6	1	9	34	59	30	59	56	57
86/7	3	2	52	58	20	47	71	99

one thing on which they are almost (though not completely) united is disapproval of protectionism. Moreover, the traditional arguments in favour of free trade do not depend on multilateral action by all governments. The governments which have most strongly advocated free trade in the past - Britain in the nineteenth century and the United States for the last four decades - were willing to reduce their own barriers to trade unilaterally, so that they could specialise according to their comparative advantage. So what has changed, and why is it that protectionism appears to be on the increase now?

49. Firstly, some recent developments in economic theory have given new life to suggestions that protectionism might be beneficial after all (see chapter 3). Protectionism may be justified in the presence of externalities. Additionally, the optimal tariff argument is applicable where a country has a major share in an imperfectly competitive world market (which is arguably rare except perhaps in the case of the United States). However, even if there is significant imperfect competition a government has a difficult task on its hands in deciding whether there are any surplus profits to be captured, what protection is necessary and sufficient to capture them, and whether any action is worthwhile given possible retaliation.

50. Secondly, there are political reasons why protectionism is favoured. Within a democracy where lobbying is an important part of political life there will always be pressures for protectionism. Since the later 1980s the United States, concerned about her current account deficit, has been in periodic danger of relinquishing her position of bastion of free trade. Competition from the Newly Industrialized Countries (NICs) is leading to global calls for protectionism by developed countries, and neither the Europeans (influenced by strong protectionist lobbies) nor the Japanese are willing to take up the crusade in the place of the United States.

51. During the period in which this thesis has been researched, there has been a political climate of rising protectionism. At the same time the Uruguay Round of the General Agreement on Tariffs and Trade (GATT) has been taking place - evidence that the need for agreement on measures to reduce

protectionism is recognized. One area of discussion of crucial importance to the negotiations is protection in agricultural products. (Others are services and intellectual property.) In Montreal in December 1988, halfway through the four year Round, six Latin American countries (Argentina, Brazil, Chile, Colombia, Peru, and Uruguay) blocked agreement on progress in other areas due to lack of progress in agriculture. In December 1990 - the end of the originally-planned four-year negotiating period - the 'final' ministerial meeting ended in disarray. The stumbling-block was EC farm subsidies, holding up the signing of agreements in all other negotiating areas. In early 1991 concessions have been made by the EC and the US (the two main protagonists), but at the time of writing (April 1991) it is not clear whether the talks can be saved.

52. The stalemate preventing progress in wheat and other temperate agricultural products has been caused largely by the European Community and United States. The US preference is an end to all subsidies and trade barriers by the year 2000. The EC sees this as a demand for the abolition of the Common Agricultural Policy, which it is not prepared to sacrifice. Even the modest compromises it has offered have generated fierce internal opposition.

53. The inclusion of the word tariff in GATT's title is indicative of the main type of protectionism it was set up to deal with - the tariff was the only instrument of protection countenanced in the GATT. However, partly because of agreed reductions in tariffs, non-tariff barriers (quotas, voluntary export restraint agreements, and health and safety regulations for example) are more significant than thirty years ago. As well as making economic modelling more difficult, non-tariff barriers require additional agreement and monitoring.

54. One of the problems leading to the slow pace of negotiations is the lack of agreement on the effects of protectionism. As discussed in chapter 3, even the sign of the effect of the CAP on many developing countries is in doubt. Many partial equilibrium models predict that food importing countries would suffer from a reduction in the CAP (hardly a surprising conclusion when

the only feature considered is the effects of higher agricultural commodity prices). On the other hand, general equilibrium models tend to predict gains for the same group of food importers due to income effects in the EC leading to greater world aggregate demand, cheaper industrial imports and more developing countries producing more food. These general equilibrium models are often more convincing than their partial cousins, but the results are nevertheless suspect as model parameters are often the result of pure guesswork.

CHAPTER 5: IMPERFECT COMPETITION AND MARKET POWER

1. To get a fuller picture of the extent to which we can explain the wheat market with reference to basic economic variables we now consider the effects of imperfect competition. The chapter is in four sections. The first describes and analyses some salient features of the private grain trade, and in particular the market power of the five largest private grain trading firms. Market power is here defined as the ability to affect prices for one's own benefit. Market power is not limited to these firms, however, as governments also play a major part in the grain trade. The second section is devoted to the subject of food aid, which is linked to the market strategies of exporters. Then the description of the policies of exporting countries in chapter 4 is complemented in the third section by a brief analysis of these policies in the context of the existence of market power. Lastly, possible ways of measuring the importance of market power are discussed.

The private sector grain trade

2. Five international commodity trading firms dominate the wheat trade. They are, in order of size: Cargill, Continental Grain, Bunge and Born, Louis Dreyfus and André. The first three are significantly larger than the other two. These same five firms are also important traders in other grains (soya, rice, oats, barley, etc) and together with the West German firm Alfred Toepfer transact about 70% of the international grain trade.

3. The firms are multinational networks with excellent communications systems and agents in many countries. Cargill is clearly a U.S. firm, although much of its trading is transacted from its Swiss subsidiary Tradax[1]. André is likewise Swiss. The other three, also European in origin, have moved their headquarters across national boundaries at least once in their history.

[1] Tradax is a major grain trader in its own right, and being partly Swiss-owned avoids U.S. taxes.

For the sake of tidiness, it can be noted that Continental's main trading base is the United States, Bunge has strong links in Argentina and Brazil, and Louis Dreyfus is historically French.

4. One of the reasons why the nationality of these firms is ambiguous is that they are all privately owned by a small number of families. Another consequence of such private ownership is secrecy. As they are not publicly quoted the firms do not have to disclose quarterly accounts publicly. This is of special advantage in a risky business like grain trading, where a firm's profits may rise and fall very dramatically. It may partly explain why family firms have been so successful in the grain trade. Another is the necessity for strong ties of loyalty between members of the firm.

5. The archetypal evolution of the trading firm has been analysed into six stages by Philippe Chalmin (1987). The first stage is that of a local or nationally-based trader in a clearly defined product area, or alternatively (and quite differently) an international trader 'on paper' who may never see the commodities he deals in. The second stage is characterised by the control of a number of physical facilities. In the case of grains the control of grain elevators and transportation is of greatest importance. The third stage is that of an international trader, a firm who ships goods and has an international network of offices and agents. This stage is also characterised by some investment of profits in areas outside trading, typically in shipping, insurance, and banking. Up to the end of the third stage a firm is still vulnerable to collapse due to the riskiness of the trading business. The best known example is Cook Industries which grew to be the fourth largest grain trader in the world in ten years, and collapsed in six months in 1977 (it is not irrelevant, following the discussion in the previous paragraph, that Cook Industries was a quoted company). After the third stage a firm may become a financial multinational (Chalmin's seventh stage). Alternatively, the fourth stage is identified with vertical integration: investment in the whole chain of the product or products traded. At the fifth stage broad industrial investment occurs, and at the sixth a distancing from trading to a greater or lesser extent. Cargill and Bunge can probably be categorized as in stage five or six, Continental in stage four, and Louis Dreyfus and André

in stage three or four.

6. The basic functions of an international commodity trader are those of agent and specialist buyer: bringing together supply and demand from two areas separated by space and time. These are the same functions as those of International Trading Companies, with which commodity traders should not be confused. International trading companies trade in a far wider variety of products than commodity traders, and have significant domestic as well as international trading interests. The difference between such companies and international commodity traders lies in the different environment in which international commodity traders operate and their concentration on trade at the international level. International trading companies have practically abandoned their role in commodity trade (with the exception of the Japanese), although they do specialise in counter-trade (as do Louis Dreyfus and André). They are very important in international trade, although their importance varies from country to country. In Japan they control 80% of all international trade, whereas in the US only 10%. The Japanese international trading companies (called sogo shosa) are huge: the nine biggest had a combined turnover equivalent to 22% of Japan's GNP in 1980 (Chalmin). However, Cargill, Continental and Bunge are also large: they each had estimated or reported annual turnovers in excess of US$10 billion in the 1980s, about one seventh of the biggest of the sogo shosa.

7. Large turnover relative to the size of the market indicates potential market power. It does not necessarily indicate large firm value. Commodity trading firms have a low level of capital funds in relation to turnover, few fixed assets (implying little medium- and long-term indebtedness) and a ratio of pre-tax cash flow of capital funds to turnover of typically 1% to 2%. The business is also heavily dependent on short-term loans and, as already mentioned, is highly risky.

8. Chalmin classifies these risks into six types. Firstly there is the risk of price fluctuation associated with the task of finding supplies when a trader has a commitment to deliver (or the converse task of finding a buyer). Secondly there is an exchange-rate risk, and also a possible

associated interest-rate risk if foreign exchange is borrowed. Thirdly there is the risk of wrongly anticipating the administrative decisions of governments such as the setting by the EC Commission of restitution levels. Fourthly, freight rates and insurance costs can vary. Fifthly, there is a risk of an exporter or importer withdrawing from a contract, and sixthly there is the risk that mistakes may occur in the management of the delivery.

9. Some of these risks can be reduced. There is an efficient futures market for wheat in which traders can hedge against price fluctuations. They can also hedge against exchange-rate and interest-rate changes on financial markets. Reducing the risk of anticipating government decisions wrongly is not easy. Normally the best a trader can hope for is that the information from which his assessment is made is as good as possible. To reduce freight rate risks the trader can hold a large 'time charter' on the freight market or invest in shipping. Lastly, by employing standard contracts with recourse to international arbitration a trader can reduce firstly the risk of withdrawal by one party occurring, and secondly the increased risk to the trader resulting from obligations to other parties if withdrawal does occur.

10. It follows from this analysis of how to cover risks that there are potential economies of scale to trading. The necessary network of communications and agents is a fixed cost with respect to the amount of trading conducted, and ownership of shipping or holding a large 'time charter' may reduce risk. Other increasing returns to scale are to be gained from the ownership of elevators and other physical facilities, although the main reason for other investments in related areas such as grain processing may be that firms want to reinvest profits - and do so in industries they are familiar with. A firm with widespread investments outside trading will face a lesser total risk than a firm of the same size involved only in trading (assuming other economies of scale have been exhausted or nearly so).

COMPETITIVENESS

11. Of interest to this study is an assessment of the distortions to international wheat trade caused by imperfect competition in the private wheat trading sector. There are three main issues that need to be addressed: the degree of competition in the world market; whether the market could be more efficient if structured differently; and how international trade might differ under a different market structure.

12. In addressing the first of these issues it can first be observed that an oligopoly exists. Economies of scale and the need for a minimum logistical knowledge provide barriers to entry. The market appears highly competitive and there is little obvious evidence of collusion. The futures market leads to considerable transparency. However, this does not necessarily mean that no collusion exists. Because the trading firms are so secretive evidence on shipments and prices is not freely available. As Dan Morgan (1979) says:

> "It is easy enough to ascertain the spot price at which farmers sell their wheat to grain elevators in, say, Enid, Oklahoma. But it is next to impossible to learn the price at which Tradax that same day may have sold thousands of tons of U.S. wheat to Iran - or even whether such a sale occurred."

The consequence of this degree of secrecy on prices and in other aspects of the workings of the commodity traders is that it is theoretically possible for limited collusion to occur in particular circumstances. A situation may exist in which two traders have some price advantage over all others for the provision of grain to a particular importer - for instance, they may have some relevant (perhaps temporary) control over international freight, in-country transportation, or in-country milling facilities. They may then collude to increase the price by more than would occur if they competed against each other. We assume that this collusion would need to be concealed from the government of the importing country (otherwise the government may be able to take some action to increase competition, or at least make it known publicly). One way to conceal such collusion would be to limit the price to some level below the monopoly price. It may also be necessary to agree fake bids which are known to be less competitive than the bid which the colluders have agreed should win. Such collusion becomes more complicated and difficult the greater the number of trading firms are involved. In particular there are incentives to cheat, say by anonymously putting in bids outside the collusive agreement.

13. The necessary conditions for collusion are probably rare, and the suggestion of widespread collusion is thus not credible. It would require enormous co-ordination, and information leaks into the public domain might be expected. Widespread collusive oligopoly is also very possibly unstable as a market structure, perhaps possessing a tendency towards merger. However, it is arguable that the motivation for firms not to merge is the avoidance of possible government action against a monopoly. Finally, the turnovers of the trading firms have been shown/estimated by Chalmin to vary independently from each other to some extent, which indicates a lack of widespread collusion. We thus assume collusion to be limited and possibly non-existent. If collusion does exist it is non-measurable and its effect on trade flows indistinguishable from similar effects caused by other factors.

14. We can now focus attention on the nature of market power that the grain oligopoly exerts. We assume that although there is little collusion, there are super-normal profits to be made due to asymmetries in information, and different space-time cost advantages between traders. In chapter 2 (paragraph 24) it was noted that where the price difference between exporter and importer is greater than the transport cost super-normal profits accrue. Transport cost must, of course, include not only the freight cost, but also the trader's overheads, insurance and other legitimate costs. There is an incentive to exploit, where it exists, local monopoly power of the type described in paragraph 12. Also, whilst commodity traders have no general incentive for altering world market prices, they may gain from an increase in price variability across space and time. The market advantage that traders possess is the ability to bear the burden of risks. As we have seen, the risk for the trader is less than that which would otherwise be faced by the importer or exporter (given that some of the means by which traders reduce risks are not available to the importer or exporter). We can assume that if

a trader charges too much, importers and exporters will do their own trading. However, in a period of global (price) instability the importer will be willing to pay more for the trader's service - in effect a larger risk premium. Assuming the increased risk can be reduced by the trader, then the higher price he (in effect) charges for his services will create higher profits for him.

15. This benefit arising from instability may help explain the massive profits of the grain traders in the early 1970s when the USSR entered the market as a major buyer on a sporadic basis. Since then predictions of the Soviet crop have improved (particularly through the use of the Landsat satellites) and risks and traders' profits have fallen. Other causes of price variability are instability in freight rates and in the international monetary system; and we have seen in chapter 3 (paragraph 12) that the existence of the CAP increases price instability. We can, however, draw the conclusion that commodity traders have an incentive not to disclose information which would create a clearer understanding of how they function and how the world market functions.

EFFICIENCY

16. Having discussed the degree of competitiveness in the market, it is pertinent to consider whether an alternative market structure could more efficiently fulfil the role of linking supply and demand. In this context efficiency is defined as that which provides the service of matching up supply and demand as effectively as under the present market structure with minimum cost to the importers and exporters (i.e. the benefit to commodity traders is excluded).

17. Because of the increasing returns to scale one might initially suppose that a structure approaching perfect competition with a large number of independent traders would be more costly if it were to provide the same services. However, this is not necessarily the case. On the one hand super-normal profits may be significant under oligopoly, and these would presumably not exist under perfect competition. The benefits would instead be

distributed to the importers and exporters by way of a lower effective price for the services provided. On the other hand, the economies of scale may change. In particular, with increased market information available publicly and quickly the fixed costs in information gathering may be reduced. On the one hand we may assume technological change in information systems as given, expecially when our counter-factual is in the past. On the other hand, if information is deliberately being withheld from the public domain by the commodity traders in order to create economies of scale (and thus barriers to entry), then the argument that economies of scale may be less important under a different market structure holds good.

18. Another alternative to the existing market structure might be a supra-national body which can reduce costs by benefiting fully from economies of scale in information whilst also being non-profit-making. Of course, such a body may not be as efficient as the private market, and there may be political pressures to re-distribute benefits according to different criteria. Such a system may be more desirable than the present market structure or perfect competition (due to distributional effects).

19. One thing clear from this brief discussion is that it is very difficult to assess the efficiency of the present system. There may be more efficient market structures such as those suggested, but there may not.

HOW MAY TRADE DIFFER UNDER DIFFERENT MARKET STRUCTURES?

20. Given this conclusion, the relevance of a discussion of how trade flows may differ under different market structures is questionable. It is desirable to consider how trade flows in the environment of the existing oligopolistic market structure differ from those under an ideal and more efficient perfectly competitive system. However, differences may not necessarily indicate inefficiencies in the way that distortions in trade flows caused by protectionism are typically seen as inefficient.

21. Comparing a perfectly competitive world with the observed oligopolistic world we may expect different local prices and trade flows. Firstly, the

general level of effective price for the transaction service may differ, which may alter demands and supplies for wheat.

22. Secondly, a geo-politically remote importer, and particularly one which is new to importing wheat, may face higher prices relative to the prices paid by others due to the existence of local monopoly rather than local oligopoly. This may be because one trader may have an advantage over others in selling wheat to the importer. Again this may affect the level of imports, and thus the matrix of world wheat trade. However, the proportions of the country's imports from various sources may only be affected if there is a distortion in the relative prices of wheat from different sources. This seems less likely, but is possible if the trading firm with the market advantage has a particular desire to sell wheat from a particular source.

23. Thirdly, imperfect competition in the freight market may similarly raise costs for the importer. The most typical reason why freight rates are relatively large for developing countries is because unloading cargo takes longer without an adequate number of berths, bulk handling equipment, adequate storage and an inland transport system capable of avoiding bottlenecks at the port. Also, ports may not be able to accept larger ships, and may depend on more expensive ships specially fitted with unloading equipment. However, if we assume that these conditions are given whatever the market structure, there may nevertheless be some additional price differentials for particular countries as and when imperfections in the freight market create opportunities for ship owners for super-normal profits.

24. Lastly, a desirable market such as the USSR attracts competition as the typically large orders result in large profits (the USSR also uses brokers). The costs of a transaction are approximately the same whatever its size (although the risks involved vary) and so a large contract is generally more desirable from the trader's point of view, and the market for such contracts more competitive. Conversely, small importers wanting smaller quantities may attract less competitive bids.

Food aid

25. An analysis of the world wheat market would be incomplete without food aid. In 1988 25% of African cereal imports were food aid, in Asia 5%, Central America 80%, and South America 50%. Globally the figure is about 20%.

26. Food aid in the 1950s and 1960s was mainly provided by the United States, but there was a need for more coordinated food aid. This resulted in the establishment of the United Nations World Food Programme (WFP) in 1963, which was dependent on voluntary contributions; and the Food Aid Conventions of 1967, 1971, 1980 and 1986. The Food Aid Conventions, signed by a number of developed countries and Argentina, provide for minimum tonnages of wheat or wheat equivalent to be given free to developing countries. The destination of aid is determined by each individual donor, and the Conventions can thus be described as guarantors of bilateral aid. Some non-exporting donor countries give aid in money which is then spent on food purchases (priority is given to Argentina to provide these sales). Since the 1980 Convention triangular transactions have occurred - a donor gives money for purchases by a recipient from a third (developing) country. This typically supports developing country exporters, reduces transport costs and provides a grain most suitable for local requirements.

27. The motivations for food aid are complicated, certainly in the case of the United States (see chapter 2 paragraph 16 ff). The political motivations are not easily included in any model, and certainly not in a simple model of wheat trade. However, we can generalise that commercial motivations have been threefold: in order to form part of a strategy to affect world price, as a retaliation against other exporters, and as a market development tool. The use of food aid to achieve the first and second of these objectives cannot be analysed separately from other protectionist policies. Where the third objective is emphasised we would expect new markets in developing countries to receive more food aid.

28. The most significant piece of legislation concerning food aid occurred before the first Food Aid Convention. This was the US 1954 Public Law 480

(PL480), whose objectives were to promote US foreign policy, combat hunger and dispose of surpluses. The original emphasis lay on the last of these - until the heavy Soviet buying and other developments of the 1970s one of the main problems of US agriculture was how to dispose of surpluses. In 1959 4/5ths of US grain exports were financed to some extent under PL480. In 1973 and 1974 food aid was cut due to domestic shortages. With time market development and combatting hunger were increasingly stressed as objectives, and to an extent the two goals are compatible - by providing cheap food dependence may be encouraged, and this may be judged to outweigh the benefits of cheap food. The Carter administration laid more emphasis on encouraging agricultural development abroad in an attempt to redress this import dependency[2].

29. As a foreign policy tool wheat was used by Kissinger - see his unsuccessful attempt to secure a grain-for-oil deal with the Soviets in the early 1970s - and by President Carter with his (also unsuccessful) 1980/81 embargo of US wheat to the USSR. However, PL480 has been less dramatically and more successfully used in many instances to exert political and economic pressures on developing countries.

30. An example of how PL480 has been used to wage economic war with the USSR and at the same time further US commercial interests, although not in wheat, is the case of US soybean oil exports to Iran, which were displaced in 1967 by Soviet counter-trade in sunflower oil for Iranian gas. The US retaliated with PL480 supported US soybean oil and beans. This was economically beneficial for the US as a domestic surplus of soybean oil had developed due to increased demand for soya meal. It had the further advantage of the development in Iran of a processing industry dependent on US beans.

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[2] Dependence on food imports may be considered excessive for three reasons. Firstly, land may be turned over to export crop production instead of food production. This may have undesirable long-term environmental consequences (e.g. mono-cropping may damage the soil), social effects (e.g. payments in cash may be wasted by wage labourers), and distributional effects. Secondly, land may be left idle. Thirdly, variability of world prices (accentuated by the CAP) increases instability in the importing country, causing planning difficulties and foreign exchange or food shortages.

Also in Iran about the same time, Canada and Australia started exporting wheat in greater quantities (due to cheaper transport costs) at the expense of US market share. The US again retaliated with PL480 from 1970 (Morgan, 1979). There are many other similar examples where PL480 has been used in trade wars.

Government policy and market power

31. The picture we now have in this dissertation of the world wheat market is becoming more comprehensive (leaving aside any analysis of product heterogeneity). We have surveyed the market structure of the private sector and the significance of food aid. Chapters 3 and 4 examined government policies of exporting and importing countries and their effects. We now consider briefly the importance of governments in trading, and the nature of government strategies in the context of the existence of market power.

GOVERNMENTS AS TRADERS

32. Since 1945 independence for many ex-colonies has led to an increase in the number of parastatal organizations involved in wheat trading. For the most part they are now national procurers of wheat, and in many cases transact or control all national wheat imports. These institutions may provide a bargaining position for the country that it would not otherwise have, and can be used to restrict imports.

33. Of the five major exporters, the United States and the EC governments do not directly engage in trading transactions (although they provide export subsidies to companies which do). In Argentina private and public sector trading co-exist. In Canada and Australia most transactions are carried out between the government (in the form of the CWB and AWB) and the importer, although the CWB may sell some of its wheat to private grain companies when facing difficulties in disposing of a bumper crop.

34. The advantage to Canadian farmers of the CWB has on occasion been cited

by US farmers as good reason for a similar institution in the US. Such an institution would protect farmers from the monopsony powers of the grain companies who control the key storage and transport facilities, and millers with similar market power such as Peavey and Pillsbury. Cooperatives and cooperative unions have not been very successful in the US, although 'Farmers Export', the most important, was the fourth largest exporter of US grain in 1980. Although US governments have shied away from the creation of a wheat board similar to the CWB, the administration can influence US exports through protectionist means including embargoes. However, it would not have been possible for Canadian wheat to rush out of the country without the government's knowledge as happened with the Soviet 'great grain robbery' from the United States in 1973 (see paragraph 36 below).

GOVERNMENT STRATEGIES

35. Market power, meaning the ability to affect international prices, is limited to a few countries and possibly also the grain trading firms. As was seen in chapter 2 the optimal tariff argument is one economic justification for protectionism, i.e. to exploit market power. Major exporting countries possess market power. Individual importing countries, on the other hand, are not able to affect world prices to their advantage, with the possible exception of the USSR.

36. Whereas many countries may time wheat purchases carefully to take into account movements in the international price, the purchases of the USSR, and possibly other major importers, have at times been sufficiently large and unpredictable to affect the world price noticeably once information concerning purchases has become public. Large purchases by the USSR will raise the price, and so the USSR strategy has been to try to buy secretly from several sources at the same time. In this way the total scale of the purchases may remain unknown until after all quantities have been contracted, and then the increased price caused by major Soviet purchases is not (or not fully) borne by the Soviets, who buy at or near the previous lower price. This is what happened in the 'great grain robbery' after the poor Soviet crop of 1972/73. If we assume rational expectations, then only 'news' will cause

a shift in the expected world price; and, as mentioned, the predictability of Soviet harvests and so import demands has increased. Also, after the first massive purchases in 1973 the US government and others were more prepared for a recurrence, and by the late 1970s/early 1980s the ability of the USSR to mainipulate the wheat market to its advantage can be assumed to have been substantially reduced.

37. In the first section of this chapter the market power of the grain trading firms was discussed. Collusion was seen as possible, but unlikely to be extensive enough to affect the international price. Even without collusion, it is suspected that the five large grain traders do exert market power and can make large super-normal profits under particular market conditions. They have little incentive to move the price systematically higher or lower over a period of time, but there is an incentive to increase price volatility, which they can achieve through limiting information. It has also been seen that governments, through national wheat boards, may use protectionist policies under conditions of imperfect competition to extract surplus profits for themselves, as opposed to leaving these to the private sector (e.g. Canada). The threat of similar intervention by other governments may even reduce the level of profits in the private grain firms by forcing collusion underground and precluding the creation of a monopoly in grain trading via merger.

38. The main holders of market power are not the importers or the grain companies, but the governments of the exporting countries, and most particularly the United States. The US is dominant in the world wheat market for four main reasons. It is the largest exporter; it is able and willing to pay its farmers to leave land fallow in order to reduce surpluses (these first two reasons are the most important); the grain futures markets are in the US - in Chicago and Kansas; and its export subsidies (PL480 subsidies, credit programmes and the Export Enhancement Program, EEP) have been used aggressively to gain export orders and develop markets.

39. US market power is used to keep international prices as high as possible, although this objective may be compromised by the build up of

surpluses. By using set-aside policies and employing PL480, GSM sales and EEP to dispose of surpluses to poorer countries (preferably ones who would not otherwise buy wheat), the surpluses can be disposed of without at least directly lowering international prices. The US can thus be said to practice discriminatory pricing. However, as has been seen, the US authorities do not directly determine sales of US wheat, and inasmuch as this reduces control over the level of exports it also limits the excercise of US market power.

40. It can be argued that other exporters also have a degree of market power, including the European Community. It too has export subsidies and a set-aside programme. However, the EC does not possess the same comparative advantage in wheat production and the goals of the Common Agricultural Policy are not consistent with maximizing EC economic growth. Producer subsidies and protectionist measures are needed to keep farmers in business, not just to insure them against risk. The exporting of EC wheat is largely a device to dispose of surpluses: the main objective is neither to increase export earnings via an economically rational process, nor to further foreign policy. It can be inferred from this that the EC has unused potential market power. It has the ability to produce wheat for export (made possible by the willingness to subsidise heavily the agricultural sector) and it has the ability to control the level of output (through guaranteed prices on the one hand and set-aside on the other). However, it chooses not to use this market power as exports are a residual vent for undesired internal surpluses, not a policy objective.

41. In one sense the EC most certainly does change international prices by its policies: the world wheat market would be very different without the CAP, as was indicated in chapter 3. However, given that the CAP exists, we have seen that the EC does not set the level of its exports to exert deliberate pressure on international prices. Insofar as there are other ways of coping with surpluses, the effect on international prices will be taken into account by EC officials when considering the magnitudes and particularly the timing of export restitutions.

42. Such lack of manipulation of the world market price to achieve policy objectives must not be confused with the EC's ability to wage trade war with the United States and others. The level of EC exports is relatively inflexible to retaliation by the United States. Typically the EC will spend whatever is necessary to dispose of its surplus, and if this causes increased EEP subsidies, for example, then the restitutions will be raised. This mechanism may even provide a partial explanation for why it is seemingly the US and the EC which are most at odds with each other - other wheat exporters yield to US market power in accordance with their rational economic objectives.

Measuring the importance of market power

GOVERNMENT MARKET POWER

43. We consider first how to measure the effects on world trade arising from the use of market power by exporting governments, in particular the United States. Put another way, we wish to ascertain the difference between the current situation and one in which countries did not try to influence the world price - a world of price takers.

44. In order to do this it is first necessary to realise that the instruments used to exploit market power are also used to further other objectives, principally political and retaliatory. Also, there may be other economic justifications for using these instruments (see chapter 2, paragraph 16 ff) such as the infant industry argument or the need to offset externalities and other distortions in other parts of the domestic economy. It may be possible to measure the effects of such instruments on international trade. What is more problematic is to determine the relative importance of particular objectives in shaping the use of the instruments.

45. The first step in such a measurement exercise is to examine the market, as has been done in this chapter, and determine where market power is likely

to lie. For a country without market power it is straightforward to ascribe all use of protectionist instruments to other motivations.

46. Thereafter a researcher might proceed in one of two ways. One is to construct a game-theoretic model to assess the expected degree of distortion (see chapter 12). The main problem with this approach is that it is difficult to parameterise such a model.

47. Alternatively, the justifications given by governments for each protectionist measure can be examined. This is not practical in many cases due to the lack of public explanation, the possible sole exception being the United States. This exception is indeed fortunate, given that the United States is the country with the most significant market power. However, it is important to recognise the possible bias in such justifications even if they cannot be accurately accounted for: politics may not allow the true motivations to be given as justification.

48. The two approaches are not exclusive to each other. Rather, they are complementary. Analysis of instrument use together with composition and timing gained from an analysis of justifications may help to parameterise a game-theoretic model.

MARKET POWER OF GRAIN TRADERS

49. We mentioned in the first section of the chapter that grain traders may attempt to increase price volatility. We can measure price volatility in the world wheat market, and can also observe (or estimate) the profits of the grain traders, but it is not possible to measure the degree to which volatility is caused by the traders. The question of what is an appropriate counter-factual is one of the main problems of assessment. In the first section the possibilities of perfect competition and a supra-national body were discussed. However, we do not know what degree of information would exist publicly without the market dominance of a few firms, nor what level of volatility there would be. Even if this were calculable we would still have to bear in mind (in any assessment of relative benefits of different market

structures) the possible reduction in efficiency of the trading function due to the existence of economies of scale. As we cannot assess the importance of market power in affecting volatility we cannot measure its impact on the pattern of trade (although we can make qualitative statements about the effect of price volatility on trade patterns - see in particular chapter 3, paragraph 26).

50. Leaving aside the issue of volatility, we also mentioned three ways in which trading patterns might be different under perfect competition due to the elimination of grain traders' market power. They were that the price difference between importer and exporter may be different, that geo-politically remote importers might face lower c.i.f. (and possibly also f.o.b.) prices than they do now, and that the size of contracts would not affect the competitiveness of the bids. Measurement of these factors, however, would require detailed information from grain traders on prices and profits associated with particular deals - information that is not likely to be forthcoming.

51. Unfortunately, this leaves empirical analysis of imperfect competition in the wheat market outside the scope of this study, although individual protectionist policies can be modelled. Nevertheless, chapter 12 details a (non-parameterised) game-theoretic framework which might in future be used to analyse strategic behaviour of the US and EC governments.

CHAPTER 6: WHEAT HETEROGENEITY

1. The production of different types of wheat with different combinations of characteristics by the major exporters is of relevance to any comprehensive attempt to understand the world wheat market. Even by incorporating relatively unsophisticated analysis into a trade model improvements in predictive power may be expected. In the case of a mathematical programming model it may be expected that modelling product heterogeneity can at least reduce the number of non-zero trade flows (see chapter 2, paragraph 28), and help explain why the EC both imports and exports wheat. This chapter first outlines the nature of wheat heterogeneity. This is followed by a discussion of the merits of the Armington and characteristics approaches to model wheat trade and a summary of three characteristics models (a summary of the Armington approach already having been presented in chapter 2).

A description of wheat heterogeneity

2. Each of the five main exporters produce several types of wheat. They are substitutable in consumption to a greater or lesser extent, but such substitutability varies from importer to importer. An importer's demands for different types of wheat is determined by prices, the importer's budget constraint and the importer's preferences for different types of wheat. The most important reasons for differences in preferences between importers are income levels, taste preferences for different wheat products, and the type of domestic wheat production. Preferences are distinguishable by the intrinsic characteristics of the wheat, and also by factors associated with the geographical location of production.

INTRINSIC CHARACTERISTICS

3. The intrinsic characteristics of wheat can be categorized under three headings: botanical, physical and chemical. The main botanical

characteristics are species and variety of species. Common wheat is the most important species, constituting over 90% of North American wheat. Other wheats of importance are club and durum. There are numerous varieties, particularly of common wheat, and they are constantly increasing in number as new ones are developed.

4. Several physical characteristics of wheat are used to determine its quality. The most important is the weight per unit volume - the higher the better. This varies with kernel shape, uniformity of kernel shape and size, and density. Density is determined by biological structure and chemical composition, including moisture content. As well as weight per unit volume, kernel weight, size and shape can be measured. Kernel hardness is not easily measured but is of importance. Hard kernels produce granular flour suitable for bread, as opposed to soft kernels which produce finer flours more suitable for cake and pastry. Hardness is important in that hard wheats tend to have higher protein levels. Hard wheat is generally more expensive than soft as it is substitutable for soft wheat but the reverse is not true. Other physical measures of quality are colour and the percentages of damaged kernels and impurities. Individual wheats can also be tested for milling quality.

5. The most important chemical characteristics are protein and moisture content. High protein wheats are desirable for bread making. High protein flour absorbs more moisture during bread making and so goes further, and also produces bread which keeps for a longer period - traditional french bread is made from soft wheat which is why it goes stale quickly. The percentage protein in wheat depends largely on environmental factors during growth. Many countries have climates which preclude production of high protein wheat. In particular it is necessary to avoid too much rain during kernel development, which is why Europe has to import its hard wheat. In the dry European summer of 1976 the protein content of British wheats were much higher than normal. The quality of protein is also important and largely dependent on variety of wheat and environmental conditions.

6. Moisture content is relevant for various reasons. Water takes up space

and affects storage life. Across the typical range of percentage moisture levels encountered, the quality of wheat varies inversely with moisture content. However, some moisture is desirable as very dry wheat is brittle and tends to break during handling. Other chemical characteristics of significance are soundness (a measure of susceptibility to deterioration) and ash content (a measure related to bran content).

7. Measurement of some characteristics is easier than that of others. The characteristics, apart from name and grade, most often used to describe wheat and to specify demand are hardness, test weight, moisture content, protein content and some measure of the percentage of foreign material. This is borne out by an International Wheat Council questionnaire survey of the characteristics preferred by importers (IWC, 1985).

GEOGRAPHICAL CHARACTERISTICS

8. There is a potential overlap between definitions of intrinsic and geographical characteristics, because a wheat's intrinsic characteristics are to a large extent determined by environmental conditions at the place of production. To avoid confusion, geographical characteristics are defined as those characteristics of a wheat supply source which are additional to intrinsic characteristics of the wheat.

9. Using this definition the main geographical characteristics are particular to exporting countries, and differences in the levels of these characteristics between exporters are mainly due to differences in government policies. Excluded here are price effects of government policies. However, the provision of credit may be regarded as a geographical characteristic.

10. There may be other non-price benefits or costs associated with particular exporters. It may be politically expedient to buy from a particular exporter. In the case of counter-trade, linkages of wheat trade to that in other goods and services may necessitate purchasing from a particular exporter. These may be considered geographical characteristics.

11. In the possible cases of geographical characteristics mentioned so far (credit, political expediency and counter-trade linkages) the degree of the characteristic associated with a particular exporter is likely to vary from importer to importer. This is a serious complication, as is the difficulty of adequately measuring geographical characteristics.

12. A remaining geographical characteristic which is not as likely to vary from importer to importer is reliability of supply. This is assumed to be mainly a function of the exporter's climate, other production factors, stocks and domestic consumption. It is nevertheless possible that in times of reduced exportable surplus an exporter may discriminate between importers such that the reliability of the exporter's supply can be said to vary from importer to importer. For poorer countries the Food Aid Conventions (mentioned in paragraph 26, chapter 5) provide a security of food supply.

<u>Wheat heterogeneity: relevant theory</u>[1]

ARMINGTON

13. The Armington approach of differentiating products by place of production (see chapter 2, paragraph 39 ff) has the attraction, of a two-stage decision process. For wheat importers this is a fairly realistic assumption. With only five major exporters, however, the need for the Armington assumption in order to reduce model complexity is small. It could be assumed that the good (wheat) comprises five products - one for each major export source. Each product is priced differently, reflecting different production costs, supply availability and demand. Importing countries can be assumed to have different product preference orderings - due principally to their different tastes and income distribution.

14. One option to describe the import demands at Armington's second

[1] For a recent examination of how to model commodity heterogeneity see Lord, 1991.

decision stage is to use a single set of preferences to represent the demands for the (intermediate) wheat products of all individuals within the country (i.e. the existence of community indifference curves). This is not a strictly accurate representation of demand where there is complementarity or substitutability between the products (bread is often made using several types of wheat) or where individuals within a country have different or non-homothetic tastes (i.e there is no community indifference map - see Scitovsky (1942)). It is noted that for modelling complementarity of products a different form of Gorman polar utility function is required than that adopted by Armington. The lack of community indifference curves cannot be solved in theory within the Armington framework. In practice, however, community indifference curves are often assumed, and with state trading this would seem appropriate.

15. What the simple Armington model does not incorporate is the differences in product substitutability between different importers. This is considered a major deficiency in modelling the wheat market. Further, there is clear evidence of high substitutability between wheats from different sources - importers often do not specify where they want wheat to come from. More important are the intrinsic characteristics of the wheat. Bearing this in mind it is difficult to justify theoretical differentiation of wheat purely by place of production. This problem may be overcome to some extent by assuming more products, reflecting not more exporters but the fact that each exporter produces several types of wheat. Even this is of limited use when importers do not express preferences for particular types of wheat (although it could be assumed that they simply want the cheapest). To solve these problems an approach is needed which models the characteristics of wheat as the determinants of demand instead of, or in addition to, the wheat's name and grade.

CHARACTERISTICS APPROACH

16. The main advantage of analysing wheat demand in terms of product characteristics rather than products as such is that the decision making

process which determines product demand is more closely modelled. This is because characteristics, combinations of which vary from product to product, are of key importance in determining the usefulness to the importer of the product in meeting final demand. The characteristics described in the first section of this chapter can be used. However, there is an added complexity in that the nature of exporters' geographical characteristics may vary from importer to importer (not to be confused with the fact that different importers will have different preferences for the characteristics). Further discussion of how to model wheat heterogeneity is determined by the choice of overall modelling technique (discussed in the next chapter) and data availability. More detailed discussion of the modelling used is therefore reserved until chapter 11.

17. The remainder of this section outlines the economic theory of product characteristics of relevance to this study. The basic contribution is that of Lancaster (1971). Ladd and Suvannunt (1976) introduced unique characteristics for products. In Ladd and Zober (1977) utility is a function of services, which in turn are dependent on product characteristics.

18. The symbols used in this section are as follows:

U	consumer's (importer's) utility and utility function
Y	consumer's fixed income
E	consumer's expenditure
λ	lagrange multiplier, marginal utility of income
r_p	price of pth product; $p = 1,\pi$
x_p	quantity of pth product consumed
q_{pc}	quantity of cth characteristic provided by one unit of the pth product; $c = 1,\chi$
x_{pc}	total quantity of cth characteristic obtained from consumption of pth product
x_{oc}	total amount of cth characteristic consumed by the consumer
s_h	amount of hth consumption service that a

consumer obtains from consumption of all products; $h = 1,H$.

Lancaster

19. Lancaster (1971) developed a theory in which consumers demand characteristics, and products are modelled as bundles of characteristics. The demands for products are derived from the demands for characteristics, and are thus seen as merely parameters in the model. Three key assumptions are:

- Utility is independent of the distribution of characteristics across products (IDC);
- Linear consumption technology (LCT), expressed in the linear constraints (6.2) below;
- Nonnegative marginal utility of characteristics (NNMU).

20. For purposes of the present discussion the first assumption is the most important, and it is this assumption which leads to the treatment of product demands as parameters. The objective function of the consumer is to maximize utility as follows:

$$\text{Maximize } U(x_{o1}, x_{o2}, .., x_{o\chi}) \tag{6.1}$$

subject to

$$\sum_p q_{pc} x_p = x_{oc}; \; c = 1,2,..,\chi \tag{6.2}$$

$$\sum_p r_p x_p \leq Y \tag{6.3}$$

$$\text{all } x_{oc} \geq 0, \text{ all } x_p \geq 0 \tag{6.4}$$

which leads to the result that the price of a product is proportional to the sum over all characteristics of the marginal utility of a characteristic times the (fixed) amount of characteristic found in the product.

Ladd and Suvannunt: introducing unique characteristics

21. The Ladd and Savannunt (1976) model is much broader than Lancaster's, which can be considered a specific example within the Ladd and Savannunt framework. For this reason the model is described here in a little more detail than Lancaster's. It does not assume LCT or NNMU, but retains the IDC assumption (another version of their model drops this also). The particular feature of note is that each product is assumed to supply one characteristic (designated by the subscript $\chi+p = \chi+1, \chi+\pi$) which is not shared with any other product.

The objective function is:

$$\text{Maximize } U(x_{o1}, x_{o2}, .., x_{o\chi}, x_{o\chi+1}, x_{o\chi+2}, .., x_{o\chi+\pi}) \tag{6.5}$$

subject to

$$f_c(x_1, x_2, .., x_\pi, q_{1c}, q_{2c}, .., q_{\pi c}) = x_{oc} \tag{6.6}$$

$$f_{o\chi+p}(x_p, q_{p\chi+p}) = x_{o\chi+p} \tag{6.7}$$

$$\sum_p r_p x_p = Y \tag{6.8}$$

As $\quad \dfrac{\delta U}{\delta x_p} = \sum_c \dfrac{\delta U}{\delta x_{oc}} \dfrac{\delta x_{oc}}{\delta x_p} \quad$ and $\quad \lambda = \dfrac{\delta U}{\delta Y}$

the first order conditions are:

$$\sum_c \frac{\delta U}{\delta x_{oc}} \frac{\delta x_{oc}}{\delta x_p} + \frac{\delta U}{\delta x_{o\chi+p}} \frac{\delta x_{o\chi+p}}{\delta x_p} - \frac{\delta U}{\delta Y} r_p = 0 \qquad (6.9)$$

Rearranging, this yields what is referred to as an hedonic price function (a price function determined by demands for characteristics)

$$r_p = \sum_c \frac{\delta x_{oc}}{\delta x_p} \frac{\delta U/\delta x_{oc}}{\delta U/\delta Y} + \frac{\delta x_{o\chi+p}}{\delta x_p} \frac{\delta U/\delta x_{o\chi+p}}{\delta U/\delta Y} \qquad (6.10)$$

22. Assuming that each unit of product produces one unit of its unique characteristic, substituting expenditure E for income Y, and re-writing the marginal rate of substitution between income and the cth product characteristic (the marginal price for the characteristic), $\frac{\delta U/\delta x_{oc}}{\delta U/\delta Y}$ as $\frac{\delta E}{\delta x_{oc}}$ equation (6.10) can be rewritten

$$r_p = \sum_c \frac{\delta x_{oc}}{\delta x_p} \frac{\delta E}{\delta x_{oc}} + \frac{\delta E}{\delta x_{o\chi+p}} \qquad (6.11)$$

23. The price paid for a product is hypothesised as the sum of the marginal yields of product characteristics times their implicit prices.

Ladd and Zober: introducing services

24. Ladd and Zober (1977) state utility as a function of services which are dependent on product characteristics, rather than stating utility as a direct function of characteristics. This is useful as in the wheat market we might think of an exporter providing a service consisting of several products.

The objective function is

$$\text{Maximize } U(s_1, s_2, .., s_H) \qquad (6.12)$$

subject to

$$\sum_p r_p x_p \le Y, \text{ all } x_p \ge 0 \qquad (6.13)$$

where $s_h = s_h(x_{11}, x_{12}, .., x_{1\chi}, x_{21}, .., x_{\pi\chi})$ (6.14)

and $x_{pc} = f_{pc}(x_1, x_2, .., x_\pi, q_{pc})$ (6.15)

The first order conditions are

$$\sum_c \frac{\delta U}{\delta s_h} \frac{\delta s_h}{\delta x_{pc}} \frac{\delta x_{pc}}{\delta x_p} - \lambda r_p = 0, \text{ if } x_p > 0;$$

$$\sum_c \frac{\delta U}{\delta s_h} \frac{\delta s_h}{\delta x_{pc}} \frac{\delta x_{pc}}{\delta x_p} - \lambda r_p < 0, \text{ if } x_p = 0 \qquad (6.16)$$

But as $\lambda = \delta U/\delta Y$, and assuming from the income constraint that $Y = E$, we can rearrange these to yield

$$r_p = \sum_c \frac{\delta E}{\delta x_{pc}} \frac{\delta x_{pc}}{\delta x_p}, \quad \text{if } x_p > 0$$

$$x_p = 0, \text{ if } r_p > \sum_c \frac{\delta E}{\delta x_{pc}} \frac{\delta x_{pc}}{\delta x_p}, \qquad (6.17)$$

25. Thus if the product's price is greater than the marginal imputed value of its characteristics, it is not demanded. This is a useful additional insight.

PART II

Spatial equilibrium modelling: the case of wheat trade

CHAPTER 7: MODEL METHODOLOGY

1. This short chapter recapitulates the specific purpose of the thesis, and explains the choice of methodology for the modelling that follows.

2. The initial aim of the enquiry was suggested to the author by the Inter-American Development Bank (IDB). It was to investigate **the effects of CAP protectionism on Latin America.** A reason for particular interest in this was that agricultural protection has been a key issue during the Uruguay round of GATT negotiations. Latin America has a special concern because the region is a net exporter of many CAP protected products, and so is possibly harmed by lower international prices for these commodities more than African or Asian countries which are net importers. This view is supported by the partial equilibrium study of Matthews (1985b) reviewed in chapter 3.

3. There are significant problems in trying to assess the effect of the CAP on Latin America. EC-Latin America trade in agricultural commodities is small, and the main effects are indirect. But CAP protectionism encourages European production, which in turn reduces import demand and, where there is over-production, increases world export supply. International prices are therefore lower and more volatile than they would be without CAP. This is damaging to competing exporters, but, in the short-run at least, beneficial to importers[1]. Secondly, the impact on the US and other major producers is important. Protectionism by the EC encourages protectionism by the US and others in retaliation. Similarly, a reduction in EC protectionism is more likely to occur in conjunction with reductions by others. Thirdly, linkages between products need to be considered: both substitution and vertical linkages such as the relationship between cereals and livestock (see chapter 3, paragraph 14).

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[1] In the long-run cheaper food imports may also be damaging to food importers, as these countries become excessively dependent on food imports (and food aid).

4. For these reasons it is not appropriate to investigate EC-Latin American relationships in isolation. A model needs first to be constructed which is capable of describing the world market for one (or more than one) commodity. As reviewed in chapter 2, trade models can be either partial or general price equilibrium models, studying respectively the world commodity market(s) in question or the whole world economy. Alternatively there are ratio market share approaches, or more sophisticated econometric methodologies from which to choose.

5. Two of the criteria for choosing a model were time and expense. It was not possible to choose a general equilibrium approach, for instance. Also, it became apparent that to study more than one CAP commodity in detail would not be possible. The advantages of studying wheat are firstly its prominence in world agricultural trade; secondly the existence of an international wheat market with a developed futures market; thirdly its central importance in the CAP; fourthly its significance in determining production and trade in other agricultural products (wheat production accounts for a large proportion of agricultural land in Europe which therefore cannot be used for other purposes; and it is a substitutable input for livestock production); fifthly that a Latin American country is one of the five major exporters (Argentina), and another (Brazil) a major importer; and lastly because of data availability.

6. Different commodity trade models yield different conclusions primarily through employing different assumptions. A model type implicitly assumes certain types of behaviour. Because of this, consideration of methodology has been left until after discussion not only of model types but also of the wheat market and the behaviour of importers and exporters in part I.

7. If we exclude general equilibrium models on the grounds of shortage of resources, and simple market share models on the grounds of lack of theoretical rigour, the remaining selection is between an econometric and a partial (spatial or non-spatial) equilibrium model. The spatial equilibrium model was chosen in preference to an econometric model on the basis of computational ease and theoretical simplicity. An additional benefit in using

a spatial equilibrium model (over non-spatial models) is that it predicts trade flow matrices. It was foreseen that these would be of significant benefit in modelling distortions (protectionism, imperfect competition, heterogeneity): the nature of distortion can be partially assessed by observing the differences between the trade flow matrix of a model and that observed in reality. Similarly, the differences between flow matrices predicted by models is helpful in assessing the relative merits of the models. Assistance is thus given in locating the cause of distortions, and the results of alterations to a model can be easily observed and understood. This methodology is highly suitable for modelling a market with a large number of distortions as it provides constant monitoring of model alteration during the model building process.

8. The spatial equilibrium model of international wheat trade proposed, being a global model, offers more than an analysis of the effect of the CAP on Latin America - even though in certain respects it offers less as it fails to capture general equilibrium effects, incorporating as it does only one commodity. It can be used to analyse the effects of government interventions and other distortions on global trading efficiency in wheat. A statistic to assist in this, λ, is defined in the next chapter. Possible effects of policy change can also be assessed. For these reasons the most important results of the research were foreseen as being those concerned with the usefulness of the methodology - of spatial equilibrium modelling[2].

9. Hence, as stated in the introduction, the thesis has two main objectives. The first is to investigate the capacity and limits of spatial equilibrium modelling in the context of international commodity trade. The second is to identify distortions from perfect competition in the international wheat market and assess their relative importance. Subsumed in this second objective is the effect of CAP wheat protectionism on Latin America.

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[2] An additional advantage of choosing wheat as the commodity of study is that the wheat market is subject to a wide variety of distortions; thus facilitating better an assessment of the capacities and limits of the methodology.

10. It was noted in chapter 4 that import demand appears to be determined to a large extent by domestic variables, as opposed to world prices. Export supply also seems to be largely unaffected by world prices. Dramatic price falls in the 1980s were not accompanied by large reductions in output. From this the distinguishing assumption of the first (transportation) model emerges: that import demands and export supplies are independent of international price (over the relevant range). This model is presented in chapter 8. Chapter 9 then introduces the possibility of importers' responsiveness to world price in the form of non-linear and other models. Chapters 10 to 12 introduce model alterations to take account of various market distortions. One of the problems with making alterations to a model is to determine the order in which they are added. This problem is partially overcome in chapter 13, the final chapter of Part II, in which alterations are individually subtracted from the full model.

CHAPTER 8: THE BASIC LINEAR PROGRAMME MODEL

1. Having decided on spatial equilibrium modelling, a basic linear programme model is now used to analyse trade flows. After a discussion of the theory and the statistics to be used for evaluating the results, the data and some expected results are outlined. In the last section the results themselves are presented and analysed.

The basic model: theory and statistics

2. In the simple transportation problem linear programming model, total import demand quantities of importing countries are assumed given and equal to total export supply quantities of exporting countries. The model then calculates the set of trade flows which minimize global transport costs. As described in chapter 2, the objective function is:

$$\text{minimize} \qquad T = \Sigma_{i=1}^{n}\Sigma_{j=1}^{m}t_{ij}F_{ij} \qquad (8.1)$$

subject to non-negativity constraints,

$$\Sigma_{i=1}^{n}F_{ij} = M_j, \qquad j = 1,m \qquad (8.2)$$

and

$$\Sigma_{j=1}^{m}F_{ij} = X_i, \qquad i = 1,n \qquad (8.3)$$

where, as in chapter 2, F_{ij} is the trade quantity flowing from exporter i to importer j, t_{ij} is the transport cost between i and j, and there are n exporters and m importers.

3. To run the program an (m by n) matrix of transport costs, t_{ij}, is required, together with import demands and export supplies: M_j, j = 1,m; and X_i, i = 1,n. The result is a set of 'optimal' (m x n -1) trade flows which

minimizes total transport costs. Many actual transport costs are unknown, and so in this chapter several sets of transport costs are used. The different results are then compared to assess which set best approximates the impact of actual (unobserved) transport costs. A general guideline is to choose the data set which produces expected flows closest to observed flows, although this is not done mechanistically as it is possible that a more inaccurate data set may produce more accurate predicted flows. Such possibilities are discussed later in the chapter. The final choice of data set is not made until chapter 13. Each data set consists of an (m x n) matrix for each year.

4. The resulting 'optimal' or expected flows can then be compared with actual (observed) flows. The correspondence between predicted and actual flows cannot be measured using a statistical device such as χ^2, because χ^2 is not dimensionless - for example, data measured in thousand tons would yield a different ,χ^2 value from data measured in million tons. Instead, comparison is made in several ways. Firstly, total expected transport cost (T as defined in equation 8.1) is compared with total observed transport costs,

$$T^o = \Sigma_{i=1}^{n}\Sigma_{j=1}^{m}t_{ij}F_{ij}^{o} \qquad (8.4)$$

where T^o = total observed transport costs, and
F_{ij}^{o} = matrix of observed flows.

This is done by way of a ratio which expresses the total observed transport cost as a percentage of the total expected transport cost (T^o/T). From this can be calculated the percentage observed transport cost, λ, not explained by the model:

$$\lambda = 100.(T^o/T - 1) \qquad (8.5)$$

STATISTICAL PROPERTIES OF λ

5. Since λ is the key indicator used in analyzing the models which follow, its statistical properties merit further investigation. To this end we internalize the constraints (8.2) and (8.3) into the minimization function (8.1), as it then becomes easier to consider the properties of λ. From equations (8.2) and (8.3) we can obtain the following:

$$F_{nj}t_{nj} = M_j t_{nj} - \Sigma_{i=1}^{n-1} F_{ij} t_{nj} \tag{8.6}$$

and

$$F_{im}t_{im} = X_i t_{im} - \Sigma_{j=1}^{m-1} F_{ij} t_{im} \tag{8.7}$$

Also, bearing in mind that $\Sigma_{i=1}^{n-1}\Sigma_{j=1}^{m-1}F_{ij} = V - X_n - M_m + F_{nm}$, where V is total trade volume, and thus that

$$F_{nm}t_{nm} = \Sigma_{i=1}^{n-1}\Sigma_{j=1}^{m-1}F_{ij}t_{nm} - (V-X_n-M_m)t_{nm} \tag{8.8}$$

we can re-write the minimization problem as:

$$\text{minimize} \quad \Sigma_{i=1}^{n-1}\Sigma_{j=1}^{m-1}F_{ij}t_{ij} + \Sigma_{i=1}^{n-1}F_{im}t_{im} + \Sigma_{j=1}^{m-1}F_{nj}t_{nj} + F_{nm}t_{nm} \tag{8.9}$$

and then substitute (8.6), (8.7) and (8.8), and ignore fixed terms to give:

$$\text{minimize} \quad \Sigma_{i=1}^{n-1}\Sigma_{j=1}^{m-1}F_{ij}\psi_{ij} \tag{8.10}$$

where

$$\psi_{ij} = t_{ij}-t_{im}-t_{nj}+t_{nm} \tag{8.11}$$

Now call the (n-1)x(m-1) vectors of ψ_{ij}, F_{ij} and $\overset{o}{F_{ij}}$ ψ, E and O respectively, and the problem becomes:

$$\text{minimize} \quad \psi' E, \qquad F_{ij} \geq 0, \text{ all } i,j \tag{8.12}$$

6. We will call C the difference between total expected costs and the minimized function, T - ψ'E, which is fixed with respect to the minimization:

$$C = \Sigma_{i=1}^{n-1}X_i t_{im} + \Sigma_{j=1}^{m-1}M_j t_{nj} - (V-X_n-M_m)t_{nm} \tag{8.13}$$

Then $$\lambda = \left(\frac{\psi' O+C}{\psi' E+C} - 1 \right) .100 \qquad (8.14)$$

As the minimization solution provides the lowest total cost possible given the freight rates and import and export totals $\psi' E \leq \psi' O$. Given this and that $T > 0$, and $T^o > 0$, it therefore follows from (8.14) that $\lambda \geq 0$.

Adding flow constraints

7. We now wish to consider the behaviour of λ when we fix some flows to be at least as large as some observed trades, as is done in chapter 10. To do this split ψ into ψ_1 and ψ_2, and E and O conformably into E_1, E_2 and O_1, O_2, and re-run the problem with the constraint E_1=O_1. Denoting the new problem variables with an asterisk, *:

$$\lambda^* = \left(\frac{\psi_1' O_1+\psi_2' O_2+C}{\psi_1' E_1+\psi_2' E_2^*+C} - 1 \right) .100 \qquad (8.15)$$

And $$\lambda^* - \lambda + 100.(\psi_1' O_1+\psi_2' O_2+C) \left(\frac{1}{\psi_1' O_1+\psi_2' E_2^*+C} - \frac{1}{\psi_1' E_1+\psi_2' E_2+C} \right) \qquad (8.16)$$

As T^o, T^* and T (the initial bracketed phrase and the two denominators in the second pair of brackets) are all positive; and $\psi_1' E_1+\psi_2' E_2 \leq \psi_1' O_1+\psi_2' E_2$ it follows that $\lambda^* - \lambda \leq 0$; i.e. that such a constraint lowers lambda or leaves it as before.

Changing freight rates

8. Suppose we change the freight rates for exporter 4 whilst leaving all other rates the same as before (as is also done in capter 10). From (8.11) we can see that:

$$\psi_{ij}^* = \psi_{ij}, \qquad i \neq 4,\ j=1,m \qquad (8.17)$$

$$\psi_{4j}^* = \psi_{4j} + (t_{4j}^*-t_{4j}) - (t_{4m}^*-t_{4m}), \qquad j=1,m \qquad (8.18)$$

9. If the changes take the form of a uniform addition across all importers we can see from (8.18) that $\psi^*_{4j} = \psi_{4j}$, and thus that $\psi^* = \psi$. This is a useful insight as it means we can add an arbitrary figure to all rates from a particular exporter without any change in the expected flow matrix. We may wish to do this as it enables us to subtract geographically differentiated amounts (representing perhaps export subsidies) from the freight rate matrix without creating negative figures. A symetric case exists if we make a uniform alteration to an importer's freight rates.

10. However, if we alter freight rates by different amounts then there is no reason to believe that $\psi^*_{4j} = \psi_{4j}$, or thus that $\psi^* = \psi$.

Nevertheless, if $t^*_{ij} \geq t_{ij}$, $i=1,n;\ j=1,m$ then $T^* \geq T$ (8.19)

Likewise, if $t^*_{ij} \leq t_{ij}$, $i=1,n;\ j=1,m$ then $T^* \leq T$ (8.20)

However, even where $t^*_{ij} \geq t_{ij}$ for all i and j, as in (8.19), an examination of (8.11) reveals that there is no reason to believe that $\psi^{*\prime} E^* \geq \psi' E$ as individual values of ψ_{ij} may go either up or down.

11. We may alter freight rates for two types of reason. In the first case we can compare the minimization results using different sets of freight rates in an attempt to approximate actual (unknown) rates. By comparing levels of λ using different rates, as well as looking to see how changing freight rates affects individual flows, we can pick the rates which best model observed flows. Such an approach for choosing freight rates is clearly flawed in the sense that a set of freight rates may produce flows closer to reality due to the existence of some market distortion which by chance is well modelled by a particular set of rates. This makes it imperative not to use λ on its own in choosing freight rates, and to consider carefully the possibility of such distortionary factors being present. In the absence of a theoretically more rigorous approach, however, this method is indeed used in the selection of freight rates.

12. In such a case, $\lambda^* = 100.(T^{o*}/T^* - 1)$, and $\lambda^* - \lambda = 100.(T^{o*}/T^* - T^o/T)$,

which may or may not be positive. The economic interpretation is that if $\lambda^* - \lambda$ is positive then the new rates (denoted by the asterisk, *) are less good at explaining observed trade flows than the old ones - i.e. the proportion of unexplained costs is higher.

13. An alternative type of reason for changing freight rates is to incorporate some distortionary behaviour as part of the modlling process. For instance, we may wish to model a particular exporter's geographically differentiated export subsidies by subtracting the subsidies from freight rates. To avoid negative rates we can use the result obtained in paragraph 9 and first add a large uniform amount to the rates applying between the exporter and all destinations. In such a scenario, however, we still wish to measure total transport costs using the unaltered rates - the altered rates provide less economic meaning as they are not true freight rates.

14. The change in λ from adding such a constraint is as follows:

$$\lambda^* - \lambda = 100.T^o(1/T^* - 1/T) \tag{8.21}$$

T is still less than or equal to T^*, as T represents the minimum costs possible given the unchanged rates ($C=C^*$).

Adding flow constraints once freight rates have been altered

15. However, if we now add an additional constraint (say a flow constraint as detailed in paragraph 7), then the behavioural limits on λ change. Continue to denote the solution with the changed rates using an asterisk, *, and that with the additional flow constraint using a double asterisk, **. Then the change in λ becomes:

$$\lambda^{**} - \lambda^* = 100.T^o(1/T^{**} - 1/T^*) \tag{8.22}$$

Now, even if all $t_{ij}^{**} \geq t_{ij}^*$, there is no guarantee that $T^{**} \geq T^*$: the relative costs in the minimization change in ways which may either reduce or increase the total transport costs calculated using actual freight rates. Neither solution represents a minimization of costs with respect to the matrix of freight rates used to calculate total transport costs, T^{**} and T^{*}. Thus in this case the imposition of a flow constraint may increase or decrease λ. The economic meaning of an increase in λ associated with the imposition of a flow constraint is that the protection (or other behaviour) modelled by the flow constraint is anti-distortionary - i.e. it counters other trade distortionary effects.

Heterogeneity and seasonality constraints

16. Product heterogeneity may be modelled, as we shall see in chapter 11, by splitting up import demands and export supplies by product and then adding premiums to freight rates. In effect this is equivalent to increasing the number of importers and exporters and thus the number of possible flows as well as changing freight rates. As with the normal case of changing freight rates discussed above, when such heterogeneity constraints are added in the absence of any other freight rate changing constraints, λ cannot increase (the analogy with simple alteration of freight rates is clear when it is realised that merely splitting up import demand and export supply without altering freight rates makes no difference to the minimization solution). However, in the presence of other freight changes λ may increase. Also, once such heterogeneity constraints are in place, the addition of other constraints may increase λ.

17. Seasonality may be modelled by splitting flows up to represent flows in quarters, say, and then setting import and export totals for countries for each quarter. In such a case freight rates are not altered, but so long as quarterly export and import totals sum to annual totals, and in the absence of any other constraints, $\psi' E \geq \psi' E^{*}$. Such seasonality constraints, like flow constraints, cannot reduce total transport costs when compared to a counter-factual in which transport cost are minimized. However, like flow constraints, when compared to a counter-factual transport cost total which does not represent a minimization of those same transport costs (i.e. freight rates have been altered) there is no guarantee that λ will not increase.

Can λ be negative?

18. We have seen in paragraph 6 that, in the absence of the altering of freight rates, $\lambda \geq 0$. However, with the possibility of using different freight rates to calculate λ from those used in the minimization, this result no longer holds. From (8.5), $\lambda = 100.(T^0/T - 1)$. So, as both T^0 and T are positive (we assume non-negativity constraints on flows and that all freight rates are positive), λ will be negative if $T^0 < T$. This is indeed possible. The economic interpretation of a negative λ is that the behaviour modelled by the various constraints has over-compensated for trade distortions, either through mispecification or because additional unmodelled behaviour exists which counters some of the distortion modelled.

OTHER STATISTICS USED

19. In addition to using λ, the matrix of calculated (or expected) flows F_{ij} is visually compared with a matrix of actual observed flows. This gives an impression as to which flows are being modelled well and which badly, and is thus of use when considering additional behavioural constraints to the model.

20. In order to complement this visual comparison, the variation between actual and expected sources of imports is analysed more mechanically. An addition to the main GAMS linear program compiles a matrix with 3 dimensions: year, data set and importer. A value of 2 is allocated to a cell if the location of the relevant importer's main importing source is predicted correctly, and a value of 1 is allocated if the main importing source is predicted as having a positive flow, but not as the main source. All other cells are allocated a value of zero. This matrix we call the **matrix of variation**. The summation of the matrix over all years and over all (or some) data sets gives an indication of which importers' trade flows are most distorted. This summation is called the **country ranking of variation.**

21. Also, a summation of the matrix of variation over all importers (i.e. the sum of matrix values corresponding to a given computer run) gives an

indication of the predictive power of the run. This is called the **total run variation**. Further, total run variations can be summed over all years to yield a relative measure of the (apparent) predictive power of the data set. This is called **data set variation**.

22. Lastly, the marginal (shadow) transport cost prices predicted by the model for predicted zero flows - i.e. the reduction in transport cost necessary to yield a positive predicted flow - can be used in investigating the model's behaviour concerning specific routes. The introduction of a constraint or the use of a different data set may cause one importer to change its flow pattern. However, this has repercussions on other flows. For example, consider a predicted flow which was zero (thus having a marginal cost) but becomes positive with a change in data set. If the marginal cost is greater than the change in transport cost on that route, then we can look elsewhere for the cause of the change in flow patterns. Also, the routes of the 10 smallest non-zero marginal costs in a program run are ranked - with a value of 10 assigned for the smallest, 9 for the next smallest etc. A summation of these ranks over all (or some) program runs yields a matrix which indicates which unused routes are probably most sensitive to changes in the model specifications. This is called a **sensitivity matrix**.

The data

23. Flows were modelled between the five major exporters and nineteen importers (table 8.i). The choice of importers was based on size of import demand over the period 1978/9-1987/8. For the smaller countries chosen (by import size) preference was given in selection to Latin American countries. Only one exporter is also an importer: the EC (referred to as one 'country' as it is one economic actor).

24. Data covering the ten years 1978/79 to 1987/8 have been taken; time and data availability prevented other years from being included. Ten years, and so ten model runs, are considered sufficient for the purposes of the study.

Table 8.i: Exporters and Importers included in model

Exporters	Importers
Argentina	Algeria
Australia	Bangladesh
Canada	Brazil
EC	Chile
USA	China
	Cuba
	Egypt
	EC
	India
	Iran
	Iraq
	Japan
	Korea (S)
	Mexico
	Morocco
	Pakistan
	Peru
	USSR
	Venezuela

25. Trade flow data were obtained from International Wheat Council (IWC) statistics, as were average freight rates for the major routes (see table 8.ii)[1] and some lesser used routes. However, many freight rate figures are largely unobtainable, whether from UN statistics, IWC, OECD, USDA, or from grain trading companies.

26. This lack of freight rate data has been a problem. Several approaches were used to try to overcome it. In all, thirteen sets of transport cost data were used. In order to predict flows the measurement units of transport costs are not paramount, but the relative sizes of transport costs are. Thus firstly, in place of freight rates, a set of shipping distances in nautical miles was used, d_{ij}. The implicit assumption here is that transport costs per nautical mile are uniform. We refer to these transport cost equivalents as data set D1 (m x n of them). In chapter 9 we consider certain extensions to

[1] Both flow data and freight rate data are in imperial long tons for the years 1978/9 to 1984/5, and in metric tonnes from 1985/6.

the basic model which require transport cost data to be in price per unit weight. Therefore data set D2 comprises distance data transformed into current dollars per unit weight. Distances in set D1 were divided by the average distance and the resulting figures were multiplied by an average freight rate. These average freight rates (one for each year) were calculated by averaging the freight rates for the major routes (as shown in table 8.ii). Set D2 transport costs are thus defined as follows:

$$b_{ijy} = d_{ij}.(m.n/r).\Sigma_{i=1}^{n}\Sigma_{j=1}^{m}f_{ijy}/\Sigma_{i=1}^{n}\Sigma_{j=1}^{m}d_{ij} \qquad (8.23)$$

where subscript y denotes year, b_{ijy} are the individual transport costs comprising data set D2, f_{ijy} are the known freight rates (in US$ per ton) for major routes (for non-major routes $f_{ijy} = 0$), and r is the number of major routes.

Table 8.ii: Major freight routes 1979/80-1985/6*

	Exporters				
Importers	Arg	Aus	Can	EC	USA
Algeria					
Bangladesh	X		X	X	X
Brazil					
Chile					
China	X	X	X		X
Cuba					
Egypt	X		X	X	
EC	X	X	X		X
India	X	X	X	X	
Iran					
Iraq					
Japan	X	X		X	
Korea (S)			X		X
Mexico					
Morocco				X	X
Pakistan	X	X	X	X	X
Peru					
USSR	X	X	X		X
Venezuela					

* Data for more routes are available for 1986/7 and 1987/8.

27. Sets D3 to D13 use the actual freight rates for major routes, f_{ijy}, as opposed to their averages, and fill in the gaps by different methods. Where there is more than one rate quoted (for different sized vessels) the cheapest is normally used, as traders are assumed to use the cheapest vessels wherever possible and they are assumed able to achieve this in the majority of cases. Of course, some ports cannot berth and discharge large vessels and some do not have the necessary bulk-handling facilities to unload certain vessel types. As a result, the cheapest vessel type in not the same for all routes. For unavailable freight rates this needs to be remembered when creating proxies.

28. For set D3 the distance data were transformed as follows. For major route rates, distance in nautical miles was divided by the freight rate to give the inverse of dollar cost per nautical mile, k_{ijy}:

$$1/k_{ijy} = d_{ij}/f_{ijy} \quad \text{for major routes} \tag{8.24}$$

These resulting ratios ($1/k_{ijy}$) vary enormously across exporting countries. Therefore, rather than divide the distances of the unfilled cells by the average of these ratios over all routes for each year, a more complicated process was used. For each exporter the average of known $1/k_{ijy}$ values was calculated, and this was then divided by an annual inflator, l_y, calculated from all known rates. Thus calculated freight rates are based on distance and (because major route rates are observed to vary with source) exporter:

$$c_{ij} = (d_{ij}/r_i Y l_y)\Sigma_{j=1}^{m}\Sigma_{y=1}^{Y}(1/k_{ijy}) \quad \text{for non-major routes} \tag{8.25}$$

where c_{ij} are the transport costs in data set D3, r_i is the number of major routes from exporter i, Y is the number of years, and $1/k_{ijy}$ is defined as equal to zero for non-major routes.

29. Data set D4 simulates proxy rates using the results of regressions run to explain major freight rates and rate per unit distance (one model for each of the ten years). Whether freight rate or freight rate per unit distance was

Table 8.iii: Regression results

Year	Dependent variable	Ind.* vars.	Coefficient	Std. Error	t-value	Partial r^2	R^2	DW
1978/9	fr/d	d	-.021	.003	-7.45	.641	.774	1.94
		d^2	1.169	.198	5.90	.529		
		q	-.0067	.0014	-4.84	.431		
		Const.	116.982	9.277	12.61	.837		
1979/80	fr/d	d	-.023	.005	-5.00	.454	.730	1.19
		d^2	1.250	.330	3.79	.323		
		q	-.0047	.0020	-2.34	.155		
		vs	-.591	.247	-2.39	.160		
		Const.	168.78	15.379	10.97	.801		
1980/1	fr/d	d	-.026	.004	-5.96	.397	.723	1.91
		d^2	1.296	.316	4.09	.237		
		q	-.0047	.0016	-2.97	.140		
		vs	-.664	.231	-2.88	.133		
		Const.	199.694	13.571	14.71	.800		
1981/2	fr	d	.0027	.0004	5.97	.543	.708	2.09
		q	.0038	.0014	-2.73	.199		
		q^2	.0004	.0002	2.05	.123		
		vs	-.421	.114	-3.68	.311		
		Const.	30.473	4.679	6.51	.586		
1982/3	fr/d	d	-.012	.004	-3.05	.237	.600	2.10
		d^2	.711	.284	2.50	.173		
		q	-.0023	.0011	-2.12	.131		
		vs	-.690	.209	-3.30	.266		
		Const.	106.261	12.792	8.31	.697		
1983/4	fr	d	.0056	.0018	3.17	.258	.735	1.91
		d^2	-.262	.129	-2.04	.125		
		q	-.0015	.0005	-2.70	.201		
		vs	-.341	.088	-3.86	.339		
		dr	-.113	.053	-2.13	.135		
		Const.	15.030	5.384	2.79	.212		
1984/5	fr	d	.0022	.0003	6.35	.566	.663	1.96
		q	-.0011	.0005	-2.26	.141		
		vs	-.307	.092	-3.33	.264		
		Const.	18.420	3.525	5.23	.468		
1985/6	fr	d	.0024	.0003	9.17	.613	.634	1.28
		vs	-.148	.069	-2.14	.079		
		dr	-.108	.041	-2.64	.116		
		Const.	13.197	2.836	4.65	.290		
1986/7	fr/d	d	-.011	.004	-3.39	.199	.616	1.60
		d^2	.684	.239	2.86	.151		
		q	-.0095	.0034	-2.75	.141		
		q^2	.0023	.0007	3.57	.217		
		vs	-.488	.194	-2.51	.120		
		Const.	88.016	10.071	8.74	.624		
1987/8	fr/d	d	-.018	.003	-5.48	.375	.636	1.98
		d^2	1.054	.231	4.55	.293		
		vs	-.489	.180	-2.72	.129		
		Const.	114.753	9.504	12.07	.745		

* These variables are those in the final model. The initial equation for each year included all the independent variables listed below - plus a GNP variable and two dummy variables distinguishing poorer from richer countries, all three of which were found to be insignificant.

fr	major route freight rate
fr/d	major route freight rate per unit distance
d	distance
d^2	distance squared
q	quantity of wheat trade
q^2	quantity squared
vs	vessel size (expressed in volume of wheat)
dr	discharge rate at receiving port

used as the dependent variable was determined by which model yielded a higher R^2. Available minor route data (see paragraph 16 below) were not included in the set of dependent observations in the regressions as the resulting equations proved less powerful than those simply using the major route data. The results of the regressions are summarized in table 8.iii. Starting from the set of variables listed, variables were excluded one by one from the equation for a given year until all of those left had significant explanatory power.

30. Besides the annual data on major freight rates, more extensive figures for some minor routes from 1979/80 onwards were obtained from the International Wheat Council. These data, however, are not as accurate as the annual data for majorroutes: they are mid-year rates as opposed to annual averages. From 1982/3 the number of minor routes detailed in this data increases, and some rates for other grains are reported which can be used as proxies where needed. There are nevertheless no data for Chile or Cuba, and almost none for Peru (all Latin American countries).

31. Data sets D5, D8 and D11 all include minor route data for wheat where available (for 1978/9 1979/80 rates are used after appropriate deflation). Data sets D6, D9 and D12 also include rates for other grains where no wheat data is available (i.e. from 1982/3). Data sets D7, D10 and D13 further include deflated rates from other years until no more gaps can be filled - i.e gaps remain only where no rate is available anywhere in the data for any year. Remaining gaps in data sets D5 to D13 are then filled in from other sources - in data sets D5, D6 and D7 with rates from D3 (average rates across exporters); in data sets D8, D9 and D10 with rates from D2 (converted distances); and in data sets D11, D12 and D13 with rates from D4 (regression-estimated rates).

32. Where there are data for Iran but not Iraq the Iranian data are used for both, and vice versa. This is justified by the closeness of Iranian and Iraqi ports in the Persian Gulf, and some correlation in rates when both are available. However, with the port of Basra out of action for much of the Iran-Iraq war (1980-88) it is recognized that this may lead to some error. In

order to assess the effect of such data manipulation runs were duplicated without the inter-changing of Iranian and Iraqi rates, and found to be less accurate in predicting observed flows.

33. Finally, assumed transport costs for gaps, and then for both gaps and minor routes, were increased by 10%. This is to take into account higher freight rates charged for less common routes. The result is thus a total of 39 data sets (3x13).

Expected Results

34. It is appropriate to state some expected results prior to running the linear programme for each year and data set. Expected flows are calculated assuming that the total export supply of each exporter is insensitive to the international wheat price and also that importers decide on how much wheat they wish to import irrespective of international price. Importers then choose the sources of import by choosing the cheapest routes, subject to availability of supply. Non-availability of supply is caused by importers with cheaper transport costs outbidding others. Thus total transport costs are minimized. The fact that it is transport costs which determine trade flows implies that f.o.b. prices are approximately equal. The model assumes that wheat is a homogenous good, and that competition is perfect with equal costs except for transport costs. We will call the conditions under which the expected results are obtained in these initial runs competitive equilibrium.

35. However, we do not expect the competitive equilibrium solution to correspond to reality - i.e. we expect positive values of λ. The data will contain errors and some assumptions will be violated. That total export and import quantities for each country are taken as given does not lead to a difference between expected and observed flows, because the totals used to calculate expected flows are those actually observed. However, due to the behaviour of governments and the non-homogeneity of wheat it is recognized that some other assumptions are broken. We shall define distortions from competitive equilibrium caused by these factors as market distortions.

36. Firstly, exporters' f.o.b. prices may not be equal. In the 1970s and early 1980s US prices were quoted as world prices, and variations between exporters' f.o.b. prices can largely be explained by differences in wheat quality. However, protectionist measures also affect prices - although in the case of credit arrangements this may not be expressed in terms of quoted prices. By the latter half of the 1980s a single world price could no longer be said to exist, due to an increase in protectionist measures by exporters. Different f.o.b. prices would lead to importers not necessarily minimizing transport costs in order to minimize expenditure on wheat. Thus we would expect λ to increase with protectionist measures (including food aid) which widen the f.o.b. price range.

37. Secondly, importers may not choose their suppliers to minimize transport costs (or even total costs if f.o.b. prices vary as mentioned above). There may be political or strategic reasons for this. This will increase λ, but it will also raise the number of non-zero flows predicted if importers buy from more sources than they would under competitive equilibrium.

38. Thirdly, wheat is not perfectly homogenous. Durum wheat (high quality wheat used to make pasta) has been excluded from this study because it has an obviously different market, but even so different exporters produce different types of wheat. If we assume that global demand patterns vary, with importing countries having different preferences, but that there is a high degree of substitutability between wheat types, then we would still expect importers approximately to minimize transport costs. As we consider less substitutability, we expect λ to increase. If we consider importers to have a taste for variety then we expect an increase in the number of non-zero flows and some increase in λ.

39. In addition to these theoretical reasons why λ may be non-zero, the results of the model may be inaccurate due to transport costs being inaccurately measured. We would expect the more accurate data sets to yield lower values of λ provided that the bias of data errors is not positively correlated with effects caused by market distortions. Turning to the thirteen

data sets used, D1 and D2 are expected to yield the same results. Also, these two sets are expected to be less accurate than those based on actual freight rates. However, freight rate data are incomplete, which is why several sets of freight rate data has been used. Whichever of these yields the lowest values of λ will be deemed the most accurate, subject to some comparison using the other designed statistics mentioned and observation of the matrices of flows predicted.

Results

40. As an example, table 8.iv shows the expected flows from one run - 1978/9 using data set D13 - together with the observed flows in that year. The values of λ and other statistics obtained from the various data sets are reported in tables 8.v to 8.x.

Table 8.iv: Expected and observed flows (D13, 1978/9)
('000 tons) (expected columns followed by observed)

	Arg		Aus		Can		EC		USA	
Alg	0	0	0	0	0	0	0	134	193	59
Ban	1166	0	0	52	0	365	0	197	0	552
Bra	607	925	0	0	0	1062	0	277	3131	1474
Chl	948	194	0	0	0	0	0	29	0	725
Chn	0	885	0	1382	4589	3181	0	0	3469	2610
Cub	0	0	0	0	0	1000	0	0	1000	0
Egy	0	0	0	1253	4887	154	0	1513	0	1967
EC	0	256	0	0	0	1530	3129	0	375	1718
Ind	0	0	0	40	0	0	0	0	311	271
Irn	0	1	982	0	0	0	0	4	0	977
Irq	0	0	0	481	0	3	0	0	972	488
Jap	0	0	2066	1161	0	1236	0	0	3467	3136
Kor	0	0	1702	0	0	31	0	0	0	1671
Mex	0	112	0	0	1057	21	0	0	0	924
Mor	0	39	0	0	0	20	0	897	1180	224
Pak	0	10	0	245	0	150	0	73	1994	1516
Per	0	299	0	0	0	148	0	0	755	308
Usr	0	0	0	136	0	1617	0	5	4725	2967
Ven	0	0	0	0	0	15	0	0	612	597

41. The first result worth noting - on the assumption that data on freight rates are reasonably accurate - is that market distortion from competitive equilibrium in wheat trade is significant. Trade transport costs are more expensive than what we would expect under perfect competition without market distortions by an average of between 23 and 30%, as shown by the values of λ presented in table 8.v.

Table 8.v: λ values in initial runs

Year	Data Set D2*	D3	D4	D5	D6	D7
1978/9	25.91	33.04	17.72	30.24	30.24	29.13
1979/80	28.18	34.94	26.54	28.71	28.71	25.10
1980/1	29.60	28.70	17.13	16.92	16.92	15.90
1981/2	27.17	27.02	17.89	25.11	25.11	21.28
1982/3	37.72	39.25	34.14	35.44	35.35	29.35
1983/4	29.70	35.37	29.90	34.64	31.75	30.70
1984/5	29.51	37.30	28.17	36.02	35.30	33.80
1985/6	30.98	33.10	29.43	30.50	30.28	29.92
1986/7	29.35	30.87	28.82	31.52	31.52	32.57
1987/8	22.88	11.11	13.83	12.09	12.05	12.01
Average	28.10	31.07	24.36	28.11	27.72	25.98

Year	Data Set D8	D9	D10	D11	D12	D13
1978/9	30.52	30.52	29.25	24.12	24.12	27.57
1979/80	28.92	28.92	25.11	24.15	24.15	23.37
1980/1	17.84	17.84	15.83	16.84	16.84	14.31
1981/2	26.06	26.06	21.05	18.51	18.51	15.61
1982/3	36.68	36.48	29.23	34.28	34.23	25.97
1983/4	36.61	33.97	30.72	32.84	32.19	27.01
1984/5	41.48	40.66	33.60	30.20	30.02	26.03
1985/6	33.20	32.76	30.02	28.65	28.39	27.00
1986/7	30.93	30.93	32.70	29.33	29.33	30.49
1987/8	16.75	16.74	12.02	14.79	14.76	11.25
Average	29.90	29.45	25.95	25.37	25.25	22.86

* data set 1 λ values, as expected, identical to those for data set 2

42. Secondly, values of λ vary considerably from year to year, especially when using freight rates as opposed to distances. This may be a reflection of volatility in the wheat market and the fluctuating nature of distortions over

time (fluctuations perhaps less accurately picked up using distance data). Interestingly, distortion appears to drop in 1980/81 and again in 1987/88. This has to reflect not a drop in total levels of protectionism - which is known not to have occurred - but rather an evening out of protectionist measures across exporters. One consequence should be the recapturing of trade by one (or more) exporter(s) using protectionist measures in retaliation to the earlier protectionist measures of a competitor. This hypothesis will be further analysed in chapter 10.

43. Thirdly, as also shown in table 8.v, values of λ calculated using distance data D2 are curiously less than those using some freight rate data sets. The obvious explanation for this is that freight rate data sets with higher average λ values than D2 (D3,D5,D8 and D9) are less accurate than distance data. This is credible when it is remembered that it is the relative values of rates which are important in determining the predicted flow pattern, and thus a data set which is largely accurate but which contains a few very inaccurate rates may predict flows worse than a data set with smaller but more widespread inaccuracies. Even if freight rates are accurate it may be that distance can better explain the pattern of flows if traders' costs are proportionate to distance, but due to imperfect competition in the shipping market these costs are not evenly transferred to buyers and sellers via freight costs. However, there is a possible alternative explanation. The freight rates in data sets D3, D8 and D9 could yet be more accurate than set D2. This hypothesis is compatible with the lower average values of λ obtained using distance data if two conditions are both fulfilled. The first condition is that market distortions are greatest across short distances (e.g. restitutions are larger than average for countries near Europe - North Africa). The second condition is that short-distance freight rates are greater in proportion to distance than long-distance freight rates. Both these assumptions look reasonable, although further work is needed to determine whether they offer an explanation of differences in results in this particular case. This subject is again returned to in chapter 10.

44. Fourthly, the explanatory power of D13 appears greater than that of other data sets when comparing values of λ. However there are exceptions to

this in 1978/9, 1986/7 and 1987/8 which need to be examined. For 1978/9 it has already been noted that no minor route data were available. In this year data set D4 (regression-estimated rates filling all non-major routes) understandably yields the lowest λ values.

45. In 1987/88 λ is slightly lower using D3 than using D13. By comparing the matrices of expected and observed flows, matrices of marginal costs and data sets of freight rates it can be seen that differences in two freight rates have caused all the differences between the expected flows of D3 and D13. By far the more important of these is the proxy rate from Iran to the EC (the other is the Argentina to Japan rate which has only a limited impact). In D13 the Iran rate, derived by deflating a 1981/2 EC-Iraq (Basra) rate, is very much higher than the rate calculated in D3. The result is a better explanation of Iranian imports using data set 13. Thus the slightly lower λ using data set 3 can be ascribed not to greater accuracy or a differing predicted flow pattern, but rather by slight variations in total expected and actual costs caused by differing rates. It is thus concluded from the analysis that there is no strong case for not using data set D13 as opposed to D3 for 1987/8.

46. In the case of 1986/7, however, not only distance data but also other data sets using regression-estimated proxies (D4,D11,D12) yield lower values of λ than D13. The reasons for this can again be gleaned by close examination of freight rates, and the matrices of marginals and observed and expected flows. The Soviet Union's largest import source in 1978/9, 1979/80 and 1981/82 was the USA (not in 1980/81 due to the US embargo on exports to the USSR). As a result of the US embargo the USSR diversified import sources after this, with an increasing trade with Canada and, particularly after 1982, with the EC. In 1985/6 and 1986/7 US exports to the USSR were very low. This behaviour is not explained on its own by the freight rates - the US and Canadian rates are typically very similar (freight rates as opposed to proxies being available for all main Soviet import routes). However, distance data better explain the actual pattern of Soviet trade in 1986/7 than freight rates, and the trade is large enough for this coincidence to lead to a lower λ value for data set D2 than for any other. Regarding the differences between

the results using D13 and the other regression-estimated data sets, the proxy rate for Australia to Iraq in D4 yields a more accurate prediction of Iraqi imports. The rate used is the Australia to Iran rate - again vindication of the swapping of Iranian and Iraqi rates - whereas D11, D12 and D13 all use Iraqi minor route data. Without this difference the predicted flows of D4, D11 and D12 would be identical. The remaining differences with D13 results are caused by a lower rate for Canada to Brazil in set D13.

Table 8.vi: Total run variation and data set variation*

	Data Set					
Year	D2	D3	D4	D5	D6	D7
1978/9	15	21	25	23	23	16
1979/80	22	17	19	14	14	10
1980/1	23	21	22	16	16	11
1981/2	18	20	16	20	20	12
1982/3	12	14	14	15	15	14
1983/4	10	10	14	14	11	12
1984/5	15	9	12	8	8	8
1985/6	22	14	12	12	12	9
1986/7	19	11	13	11	11	11
1987/8	14	13	13	13	13	14
Data set variation	170	150	160	146	143	117

	Data Set					
Year	D8	D9	D10	D11	D12	D13
1978/9	23	23	16	21	21	19
1979/80	14	14	10	12	12	14
1980/1	16	16	11	16	16	14
1981/2	20	20	12	18	18	13
1982/3	9	11	12	13	13	14
1983/4	11	8	12	10	9	14
1984/5	8	8	8	8	8	8
1985/6	7	7	9	12	12	7
1986/7	7	7	9	11	11	11
1987/8	14	14	14	13	13	16
Data set variation	129	128	113	134	133	130

* The total run variation values are summed across years to give data set variation values.

47. Fifthly, the λ statistics for various years can be compared to the total run variation and data set variation statistics presented in table 8.vi. There is no striking visual correlation - a low λ in table 8.v does not necessarily imply a high total run variation in table 8.vi. From this it may be concluded that misprediction by the (naive) model so far presented of importers' main sources of wheat is not an accurate guage of overall distortion in the wheat market (as measured by λ).

48. However, it may be that these statistics reveal something which λ does not. It can be seen that the data set variation is highest (indicating better prediction of major import sources) using distance data. This observation is consistent with the hypothesis (see paragraph 29) that distortions are correlated with distance, hence the better prediction using distance data. Further, it can be seen that the inclusion of minor rates reduces ability to predict importers' major import sources. This can again be explained if distortion is correlated with distance, as the data sets which do not use minor routes have gaps filled with distance dependent proxies. However, as the λ statistic does not decrease in the same way when minor routes are excluded, the important conclusion can be drawn that distortion is less distance dependent over non-major routes than over major ones - if the converse were true lower λ values would be yielded by data sets not including minor routes than those which do.

49. Sixthly, comparing the λ values presented in table 8.v with those in tables 8.vii and 8.viii it is possible to assess the effect of increasing the rates of non-major routes by 10%. Data set 2 rates have not been increased and so the corresponding λ values are the same. It can be seen that the levels of λ are not consistently higher or lower than in table 8.v. In 1978/9 and 1979/80 λ tends to be lower with the 10% increases and in 1980/1 and 1981/2 higher. In later years the pattern is not as clear. Predicted trade patterns are not significantly affected, nor is the variation in import source matrices.

Table 8.vii: λ values adding 10% to gaps

	Data Set					
Year	D2	D3	D4	D5	D6	D7
1978/9	25.91	36.13	17.37	30.01	30.01	29.13
1979/80	28.18	35.96	25.76	28.34	28.34	25.03
1980/1	29.60	30.69	17.60	17.33	17.33	15.87
1981/2	27.17	28.50	18.14	25.16	25.16	21.23
1982/3	37.72	40.79	34.55	35.50	35.33	29.25
1983/4	29.70	38.25	30.61	34.71	32.20	30.66
1984/5	29.51	40.27	28.72	36.54	35.73	33.69
1985/6	30.98	36.25	30.04	31.03	30.75	29.96
1986/7	29.35	29.94	28.87	32.19	32.19	32.53
1987/8	22.88	12.06	13.29	11.80	11.75	12.08
Average	29.10	32.88	24.49	28.26	28.01	25.94

	Data Set					
Year	D8	D9	D10	D11	D12	D13
1978/9	30.30	30.30	29.52	23.99	23.99	27.92
1979/80	28.58	28.58	25.27	23.56	23.56	23.55
1980/1	18.34	18.34	15.93	17.22	17.22	14.49
1981/2	26.19	26.19	21.15	18.05	18.05	15.68
1982/3	36.72	36.53	29.12	34.25	34.24	25.59
1983/4	36.64	34.61	30.67	33.79	33.12	26.91
1984/5	40.62	39.74	33.47	30.23	29.97	25.25
1985/6	32.42	31.98	30.06	28.62	28.45	27.24
1986/7	30.59	30.59	32.50	29.76	29.76	30.32
1987/88	16.00	15.99	11.96	14.12	14.08	11.32
Average	29.64	29.28	25.97	25.36	25.24	22.83

50. To some extent data sets using regression-estimated rates may already capture the effect of increased costs on non-major routes. This is because volume of trade (and volume of trade squared), vessel size and discharge rate are included in the set of possible explanatory variables. Thus, without strong indications that increasing non-major freight rates models freight rates better, and in light of the observations that trade patterns are not strongly affected and that D13 still yields the lowest λ values, it is concluded that it is not necessary to increase calculated freight rates for non-major routes.

Table 8.viii: λ values adding 10% to gaps and minor routes

Year	D2	D3	D4	D5	D6	D7
	Data Set					
1978/9	25.91	36.13	17.37	27.97	27.97	26.91
1979/80	28.18	35.96	25.76	27.19	27.19	23.90
1980/1	29.60	30.69	17.60	17.54	17.54	16.53
1981/2	27.17	28.50	18.14	26.14	26.14	21.88
1982/3	37.72	40.79	34.55	36.95	36.85	30.16
1983/4	29.70	38.25	30.61	34.90	31.96	30.15
1984/5	29.51	40.27	28.72	35.97	35.13	33.40
1985/6	30.98	36.26	30.04	30.24	30.01	29.11
1986/7	29.35	29.94	28.86	32.19	32.19	34.73
1987/8	22.88	12.06	13.29	11.78	11.74	12.64
Average	29.10	32.88	24.49	28.09	27.67	25.84

Year	D8	D9	D10	D11	D12	D13
	Data Set					
1978/9	28.29	28.29	27.06	22.05	22.05	26.02
1979/80	27.43	27.43	23.91	22.52	22.52	22.22
1980/1	18.53	18.53	16.44	17.41	17.41	14.55
1981/2	27.15	27.15	21.62	18.93	18.93	16.06
1982/3	38.33	38.11	30.03	35.56	35.51	26.48
1983/4	36.60	34.03	30.17	33.67	32.91	26.25
1984/5	41.09	40.15	33.19	29.82	29.56	25.23
1985/6	32.30	31.96	29.21	28.09	27.91	25.41
1986/7	30.59	30.59	33.70	29.76	29.76	31.42
1987/88	15.98	15.97	12.52	14.04	14.00	11.80
Average	29.63	29.22	25.79	25.18	25.06	22.54

51. With regard to the conclusions and analysis presented so far in this section, data sets D2, D4, and D13 are chosen for use in subsequent chapters. Data set D2 is chosen because of its ability to predict importers' major import sources. Data set D4 is chosen for its lower λ values in 1978/9 and 1986/7, data set D13 because of its overall low λ values.

52. Seventhly, from table 8.ix it can be seen which importers' trade appears to be most distorted, and thus most in need of attention in future modelling. The country ranking is here taken from all data sets and from data sets D2 and D13. A guess at why Cuba is top of the list can be made straight away - the US embargo on wheat exports to Cuba. Further use of the information in table 8.ix is made in chapters 10 to 12 in which attempts are made to model distortions.

Table 8.ix: Country ranking of variation

	Data set(s)		
Importer	All	D2	D13
Cuba	1	1=	1=
Chile	4	9=	1=
Mexico	8	9=	1=
EC	2	1=	4
Bangladesh	3	3=	5=
Morocco	5	5=	5=
India	6	3=	5=
Algeria	7	5=	5=
Iraq	12	16	5=
Egypt	10	8	10=
Korea	11	17=	10=
China	9	11	12
Japan	15	19	13
Pakistan	13	5=	14
USSR	17	14=	15
Iran	14	13	16=
Brazil	16	12	16=
Peru	18	14=	18
Venezuela	19	17=	19

53. Eighthly, by looking at the sensitivity matrix presented as table 8.x it can be seen which unused routes are suspected of being most sensitive to change in the model specification. The matrix is the summation from all runs using the 13 data sets. High marginal (shadow) transport costs do not necessarily go hand in hand with accurate import source prediction at this stage of modelling - though when further constraints are added and as the full model is developed we expect this to be the case for more and more importers (as slightly inaccurate transport data has little effect on the results when marginal transport costs are high). Two countries with low values in the sensitivity matrix are Venezuela and Cuba. Referring to the country ranking of variation (and the expected flow matrices - see table 8.iv for an example) it can be seen that Venezuelan import sources are well predicted (the main source being the US). By contrast, Cuba, as already noted, is top of the country ranking. The supposition that this is because of the US embargo is strengthened when we see that values of marginals for routes from other exporters are high, and note that Cuba is predicted as importing from the US (see table 8.iv). In contrast to these two case types

(both with low sensitivity but with one showing good and the other poor prediction), when sensitivity is high the pattern of predicted flows may change more readily with alterations to the model (for example the North African countries and Japan and Korea). This is noted for future reference.

Table 8.x: Sensitivity matrix

			Exporter			
Importer	Arg	Aus	Can	EC	USA	Total
Algeria	42	6	98	86	**330**	562
Bangladesh	8	27	4	64	71	174
Brazil	16	.	**230**	4	9	259
Chile	1	21	127	.	38	187
China	28	37	97	.	108	270
Cuba	.	.	3	.	.	3
EC	31	.	87	21	90	229
Egypt	32	2	162	26	**308**	530
India	42	77	31	33	38	221
Iran	60	62	66	15	69	272
Iraq	66	53	104	66	90	379
Japan	43	137	114	.	**180**	474
Korea	.	**204**	**265**	4	68	541
Mexico	51	.	170	38	157	416
Morocco	153	.	**323**	130	125	731
Pakistan	50	67	128	4	**210**	459
Peru	36	5	**272**	.	92	405
USSR	.	.	141	**259**	52	452
Venezuela	23	.	122	34	32	211
Total	682	698	2544	784	2067	

Dots denote a value of zero
The highest 10 values are emboldened.

54. The ninth conclusion, from the column totals in table 8.x, is that Canadian unused routes have more low marginal transport costs than other exporters (as rankings forming the sensitivity matrix are higher). This may indicate some greater benefit from price cutting (in terms of market capture) for Canada than for other exporters.

CHAPTER 9: PRICES AND NON-LINEAR PROGRAMMING

1. One potential weakness of the transportation model is that it ignores the effects of international commodity prices on import and export levels. For those countries which vary the level of imports or exports according to the world price, quadratic or other non-linear programming is (at first glance) more appropriate than linear programming. The purpose of this chapter is to introduce linear price equations into the model developed so far, which as a result becomes a quadratic programming model, as described in chapter 2, paragraphs 26 and 27 (see also paragraph 41 below). The first section is a preliminary discussion of price responsiveness. Then in the second section it is determined whether importers and exporters are price responsive, and if so, what the relevant price elasticities are. The third section then discusses possible quadratic programming models and alternative 2-stage price models, and presents some results.

Meanings and relevance of price responsiveness

2. It is convenient in the context of this study to distinguish between two types of price responsiveness when analysing the behaviour of importers and exporters. The first, which for convenience can be called route price responsiveness, is the response to price differences between import sources (in the case of an importer) or export destinations (in the case of an exporter). The second is a conventional demand or supply price responsiveness, as measured by annual import demand or export supply elasticities with respect to international price.

3. On a day-to-day basis the price responsiveness of an importer (or exporter) may vary significantly. We shall characterise this behaviour by using the term 'short-run elasticity'. The short-run price elasticity is related to the time period a country can last without trading. This time period is a function principally of storage capacity and the level of stocks. As the level of stocks varies over time so does the elasticity. If we assume

(in the case of an importer) that offers from various exporters to sell wheat are for delivery on different days then expected variation in the short-run elasticity may cause differing quantities of wheat to be ordered depending on delivery date. Thus differences in delivery date are to some extent substitutable for price differentials. For example, one export source may be preferred by an importer over another on the basis of delivery date when prices are equal. Route price non-responsiveness may thus in part reflect variations in such short-run elasticities.

4. Over a few days or a few weeks it can be assumed that no country has insufficient storage capacity and stocks to be significantly route price non-responsive due to such elasticity variations. This does not preclude the possibility that short periods of such non-responsiveness may occur during crises such as famine or war.

Table 9.i: Average monthly exports 1978/9-85/6 ('000 m.t)

Month	Arg	Aus	Can	EC	USA	Total(5)
Jan	1161	1180	852	1172	2953	7318
Feb	1441	1211	851	1214	2989	7706
Mar	1022	1294	991	1239	2990	7536
Apr	512	1069	1305	1194	2861	6941
May	300	1174	1867	1067	2440	6848
Jun	219	987	1899	1156	3096	7357
Jul	205	868	1717	705	3289	6784
Aug	140	788	1732	756	3469	6885
Sep	168	769	1950	1058	4032	7977
Oct	198	929	1721	984	3360	7192
Nov	195	896	1618	1183	2803	6695
Dec	341	863	1222	1167	3100	6693
Mean	492	1003	1477	1075	3115	7161

5. It is pertinent to consider seasonal variations in exporters' output and world price. On a seasonal basis exporters tend to export more in some months than others - see tables 9.i and 9.ii. Argentina's peak export month is February, and that of the other southern hemisphere producer, Australia, is March. Similarly related to harvest time is the September export peak of

the northern producers Canada and the United States. The exception appears to be the EC with peak exports occurring in March (indicating large storage costs as this is before the main harvest).

Table 9.ii: Average monthly exports 1978/9-85/6 (percentage above or below mean month)

Month	Arg	Aus	Can	EC	USA	Total(5)
Jan	+136	+18	-42	+9	-5	+2
Feb	+193	+21	-42	+13	-4	+8
Mar	+108	+29	-33	+15	-4	+5
Apr	+4	+7	-12	+11	-8	-3
May	-39	+17	+26	-1	-22	-4
Jun	-56	-2	+29	+7	-1	+3
Jul	-58	-13	+16	-34	+6	-5
Aug	-71	-21	+17	-30	+11	-4
Sep	-66	-23	+32	-2	+29	+11
Oct	-60	-7	+16	-8	+8	0
Nov	-60	-11	+9	+10	-10	-7
Dec	-31	-14	-17	+9	0	-7
Average % from mean	73	15	24	12	9	5

Table 9.iii: Average monthly international price 1978/9-85/6

Month	IWC Price Index	% from annual mean
Jan	1346	+1.5
Feb	1336	+0.8
Mar	1333	+0.5
Apr	1342	+1.2
May	1323	-0.2
Jun	1304	-1.6
Jul	1294	-2.4
Aug	1288	-2.8
Sep	1311	-1.1
Oct	1329	+0.2
Nov	1355	+2.2
Dec	1346	+1.5

6. In order to determine price responsiveness of the five exporters on a seasonal basis we relate table 9.ii to table 9.iii, which shows average monthly international wheat price as expressed by the International Wheat

Council wheat price index. Argentine exports exhibit by far the most prominent seasonal pattern, with large exports in the first three months of the year. There appears to be some seasonal price responsiveness between May and November in that some exports seem to be held back until prices rise in October and November. Australian exports exhibit a similar pattern. Exports are far more evenly spread over the year, but some output is stored for export in October and November. Canadian exports appear fairly responsive to price between June and September, exports then falling away as price declines after November, picking up again briefly in April before price falls with the first northern hemisphere harvests. The US, being the largest producer and thus having the largest effect on seasonal price variation, displays less evidence of price-responsive behaviour than the other exporters. Only an increase in exports in September and decreases in January and May provide evidence of seasonal price responsiveness. Lastly, the EC is by far the most responsive, with exports being held back until winter months when prices are higher.

7. The degree to which a country's exports vary over a year is an indication of ability to withold exports until market conditions for selling are favourable, and thus possibly also an indication of market power. This is qualified by the observation that the incentive to withold is less for the two southern countries (due to higher prices at their harvest times than those for northern countries). Nevertheless, on this basis exporters can be ranked as follows (with the US spreading exports over the year more than others): USA, EC, Australia, Canada, and (very much further behind) Argentina. Again from table 9.ii it can be seen that total exports do not vary enormously from month to month - indicating that global demand is fairly steady. Whilst importers may have enough leeway to be able to choose between various export sources on the basis of price for delivery in a particular month (i.e. to display short term route price responsiveness), it is uneconomic (due to storage costs) to buy a year's supply of wheat during the month of the year when it is cheapest (it is similarly uneconomic for exporters to time their exports such that seasonal price trends are likewise completely eliminated). The result is route price non-responsiveness on an seasonal basis which might be misinterpreted as economically irrational

behaviour in a simple analysis of price responsiveness using annual data. This will be returned to in chapter 11. In addition to this economically rational justification for route price non-responsiveness, other major causes are government intervention and other market distortions.

8. We turn now to the second type of price responsiveness - in longer-term (annual) demand and supply levels, which for convenience we shall call 'price responsiveness' (as oppossed to route price responsiveness). An importer's demand for wheat may be fairly price elastic over periods of a few weeks but this is less likely over a period of a year (the opposite of conventional textbook supposition). It is quite believable - in particular where there is state buying or other government price intervention - that demand for wheat imports may be insignificantly sensitive to the world price. Similarly, farmers may not vary production and export levels in response to variations in international price if they are fully protected from variations in world price. The question of a possible relation between such non-responsiveness to price and to route price responsivenes is discussed below (paragraph 10 ff).

9. Having identified two distinct classes of price responsiveness, we now consider how they are relevant to the purpose of the current model being developed. In order to measure the importance of various distortions in the international wheat market this study attempts to model the relative impacts of such distortions on the pattern of international wheat trade. It does so by building onto a basic transportation model, with various constraints and model additions representing the effects of the distortions. As many of these distortions are route- or country-specific price alterations (as in the case of export subsidies and tariffs etc.) the explaining of otherwise apparent route price non-responsiveness is implicit to the technique. For example, subtracting a cost from a particular freight rate to represent a price concession extended by an exporter to an importer builds into the model a

route price[1] non-responsiveness on the part of the importer which has previously been observed. In chapters 10, 11 and 12 different causes of such non-responsiveness are modelled.

10. Route price non-responsiveness is important because it affects the pattern of trade. A question of interest is: is there a relationship between either international price or price responsiveness and route price responsiveness. There is no a priori reason for a correlation between the two types of price responsiveness (when a short run elasticity varies, its long run corollary is not, except by coincidence, its average or other simple function). Nevertheless, it is worth briefly considering some possible theoretical linkages.

11. Let us first consider the possibility, assuming static non-zero long-run elasticities, that changes in demand or supply conditions affect route price responsiveness. Suppose world price unexpectedly increases, and is expected to stay at the higher level. An importer with a significantly negative import demand elasticity will demand less wheat. This decrease in demand for wheat may make an importer less route price responsive because the timing of imports is more crucial to make up for shoralls in internal supply during the year. Alternatively, with no change in storage capacity, reduced imports mean longer storage periods are possible after the price increase. This may lead to greater route price responsiveness.

12. Other possibilities include firstly that the price increase itself (which is not dependent on the long run import demand elasticity) may lead to greater or lesser route price responsiveness. As relative price differences between exporters become a smaller proportion of the domestic price this may lead to a decrease in route price responsiveness. Alternatively, the higher price may create a stronger incentive to economize. Secondly, elastic behaviour vis-à-vis effective price is not captured in terms of international

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[1] The price to which the importer is not fully responsive is the international price that would exist, ceteris paribus, without the price concession.

dollar price in the presence of importer tariffs or similar protection. Thirdly, protectionism may increase uncertainty, thus leading to a change in market strategy and route price responsiveness. Lastly, it should be noted that expectations of future price changes (and other variables) may play a role. For instance, if a price rise is not expected to be sustained, importers are likely to delay purchases by running down stocks. If the price rise is anticipated then a building up of stocks beforehand is likely.

13. This variety of possible causal linkages makes it plain that the possible relationship between long-run elasticities and route price responsiveness is both potentially complex and difficult to measure. Apart from data problems, it would not be a simple matter to distinguish between effects caused by different factors. The problem is compounded when the nature of causality is considered. In particular, the appropriateness of using elasticities is often debatable in that it is questionable whether an elasticity can be said to cause anything, not being a direct measure of behaviour[2].

14. It is probably sensible to assume that all importers and exporters are route price responsive. This assumption becomes more reasonable when constraints are introduced in chapters 10 - 12 to model protectionism and other distortions which in some cases give rise to route price non-responsive behaviour and in others alter prices and thus create the appearance of route price non-responsiveness. It is also assumed that price responsiveness and route price responsiveness represent different categories of behaviour and that they are not linked.

Are importers and exporters price responsive?

15. We now consider, for each importer and exporter in turn, whether

[2] Few would disagree that elasticities are important tools in the understanding and modelling of behaviour, but in practice they are often wrongly assumed constant, which may be equivalent to assuming that behavioural relationships exist when they do not.

international price is important in determining annual import and export totals, i.e. the degree to which importers and exporters are price responsive.

16. Firstly, tests were carried out for co-integration[3] between international price and local price. Secondly, by regressing import (export) levels on a number of variables and excluding those which were not significant one by one, simple models of import and export levels were obtained. Annual lags were included at the beginning of this process for all the explanatory variables. If no co-integration was found, and international price was not a significant explanatory variable then it was assumed that the import demand (export supply) elasticity with respect to international price is not significantly different from zero. If local price was found to be significant but international price dropped out during model formation, and international and local price are co-integrated, then international price was re-introduced into the model as a substitute for local price, and the effect on the R^2 and Durbin-Watson statistics noted.

17. Before presenting the results of these tests we briefly consider two problems relating to data restrictions and causality. All the data used were annual. With data series going back to 1960 or 1966 in most cases this meant that at best 29 observations were available (1960-1988). In some cases data series were more limited (for example Bangladesh and what is now Pakistan date from 1972). Also, some data series were simply not available. As the purpose of these tests is to assess the importance of international prices in determining import (export) levels, and not identify whatever variables are important, this limitation is not considered crucial. Nevertheless, if a good explanation of import (export) levels is obtained so much the better.

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[3] Testing for co-integration establishes whether there is a likelihood that a causal relationship exists between variables by examining whether their time trends diverge or not. A time series with constant mean and variance and no long-term autocorrelation is said to be 'integrated of order zero', i.e. it has no trend upwards or downwards. Two variables, A_t and B_t, are 'co-integrated' if a constant, c, exists such that $E_t = A_t - cB_t$ is integrated of order zero, where E_t is the residual error.

18. The need to establish the direction of causality is important. Of interest is whether international price causes import and export behaviour. Only where countries are not price takers - the United States is the only serious contender - are we also interested in the influence of a country's export (or import) level upon the international price. In fact it is the US price which is used to represent the international price[4], itself a result of US market dominance. With annual data, and in some cases a limited number of variables, Granger causality tests are of limited applicability. Of more use is prior knowledge of the market, and in particular an observation of the sign of the international price coefficients. For example, for international price to cause the level of a country's imports it is expected that the estimated international price coefficient be negative (higher prices causing a reduction in imports). If the coefficient is positive, the model is picking up some other relationship. The coefficient of local price may also be important in establishing probable causality, as will be shown.

19. Finally, what these econometric techniques can show with some reliability is that no supply/demand responsiveness exists. Considering the data constraints already mentioned, any conclusion of responsiveness is less certain, as the importance of variables representing the true causes of import (export) levels may remain untested. It is a possibility that such variables also affect international price which as a result may be shown to have insignificant explanatory power if such variables were to be introduced to the regression.

CO-INTEGRATION AND REGRESSION RESULTS

20. The results of the co-integration tests between international (US) and local price are presented in table 9.iv. The explanatory variables which, using regression analysis, best model imports and exports from the specified data are presented in tables 9.v and 9.vi.

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[4] For the period for which figures are available the US wheat price was commonly quoted and agreed to be the world price, although since 1985 and the rise of US protectionism this has become less clearly the case.

Table 9.iv: Local and international price co-integration results

Importer	Price Co-I	Exporter	Price Co-I
Algeria	X	Argentina	.
Bangladesh		Australia	
Brazil	.	Canada	
Chile	X	EC	.
China	X	USA	N/A
Cuba			
Egypt			
EC	.		
India			
Iran	X		
Iraq	.		
Japan	X		
Korea	.		
Mexico			
Morocco			
Pakistan	X		
Peru	X		
USSR	.		
Venezuela	X		

A dot . denotes no test possible. An X indicates that local and international price are co-integrated C(1).

21. In both tables 9.v and 9.vi the second column shows the set of possible explanatory variables. For importers IMF data on balance of payments (of possible importance for poorer countries), GNP and population were included. GNP per capita was calculated by dividing the GNP series by the population series. It was ensured that at most two of these three inter-dependent variables were included in the final model. Wheat variables (from USDA) include US price (used as the international price), local price and output. Also lagged changes in stock levels were included, although not current levels as these were thought more likely to be caused by the current level of imports or exports than vice versa. For the same reason data on wheat consumption (probably derived from other variables), although used for modelling exports, was not included in the modelling ofimports. Many of the variables required conversion from local currencies into US dollars (performed using IMF reported exchange rates). In countries with hyper-

Table 9.v: Importers: regression results

Importer	Initial[a] variables	Final[b] vars.	Coefficient	Std. Error	t-value	Partial r^2	R^2	DW
Algeria	I,B,G,N,	I	10.38	1.47	7.02	.744	.978	1.91
	O,P,S,Y	G1	162.04	19.06	8.50	.809		
		O	-.28	.12	-2.27	.232		
		Y1	-2761.41	441.21	-6.26	.694		
		Const.	730.34	224.08	3.26	.385		
Bangladesh	I,B,G,N,	IB	24.39	4.89	4.99	.713	.801	2.10
	O,P,S,Y	IB1	-17.49	3.73	-4.69	.687		
		N1	126.82	29.60	4.28	.647		
		O1	-1.98	.43	-4.63	.682		
		Const.	-8770.38	2683.46	-3.27	.516		
Brazil	I,B,G,N,	M1	.79	.13	5.92	.745	.878	1.99
	O,S,Y	O	-.73	.12	-6.17	.760		
		O1	.67	.16	4.27	.603		
		S1	-2.02	.47	-4.29	.605		
		Const.	1053.22	637.98	1.65	.185		
Chile	I,B,G,N,	I	2.32	1.12	2.06	.199	.889	2.36
	O,P,S,Y	O	-.90	.10	-8.93	.824		
		Const.	1412.76	203.25	6.95	.740		
China	I,B,N,O,	I1	-31.51	14.46	-2.18	.240	.898	1.80
	P,S	M1	.46	.17	2.62	.315		
		O	-.25	.07	-3.58	.461		
		O1	.30	.06	4.72	.598		
		P	52.25	15.36	3.40	.435		
		S1	-.23	.09	-2.54	.300		
		Const.	-1572.43	1285.89	-1.22	.091		
Cuba	I,O,S	IA1	3.66	1.27	2.87	.303	.605	1.48
		O1	.08	.02	3.34	.378		
		Const.	596.96	101.08	5.87	.644		
Egypt	I,B,G,N,	M1	.76	.10	7.75	.760	.951	1.96
	O,P,S,Y	P	9.76	3.89	2.52	.249		
		Const.	-26.71	276.59	-.10	.008		
EC	I,O	I1	-15.76	6.36	-2.48	.244	.544	1.74
		O1	.09	.02	4.76	.544		
		Const.	8552.78	959.04	8.92	.807		
India	I,B,G,N,	I1	56.78	8.35	6.80	.743	.854	1.96
	O,P,S,Y	G1	230.90	36.98	6.24	.710		
		S1	-.40	.09	-4.54	.563		
		Y	-85072.19	14855.44	-5.73	.672		
		Y1	-139012.46	27448.52	-5.06	.616		
		Const.	10361.69	1230.48	8.43	.816		
Iran	I,B,G,N,	B1	.09	.01	5.75	.661	.948	1.87
	O,P,S,Y	G	20.08	1.39	14.48	.925		
		O	.74	.12	-6.26	.697		
		Const.	3152.29	478.27	6.59	.719		
Iraq	I,N,O	N	316.58	22.58	14.02	.883	.888	2.07
		O	-.48	.17	-2.74	.224		
		Const.	-1998.54	324.95	-6.15	.593		
Japan	I,G,N,O,	I1	3.67	1.73	2.12	.200	.856	1.86
	P,S,Y	O	-1.33	.22	-6.11	.675		
		P1	1.15	.21	5.55	.631		
		Const.	5139.74	195.69	26.26	.975		
Korea	I,N,O,S	I	-9.14	3.19	-2.87	.302	.760	1.43
		N1	229.74	30.29	7.58	.752		
		Const.	-5244.69	954.89	-5.49	.614		

Table 9.v (continued): Importers: regression results

Importer	Initial[a] variables	Final[b] vars.	Coefficient	Std. Error	t-value	Partial r^2	R^2	DW
Mexico	I,G,N,O,	M1	.68	.20	3.47	.481	.901	1.99
	P,S,Y	O	-.59	.09	-6.35	.756		
		O1	.61	.10	5.78	.720		
		P1	-6.65	2.85	-2.33	.295		
		S1	-1.16	.22	-5.25	.679		
		Y	418.28	162.00	2.58	.339		
		Const.	317.71	148.75	2.13	.260		
Morocco	I,B,G,N,	B	.31	.11	2.89	.330	.873	1.99
	O,P,S,Y	G	83.00	16.26	5.10	.605		
		M1	.48	.14	3.54	.424		
		O	-.58	.10	-5.84	.668		
		Const.	1069.43	186.85	5.72	.658		
Pakistan	I,B,G,N,	G1	123.39	28.95	4.26	.623	.752	1.86
	O,P,S,Y	O	-.53	.14	-3.88	.578		
		P1	-16.72	6.28	-2.66	.391		
		S1	-.56	.17	-3.38	.509		
		Const.	5662.68	1053.62	5.37	.724		
Peru	I,G,N,O,	N	54.76	6.85	7.99	.780	.862	2.08
	P,S,Y	O	2.27	.82	2.76	.298		
		O1	-1.83	.91	-2.01	.184		
		Const.	-127.63	188.85	-.68	.025		
USSR	I,O,S	M1	.87	.10	9.02	.780	.800	2.23
		O	-.29	.06	-4.66	.486		
		O1	.29	.06	4.70	.490		
		S1	-.30	.10	-2.96	.276		
		Const.	2238.45	5246.81	.43	.008		
Venezuela	I,B,G,N,	I	-1.87	.50	-3.75	.440	.887	1.94
	S,Y	N	32.04	13.83	2.32	.230		
		P1	.57	.22	2.62	.276		
		Const.	417.80	120.09	3.48	.402		

key to variables

B	Balance of payments (MUS$)
C	Consumption of wheat ('000 tons)
G	GNP (GDP where not available) (MUS$)
I	International price (US$/ton)
IA	International price adjusted for fluctuations in dollar exchange rate
IB	International price adjusted as above and deflated
M	Imports ('000 tons)
N	Population (millions)
O	Output of wheat ('000 tons)
P	Domestic Price (US$/ton)
S	Change in wheat stocks ('000 tons)
Y	GNP per capita (or GDP per capita) (US$)

notes

a The dependent variable is M. One period lags are included in addition to the variables listed.

b This list comprises the explanatory variables in the model, in addition to a constant, once all insignificant variables have been eliminated. To make certain international price is not significant I and I1 may be re-introduced at several points in the elimination process. IA, IA1, IB, and IB1 may also be introduced in some cases.

Table 9.vi: Exporters: regression results

Exporter	Initial[a] variables	Final[b] vars.	Coefficient	Std. Error	t-value	Partial r^2	R^2	DW
Argentina	I,C,O,S	O	.74	.07	10.04	.801	.876	2.13
		O1	.17	.07	2.36	.182		
		Const.	-3459.35	597.94	-5.78	.572		
Australia	I,C,O,P, S	C	-1.04	.48	-2.16	.169	.887	2.07
		O	.52	.06	8.49	.758		
		O1	.49	.08	6.13	.620		
		S1	-.36	.13	-2.83	.258		
		Const.	57.27	1309.23	.04	.000		
Canada	I,C,O,P, S	O	.60	.10	6.17	.585	.585	1.76
		Const.	3023.62	1904.41	1.59	.085		
EC	I,C,O	C	-.44	.19	-2.29	.226	.966	1.54
		O	.48	.07	6.58	.706		
		O1	.34	.06	5.60	.636		
		Const.	-6118.99	5768.08	-1.06	.059		
USA	I(=P),C, O,S	I	112.50	48.14	2.34	.214	.660	1.39
		O	.35	.15	2.38	.221		
		Const.	617.86	5702.86	.11	.001		

key and notes as for table 9.v
Imports (M) replaced by Exports (X) as dependent variable.

hyper-inflation this created data inaccuracy for some variables (in particular for Argentinian and Brazilian domestic wheat price series).

22. The third column (again in both 9.v and 9.vi) shows those explanatory variables retained in the regression model once all insignificant variables (as measured by the t-statistic) were excluded. To ensure that international price was not significant it may have been re-introduced several times (and excluded several times). Models are free from auto-correlation where possible. In order to compensate for fluctuations in the dollar exchange rate another price series was created (IA). The only country for which this variable was more significant than the unadjusted variable I was Cuba (which has very limited trade with the US and which presumably uses other hard currencies more). The variable IB is IA deflated to 1985 prices. This was more significant than I only in explaining Bangladeshi imports. Using I the final model variables for Bangladesh are I, I1, N, and N1. The R^2 statistic is slightly higher than that recorded for Bangladesh in table 9.iv at .823, but the Durbin-Watson statistic is 2.89 (as opposed to 2.10), clearly suggesting model mis-specification.

23. In those cases where local and international prices were found to be co-integrated, and local price was found to be a significant explanatory variable (Japan and Pakistan), the effect of substituting international price for local price was noted. International price was found to be significant for Japan, but local price needed to be kept in the model. In the case of Pakistan international price was found not to be significant in any circumstance. Although the DW statistic improved slightly from 1.86 to 1.90, R^2 went down from .752 to .662 and the t-value for I1 (the substitute variable) indicated insignificant explanatory power at -1.50.

24. For those countries with high explanatory power (R^2 close to 1), no obvious model specification inadequacies (a DW close to 2) and no international price in the list of explanatory variables it can be tentatively concluded that the import demand (export supply) elasticity with respect to price is insignificant from zero. These countries are the 8 importers Brazil, Egypt, Iran, Iraq, Mexico, Morocco, Peru, and the USSR; and the exporters Argentina and Australia. Other countries for which international price is not a significant explanatory variable are the exporters Canada (which has a low R^2) and the EC (low DW) and the importer Pakistan (discussed in the paragraph above). In all three cases international price is found insignificant when re-introduced to the final model, again suggesting that the elasticities are zero, although this result is less certain than for the 10 countries already discussed.

25. The remaining 10 importers and one exporter need further analysis. Table 9.vii demonstrates that the estimated international price coefficient is positive for some of the importers. In these cases, as already noted, the relationship being looked for (price causing import behaviour) is not being observed. It is possible that global import levels are causing changes in the international price, or that the measured relationship between international price and imports is spurious. In either eventuality there is no evidence of non-zero import elasticity. Of the remaining five importers price co-integration was observed for two (China and Venezuela). This is evidence to support the thesis that international price variations are transmitted via local price to domestic producers and consumers. For two others

co-integration tests were not possible due to the lack of reliable price data (EC and Korea).

Table 9.vii: Signs of international price coefficients in regressions to explain imports

Importer	I^*	$I1^*$
Algeria	+	
Bangladesh	+	-
Chile	+	
China		-
Cuba		+
EC		-
India		+
Japan		+
Korea	-	
Venezuela	-	

* IB and IB1 for Bangladesh, IA1 for Cuba

26. This leaves Bangladesh, where no co-integration was found. The situation in Bangladesh is possibly explained by high dependence on food aid, donors giving more in gluts irrespective of fluctuations in domestic price (and domestic demand always being higher than available supplies). Such an explanation is consistent with the observed feature that IB is better at explaining imports than I. This may be because it is the purchasing power of the wheat throughout developed countries which is of interest to exporters - when this increases the incentive to provide food aid decreases (the undeflated dollar value is observed to be more important for other developing countries, possibly the result of limited foreign exchange supplies). This possibility is further strengthened by the fact that Bangladeshi data series go back only as far as 1973. The increased importance of food aid in the 1980s is thus more significant than for countries with data going back further.

27. The exporter for whom international price appears to be a significant determinant of export levels is the United States. Of course, it must be

remembered that the international price used is the US export price. The sign of the estimated coefficient is positive, i.e. consistent with the direction of causality being from price to export level.

28. Before a quadratic programming model is presented in the next section it is necessary to consider the determinants not only of import and export levels, but also of international (US) price. A regression analysis identified three significant explanatory variables: lagged US price, lagged summed output of all five exporters, and current trade (summed exports of the five main exporters). The current trade coefficient is positive suggesting that price is not a function of exports, rather that the level of global import demand determines international price.

29. To conclude this section, table 9.viii shows the non-zero coefficients which may indicate the magnitude of import demand and export supply changes caused by changes in international price. Associated t-values are also shown. There is some doubt about the coefficients which have been starred - for Bangladesh for the reasons noted in paragraph 26, for the EC and Korea because of poor model specification (see table 9.v).

Table 9.viii: Coefficients showing price responsiveness
('000 tons/US$)

Country	Importer(M) Exporter(X)	Coefficient	t-value
Bangladesh	M	-17.49*	-4.69
China	M	-31.51	-2.18
EC	M	-15.76*	-2.48
Korea	M	-9.14*	-2.87
Venezueala	M	-1.87	-3.75
USA	X	112.51	2.34

The quadratic programming model

30. Further to the discussion in chapter 2, the structure of a simple quadratic programming model can be summarised by the objective function (9.1)

and the two constraints (9.2) and (9.3) below. The parameters in the objective function are defined by equations (9.4) to (9.8).

$$\text{Maximize } \pi = \Sigma_{j=1}^{m}(b_jM_j+c_jM_j^2) - \Sigma_{i=1}^{n}(b_iX_i+c_iX_i^2) - \Sigma_{i=1}^{n}\Sigma_{j=1}^{m}t_{ij}F_{ij} \tag{9.1}$$

subject to

$$\Sigma_{i=1}^{n}F_{ij} = M_j, \qquad j = 1,m \tag{9.2}$$

and

$$\Sigma_{j=1}^{m}F_{ij} = X_i, \qquad i = 1,n \tag{9.3}$$

where

$$p_{ji} = p_{ij} + t_{ij} \tag{9.4}$$

$$p_j = \Sigma_{i=1}^{n}F_{ij}p_{ji}/\Sigma_{i=1}^{n}F_{ij} \tag{9.5}$$

$$p_i = \Sigma_{j=1}^{m}F_{ij}p_{ij}/\Sigma_{j=1}^{m}F_{ij} \tag{9.6}$$

$$p_j = b_j + c_jM_j \tag{9.7}$$

$$p_i = b_i + c_iX_i \tag{9.8}$$

and where b_j, c_j, b_i and c_i are parameters, and

M_j = imports into country j (j=1,m)
X_i = exports from country i (i=1,n)
t_{ij} = transport cost from i to j
F_{ij} = trade flow from i to j
p_{ji} = entry port price paid by j for imports from i
p_{ij} = price received by i for exports to j
p_j = average entry port price paid by j
p_i = average price received by i

31. Equation (9.4) introduces transport costs as the difference between the

price paid by an importer and that received by an exporter. As an exporter may sell at different prices to different importers (and importers buy at different prices from different exporters), equations (9.5) and (9.6) are necessary to obtain average prices paid by importers and received by exporters. Thus this model does not require a single world price. The levels of imports and exports are then related to average prices in equations (9.7) and (9.8).

32. In the previous section possible causal relationships between US price and import and export levels were identified. These relationships are summarized in equations (9.9) and (9.10).

$$M_j = d_j + e_j p^W + f_j p^W_{-1} \tag{9.9}$$

$$X_i = d_i + e_i p^W \tag{9.10}$$

where $p^W = p_i$, i=USA; and $p^W_{-1} = p^W$ lagged

In the case of Bangladesh f_j is not constant over time. This is because the coefficient for IB1 is constant rather than that for I1.

33. As many c_i and c_j values are zero many average prices, p_i and p_j, are fixed with respect to the model's optimization. The value of these prices can conveniently be set to zero (i.e. by setting b_i and b_j values equal to zero and excluding equations (9.4), (9.5) and (9.6) for the relevant countries). This is quite acceptable as these prices are not of importance in determining import and export behaviour; for the countries in question maximizing % yields the same result as minimizing transport costs. Those imports and exports which are not modelled as having non-zero c_i or c_j values need to be entered into the model at observed values, as was done in the linear model presented in chapter 8.

34. A problem with the model presented so far is that it is not in general

possible to incorporate equations of type (9.9) and (9.10). However, this can be overcome for equation (9.9) if the level of imports can be related to p_j as opposed to US price p^W. And for the single example of equation (9.10) - US export behaviour - we can transform the relationships to yield the parameters in equation (9.8) as follows:

$$b_i = -d_i/e_i \quad \text{and} \quad c_i = 1/e_i, \quad \text{for } i=\text{USA}. \tag{9.11}$$

35. Further, as the observed behaviour of price-sensitive importers is responsive to changes in international (US) price, equation (9.7) can be adjusted[5]:

$$p_i = b_j + c_j M_j, \; i=\text{USA} \tag{9.7a}$$

and so, for those importers which are price responsive:

$$b_j = -(d_j+f_j p^W_{-1})/e_j \quad \text{and} \quad c_j = 1/e_j, \tag{9.12}$$

which, with $f_j = 0$ simplifies to:

$$b_j = -d_j/e_j \quad \text{and} \quad c_j = 1/e_j. \tag{9.13}$$

Incidentally, if exporters apart from the US were seen to be responsive to US price, equation (9.8) could be similarly altered:

$$p_i = b_i + c_i X_i, \; i=\text{USA} \tag{9.8a}$$

36. The model so far developed includes international price as an endogenous variable, determined simultaneously by the US export supply

[5] From Samuelson's original (1952) formulation of the non-linear spatial equilibrium problem (see chapter 2, paragraph 26) it can be seen that this is appropriate. For countries whose imports are chiefly a function of international rather than domestic price, excess demands and so Samuelson's "social pay-offs" are also functions of international price.

equation (9.8) and a number of import demand equations (9.7a) yet to be identified. The unknowns are: (a) as many trade totals as import demand equations and (b) international price (see paragraph 44 below). The accuracy of modelled US prices and thus the model itself might be improved by the addition of an equation determining US price from total trade:

$$p = B + C\Sigma_{j=1}^{m} M_j \tag{9.14}$$

37. As in chapter 8, the models so far developed are non-dynamic in the sense that optimization results in one period do not affect optimization in the next period. This can be changed, either by maintaining a series of separate optimizations, one for each year, but with dependent variables in one period becoming independent variables in the next; or by maximizing one multi-year objective function. Using the second approach it would be implicit that events in the future affect current events. Even considering just a two-year model, this is a hard assumption to swallow in an agricultural product where output in the current year let alone future years is so unpredictable. If such a model were chosen, the formulation of a reasonable objective function would pose serious problems (but see chapter 11 for a seasonal model).

38. In the first type of dynamic model, taking variables estimated in the model for one year and inserting them as exogenous variables in the next year's equations is second-best to using actually observed values of such variables. This is not to deny that such an approach may be of use in predictive models or in policy simulation. The import levels of those countries that have been found partly determined by US price in the previous year (Bangladesh, China, EC) are thus taken as exogenous in the current period, as if no price relationship existed.

39. Before constructing a non-linear model it is useful to consider whether non-linear programming as opposed to linear programming is necessary for solution of the mathematical programme, whether a feasible solution is likely and the accuracy of any results.

40. One merit of quadratic as opposed to linear programming is that a model which does not treat total national export and import figures as exogenous has potentially more predictive power than one (such as the transportation model) which does. This is not to suggest that by simple incorporation of a few price elasticities such trade quantities are easily predicted. Other variables are at least as relevant as prices, and may (like climatic variables) be difficult or impossible to specify to the degree necessary to generate usable predictions of wheat production and trade. Partly on account of these difficulties it is not within the scope of this study to come up with an endogenous model of production. In any event, non-linear programming may not be necessary in order to include prices in the model being developed, as we shall now see.

41. Non-linear mathematical programming (as opposed to linear) is necessary if trade flows are determined in part by a price or a set of prices and those same prices are partly determined by the flow pattern of trade. If the trade flows are not determined by prices (all importers and exporters are non-responsive to price) then we have a transportation problem. Alternatively, if the price or prices which determine trade flow levels are not determined by the spatial flow pattern then we can solve the problem in two stages. First prices and each country's total imports or exports are calculated (simultaneously if prices are determined by supply and demand). Then a transportation model can again be used in a second stage. Such a 2-stage approach is reminiscent of the Armington methodology (see chapter 2, paragraph 39 and chapter 6 paragraph 13).

42. One case where price may not be determined in any significant way by the pattern of flow arises when there is only one international f.o.b. price for wheat at all export ports. Alternatively different exporters may have different f.o.b. prices but ones which are related by fixed differentials to a single lead price. This is indeed close to observed reality, with price differentials depending on characteristics such as wheat quality and credit conditions. Also, the regression analyses in the second section of this chapter highlighted the unimportance of both local prices and (for most countries) international prices in determining supply and demand. All in all,

it seems reasonable to assume that most local prices are unimportant in determining international price, and that international price is, whilst dependent on total imports, independent of the trade flow pattern.

43. The rationale for using quadratic programming is thus unclear. Whether we use a quadratic programme or a 2-stage programme should make no difference to the result and the choice of which to use can be made on the basis of convenience. In any event we need to know how to calculate countries' import demands and export supplies. For non-price-responsive countries we can use observed totals; for the others we can solve a set of simultaneous equations to give the necessary totals.

44. Together with world price the three price responsive trade totals, viz. the import totals for Korea and Venezuela and the export total for the United States, yield four unknowns. However, as total imports must equal total exports, one trade total can be expressed in terms of the other two, yielding only three unknowns. It is important to consider which three price equations to include - more than three would overdetermine the model. Thus two import level equations (9.7a) - one for each of the two importers - and an export level equation (9.8) for the USA would be sufficient for a solution. If we want to include an equation modelling international price as a function of total imports (9.14) one of the other equations has to be dropped.

45. As regards the issue of the expected accuracy of the models being developed, it can firstly be noted that inaccuracy is to be expected on account of the small number of endogenous variables and the lack of a convincing determination of international price. In addition to this problem it can be seen from table 9.ix that the estimations (from USDA data) of import and export levels differ considerably from observed USDA figures. The error is even greater between the estimated levels and the IWC data used in the linear programme. This includes flows only between the five exporters and 19 importers in the model and does not include durum wheat. Nevertheless, some IWC figures are higher than USDA ones, highlighting the difficulty of obtaining reliable data.

Table 9.ix: Comparison of observed and estimated variables

Year	Korean Imports Est	Korean Imports USDA	Korean Imports IWC	Venezuelan Imports Est	Venezuelan Imports USDA	Venezuelan Imports IWC
1978/9	2123	1652	1702	800	800	747
1979/80	1978	1810	1797	754	860	736
1980/1	2033	2095	2072	770	800	797
1981/2	2269	1868	1906	862	830	818
1982/3	2490	1880	1803	945	826	786
1983/4	2611	2351	2463	986	925	970
1984/5	2786	3111	3043	1009	1088	1100
1985/6	3029	3032	3027	1012	1045	933
1986/7	3315	3895	4006	1130	1230	1128
1987/8	3356	4459	4537	1219	1200	1155

Year	US Exports Est	US Exports USDA	US Exports IWC	US Price Est	US Price USDA
1978/9	29719	32500	23284	102	109
1979/80	36488	37422	23365	120	139
1980/1	39729	41204	34103	144	147
1981/2	42323	48199	35994	154	136
1982/3	41120	41068	29426	129	127
1983/4	52587	38890	26960	121	129
1984/5	39281	38758	27509	127	125
1985/6	36323	24902	15080	91	113
1986/7	30461	27324	15948	104	89
1987/8	31174	43327	33785	103	94

Est   Regression estimates using observed USDA data for dependent variables
USDA   US Department of Agriculture data series
IWC   International Wheat Council data (excludes residual world trade and durum)

46. The largest such discrepancy in table 9.ix is for US exports. Accordingly, equation (9.8) is excluded from the model. The first model is thus described by equations (9.1), (9.2), and (9.3) with most import and export levels set exogenously and corresponding b_j, c_j, b_i, and c_i parameter values set to zero. For Korea and Venezuela (9.7a) and (9.13) hold. US price is defined by equation (9.14).

47. The expected US exports to Korea and Venezuela and expected US prices from running this model are shown in table 9.x, together with the observed levels of the two flows. The model is of insufficient accuracy to be very

Table 9.x: Regression estimated price model: expected price-responsive flows and world price
('000 tons and US$ respectively)

	US-Korea		US-Venezuela		
Year	Exp	Obs	Exp	Obs	Price
1978/9	2504	1671	869	732	64
1979/80	2515	1791	866	732	80
1980/1	2346	2055	837	797	111
1981/2	2084	1881	906	818	112
1982/3	2787	1750	1006	786	89
1983/4	2566	1986	1041	936	82
1984/5	2192	2070	817	777	83
1985/6	2390	1788	885	634	47
1986/7	1463	1860	941	845	59
1987/8	1292	2085	691	401	60

Exp Expected
Obs Observed (including durum)

useful. Other results from this model run have therefore not been presented (US exports in particular are predicted very badly and λ values, especially for D2, are high). If equation (9.8) is included in the model and equation (9.14) excluded, the model fails - Korean imports from the US being predicted as negative. The analysis can be resurrected by running the full quadratic model and relaxing some of the constraints, for instance by including slack variables. Equations can be introduced to define strict relationships between slack variables such that the excess supply or demand in the model is spread evenly or according to a set of defined proportions. It would seem appropriate to allocate such proportions on the basis of estimated import or export elasticities, which have previously been assumed equal to zero!

CHAPTER 10: PROTECTIONISM AND GOVERNMENT POLICIES

1. Having decided to continue using a linear rather than a quadratic programme as more appropriate to the international wheat market, we embark in this chapter on extensions which model protectionist policies. The objective is an assessment of the importance of protectionism in causing distortions. Chapters 11 and 12 similarly consider heterogeneity and aspects of strategic behaviour respectively. Following the partial analysis in these three chapters a fuller model is then developed in chapter 13, designed to shed light on the relative importance of the various types of distortion.

2. The first section of this chapter outlines possible methods of modelling protectionism including the use of price elasticities within a linear programming framework. The second section discusses the choice of constraints and appropriate methodology. The results of the models run are set out in the final section, together with some tentative conclusions ahead of the main conclusions presented in chapter 13.

Methods of modelling protectionism

3. The term protectionism here encompasses all types of conscious government action designed to affect international trade and prices in wheat, by both exporters and importers. As mentioned in chapter 4, these actions can be classified into three types: domestic price support, export policy and measures to affect market structure. The main features of exporters' protectionism have been discussed in chapters 4 and 5, together with some detail of importers' behaviour. This section considers ways of building such features into a linear programming model. We concentrate here on domestic price support and export policy, leaving to Chapter 12 the issue of imperfect competition and market structure.

A ROLE FOR PRICE ELASTICITIES IN LINEAR PROGRAMMING

4. By abandoning the idea of endogenizing international price, the

mathematical programme reverts to a transportation problem. However, this does not mean that the import demand and export supply elasticities with respect to price are no longer of use. When trying to build in constraints to model reality there seems little advantage in using derived import and export levels when the actual levels have been observed; but this is not necessarily the case if counter-factuals are being modelled.

5. The competitive equilibrium solution generated by the basic model of chapter 8 can be considered as a (comparative static) counter-factual to the observed trade flow pattern. As protectionism significantly alters the import demands and export supplies of some countries, it is appropriate to change the counter-factual in order to capture the effect of shifting import and export quantities on trade patterns. Econometric or other techniques can be used to determine the changes in import and export levels resulting from, say, a reduction in protectionism. The linear programme can then be run using the new trade totals without the constraints modelling protectionism, and compared with runs in which the protectionist constraints are included but not the new import and export totals. The λ statistic can be adjusted through multiplication by the ratio of original to altered trade.

6. An alternative may be required to the regression-estimated coefficients of chapter 9 as most countries have been shown largely non-responsive to international price, and the specification of only a few countries as price-responsive has led to implausible results. This perhaps indicates that any inclusion of price into a spatial wheat trade model is unnecessary, and a transportation model (fixing trade in the first stage equal to observed levels) is sufficient.

7. However, if distortions such as protectionism were removed, volumes of wheat imports and exports could turn out radically different from that previously observed. Assuming fixed trade volumes or using econometric estimations of behaviour calculated from time series under different structural conditions may thus be inappropriate. In particular, more elasticities can be assumed non-zero. Whether methodologies other than econometrics offer better estimations of elasticities remains an unanswered

Table 10.i: SWOPSIM import and export elasticities

Importers		Exporters	
Algeria	-0.11	Argentina	0.60
Bangladesh	-0.35	Australia	0.90
Brazil	-0.46	Canada	0.50
Chile	-0.30	EC	0.50
China	-0.10	USA	0.60
Cuba	-0.40		
Egypt	-0.20		
EC	-0.27		
India	-0.30		
Iran	-0.11		
Iraq	-0.11		
Japan	-0.40		
Korea	-0.40		
Mexico	-0.30		
Morocco	-0.11		
Pakistan	-0.35		
Peru	-0.30		
USSR	-0.25		
Venezuela	-0.25		

Source: Sullivan, J. et al., "A Database for Trade Liberalization Studies", USDA, ERS, 1989.

question. If we reject econometrically estimated elasticities, an appropriate alternative is elasticities designed for policy simulations in other mathematical programming models. For this reason it has been decided to use USDA elasticity estimates calculated for use in their Static World Policy Simulation (SWOPSIM) modelling framework (see table 10.i).

8. An example of an application of these elasticities in a two-stage model is as follows. Consider what the pattern of trade would be without producer and consumer protection (expressed in terms of producer and consumer subsidy equivalents). Take first the removal of an exporter's producer subsidy equivalent, PSE. The change in price faced by the producer is equal to the change in international price minus the PSE. The (arc) export supply elasticity is defined as:

$$\epsilon = \frac{\Delta X}{\Delta P} \cdot \frac{P}{X}$$

and the new level of exports (for exporter i) is given by:

$$X_i = XO_i + \epsilon_i.XO_i.(P-PO-PSE_i)/PO \qquad (10.1)$$

where XO_i is the observed level of trade, PO the observed world price, and PSE_i the level of producer subsidy equivalent abolished.

Similarly, the level of imports after abolition of a consumer subsidy equivalent (CSE_j) is given by:

$$M_j = MO_j + \epsilon_j.MO_j.(P-PO+CSE_j)/PO \qquad (10.2)$$

Of course, it is also necessary that:

$$\Sigma_{i=1}^{n}X_i = \Sigma_{j=1}^{m}M_j \qquad (10.3)$$

9. Thus a set of n export equations (10.1), m import equations (10.2) and equation (10.3) comprise the first stage of the model[1]. The second stage is a linear optimization as described in chapter 8. The results of this particular model using PSE and CSE figures are presented in the results section at the end of the chapter.

IMPORTERS' PURCHASING POLICY

10. If we assume that the distortionary actions of importing governments are independent of each other, then one modelling approach is to look at importing countries one at a time and include mathematical constraints where this is justified by the existence of some known government policy which affects the proportions of imports from the five exporters. The country ranking of variation (as defined in chapter 8) can be used to indicate which importers are in need of such attention.

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[1] These simultaneous equations can be solved conveniently in a linear programme framework such as GAMS by introducing a positive slack variable and an objective function which minimizes it, in effect setting it to zero.

11. The first example is that of a country with a wheat import policy determined largely by considerations other than transport costs, for example political factors or the desire to diversify sources for strategic reasons. Such behaviour could be incorporated into the model in three ways. Firstly, if the behaviour of the importer is considered to be completely non-responsive to transport costs, the import flows can be treated as exogenous and given. This can be done either by excluding the country from the linear program, or by constraining the expected flows to those observed. If only a proportion of the country's trade is considered non-responsive in this way then only that proportion of imports need be so restricted. For example, a country's imports of food aid may be not dependent on transport costs, while other imports are. The country's transport costs should be included in both the total expected and observed costs so as to yield a λ value which can be compared to that produced without the constraint.

12. Secondly, if the method of determination of import source is partially dependent on transport costs, then it is appropriate to model import sources using price rather than quantity constraints. It may be possible to capture such behaviour by altering transport costs - if this is not possible it may be difficult to determine what the program's objective function should be. It is worth remembering that an implicit assumption of the transportation problem when decision-making is decentralised is that the cheapest routes will be used most because traders are willing and able to cut the wheat price below that of their competitors by the amount they save on lower transport costs. Because of this assumed behaviour it is not the levels of one country's transport costs which by themselves determine a country's flows, and so it is not necessarily adequate to model behaviour by simply altering the country's freight rates. It is important also to note that flow pattern in such an environment may depend on whether the aforementioned trader is an exporter, an importer or a grain trading firm.

13. For the moment, we describe one case where altering rates may be acceptable. If it can be assumed that an importer is responsive to differences between transport costs but is willing to pay a premium for imports from a particular source, then a reduction in the corresponding

freight rate by the amount of the premium is justified. Such behaviour need not, however, lead to a positive flow along the route in question. This is guaranteed only if an appropriate quantity restriction is also imposed.

14. Thirdly, risk aversity/strategic motivations causing diversity of supply may be incorporated. This may be done by using some aggregate estimated measure of risk aversity to represent the desire to diversify supply (see chapter 11, paragraph 17).

CONSUMER SUBSIDIES

15. The effect of consumer subsidies in importing countries may be to increase demand. Such a policy may thus affect the total level of imports. It is desirable, as discussed above, to set an adjusted level of imports (that which would occur without consumer subsidies) in the competitive equilibrium counter-factual. The import demand elasticity with respect to domestic consumer price multiplied by the negative of the consumer subsidy equivalent (CSE) yields the proportionate change in import level. The CSE, an ex post concept, is defined as the total value of policy transfers to consumers divided by total consumer expenditure on the commodity. The negative consumer subsidies of exporting countries (those policies yielding positive changes in consumer price) may similarly be incorporated if changes in consumer price cause changes in the level of exports. However, there are no significant consumer subsidies (positive or negative) in Argentina or Australia, and for none of the five exporters except the US was domestic price found to be a significant determinant of exports (see chapter 9). In the US producer price was found to be important, and is linked to the consumer price. However, it may be assumed that the relatively small CSEs in the US up to 1986 (see table 10.ii) did not have sufficient impact on consumer demand to affect export levels significantly.

PRODUCER SUBSIDIES AND PRODUCER SUBSIDY EQUIVALENTS

16. Together with export subsidies, import levies, tariffs, quotas,

voluntary export agreements and the like, producer subsidies give the producer a price advantage over foreign competitors, both in the domestic market and in external markets. The value of this price advantage is equal to the per unit subsidy. It is thus convenient to calculate Producer Subsidy Equivalents (PSEs), measures similar to CSEs. A PSE, again an ex post notion, is defined as the total value of policy transfers to producers divided by the total producer income from the commodity. As with CSEs, the level of PSE multiplied by the producer's export supply elasticity yields the proportionate increase in exports.

Table 10.ii: Exporters' CSEs and PSEs (US$/ton)*

	CSEs					
Exporter	1982	1983	1984	1985	1986	1987
Argentina	0	0	0	0	0	0
Australia	0	0	0	0	0	0
Canada	-14	-16	-9	-17	-41	-35
EC	-44	-13	-4	-47	-107	-105
USA	0	0	0	-4	-10	-25

	PSEs					
Exporter	1982	1983	1984	1985	1986	1987
Argentina	-38	-40	-47	-16	-4	4
Australia	14	4	4	4	12	5
Canada	28	35	47	51	63	67
EC	48	16	5	50	109	104
USA	22	69	44	59	101	100

* Source: ERS Statistical Bulletin 803, USDA

17. Our main interest in PSEs and CSEs is their use in determining national and world prices and thence countries' total import and export levels. Outside the mathematical programming framework these totals can be calculated as indicated above, using PSEs to calculate changes in export levels and CSEs to calculate changes in import levels. The figures may have to be adjusted so that estimated global imports equal estimated global exports. There is also bound to be some doubt about the resulting figures, as any set of estimated elasticities used to create the totals is suspect: in an environment without

protectionism elasticities may simply be different from those observed in reality. The large range of estimated values (see for example Gardiner et al (1989)) also suggests unreliable measurement of such elasticities.

18. One observation related to the measurement problem which sheds light on why elasticities may be different in a scenario of zero protectionism relates to the identification of Ricardian comparative advantage. It is difficult to estimate how much an exporter's protectionism enables exports which would not occur in a world without any protectionism, and how much it merely counters the protection of others. An exporter who uses protective measures to compete against others' protection may yet have a comparative advantage in wheat production. Conversely, to the extent an exporter uses protection solely to be able to export its wheat due to lack of price competitiveness it does not enjoy comparative advantage. Of course, a sufficient indication of comparative advantage is the ability to export in a protectionist international environment without using protection. This is true of Argentina and also Australia (see table 10.ii). There is a possibility of the emergence of a different set of exporters in a world without protectionism. In such a world, as the behaviour of one exporter depends to a large extent on that of others, actual export supply elasticities of all the exporters are likely to be drastically different.

19. If the protectionist measures are not geographically differentiated by export destination, i.e. the addition to transport costs is applied equally to all destinations, the linear programme results will be unchanged. Only a change in the absolute differences between an exporter's routes (when the total export volume is fixed) will cause changes in the pattern of trade. Thus once PSEs and CSEs have been used in the calculation of counter-factual import and export totals we are interested only in those protectionist measures which are geographically differentiated. Since product price as opposed to transport cost is now of no importance in solving the linear model, an implicit assumption is that route price responsiveness (see chapter 9) is not functionally related to product price. The rest of this section deals with various forms of geographically differentiated protectionist measures and relevant government policies chiefly orchestrated by the

exporting countries.

TARGETED EXPORT SUBSIDIES

20. The feature noted in the above paragraph - that as a country's total trade is fixed, only the absolute difference between transport costs for various routes determines flows - creates a major advantage for the transportation model over the non-linear programming model. Starting from the counter-factual with the altered volumes as outlined above, targeted export subsidies can be subtracted from transport costs to yield an estimation of flows with export subsidies. Take the example of a world with only two importers and more than one exporter. If an exporter's export subsidy to country A is $100/ton and to country B $110/ton, all that is necessary to model the change in flows with the subsidies is for $10 to be subtracted from the transport cost between the exporter and B. If negative transport costs are to be avoided for a feasible solution this can be done by adding a suitable number to every cell of the transport cost matrix.

21. A possible explanation for the existence of EC exports is that transport costs are more than compensated by EC restitutions, so that it is more profitable for producers or traders to export than sell within the EC. Because of lack of internal demand for EC wheat the CAP ensures that this is the case, the alternatives being expensive storage or destruction, or a reduction in support prices. The subtraction of EC restitutions is expected to decrease EC-EC flows, which were predicted as large in the basic model (the EC-EC transport cost being zero).

CREDIT

22. One geographically differentiated protectionist policy which is difficult to model is credit. This is the result of difficulties in accurately measuring trade-offs between price and credit and trade-offs between different credit terms. This is not to deny that such trade-offs exist. The widely acknowledged fact that Argentina has to offer lower prices

than her competitors for similar wheat is evidence to the contrary. Measurement is made difficult by the constant changes of these trade-offs over time and their particular geographic differentiation. It may be possible to compare sales from different exporters to the same markets in order to estimate these trade-offs, although wheat heterogeneity complicates this approach as it is necessary to distinguish between price premiums attached to particular wheat characteristics and particular credit terms. Alternatively, government budgetary allocations to subsidise credit terms may be a crude measure of the level of equivalent price advantage. However, financial market conditions are by no means uniform across exporters, and Argentina faces the added burden of foreign exchange constraints, so such an approach is again difficult. A third way of modelling credit is to constrain credit sales at observed levels. This approach is partly justified by the assumption that the terms of credit offered are so flexible to the particular requirements of each sale that there is little constancy in the abovementioned trade-offs. In other words, empirical estimation of trade-offs would have minimal predictive power.

EMBARGOES

23. A mathematical constraint to model a known embargo is fairly straightforward providing, as in the case of the US embargo of Cuba, that it is effective. The Carter Administration embargo of US wheat sales to the USSR was ineffective, as has already been mentioned in chapter 4. Incorporation of such a one-off event into the model can be done satisfactorily only by setting the observed 1980/81 US-USSR flow as given. The effect of such an embargo may nevertheless be estimated by comparing the actual flow with that predicted by a model without the constraint.

LONG-TERM GRAIN SALE AGREEMENTS

24. A further area of government policy which is geographically differentiated is that of long-term grain sale agreements. These can be included by use of minimum flow constraints along the specified routes. It is

expected, however, that some of these constraints will leave the solution unaltered. Freight rates are expected to be taken into account when agreements are signed. This includes future expected freight rates. To the extent that freight rates do not change significantly from one year to the next this implies that the sales would have gone ahead anyway. In particular in the case of centrally-planned economies a long term agreement may simply be the political expression of a normal commercial relationship. However, in some cases imperfectly competitive market share strategies and more overtly political motivations may be at work. In such cases the constraints are more likely to be binding.

FOOD AID

25. Food aid is an important component of international wheat trade. Motives for provision of food aid are typically political or humanitarian in nature, and as such difficult to model. Food aid and other non-commercial trade can simply be subtracted from the observed and modelled data. However, food aid may also be more readily given in periods when the purchasing power of wheat is low, as was suggested in chapter 9 concerning food aid to Bangladesh. In any event it is a politically beneficial way of disposing of surpluses. It may also be used as a protectionist measure, in particular to develop markets.

The choice of model constraints

26. Data availability is a major factor in determining the choice of constraints and methodology. The International Wheat Council supplies data on non-commercial trade from 1983/4, defined as gifts and long term credit sales under Titles I and III of US Public Law 480. Secondly, data on credit is incomplete, as already mentioned. Figures are available for the years 1980/1 to 1986/7, again from the IWC. Thirdly, PSE and CSE data has been computed by the USDA (see table 10.ii) and although not geographically differentiated by export destination, details of the relative importance of component parts are

supplied. Some PSE components are geographically differentiated, and further details are needed of these. Such details were available for EC restitutions and the US Export Enhancement Programme (EEP). Lastly, SWOPSIM price elasticities are available, as listed in table 10.i.

27. The choice of constraints may be aided by referring to the country ranking of variation from the results of chapter 8, table 8.ix, or preferably by referring to the country ranking after other measures have been modelled. The latter is chosen, and so first a model is run which incorporates non-commercial flows, credit, long-term agreements, EEP sales and EC restitutions.

28. There is a significant problem concerning the potential overlap of credit, EEP and other measures. Also, available figures for these items do not differentiate between durum and other wheats (remembering that durum has so far been excluded from this analysis). In order to overcome these difficulties durum trade is added to the observed flows, and thus also to the import and export totals, but trade is constrained to be at least as large as the durum flows. Also added to the model are quantity constraints representing credit, long-term agreements and EEP sales, but these are not added together, e.g. if a credit sale is known of on a particular route in a particular year but a larger minimum flow is specified in a long-term agreement, then the credit constraint will automatically be non-binding. However, non-commercial trade (food aid) is added to the matrices of credit, long-term agreements and EEP sales (though not to durum sales as some food aid is in durum). Thus the model is specified to under-estimate the joint effects of such measures rather than over-estimate them.

29. Further, all constraints are binding only up to the level of observed flow levels. If, for instance, an observed flow is not as large as that specified as a minimum requirement in a long-term agreement, then the model constrains flow only to the level actually observed.

30. EEP sales are modelled using quantity trade constraints partly due to

a lack of data on the price advantage offered to exporters. EC restitutions, on the other hand, are modelled by subtracting (adding) the dollar differences in restitutions to transport costs. For example, in 1983/4 restitutions for exports to Egypt were higher than that generally available. This difference was subtracted from the EC-Egypt freight rate. Durum flows are constrained to those observed.

31. The number of years modelled is reduced to 5: from 1983/4 to 1987/8. No data is available for 1987/8 credit sales, and thus there are no constraints.

32. In order to facilitate comparison with the results reported in chapter 8, λ has been adapted to exclude distortion in durum trade (by subtracting durum transport costs from total expected and total observed transport costs).

33. The first model whose results are reported in the next section (we call this model 10.1) has the following five constraints as detailed above: non-commercial flows, credit, long-term agreements, EEP sales and EC restitutions. Other behaviour reflecting national policies, such as the US embargo on trade with Cuba, is not included at this stage. To glean an initial idea of the relative importance of the various protectionist measures in creating distortion, models 10.2 to 10.6 are identical to 10.1 except that each omits one of the the five sets of constraints included in model 10.1 respectively. Models 10.7 to 10.10 add some further constraints, to be discussed in the next section. Model 10.11 uses PSEs and CSEs and the 2-stage model developed earlier in the chapter to assess the trade levels, and world price without the protectionism represented by the PSEs and CSEs.

Results

34. The λ values from model 10.1 are presented in table 10.iii below.

Table 10.iii: Model 10.1 λ values

Year	D2	D4	D13
1983/4	7.35	8.56	7.92
1984/5	6.29	9.24	9.59
1985/6	11.57	9.72	9.28
1986/7	10.83	11.06	9.87
1987/8	6.99	3.86	2.44
Average	8.61	8.49	7.82

These must be compared with those in table 8.v. The 5-year averages without the constraints (calculated from table 8.v) are 28.20, 26.17, and 24.54 for D2, D4 and D13 respectively. Thus the introduction of the constraints has decreased market distortion (as measured by λ) by 69%, 68% or 68% respectively for the three data sets.

35. One finding in table 8.v repeated in table 10.iii is the drop in λ in 1987/8. In chapter 8 it was suggested that this might be due to a smoothing of protectionist measures rather than a reduction in the overall or average level of protectionism. Now that many protectionist measures have been included in the model we might expect such a drop to lessen. For D2 and D4 this is arguably the case, but not for D13. This suggests that factors causing the lower λ values in 1987/8 are not captured by the model (be they protectionist measures or some other type of distortion).

36. Another observation is that D2 yields lower λ values than the other two data sets in 1983/4 and (to a more significant extent) 1984/5. By comparing the matrices of expected flows it can be seen that for both years the distance data, D2, yields better predictions of the import patterns of the EC, Cuba, Japan, Korea, and the USSR. Moreover, whereas in 1983/4 the number of importers better predicted by D12 than D2 is equal to the number better predicted by D2 (6 each), this is not the case in 1984/5 where distance data clearly yields more accurate predictions.

37. In chapter 8 it was suggested that D2 might be better at predicting flows if both freight rates and protectionism are greater for shorter routes

than for longer ones. Thus in model 10.1, as most protectionism has been modelled, we would expect D2 to be relatively less able to predict flows than D13. The fact that this is not the case (see also table 10.iv) indicates that there is an additional explanation for this phenomenon. Also significant is

Table 10.iv: Model 10.1 total run variation and data set variation

	Total run variation		
Year	D2	D4	D13
1983/4	32	29	27
1984/5	28	25	23
1985/6	34	25	26
1986/7	34	31	31
1987/8	27	24	27
Data set variation	155	134	134

the fact that 1984/5 freight rates (the year when D2 performs best relative to D13) do not appear to be dependant on distance squared (see table 8.iii). However, it is noted that most above-normal EC restitutions in the study period are for exports to North Africa, and that freight rates from the EC to North Africa are more expensive per unit distance than most. This issue will be further examined in chapter 13.

38. It is also observed that in 1984/5 D4 yielded a lower λ than D13. By looking at expected and marginal flow and freight matrices it can be ascertained that the difference in predicted flow pattern is caused by the differences in the Australia to Iran rate (which is lower in D4) and the Canada to Iran rate (which is slightly higher). As a result D4 better models Iranian imports. A similar effect was noted in chapter 8, paragraph 32, for 1986/7.

39. In 1987/8 using D13 a λ value of only 2.44 was obtained (even without any data on credit flows!). On 13 non-zero routes the quantities predicted were exactly as observed; and 51 routes were predicted non-zero (out of 69 observed) as compared with 23 in the chapter 8 model. Using D4 the same

discrepancy as in chapter 8 is observed - the EC to Iran rate is a better predictor in data set D13. D2 predictions in this year are better only for the EC and Iran.

40. In 1986/7 the flow patterns predicted by D4 and D13 are identical. This gives an indication of the limitation of comparing λ values using different data sets - the difference in λ here is 0.96. One possible implication of this is that we should not perhaps attach too much importance to the lower λ values obtained using D2 in 1983/4 and 1984/5. However, as can be seen from table 10.iv, D2 does seem better able to predict the larger flows (as previously noted in chapter 8).

41. Table 10.v presents the 5-year average λ values obtained in models 10.2 to 10.6, which each omit one set of constraints: respectively non-commercial flows, credit, long-term agreements, EEP sales and EC restitutions. The averages for model 10.1 are also included for comparison.

Table 10.v: Models 10.1 to 10.6 - average λ values

Model	D2	D4	D13
10.1	8.61	8.49	7.82
10.2	12.03	10.35	9.60
10.3	13.30	12.62	11.12
10.4	10.28	9.45	9.40
10.5	8.53	8.10	7.85
10.6	9.29	8.97	7.99

42. From this table we can make an initial assessment of the relative importance of the different sets of constraints, and thus the relative importance of the protectionist measures (leaving final analysis to the fuller model of chapter 13). The further λ is from that observed for model 10.1 the greater the importance of the respective constraints. As the removal of a set of constraints builds distortions back into the model this gives an indication of the importance of the distortions. Thus credit is of most importance, followed by non-commercial flows (food aid), long-term

agreements, the Export Enhancement Programme and EC export restitutions. For example, the re-introduction of credit distortion into model 10.1 increases λ by 42% using D13 (54% and 49% using D2 and D4 respectively).

43. A very significant result is that λ values in model 10.5 - excluding EEP constraints - are lower than those yielded by model 10.1. This implies that the EEP redresses some of the distortions in the world wheat market. It provides some credence to the US claim that the EEP is a measure necessitated by EC protectionism. The same is true of credit flows in 1987/8 (model 10.3).

44. The fact that λ has, in effect, risen with the inclusion of flow constraints in the presence of altered freight rates is an example of the phenomena described in chapter 8, paragraph 15. By way of confirmation, measures of T and T^0 were calculated for 1987/8 using the altered freight rates, i.e. the ones incorporating EC restitutions which were used for the minimization. Using λ values using this method of calculating T and T^0 has less economic meaning than using unaltered freight rates, but we now expect the change in λ associated with the inclusion of a flow constraint to be less than or equal to zero - i.e. the λ values for model 10.1 should now be equal to or lower than those for 10.3 and 10.5. This was in fact found to be the case, as table 10.vi confirms.

Table 10.vi: Models 10.1, 10.3 and 10.5: λ values for 1987/8 calculated using altered and unaltered freight rates

	altered λ			unaltered λ		
	10.1	10.3	10.5	10.1	10.3	10.5
D2	1.60	1.66	2.06	6.99	6.87	6.57
D4	1.41	1.47	1.71	3.86	3.78	1.39
D13	1.30	1.37	1.75	2.44	2.43	1.93

45. Returning to model 10.1, the country ranking of variation is presented below in table 10.vii. The importers at the top of the list have their main import source less well predicted than those further down (see chapter 8, paragraph 20).

Table 10.vii: Model 10.1 - country ranking

Importer	Data set(s) All	D2	D13
EC	1	5=	1
Cuba	3	5=	2=
Japan	5	17=	2=
Mexico	2	1	4
Chile	4	2=	5=
Venezuela	8=	5=	5=
USSR	6=	4	7=
Korea	6=	10=	7=
Egypt	8=	5=	7=
Peru	8=	5=	7=
China	11	10=	11=
Iran	12=	10=	11=
Pakistan	12=	10=	11=
Bangladesh	15=	10=	14=
Iraq	15=	10=	14=
Brazil	18	17=	14=
Algeria	14	2=	17=
India	17	10=	17=
Morocco	19	17=	17=

46. The basic model presented in chapter 8 predicts that the EC imports mostly from itself - not surprising in view of the zero transport cost assumption. The observed behaviour of both importing and exporting wheat, as already mentioned, is partly due to wheat heterogeneity; but EC exports are only possible because of restitutions, which can be modelled by their addition to transport costs from the EC. The analysis of wheat heterogeneity has been left until chapter 11, and the EC-to-EC freight rate has been left unaltered in model 10.1. Nevertheless, none of the 90 model runs in models 10.1-10.6 predicts a positive EC-EC flow. This is an important result, as it suggests that there may be some economic justification, even without consideration of wheat heterogeneity, for the EC simultaneously importing and exporting wheat, rather than trading only its excess supply or demand.

47. The reason why the EC is ranked first in table 10.vii is thus not because the model wrongly predicts EC-to-EC flows, but rather because it consistently over-predicts Argentine imports into the EC using D4 and D13 (although not D2). It is suspected that the reason why the EC does not import

more from Argentina is because of wheat heterogeneity and a preference amongst EC consumers for North American wheat. Further analysis of EC imports is left to the next chapter.

48. Cuba is next on the country ranking (using D13). The US embargo on Cuba has previously been posited as a major reason for distortion of Cuba's import pattern. However, model 10.1 does not predict any US-Cuba flows, indicating that the embargo is not binding. Canadian exports are under-predicted, although as for EC imports not using D2. No clear explanation for this emerges yet.

49. To model Japanese imports better we can impose a constraint to set Japanese imports equal to those observed. This is done in model 10.7. It is justified by the known policy of Japanese purchasing in fairly constant proportions from Australia, Canada and the US and at higher prices than those paid by most importers. It is clear that Japan is route price non-responsive. Long-term agreements with Australia and Canada are already included in the model, but not all model runs correctly predict US exports to Japan. Model 10.7 λ values are presented below in table 10.viii. Using D13 there is an 8% reduction in λ from that yielded by model 10.1, indicating that significant distortion is caused by Japanese purchasing policy.

Table 10.viii: Model 10.7 λ values

Year	D2	D4	D13
1983/4	7.30	8.52	7.85
1984/5	6.25	8.25	8.21
1985/6	11.51	8.17	7.74
1986/7	10.81	10.94	9.76
1987/8	6.93	3.78	2.37
Average	8.56	7.93	7.19

50. In the case of Mexico more imports from Australia are observed than predicted, and for Chile more imports from Argentina are predicted than observed. The main reason for Venezuelan inaccuracies is that whereas

Venezuela normally imports mostly from the USA, in 1987/8 she imported slightly more from Canada. This was not picked up by the model, which predicted imports coming just from the US.

51. The USSR is the largest wheat importer. In 1983/4 and 1984/5 the US was wrongly predicted as the main import source instead of Canada; and in 1985/6 Canada was predicted as the main import source, but it turned out to be the EC. With a centrally-planned economy and politics playing a key role Soviet imports are inevitably difficult to model. A measure of the importance of the distortion caused by Soviet purchasing is given by again constraining import flows to those observed. Model 10.8 does this (also including all the constraints in model 10.7). Using D13 λ is reduced by 58% (from that in model 10.7), indicating that over half the world market distortion not yet modelled is manifested in distortions to Soviet imports.

Table 10.ix: Model 10.8 λ values

Year	D2	D4	D13
1983/4	2.89	2.34	2.45
1984/5	3.55	2.67	3.04
1985/6	5.56	4.78	4.36
1986/7	5.96	4.61	3.66
1987/8	6.62	1.32	1.86
Average	4.19	3.14	3.07

52. Korean purchasing policy is heavily controlled by import quotas, and it may be that Korea is route price non-responsive due to political factors affecting import policy (as in Japan). Model 10.9 constrains Korean imports to those observed in addition to the constraints in model 10.7. A further 5% reduction in λ is observed using D13 (see table 10.x below). This constraint is taken out again in subsequent modelling, however, as it is not certain that Korea is indeed wholly route price non-responsive.

Table 10.x: Model 10.9 λ values

Year	D2	D4	D13
1983/4	7.28	8.26	7.77
1984/5	5.81	7.19	6.86
1985/6	11.40	7.94	7.26
1986/7	10.77	10.89	9.71
1987/8	6.92	3.72	2.37
Average	8.43	7.60	6.79

53. Egypt's imports in 1985/6 and 1986/7 are perfectly predicted. However, in the remaining three years imports from the USA are higher than expected and those from the EC lower. The final observation prompted by the country ranking is that Peru is observed to import more than predicted from Argentina. On investigation (after the current modelling) it appears that there is a history of Argentine lines of credit extended to Peru for wheat imports. To accommodate this distortion model 10.10 adds to model 10.7 a constraint setting Argentinian exports to Peru at observed levels. The results are presented in table 10.xi. The reduction in λ (using D13) is 0.6%.

Table 10.xi: Model 10.10 λ values

Year	D2	D4	D13
1983/4	7.28	8.48	7.84
1984/5	6.12	7.93	8.00
1985/6	11.46	8.24	7.83
1986/7	10.81	10.94	9.76
1987/8	6.93	3.78	2.37
Average	8.52	7.86	7.14

54. Earlier in the chapter SWOPSIM elasticities were included in a framework which can be used for simulating the effect of the reduction of protectionism in a comparative static framework. Model 10.11 uses this framework together with the PSE and CSE values set out in table 10.ii to yield expected flows and associated statistics in a situation where the protectionism encapsulated by the PSEs and CSEs is removed. Predicted US price can be compared with that actually observed in table 10.xii. It can be

concluded that the fall in wheat prices in the 1980s amounting to 27% of the 1983/4 price by 1987/8 (not accounting for inflation) is to a large extent due to protectionism.

Table 10.xii: Model 10.11 - observed and predicted US price ($/ton)

Year	Observed	Predicted
1983/4	129	154
1984/5	125	141
1985/6	113	138
1986/7	89	137
1987/8	94	156

Table 10.xiii: Model 10.11 changes in export volumes (%)

Year	Arg	Aus	Can	EC	USA	Total
1983/4	+30.5	+14.6	-3.6	+3.6	-20.2	-2.33
1984/5	+30.3	+8.7	-12.4	+4.3	-13.5	-2.68
1985/6	+22.1	+17.0	-4.5	-10.8	-17.7	-1.77
1986/7	+31.6	+36.1	-8.5	-34.6	-36.0	-8.46
1987/8	+36.5	+54.6	-2.7	-27.7	-24.2	-5.45

55. The changes in exporters' export levels expressed as a percentage of the observed levels is reported in table 10.xiii. It can be seen that Argentina and Australia suffered reduced exports as a result of protectionism. The US has been the main beneficiary of protectionism. Interestingly, the EC would have gained with trade liberalization in the first two years, but would have been a major loser in the last three.

56. Table 10.xiv shows λ values from the model, where λ is a measure of the distortion of observed flows when compared to our counter-factual with protectionism and all other distortions removed. λ is adjusted for the changes in volume in total trade by multiplying total expected cost by the ratio of observed to expected trade volume. Chapter 8 averages are presented at the end of the table for comparison (durum trade is not included in calculating λ for either model).

Table 10.xiv: Model 10.11 adjusted λ values

Year	D2	D4	D13
1983/4	30.68	26.33	22.26
1984/5	30.30	25.49	21.72
1985/6	32.04	28.29	26.22
1986/7	25.05	19.89	22.07
1987/8	22.97	8.20	6.26
Average	28.21	21.64	19.71
(Ch. 8	28.20	26.17	24.54)

CHAPTER 11: PRODUCT HETEROGENEITY AND SEASONALITY

1. As mentioned in chapter 6, one of the theoretical reasons why the predictions of a mathematical model may diverge from the patterns of observed flows is that the assumption of product homogeneity is unrealistic. The first intention in this chapter is thus to investigate how product heterogeneity may be incorporated within our mathematical modelling framework. Once such a model has been presented, and further to the discussion of seasonality in chapter 9, the second intention of the chapter is to incorporate seasonality into the modelling framework using quarterly supply and demand constraints. Although seasonality may be considered a characteristic associated with products it is here analysed separately.

Data on wheat heterogeneity

2. Available data on the characteristics of wheat produced and of the characteristics preferred by importers come from a 1985 questionnaire survey carried out by the International Wheat Council (IWC, 1985). Eighteen characteristics, in addition to wheat name and grade, specify the wheats produced, and seventeen those preferred. There are many gaps in the data, particularly on the side of characteristics preferred by importers. However, in that these gaps are caused by importers not expressing preferences when given the opportunity to do so, they may indicate that certain characteristics are less important to some importers than others. The five characteristics for which sufficient data is available for general analytical use are: hardness, test weight, moisture content, protein content and the percentage of total foreign materials. These are referred to from now on as characteristics 1 to 5 respectively.

3. Some data on price premiums for different types of wheat is available, again from the IWC. These premiums represent stated as opposed to actual selling prices, and are not differentiated by import destination. Nevertheless they may be of use in calibrating the model.

4. In chapter 6 characteristics were classified into intrinsic and geographical characteristics, the five listed in paragraph 2 above being intrinsic. It was mentioned that a problem existed in measuring geographical characteristics, and also that modelling would be complicated by different intensities or levels of characteristics facing different importers from the same exporter. Possible geographical characteristics include the provision of credit and long-term trade agreements. Both of these do indeed vary across importers. However, as pointed out in chapter 10, in both cases there is insufficient data to calculate imputed values, so they were modelled using simple flow quantity constraints.

5. Another possible geographical characteristic is reliability of supply. It is questionable, however, whether a significant residual effect of this type remains to be identified after long-term agreements and the other government policies detailed in the previous chapter have been modelled. If it does, it may conveniently be picked up by analysing importers' purchasing policy, rather than by modelling product characteristics.

6. The seasonality of export supply is an important geographical characteristic which does not vary across importers. Monthly export data are available and are appropriate as measures of supply availability, seasonal patterns being a complex function of production and price seasonality, storage facilities, market power and government policy. Consumers in importing countries may be assumed to demand a fixed monthly quantity of wheat during the year. This will be met from stocks and domestic production as well as imports, and imports may also be impacted by government policy. As with export supply, the most convenient measure of seasonal demand is to use observed seasonal data. Cumulative quarterly data from the FAO's Monthly Bulletin of Statistics and Quarterly Bulletin of Statistics were used to calculate average quarterly percentages of annual trade for countries' imports and exports.

Developing a theoretical model

7. Using Lancaster's characteristics approach we might assume that an importer's utility is determined by total quantities of characteristics independent of their product origins (equation (6.1)). We can regress known product price differentials on variables representing the characteristics of the products concerned. In order to give a better impression of relative importance, measures of the characteristics were first standardized in a simple manner such that higher value represents higher quality, and such that the range of values for characteristics is from .001 to 1. The exception to this is hardness, which takes the value of either 1 (representing hard wheat) or 0 (soft wheat). As an example of these conversions consider protein content (characteristic 4), data for which range from 8% to 15%:

$$\gamma_{j4} = \frac{G_{j4} - 8}{7} \qquad \text{and} \qquad q_{p4} = \frac{Q_{p4} - 8}{7} \qquad (11.1)$$

where G_{jc} and Q_{pc} are characteristic levels preferred and offered respectively. After the lowest value, 8, is subtracted, these are divided by the the difference between the minimum and maximum, 15-8=7, yielding the standardized measures γ_{j4} and q_{p4}.

8. Price differentials between different types of wheat were regressed on various functions (integer powers, logs and exponentials) of the above standardized variables in an attempt to estimate the technical relationship between characteristics and price differentials. The following function was chosen on the basis of explanatory power (R^2 of 0.98, t statistics for the three explanatory variables included of 3.63, 8.15, 4.26, and standard errors shown below the coefficients in brackets):

$$\underset{}{DF_p} = \underset{(33.2)}{-\,137} + \underset{(14.0)}{50.9q_{p3}^4} + \underset{(3.1)}{25.1q_{p4}^4} + \underset{(39.5)}{168q_{p5}^2} \qquad (11.2)$$

where DF_p is the price differential of product p above the price of standard

EC soft wheat. As can be seen, characteristics 1 and 2 (hardness and weight) have both fallen out of the regression. There is some doubt as to the validity of the regression, given the limited number of observations from which it was estimated. This is particularly true of the significance of characteristic 5 (foreign material content) as the sample products used for estimation all had high and similar standardized values. If characteristic 5 is excluded from the set of possible explanatory variables, equation (11.3) emerges as a possible alternative (R^2 of 0.78, t statistic 4.68, and standard errors shown in brackets)[1]:

$$DF_p = \underset{(8.0)}{-\,15.6} + \underset{(11.0)}{51.3q_{p4}} \qquad (11.3)$$

9. From these equations estimates of average price premiums for products can be calculated. So can estimates of the premiums that an importer may have to pay to import a wheat with specified preferred characteristics. In addition, the equations may be used to guesstimate the relative importance of characteristics in importers' utility functions (in the absence of more theoretically respectable methods).

10. We may choose a utility function in which an importer's total utility from wheat imports is a simple sum of utilities from characteristics. This approach denies the possibility that the value to an importer of one characteristic of a particular product is dependent on other characteristics of the product. In order to capture this possibility it is necessary to model demand for products, although it is still desirable to describe products in terms of their characteristics. This product approach is also justified by the observation that in answer to the IWC questionnaire asking importers for

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[1] It was pointed out to the author after the first draft of the thesis was complete that another possibility would be to renormalize quality variables around the values for EC standard soft wheat, which would set the intercepts of these equations to zero, and which in turn may lead to better determined equations. This was not attempted, however, as whilst it is quite a minor task in itself, the changes necessary to subsequent GAMS programming would be substantial.

the characteristics they prefer (IWC 1985), many specified products. Some characteristics of a product may, however, still be seen as independent of the five physical characteristics of the wheat. These 'independent' characteristics include reliability of supply, handling costs, credit terms and also transport costs. We can assume that the 'independent' characteristics are not only separate from 'physical' characteristics in the utility they yield to the importer, but are also identified with particular exporters and importers (and so particular routes) rather than with particular products.

11. In order to model utility as a function of these two types of characteristic (which for convenience we continue to call physical and independent characteristics) we can follow Ladd and Zober (1977) (see chapter 6) in introducing services. The first possibility is that we may think of each exporter as providing to a particular importer one service which is a combination of the products offered and the independent characteristics between importer and exporter. This is reminiscent of the second decision stage of the Armington model in the context of a linear model with fixed import totals (see chapter 2, paragraph 39 ff). The second possibility, which is more satisfactory, is to consider each exporter as providing a separate service connected with each product it produces, and similarly importers demanding different services when they have expressed preferences for more than one type of wheat. One consequence of this approach is that the number of positive flows predicted is likely to increase, our procedure being similar to increasing the number of importers and exporters in the model.

12. Whichever of the two possible methods described in the above paragraph we use, it is necessary to model an importer's utility from a product. The choice of utility function is inevitably arbitrary in the absence of detailed empirical investigation of importers' utility functions (which is outside the scope of this research). Nevertheless, it seems sensible to define a function which ascribes greater utility where there is a close match between the physical characteristics of the product and those preferred by the importer. Using the standardised measures of characteristics mentioned earlier, an importer's unit product utility (defined as the quantity of utility accruing

to an importer from importing one unit of the product) can be modelled by several functions, one example being the following.

$$U_{jp} = \mu_j q_{p1}\ [(\gamma_{j2}q_{p2})^2(\gamma_{j3}q_{p3})^2(\gamma_{j4}q_{p4})^4(\gamma_{j5}q_{p5})^2]^{0.1}$$

when hard wheat is preferred, and

$$U_{jp} = \mu_j\ [(\gamma_{j2}q_{p2})^2(\gamma_{j3}q_{p3})^2(\gamma_{j4}q_{p4})^4(\gamma_{j5}q_{p5})^2]^{0.1}$$

when soft wheat is preferred (11.4)

where U_{jp} is an importer's unit product utility, $0 \leq U_{jp} \leq 1$, and μ_j is an increasing monotonic transformation of GNP per capita, $0 < \mu_j \leq 1$, representing the amount a country is prepared to pay (relative to other countries) to fulfill its preferences.

13. The above function assigns low utility levels where wheats with low levels of characteristics are preferred. This possibly undesirable feature can be avoided by using a different functional form:

$$U_{jp} = \mu_j q_{p1}\ [|\gamma_{j2}-q_{p2}|^2|\gamma_{j3}-q_{p3}|^2|\gamma_{j4}-q_{p4}|^4|\gamma_{j5}-q_{p5}|^2]^{0.1}$$

when hard wheat is preferred, and

$$U_{jp} = \mu_j\ [|\gamma_{j2}-q_{p2}|^2|\gamma_{j3}-q_{p3}|^2|\gamma_{j4}-q_{p4}|^4|\gamma_{j5}-q_{p5}|^2]^{0.1}$$

when soft wheat is preferred. (11.5)

14. As can be seen in both (11.4) and (11.5), when hard wheat is preferred the utility gained from a soft wheat is zero, but the reverse is not true. This form of linkage between hardness and other characteristics would not be possible in the simple version of the Lancaster approach. Premiums paid on hard wheats only are modelled (a premium being the price of the wheat above a standard soft wheat). It is not as important to model soft wheat premiums; nor is it as easy, because whether soft wheat is used in a given case for milling or feed is important in determining substitutability, and such information is not available.

15. Another important feature is that, by raising to a power greater than one, dominance in determining the level of the expression in square brackets

is assigned to cases where (for a particular importer, product and characteristic) $\mu_{jc}q_{pc}$ is high (a fussy importer's preference is catered for). Moreover, only importers fussy about all characteristics can hope to achieve a value of U_{jp} close to unity. The protein characteristic ($c = 4$) is deemed twice as important as the characteristics of weight, moisture or foreign material, and so is raised to a power twice as large (see paragraph 8 and equation 11.3 above).

SERVICES AS PRODUCT COMBINATIONS

16. Ignoring for the moment independent characteristics, we turn now to the case where each exporter provides one service to each importer. We denote by the S_{ij} the total utility gained by the importer from this service:

$$S_{ij} = \sum_{pi} \frac{U_{jp}x_{jp}}{M_j}, \quad 0 \le S_{ij} \le 1 \qquad (11.6)$$

where pi is the set of products produced by exporter i, x_{jp} is the amount of product p demanded by importer j, and M_j is the total level of j's imports, included to standardize utility across importers so that S_{ij} is functionally related to the proportion of imports from j rather than tonnage.

17. The importer's utility function is a function of these services, thus:

$$U_j = \sum_i S_{ij} = \sum_p \frac{U_{jp}x_{jp}}{M_j} \qquad (11.7)$$

or

$$U_j = \sum_i (S_{ij})^a \qquad (11.8)$$

where any value of a between zero and unity is taken as denoting a desire to import from more than one exporter, possibly to reduce risk[2]. This may

[2] It is likely that multi-source buying by importers to reduce risk of non-supply is minimal. Where multi-source buying does occur for political reasons or to reduce risk, modelling on a country-specific basis may be more appropriate than using a parameter such as a in equation (11.8), which is likely to vary

increase the number of non-zero flows.

18. Maximizing utility as defined in (11.7) subject to a budget constraint yields the following set of conditions:

$$\frac{U_{jp}}{M_j} - \frac{\delta U_j}{\delta Y_j} r_p = 0, \text{ if } x_{jp} > 0;$$

$$\frac{U_{jp}}{M_j} - \frac{\delta U_j}{\delta Y_j} r_p < 0, \text{ if } x_{jp} = 0 \qquad (11.9)$$

where Y_j is the income of importer j and r_p the price of product p. Thus, as in the Ladd and Zober model, we can state that if the product price is greater than the imputed value of its characteristics (which is proportional to U_{jp} as the marginal utility of income, $\delta U_j/\delta Y_j$ and M_j are constant) it will not be demanded.

SERVICES AS PRODUCTS

19. Our model can be further refined. Its main limitation so far is that it does not allow the possibility of more non-zero flows than the basic model presented in chapter 8, except by the introduction of a risk aversion parameter such as a in equation 11.8. To overcome this we can use the second approach discussed in paragraph 11 above, namely treating each product as coming from a different exporter, and similarly treating an importer's multiple preferences as if each preference is that of a different importer[3]. Thus the number of routes in the mathematical program is increased. In this context each service is a combination of the utility to a particular importer

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across importers.

[3] Where this approach is adopted it is necessary to split up importers' and exporters' trade figures so that each product can be modelled as if it stood for an exporter and each preference an importer. In splitting up trade figures in the models that follow equal weights were assigned to each product of an exporter and each preference of an importer (where an importer expressed more than one preference).

of the physical characteristics of one product and the utility to the same importer of the independent characteristics particular to the exporter.

20. If a service is to constitute more than simply the utility from a product, we need to bring in independent characteristics. As utility gained by the importer from independent characteristics is by definition independent of product type, a service can be defined in the following additive form:

$$S_{pj} = U_{jp}x_{jp} + g_{ij}(I_{ij}, x_{jp}) \tag{11.10}$$

where g is some function and I_{ij} is a vector of independent characteristics. As in equation (11.6) the first right hand term could alternatively be divided by M_j, yielding a utility function described in terms of market shares rather than absolute product import levels so that utilities of different importers can more readily be compared with each other. A simple application of equation (11.10) would be the case where the only independent characteristic is a constant per unit product freight rate, f_{ij}:

$$S_{pj} = U_{jp}x_{jp} - (1/\varphi_j)f_{ij}x_{jp} \tag{11.10a}$$

The parameter φ_j, which is the same for all services, is a conversion factor equal to the dollar reduction in per-unit-product freight rate which just compensates importers for a unit reduction in per-unit-product utility.

21. The introduction of a set of independent characteristics for each service has some similarities with the introduction by Ladd and Savannunt of unique characteristics for each product. However, the set of independent characteristics are service- not product-specific, and they are not all unique.

22. If we assume a utility function similar to (11.7):

$$U_j = \sum_p S_{pj} \tag{11.11}$$

then, using the specification in (11.10a), the first order conditions (with $x_{jp} > 0$) are:

$$U_{jp} - f_{ij}/\varphi_j - \frac{\delta U_j}{\delta Y_j} p_p = 0 \qquad (11.12)$$

So long as freight rates represent the only independent characteristic and are measured in the same unit as income, US$, it follows that $1/\varphi_j$ is equal to the marginal utility of income, $\delta U_j/\delta Y_j$.

Thus if $$p_p \leq \frac{U_{jp}}{\delta U_j/\delta Y_j} - f_{ij}$$, the flow is positive (11.13)

23. Equation (11.13) demonstrates that where freight cost is the only independent characteristic and the marginal utility of the product is constant, then whether a flow is positive or not is a simple function of product price, freight rate and unit product utility (the marginal utility of income being independent of product type).

Incorporating heterogeneity into the LP model

24. In chapter 9 it was suggested that what were called (for convenience) price responsiveness and route price responsiveness should be analysed separately. It has been assumed that importers by and large are not price responsive but are route price responsive. With importers exhibiting identical preferences but with different wheat prices, we can treat freight rates and price premiums in a similar way. We could simply add price premiums for more expensive wheats to freight rates in a linear program. By doing this, as in the simple transportation problem, the minimization solution of the mathematical program corresponds to efficient equilibrium in the market without excess supply or demand after accounting for geographical differences in prices. In a program in which all **product** export totals as well as import totals are fixed, however, in that a price premium is not geographically differentiated the adding of premiums will not affect the pattern of trade. This is not the case if product trade quantities are not fixed, even if

exporters' trade totals are.

25. However, in reality preferences do vary from importer to importer. Competition between importers for wheat products can be incorporated in an extended model (as described in paragraphs 11 and 19) with each product being modelled as a supply source and each preference a demand point. Each demand point is assigned the freight rates of the relevant importer; where the characteristics of a product (as measured by some utility function) are preferred, the relevant freight rate can be reduced to represent increased competition for that product. The reduction in the freight rate is a function of the degree of preference for the product. The closer in size the various reductions for a particular demand point or importer, the greater the potential for product substitution.

26. In such a model it is not price premiums actually paid which determine whether a flow takes place or not, but rather the price premium that an importer would be prepared to pay; and this is already implicitly modelled by altering freight rates as outlined. In any event data is available only for average price premiums, and, as already mentioned, even this is not particularly reliable.

27. The relative freight rates in a linear programming model determine whether or not a particular flow is non-zero. Supply and demand constraints determine only the magnitude of each non-zero flow. Equation (11.13) shows that the price an importer needs to be prepared to pay in order for a flow to be non-zero equals the freight rate plus the price of the product. So far the price of the product is unknown. Nevertheless, considering the difference between an environment where products are homogenous and one where they are not, we know that a c.i.f. price in the environment with product heterogeneity just necessary for a non-zero flow is equal to that in the homogenous environment plus the difference between the unit product utilities in the two environments divided by the marginal utility of income. Thus, altering freight rates by this difference models the effect of wheat heterogeneity.

28. Having established a theoretical justification for altering freight rates, it is now necessary to consider the functional form of the additions, $U_{jp}/(\delta U_j/\delta Y_j)$, where U_{jp} is (marginal) utility of a unit of standard product minus that of product p. It is at this point that data deficiency becomes a serious constraint to modelling. Given the IWC preference data, it is not possible to determine what form the utility functions should take. Nevertheless, we can use the utility functions described in the previous section in equations (11.4) and (11.5) and compare their results (assuming a constant marginal utility of income). We can also use equations (11.2) and (11.3) to create two other proxy utility functions, numbered (11.14) and (11.15) below.

$$U_{jp} = \mu_j q_{p1}[-137+50.9(\gamma_{j3}-q_{p3})^4+25.1(\gamma_{j4}-q_{p4})^4+168(\gamma_{j5}-q_{p5})^2]$$

when hard wheat is preferred, and

$$U_{jp} = \mu_j[-137+50.9(\gamma_{j3}-q_{p3})^4+25.1(\gamma_{j4}-q_{p4})^4+168(\gamma_{j5}-q_{p5})^2]$$

when soft wheat is preferred. (11.14)

$$U_{jp} = \mu_j q_{p1} [-15.6 + 51.3(\gamma_{j4}-q_{p4})]$$

when hard wheat is preferred, and

$$Ujp = \mu_j [-15.6 + 51.3(\gamma_{j4}-q_{p4})]$$

when soft wheat is preferred. (11.15)

29. The models presented below share certain features. They have quantity constraints for Cuba, the EC, and Korea to model flows of particular products where these are specifically mentioned as preferred by importers in the IWC questionnaire. Freight rates are altered by adding (or subtracting) measures of utility from the freight matrix. The number of demand points equals the number of preferences, and the number of supply points equals the number of products (which are then re-aggregated for analysis after the LP solution has been found). Finally, a constant marginal utility of income is assumed for all importers. Preference data was available only for Algeria, Brazil, Cuba, EC, Iraq, Japan and Korea. Other Latin American importers were assumed to have the same preferences as Brazil, and Iran the same as Iraq. All constraints of model 10.10 are included (capturing non-commercial trade,

credit, long-term agreements, the EEP, EC restitutions, Japanese import policy and Argentina-Peru trade).

30. From a comparison of model results it appears that equations (14) and (15) are more appropriate than (4) and (5). Model 11.1 uses equation (14) with μ_j set such that the average of U_{jp} equals the average observed price premium in IWC data. Model 11.2 similarly uses equation (15). The λ results of these two models are presented in tables 11.i and 11.ii respectively.

Table 11.i: Model 11.1 λ values

Year	D2	D4	D13
1983/4	7.12	7.21	4.62
1984/5	5.52	3.31	2.75
1985/6	6.18	0.35	1.20
1986/7	6.11	6.84	7.15
1987/8	6.54	3.26	1.95
Average	6.30	4.19	3.53

Table 11.ii: Model 11.2 λ values

Year	D2	D4	D13
1983/4	3.64	6.86	1.26
1984/5	3.12	3.30	0.47
1985/6	3.46	4.09	0.40
1986/7	2.76	4.24	4.21
1987/8	4.97	2.53	-0.38
Average	3.59	4.20	1.19

31. These λ values can be compared with those in table 10.x; average λ for D2, D4 and D13 was 8.52, 7.86 and 7.14 respectively. However, on closer examination of the expected flow matrices (and total run variation statistics) it is less clear whether these lower λ values are due solely to better modelling of wheat heterogeneity. For one thing, the negative value of λ for 1987/8 using D13 may indicate mis-specification (see chapter 8, paragraph 18). For another, while trade flows of the three countries for which some form of quantity constraint was included are better predicted in

models 11.1 and 11.2 than in model 10.10 (Cuba, the EC and Korea), the same is not true of various countries for which preference data was used to alter freight rates: Algerian and Brazilian flows were not as well predicted in either model 11.1 or 11.2, Peru and Venezuela were not as well predicted in model 11.1, and Iraq not as well predicted in model 11.2. Countries where prediction was improved in both new models were Chile and Mexico, with additional improvements in model 11.1 in predicting Iranian flows. Of those countries for which no preference data was used, Chinese imports are predicted less well in both new models, but Soviet imports are better predicted, which is perhaps significant in explaining lower λ values in view of the scale of Soviet imports. Bangladeshi imports are better predicted in model 11.1 and Pakistani imports are better predicted in model 11.2. Other flows are the same as in model 10.10.

32. These comparisons between predicted and observed flows leave matters in an inconclusive state. Wheat heterogeneity may or may not have been reasonably well modelled by adjustments to freight rates. It is of course true that the preferences of one importer may affect another importers' flow pattern; but once these preferences have been modelled, we would not expect a greater number of flows to be less well rather than better predicted for importers expressing a preference. Yet this is what has occurred. Admittedly, values of λ have declined due to better modelling of the imports of other countries, but it is not known what features of these other countries' trade have been captured by the model. It is noted that in choosing the utility specification of the models, those specifications which produced smaller reductions in λ - implying fewer improvements in modelling of these countries' flows - were not adopted.

33. An increase in λ can also be ascribed to the quantity constraints included in models 11.1 and 11.2. Model 11.3 includes these but not the alterations to freight rates. The λ results are presented below in table 11.iii.

Table 11.iii: Model 11.3 λ values

Year	D2	D4	D13
1983/4	7.18	7.31	4.91
1984/5	5.54	3.40	3.29
1985/6	11.05	6.64	6.18
1986/7	10.62	10.06	8.91
1987/8	8.42	4.52	2.36
Average	8.56	6.39	5.13
(10.10	8.52	7.86	7.14)

Whilst λ is mostly lower than in model 10.10 (whose average λ are shown in table 11.iii for comparison), these quantity constraints included in model 11.3 but not 10.10 have caused an increase in λ in 1983/4 and 1987/8 using D2 and in 1987/8 using D4, a clear indication that the constraints are not accurately predicting import behaviour.

34. Three main factors are suspected of being responsible for the poor performance of models 11.1 and 11.2. Firstly, the data on preferences is incomplete. Secondly, the forms of the utility functions may be incorrectly specified. Lastly, the usefulness of quantity constraints is hampered by a lack of data on imports and exports disaggregated by wheat type, which could be used for better specification of such constraints.

Introducing Seasonality

35. It is theoretically possible to specify time of delivery as an independent characteristic within the framework already outlined to model wheat heterogeneity. However, partly in recognition of the poor performance of models 11.1 and 11.2, it is instead proposed that seasonality be taken into account by ensuring that supply equals demand at the end of each quarter. If there were no annual constraints built into the model the same effect could be reached by employing four separate linear models, one for each quarter. Annual models could be linked together in a similar way to better model multi-annual constraints, such as long-term agreements which

specify a given level of imports over a period of more than one year but not a minimum sale for any one year. The effect of such seasonal constraints can perhaps best be illustrated by an example. Argentina exports mostly in the first quarter. Without quarterly constraints an importer near Argentina but distant from others might be predicted as importing mostly from Argentina. However, with quarterly constraints, the fact that imports from Argentina during the three latter quarters are restricted by lack of supply may result in the country importing less from Argentina over the period of a year.

36. In order to impose quarterly supply and demand constraints, trade totals for the exporters and importers in each quarter need to be established. Quarterly total trade can be obtained by first multiplying each exporter's annual trade by the proportion of the exporter's trade normally occurring in the quarter. These figures are then summed over the exporters to yield total quarterly trade. However, when we sum the imports calculated using importers' proportions the exact same totals for quarterly trade are not obtained. This is not surprising as the proportions are only estimates, and the quarterly trade figures are somewhat inaccurate (a reflection of the general state of global balance of payments statistics).

37. To overcome this problem a front-end linear program was written to alter importers' quarterly proportions such that the sum of quarterly imports equals the sum of quarterly exports, the alterations being spread equally amongst all importers. This was done by introducing slack variables which were added to the proportions and constrained such that total imports equal total exports. The objective function minimized the differences between slacks for importers and also the differences between slacks for exporters.

38. Model 11.4 accordingly introduces to model 10.10 the seasonal constraints of supply equalling demand in each quarter, while models 11.5 and 11.6 introduce similar seasonal constraints to models 11.1 and 11.2 respectively.

39. By comparing table 11.iv with table 10.x (reproduced below table 11.iv for the reader's convenience) it can be seen that the introduction of the

seasonal constraints has reduced λ (using D13) by 30%. Nevertheless, this is not the case using other data sets. Three λ values have increased from model 10.10. These are the same three figures observed to increase in model 11.3: 1983/4 and 1987/8 using D2 and 1987/8 using D4. This may again indicate mis-specification of the constraints, which could be reduced by using more accurate quarterly supply and demand trade totals.

Table 11.iv: Model 11.4 λ values

Year	D2	D4	D13
1983/4	7.18	7.31	4.91
1984/5	5.54	3.40	3.29
1985/6	11.05	6.06	5.43
1986/7	10.61	10.06	8.91
1987/8	8.42	4.52	2.36
Average	8.56	6.27	4.98

Table 10.x: Model 10.10 λ values

Year	D2	D4	D13
1983/4	7.28	8.48	7.84
1984/5	6.12	7.93	8.04
1985/6	11.46	8.15	7.73
1986/7	10.81	10.94	9.76
1987/8	6.93	3.78	2.37
Average	8.52	7.86	7.14

Table 11.v: Model 11.5 λ values

Year	D2	D4	D13
1983/4	7.12	7.21	4.43
1984/5	5.52	3.31	2.75
1985/6	6.96	1.26	1.40
1986/7	6.08	6.88	7.15
1987/8	6.43	3.26	1.95
Average	6.42	4.38	3.54

40. The negative values in table 11.vi may similarly indicate

mis-specification. Seasonal constraints have generally increased λ levels for the product heterogeneity models 11.5 and 11.6 compared with models 11.1 and 11.2 respectively.

Table 11.vi: Model 11.6 λ values

Year	D2	D4	D13
1983/4	3.64	6.86	1.26
1984/5	3.12	3.30	0.47
1985/6	4.06	2.26	-0.70
1986/7	4.48	5.25	5.21
1987/8	4.99	2.52	-0.11
Average	4.06	4.04	1.23

41. One general conclusion to draw at this point concerns sensitivity to data errors and mis-specification: our LP model is now predicting flow matrices sufficiently close to the observed flow matrices that data errors are causing changes in λ at least as significant as constraints designed to improve our modelling of market behaviour. More accurate data and better estimates of importer's utility functions are needed if heterogeneity and seasonality are to be convincingly captured in our model.

CHAPTER 12: AN APPROACH TO ANALYSING STRATEGIC BEHAVIOUR

1. In chapter 10 observed protectionist measures were simulated using various constraints. It is of interest to determine the government priorities which cause and shape protectionism. This requires a more detailed analysis of market power and strategies. The existence of unutilized market power may also emerge from such an analysis. The purpose of this chapter is to discuss ways of estimating the policy objectives behind observed protectionism, and ways of simulating the effects on world wheat trade of different protectionist strategies. Game theory is used for this purpose. In particular, methods incorporating spatial mathematical programming models are discussed. Due to shortage of data and time available to the author it is not the intention to create a workable game-theoretic model here. Nevertheless, it is envisaged that such a task could be accomplished in an extension to the current research. The point of this chapter is to highlight the advantages (and disadvantages) in a game-theoretic setting of using spatial as opposed to non-spatial models.

Wheat Market Structure

2. When economists talk of a market structure they refer to a system of trading relations among firms and consumers, and an analysis of where market power to set prices lies and what its consequences are. In the case of wheat there is a large number of production units (farms) and consumers, and little evidence of imperfect competition due to scale economies. Yet competition in the world market is not perfect, due to government intervention. As noted in chapters 4 and 5, governments of major exporting countries have varying but significant influence over export prices and quantities. In many cases countries' imports may also be largely determined by the government of the importing country, often through state trading. Thus, when considering market power we can think of governments, not production units or individual consumers, as the basic economic agents in our analysis.

3. There are of course far fewer countries, particularly wheat exporting countries, than production units or consumers. Some have and choose to use market power, by which is meant the ability to alter world prices and/or traded quantities (or prices) of other countries by varying one's own traded quantities (or prices). The objective of firms with market power is normally assumed to be to maximize profits. If national economic gain is similarly the sole objective of governments then we arrive at the optimal tariff or optimal protection argument alluded to in chapter 3, or a more complex sequence if retaliation is anticipated. However, unlike firms, governments have other objectives as well.

4. Other government objectives include political (non-economic) ones and, because governments have responsibilities to the whole economy and not just to the wheat sector, the interests of other sectors in the economy (traditional economic theory shows that the main damage of protectionism is typically to non-protected sectors of the protecting country). The ineffectual attempt by President Carter to use a wheat embargo as a political weapon against the USSR in 1980/81 has already been mentioned (see chapter 4, paragraph 46 ff). In contrast all major wheat exporters participated in the UN embargo of 1990/90 on Iraq which successfully prevented Iraqi wheat imports[1]. Food aid is another example where government intervention in the wheat market is justified mainly on political grounds, comprising a significant share of wheat trade.

5. Although such political objectives are important, they are peripheral to the analysis of market power. The second type of objective mentioned was concern for other sectors of the economy. Damage to other sectors arises not only or even mainly from retaliatory moves by other countries, but from the

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[1] At the time of writing it is too early to assess the impact of the wheat component of the 1990/91 UN embargo on Iraq. Wheat stocks at the start of the crisis in August 1990 were known to be high, but the level of stocks at the close of the conflict are not known. On the one hand the wheat embargo may have had little effect on Iraqi policy (the presumed purpose of the embargo) even if stocks were low. On the other hand, there are indications that troop morale was dented by inadequate supplies, but these were probably the result of cut supply lines rather than any severe national shortage.

protectionism itself (see chapter 3, paragraph 5 ff).

6. The countries which are the least vulnerable to successful attack in non-wheat sectors are those which are diversified and also have market power in other sectors, i.e. large countries. In the case of wheat exporters, the EC and the USA (which both have market power in wheat) are the two largest trading blocs in the world. Canada, Australia, and especially Argentina are more vulnerable in other sectors. We might therefore expect the EC and USA to initiate protectionist policies, and the other three exporters to follow[2]. Among importers the USSR and China both have significant market shares, but in the analysis which follows importers are not assumed to be strategic players. Aside from theoretical convenience, wheat appears to have faced a buyer's market throughout the 1980s. The author has also found no evidence of significant intervention to compete for wheat imports.

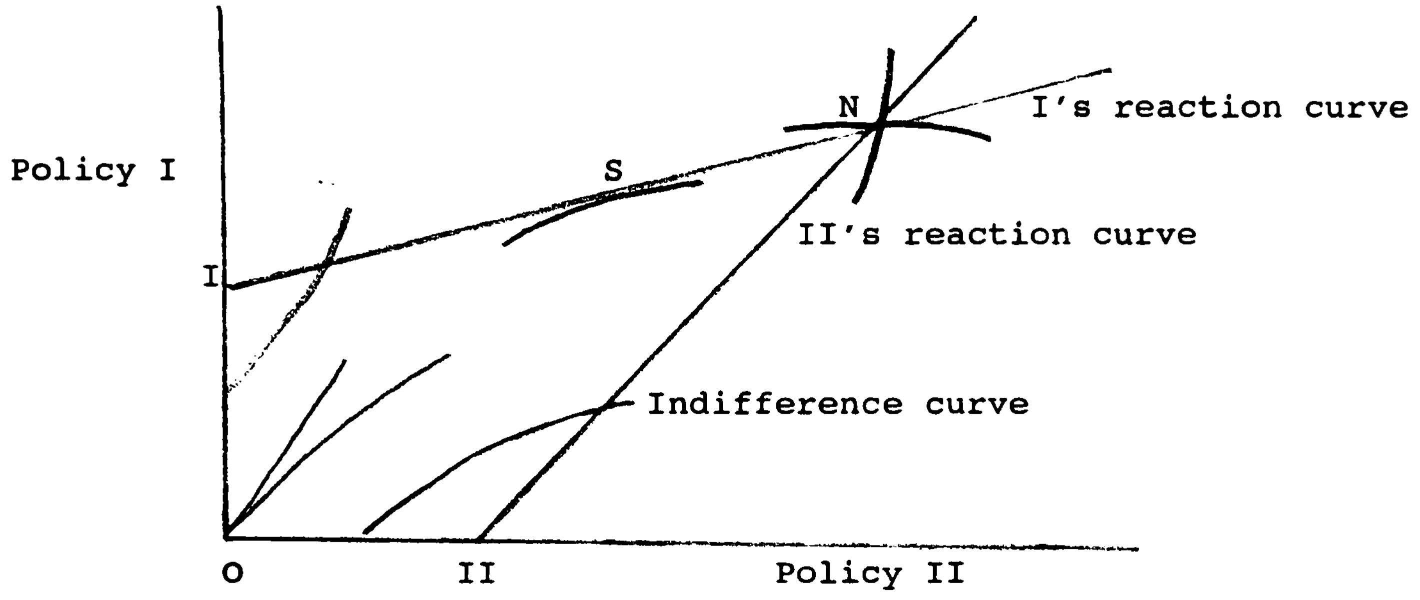
A Non-Spatial Game Theory Model

7. In order to model the effects of strategic behaviour of countries it is useful to use game theory. The familiar duopoly model can be converted for use to model government trade strategies and also policy co-operation. A strategy is defined as a predetermined set of rules which a government follows when deciding policy. Interest focuses on the policy outcome - trade quantity or price - that results. Figure 12.1 (after Hamada, 1979) illustrates a number of possible outcomes in a two-country strategic setting. The outcomes depend on the assumptions of the model (appropriate assumptions for the wheat market are discussed from paragraph 10 below). Here the reaction curves describe the optimal policy behaviour to maximize domestic economic gain of each of two countries given the policy level set by the other. Indifference curves are shown with utility decreasing with distance from the origins of the curves (points II and I). Point N is the Nash

[2] Canada and Australia may be considered capable of initiating increases in global protection, but relative strength is more important than absolute strength.

equilibrium, resulting from each country reacting in turn according to their reaction curves until equilibrium is reached. Point S represents a Stackelberg equilibrium, where country II plays first knowing country I's reaction (i.e country I is a follower). As drawn, the origin, O, represents

Figure 12.1: Two-country game theory



the Pareto optimal solution, with indifference curves tangential, which may be reached by cooperation. The benefits from such cooperation are represented in figure 12.1 by the difference in utilities at O as compared with those at either N or S.

8. In the case of trade war, governments may be prepared to adopt positions which do not necessarily maximize short-term domestic gains as usually defined, in order to inflict damage on competitors. In the game-theoretic model of the Export Enhancement Program developed by Hillberg-Seitzinger and Paarlberg (1989 and 1990) the reduction in EC wheat sales to target markets was found to be one of the objectives of the Commodity Credit Corporation in administering the EEP.

9. Applying game theory to analyse the wheat market we have to decide a number of questions concerning the choice of countries to model and the assumptions to be made about their objectives, perceptions, and strategies.

10. We choose to model the EC and USA as exporters (i.e. ignoring EC imports). The other three main exporters are assumed in this model not to be principal game-players, although their behaviour is taken into account in the model. Cases of non-cooperation (the assumed current situation with no order of play between the EC and US) and of cooperation are considered. In a dynamic model framework various stages of the multi-stage game can be considered in more detail - this, however, requires careful parametization of a starting point, together with realistic assumptions concerning timing. Quantities (Cournot) rather than prices (Bertrand) are taken as policy objectives, governments being assumed to seek a given volume of trade in particular markets rather than a certain price. In other words, quantity traded as the policy outcome is a better measure of policy success than price[3]. The policy instruments are EC export restitutions and EEP subsidies, both defined as per unit subsidies. Each player is assumed to have imperfect knowledge of the other's strategy, with each perceiving the other's strategy without bias but with uncertainty.

11. As we have assumed no leader-follower relationship between the EC and the US, Nash equilibrium is a more appropriate concept than Stackelberg equilibrium. However, we have also assumed some perception of the other's strategy which implies that there may be implicit cooperation. For this reason Nash equilibrium may not be reached. This of course in no way detracts from the welfare argument for co-operation, which rests on a comparison of the Nash equilibrium with cooperative equilibrium.

12. Bearing this in mind, let us start by modelling the Nash equilibrium in a two-player game. We assume that both the US and the EC set export subsidies to maximize economic gain from wheat sales. The following variables are defined:

$x = x(r,y)$ = EC export tonnage
$y = y(s,x)$ = US export tonnage
$a = a(x+y)$ = Argentine export tonnage
b = Australian and Canadian export tonnage (fixed)

[3] This choice reflects the desire by both the US and EC to reduce surpluses.

r = EC restitution
s = US EEP export subsidy
$c = c(x)$ = EC variable costs
$k = k(y)$ = US variable costs
$p = p(x+y+a+b)$ = world price.

where the first and second order derivatives with respect to r and s are assumed to have the following signs:

$$\begin{array}{lll} x_r > 0 & x_{rr} < 0 & x_{rs} < 0 \\ y_s > 0 & y_{ss} < 0 & x_{sr} < 0 \\ p_r < 0 & p_{rr} < 0 & y_{sr} < 0 \\ p_s < 0 & p_{ss} < 0 & y_{rs} < 0 \\ c_r > 0 & c_{rr} < 0 & \\ k_s > 0 & k_{ss} < 0 & \end{array}$$

and $(p-r) > 0$, $(p-s) > 0$

Of note is the absence of world price in export equations and the behaviour of Argentine, Australian and Canadian exports. Australia and Canada confront EC and US protectionist moves and their exports are assumed fixed. Argentina, however, is unable to take effective counter-measures and its exports are therefore assumed to fall. The second derivatives of x and y with respect to r and s respectively may in practice not be of uniform sign over the relevant ranges of x and y, but are taken to be so for theoretical convenience: i.e. it is assumed that the marginal gain in exports attained by increasing export subsidies declines with the subsidy.

13. Economic gain is defined as:

$$\pi = xp - c - rx \qquad \text{for the EC, and} \qquad (12.1)$$

$$\rho = yp - k - sy - xp \qquad \text{for the US.} \qquad (12.2)$$

It is noted that the US is assumed to give equal weight to maximizing its own sales and reducing EC sales (a reflection of the findings of the Hillberg-Seitzinger and Paarlberg model). However, the EC reaction function does not contain a term with yp - the EC is assumed to be interested only in disposing of surpluses as cheaply as possible. Maximizing (12.1) and (12.2), first order conditions are obtained which describe the reaction functions of the EC and the US, and are necessary conditions for a Nash equilibrium:

$$\pi_r = x_r p + x p_r - c_r - x - r x_r = 0 \tag{12.3}$$

$$\rho_s = y_s p + y p_s - k_s - y - s y_s - x_s p - x p_s = 0 \tag{12.4}$$

Rewriting these we obtain:

$$x_r p = r x_r + c_r + x(1-p_r) \tag{12.5}$$

$$y_s p = s y_s + k_s + y(1-p_s) + (x_s p + x p_s) \tag{12.6}$$

In the case of the EC the incremental gain from an increase in subsidy - the marginal increase in exports (caused by a rise in export subsidy) multiplied by the export price - is equal to incremental costs. These costs are the marginal cost of production plus the marginal cost of the subsidy (defined as the extra subsidy expenditure associated with an additional unit of subsidised wheat) plus the cost of the reduction in world price. For the US the additional term on the right hand side of equation (12.6) represents the increased EC sales revenue resulting from an increase in s, which we would typically expect to be negative[4].

14. The Routh - Hurwitz condition for reaction function stability (see Brander and Spencer 1985) is:

$$\pi_{rr} \cdot \rho_{ss} > \pi_{rs} \cdot \rho_{sr} \tag{12.7}$$

A sufficient condition for this to be met is that π_{rs} and ρ_{sr} are both negative and of smaller magnitude than π_{rr} and ρ_{ss} respectively: i.e. a country's

[4] This is not necessarily the case as EEP sales to targeted countries may reduce the supply available to non-targeted markets sufficiently to increase world price. However, the current (non-spatial) model is not able to capture such a possibility.

marginal increase in exports diminishes faster with increases in its own export subsidy than with increases in the foreign country's subsidy.

15. If we rearrange the reaction functions in terms of r and s instead of x and y, we can exploit the fact that the derivatives of price with respect to x and y are the same. To this end, again from (12.1) and (12.2), we have first order conditions:

$$\pi_x = p + xp_x - c_x - r_x x - r = 0 \tag{12.8}$$

$$\rho_y = p + yp_y - k_y - s_y y - s - x_y p - xp_y = 0 \tag{12.9}$$

which are re-arranged to give:

$$p = c_x + (r_x x+r) - xp_x \tag{12.10}$$

$$p(1-x_y) = k_y + (s_y y+s) - (y-x)p_y \tag{12.11}$$

The gain from the last unit of export volume is equal to the marginal cost of production plus the marginal cost of subsidy plus the marginal loss due to a fall in the world price.

16. We assume first derivatives with respect to x and y to be positive with the exception of $p_x = p_y < 0$; and all second derivatives with respect to x and y negative, as in paragraph 12.

17. To give the model specific functional form in accordance with the assumptions listed in paragraph 10, we assume:

$$a = \gamma_1 - \gamma_2(x+y) \tag{12.12}$$

$$c = \delta_1 x \tag{12.13}$$

$$k = \delta_2 y \tag{12.14}$$

$$p = \eta_1 - \eta_2(x+y+a+b) \tag{12.15}$$

$$x = \alpha_1 + \alpha_2.\ln(\alpha_3 r) + \alpha_4 y \tag{12.16}$$

$$y = \beta_1 + \beta_2.\ln(\beta_3 s) + \beta_4 x \tag{12.17}$$

with the constraints $r > 0$; $s > 0$. Equations (12.16) and (12.17) can be re-written:

$$r = (1/\alpha_3).e^{(x-\alpha_1-\alpha_4 y)/\alpha_2} \tag{12.18}$$

$$s = (1/\beta_3).e^{(y-\beta_1-\beta_4 x)/\beta_2} \tag{12.19}$$

Exports are written as a logarithmic function of export subsidies (exports increasing with subsidy by a decreasing amount) and a linear function of the other country's exports. If, for example, there is a sudden fall in US exports, EC exports rise by a constant share of that fall.

18. Using equations (12.12) to (12.16), (12.18) and (12.19) the two reaction curves (12.10) and (12.11) become:

$$\eta_1-\eta_2[\gamma_1+b+(1-\gamma_2)(x+y)] = \delta_1 + ((x+\alpha_2)/\alpha_2\alpha_3).e^{(x-\alpha_1-\alpha_4 y)/\alpha_2} + x\eta_2(1-\gamma_2) \tag{12.20}$$

$$\eta_1-\eta_2[\gamma_1+b+(1-\gamma_2)(x+y)] =$$

$$[\delta_2 + ((y+\beta_2)/\beta_2\beta_3).e^{(y-\beta_1-\beta_4 x)/\beta_2} + (y-x)\mu_2(1-\gamma_2)]/(1-\alpha_4) \tag{12.21}$$

In other words, the reaction functions are described in terms of x and y and the constant parameters defined by equations (12.12) to (12.17). In Nash equilibrium the right-hand side of equation (12.20) equals the right-hand side of equation (12.21) as the left-hand sides (price) are identical. The parameters which determine the Nash equilibrium are: unit production costs (δ_1 and δ_2), the α and β parameters defining EC and US reactions to own subsidy and competitor's output, the price parameter (η_2), the parameter determining Argentine output from EC and US output (γ_2), and the world price (the left-hand side of both equations). Specific trade flows are not modelled, but total EC and US exports are obtained, as is the level of total Argentine exports.

19. From the above discussion we have seen how to derive reaction functions and Nash equilibria. We now consider how an equilibrium might be obtained with cooperation between the US and the EC. Assuming that production costs are significantly higher in the EC than in the US and that there is sufficient spare US production capacity, a Pareto optimal solution would comprise no production for export in the EC. There may be some compensation to the EC from the US, possibly in the form of other trade concessions under the auspices of GATT negotiations. However, as the CAP is particularly damaging to the domestic economies of the EC, such compensation may be small. Internal political pressure within the EC to reform the CAP is also important in making the abolition of its protectionist features possible without significant US compensation.

20. We investigate here the case of cooperation where EC exports are zero (x=0). Given this constraint, maximization of joint economic gain from exports becomes maximization of US economic gain as defined in (12.2) but without the final term (which is zero anyway). Using y as choice variable, rather than r and s, and again assuming (12.12), (12.14), (12.15) and (12.19), the problem becomes:

Maximize(y)

$$\rho = yp - k - sy$$

$$= (\eta_1-\eta_2(b+\gamma_1)-\delta_2)y - \eta_2(1-\gamma_2)y^2 - (1/\beta_3).e^{(y-\beta_1)/\beta_2} \tag{12.22}$$

The first order condition is then:

$$\eta_1-\eta_2(b+\gamma_1)-\delta_2-2\eta_2(1-\gamma_2)y-(1/\beta_2\beta_3).e^{(y-\beta_1)/\beta_2} = 0 \qquad (12.23)$$

21. If we assume that the Nash equilibrium is reached in current conditions of non-cooperation, then by comparing the Nash equilibrium (paragraph 18) with the cooperative equilibrium (paragraph 20) we can calculate the effects of an end to EC exports not just on US exports, but also on Argentine exports. As EC and US subsidies decline, the total of EC and US exports (x+y) may decrease, leading to greater Argentine exports.

A Spatial Game Theory Model

22. A weakness of the model outlined in the preceding section is that it fails to differentiate between targeted and non-targeted markets. A method to overcome this weakness is to iteratively incorporate game-theoretic bargaining solutions within a mathematical programming framework. This improves on our LP modelling in previous chapters. The advantage of game theory modelling is that the reasons behind the observed protectionism can be better understood, which is of use in policy simulation.

23. Hillberg-Seitzinger and Paarlberg (1989 and 1990) have shown, using such an approach, that in the first quarter of 1986 there was a strong spatial effect of the EEP, which was then targeted on a small number of countries (Algeria, Morocco, Philippines, Turkey and Zaire). Whilst US exports to EEP targeted countries increased, US sales to 'Developed Asia' and non-targeted African countries fell. The EC was displaced from targeted markets but increased sales to the USSR and non-targeted Africa. A reduction in Australian sales to the USSR was offset by increased Australian sales to Developed Asia. The EEP subsequently increased in size as did the number of countries targeted. In the second quarter of 1987 the targeted countries were mainly the USSR and countries in North Africa and the Middle East.

Accordingly, US sales to Latin America, Middle East, Developed Asia and China fell, although they rose to the targeted countries. EC exports increased to the Middle East and other European countries, and decreased to the targeted countries. Likewise, Canadian sales to the USSR were displaced by US sales, but Canadian sales increased to Latin America, Developed Asia and China. Australian trade to the targeted countries of Iraq, Jordan and Sri Lanka decreased, while increasing to other Middle East and Developed Asia countries (Hillberg-Seitzinger and Paarlberg, op. cit.).

24. The LP model developed in previous chapters is of course only annual, as opposed to the quarterly model of Hillberg-Seitzinger and Paarlberg, but it explains observed flows reasonably well. Moreover, by subtracting only those constraints which model a particular policy instrument we have been able to gauge the effects of that policy. Similar patterns to those observed by Hillberg-Seitzinger and Paarlberg were obtained in the 1987/8 LP model: the EC being displaced by the US in Egypt, Iraq and Morocco, but not in Algeria or the USSR.

25. We can adapt the model developed in the previous section so that it is spatial in nature, and solvable in a mathematical programming framework. One appropriate change, whilst still maintaining the overall objectives of exporters as embodied in their reaction functions, is to consider that in each market (importing country) the EC and US engage in price competition to win trade. If a battle is lost in one market it gives greater incentive to win in another, and all battles are fought simultaneously. Thus for each importing country, j, the maximization problems of the two main game players become:

$$\pi = \sum_j w_{ecj} \cdot (x_j p - c_j - r_j x_j) - \sigma_{ec} \ , \ x_j \geq 0 \text{ each } j \tag{12.24}$$

$$\rho = \sum_{j \in n} w_{usj}(y_j p - k_j) + \sum_{j \in t} w_{usj}(y_j p - k_j - s_j y_j - x_j p) - \sigma_{us} \ , \quad x_j, y_j \geq 0 \text{ each } j \tag{12.25}$$

where n is the subset of importers, j, which are not targeted by the EEP, and t the subset of those targeted; and where w_{ecj} and w_{usj} are weights applied to payoffs for the EC and US respectively dependent on political factors (we might assume these are all equal to 1). Storage costs of un-exported wheat, σ_{ec} and σ_{us} provide a mechanism by which the outcome in one market affects that in another:

$$\sigma_{ec} = \tau_{ec} \cdot (I_{ec} - \sum_j x_j) \tag{12.26}$$

$$\sigma_{us} = \tau_{us} \cdot (I_{us} - \sum_j y_j) \tag{12.27}$$

where τ_{ec} and τ_{us} are unit storage costs and I_{ec} and I_{us} are stock levels.

26. Notice that whereas the EC targets all markets, the US does not. The issue of which countries are to be targeted is assumed to be decided (by political and budget factors) before the game starts. When calculating the first order conditions from (12.25), the first term on the right hand side is excluded as economic gain obtained without targeting cannot be assumed maximized.

27. We might also (or alternatively) assume the weights w_{ecj} and w_{usj} to be functions of the outcomes in other markets, for example in the case of market 1:

$$w_{ec1} = w_{ec1}(x_2, x_3, \ldots x_{19}) \tag{12.28}$$

A possible simple functional form of (12.26) is given below, with ω_{ec} a parameter measuring the percentage reduction in payoff per percentage surplus exports (exports predicted greater than those observed). TO_{ec} is total observed EC exports, and O_{ecj} is the observed EC flow to market 1:

$$w_{ec1} = \omega_{ec}(TO_{ec} - O_1) / (x_2 + x_3 + \ldots + x_{19}) \tag{12.28a}$$

28. The determination of such a system of weights may be made easier by

ranking the markets according to the priority attached by the exporters. Such a ranking may be determined by the relative sizes of the potential payoffs to the exporters. Thus the USSR (j=18) may be considered the most important market by both the US and EC, and the weights w_{ec18} and w_{us18} not functions of the outcomes in other markets. The weights for the next most important market would then be functions of the outcome in the USSR but not elsewhere; and so on, with the weights for the least important market being functions of all other outcomes.

29. Of course, the payoffs of the US and EC may not be ranked identically, making an ordered (as opposed to simultaneous) solution impossible. Regardless of this, however, in the context of mathematical programming trade flows are determined simultaneously anyway - making necessary simultaneous solution of all weights and trade flows, and so whether rankings are identical or not makes little difference to the computational difficulty.

30. If we assume that transport costs are borne wholly by the exporter (the locations of competition with other exporters being situated within each importing country rather than at exporting ports), then for the EC and US transport costs can be considered components of variable costs, c_j and k_j. In the non-spatial game theory model developed in the previous section, variable costs per unit trade were assumed constant. Similarly we might assume constant unit costs in the spatial model, these unit costs being equal to freight rates:

$$c_j = t_{ecj}x_j \tag{12.29}$$

$$k_j = t_{usj}y_j \tag{12.30}$$

where t_{ecj} and t_{usj} are the freight rates to importer j from the EC and US respectively. If we assume that transport costs are not borne wholly by the exporter then that component which is can be included as a cost and that which is borne by the importer will affect the demand schedule for the exporter's wheat. It is noted that storage costs are already included separately in equations (24) and (25).

31. The effect of export subsidies can now be expected to vary from one market to another. Accordingly, equations (12.16) and (12.17) from the non-spatial model are altered to separately model exports to each importer:

$$x_j = \max(\alpha_{1j} + \alpha_{2j}.\ln(\alpha_{3j}r_j) + \alpha_{4j}y_j,\ 0) \tag{12.31}$$

$$y_j = \max(\beta_{1j} + \beta_{2j}.\ln(\beta_{3j}s_j) + \beta_{4j}x_j,\ 0) \tag{12.32}$$

The price equation (12.15) becomes:

$$p = \eta_1 - \eta_2.\sum_j(x_j+y_j+a_j+b_j) \tag{12.33}$$

and (12.12) becomes:

$$a_j = \gamma_{1j} - \gamma_{2j}(x_j+y_j) \tag{12.34}$$

32. Assuming for the moment that all weights w_{ecj} and w_{usj} equal 1, differentiating (12.24) and the second right hand term in (12.25), and substituting from (12.26), (12.27), (12.28a), (12.29), (12.30), (12.31), (12.32), (12.33) and (12.34) we can specify the reaction functions of the EC and US cannot be written in closed form. Nevertheless, it is noted that, if x_j, $y_j > 0$ all j, the functions are as follows:

$$\begin{aligned}&\eta_1-\eta_2.\sum_j[\gamma_{1j}+b_j+(1-\gamma_{2j})(x_j+y_j)] = \\ &\eta_2(1-\gamma_{2j})\sum_j x_j + t_{ecj}+((x_j+\alpha_{2j})/\alpha_{2j}\alpha_{3j}).e^{(x_j-\alpha_{1j}-\alpha_{4j}y_j)/\alpha_{2j}} -\tau_{ec}\end{aligned} \tag{12.35}$$

$$\begin{aligned}&\eta_1-\eta_2.\sum_j[\gamma_{1j}+b_j+(1-\gamma_{2j})(x_j+y_j)] = \\ &\eta_2(1-\gamma_{2j}).\sum_{j\in t}(y_j-x_j)+t_{usj}+((y_j+\beta_{2j})/\beta_{2j}\beta_{3j}).e^{(y_j-\beta_{1j}-\beta_{4j}y_j)/\beta_{2j}} -\tau_{us}\end{aligned} \tag{12.36}$$

Similar reaction functions are obtained when weights are not assumed to have unitary values.

33. These reaction functions can be partially parameterised using observed trade flows and predictions of trade flows without the targeted protectionism. As with the non-spatial model, a co-operative equilibrium can also be investigated.

34. The next step is to incorporate strategic behaviour into a mathematical programming trade model. This can be achieved by means of an iterative method in which the bargaining solutions and non-targeted trade flows are calculated simultaneously. We can use bargaining theory for those flows where there is targeting and mathematical programming for the other flows. An iterative method is required as the bargaining solutions depend on the outcome of flows solved by the mathematical programming and vice versa. Although a particular algorithm may solve the bargaining and non-bargaining problems simultaneously, it is convenient for the sake of explanation to think of them being solved alternately. First the bargaining solutions are found and fed into the mathematical program. The results of these are then used in calculating the second iteration bargaining solutions, which are then fed back to the mathematical programming part of the model; and so on, until further iterations yield no further changes.

35. We have previously concluded in chapter 9 that importers are "route price responsive", but not particularly "price responsive". It seems appropriate therefore to continue using the linear programming model, in which price responsiveness cannot be captured, as opposed to a non-linear program such as those described in chapter 9. Alternatively, we might try to use substitution elasticities between different exporters in an Armington type model in which national export and import totals are fixed.

36. One problem, which particularly comes to light when using linear programming, is that equations (12.31) and (12.32) may incorrectly specify the relationship between export subsidies and sales. For smaller importers in particular the level of purchases from a particular exporter is a discreet function of the price offered by the exporter which cannot be easily

approximated by a continuous function. In any short time period importers will tend to obtain all their imports from the source that is cheapest, whatever the price difference with the next cheapest exporter. This behaviour is well modelled by our linear model, but means that the equations (12.31) and (12.32) may not be fully differentiable.

37. In addition to not knowing the degree of implicit cooperation, we also still lack knowledge of many parameter values. The estimation of these is beyond the scope of this study. Considering dynamics, without knowledge of a starting point we cannot meaningfully analyse a multi-stage game at each stage, only the final equilibrium - as has been done. In addition, our simple model incorporates no budget constraints on export subsidy expenditure. Targeted countries are specified at the start. And other protectionist policies need incorporating (of the EC and US and also of other countries).

38. A further criticism is that Cournot-Nash equilibrium may not be reached. We have already mentioned that US economic gain is not maximized in non-targeted countries, and this may also be the case in targeted countries, as the US and EC fail to comprehend fully the results of their actions, or else do not behave rationally given their objectives. Alternatively, the objectives may be incorrectly specified.

39. The issue of imperfect competition in the private grain trade is also of interest, but as noted in chapter 5 it is difficult to assess its importance. Hillberg-Seitzinger and Paarlberg (1989 and 1990) in their model of the EEP find it makes little difference to predicted flow patterns; but more work is needed in this area.

40. Comparing our non-spatial and spatial models is difficult without being able to parameterise and run them. We can conclude that, despite the difficulties mentioned above, a workable spatial model is desirable, as it yields (like non-game-theoretic spatial models) a far more detailed insight into the structure of international trade. The fact that one can integrate mathematical programming and game theory is heartening, and this is an area

for future research.

CHAPTER 13: A MODELLING SYNTHESIS

1. This chapter brings Part II of the thesis to a close by producing a full model with many of the constraints already detailed. Possible further adjustments are also discussed. From this full model various constraints are then removed in order to assess, principally by observing changes in λ, the relative importance of the distortions[1] they represent. In other words, distortions previously modelled out are individually re-introduced.

The full model

2. There are three possible approaches to compiling the full model. Firstly, we can include constraints modelling protectionism, but not heterogeneity or seasonality, data on which are less reliable. Secondly, we can incorporate wheat heterogeneity and seasonality constraints along with protectionism. Thirdly, starting from one of these two model types, we can try altering freight rates bit by bit, until observed flows are yielded when total transport costs are minimized. However, whilst this third approach may be computationally possible[2], trying to decrease λ by tampering with freight rates without theoretical justification is analytically invalid. As a result this third approach is rejected and not considered further.

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[1] Note that a distortion is defined as a departure from the 'competitive equilibrium' pattern of trade predicted in the basic model. It is recognised that product heterogeneity and seasonality cause such distortions, but that, unlike protectionism, these need not represent departures from global economic optimality.

[2] On the one hand, the required set of freight rates may not exist as constant costs per unit product. Existence can only be theoretically guaranteed if we allow, on each route, a different freight rate for each 1000 tonne unit of global trade (observed flows are recorded in units of this size). On the other hand, the required set of freight rates may not be unique.

3. Using the first approach, model 10.10 is a good candidate for full model status. To recap, this model includes constraints for non-commercial flows, credit, long-term agreements, EEP sales, EC restitutions, the national import policy of Japan, and Argentinian-Peruvian sales. However, λ values are still a little high (8.52, 7.86 and 7.14 for D2, D4 and D13 respectively). An additional constraint detailed in chapter 10 is that USSR imports be constrained to the observed levels. This is at least partially justified by the observation that although freight rates to the Soviet Union are fairly constant the import pattern is highly changeable. It is suggested that Soviet import patterns are determined less by freight rates - and more by political and other factors - than the imports of other importers. It is likely that concessions unknown to the author, including counter-trade deals, have been made to the USSR. Another constraint to be included, although not necessarily binding (see chapter 10, paragraph 47), is to set US-Cuba flows to zero on account of the US trade embargo. We shall label this package (model 10.10 plus the USSR and Cuban/US constraints) model 13.1.

Table 13.i: Model 13.1 λ values

Year	D2	D4	D13
1983/4	2.85	2.32	2.35
1984/5	3.45	2.62	3.02
1985/6	5.50	4.75	4.34
1986/7	5.96	4.61	3.66
1987/8	6.62	1.32	1.86
Average	4.87	3.13	3.05

4. We now consider which data set(s) to use, and whether there are any theoretically-justified alterations we can make to individual freight rates. Model 13.1 λ values are shown in table 13.i. From these we can see that freight rates D4 (observed major route freight rates with other rates estimated using regression analysis) and D13 (as D4 but with less-accurate minor route freight rates included) are better at explaining observed flows than distances (D2).

5. As mentioned in chapter 8, paragraph 32, D2 better explains Soviet imports than the other data sets. With the inclusion of the Soviet constraint in model 13.1, D2 no longer yields better flow predictions than D4 and D13. We deduce that the coincidence of the large (distorted) Soviet imports being better predicted using distance data accounts for relatively low λ values using D2 in previous models. Our confidence in the accuracy of the freight rates is increased as we now find (in model 13.1) they predict better than distance data.

6. A provisional choice between D4 and D13 can be made on the basis of lowest λ in table 13.i. Thus, D4 is chosen for 1983/4, 1984/5 and 1987/8 and D13 for 1985/6 and 1986/7. The total run variation statistic (measuring ability to predict importers' main sources) is also higher for D4 than D13 in 1983/4, 1984/5 and 1987/8; lower in 1985/6; and equal in 1986/7.

7. None of the anomalies concerning particular freight rates discussed in chapters 8 and 10 - which could justify altering particular rates - merit further alterations to model 13.1. For 1987/8 the EC-Iran rate is no longer very important, as the difference between the observed and expected flows is only 101 thousand tonnes. The 1987/8 Argentina-Japan rate is no longer relevant in determining the matrix of predicted flows because of the Japan constraint (which constrains all Japanese imports to those observed). The 1986/7 Soviet rates are similarly unimportant, as are the Australia-Iraq and Canada-Brazil rates (for which observed flows equal those expected).

8. As in chapters 8 and 10, it is appropriate to look at the differences in predicted flow patterns using the two data sets D4 and D13 in model 13.1. This is done with a view to possibly altering individual freight rates where there is evidence to suggest that they are inaccurate. We first identify those predicted flows which vary when the data set is changed. Of these, those for which freight rates are different are then noted (they number for the five years respectively 10, 6, 1, 0 and 0). For routes which have a zero flow predicted using one of the data sets the model produces a figure for marginal cost. If this is greater than the change in freight rate, or the change in freight rate is of the incorrect sign to induce the change in

expected flows, then these flows can be excluded from the list of possible causal differences[3]. By then noting the size of flow differences between the two expected flow matrices, and if necessary bearing in mind the sizes of changes in freight rates on particular routes, it can be assessed which rate changes are causal and which are not. In general, we wish to use the data set which predicts the flows best where rates are causal.

9. For 1983/4 the rate differences from Argentina to Iran and India and to Algeria from the EC and Canada are causal, and possibly also those from Australia to Bangladesh and from the US to Iraq. All of these are best predicted by the chosen data set D4 (which uses regression-estimated rates and excludes minor route data) except the Canada-Algeria and US-Iraq rates. However, there is no strong reason for changing these individual rates within D4 because the overall prediction of Algerian trade is better using D4 than D13 already and the US-Iraq difference may not be causal. For 1984/5 the two routes where there are causal differences (Australia-Iran and US-Brazil) are both predicted best by the chosen data set, D4. There is only one causal rate in 1985/6: from the US to Brazil. Although D4 predicts Brazilian trade marginally better, both data sets are poor in this respect, and so there is again no strong case for altering the rate in D13. For the remaining two years no causal freight rates exist, although the solutions for 1987/8 do differ. This is because there is no unique solution to this particular transportation problem. The solution actually reached (using either data set) depends on the algorithm used. Specifically, US and Canadian rates to China are equal, and so are US and Canadian rates to Korea. Thus, for example, starting with an optimal solution in which these four flows are all positive, moving one tonne less from the US to China, one more from the US to Korea, one less from Canada to Korea and one more from Canada to China results in the same total transport cost.

10. Having decided not to change any individual rates, we now examine model

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[3] A causal difference between two data sets is defined here as one which if it were the only difference between the data sets would yield a difference in expected flows.

13.1 a little more before discussing our second full package. Firstly, it is useful to consider how adding the USSR constraint has affected the results. Comparing the predicted flows with those of model 10.10 leads to two observations. First, more flows are better predicted than worse predicted by 13.1. EC **imports** are significantly better predicted in four out of the five years. The reason for this is unclear. The proximity of the EC to the Soviet Baltic ports may be significant.

11. Secondly, the sensitivity matrix for model 13.1 using D2, D4 and D13 for all five years (table 13.ii) shows high values for Argentina. Of the zero-predicted routes there are

Table 13.ii: Sensitivity matrix for model 13.1

	Exporter					
Importer	Arg	Aus	Can	EC	USA	Total
Algeria	**64**	.	.	.	.	64
Bangladesh	6	.	.	.	.	6
Brazil	8	7	.	9	.	24
Chile	.	6	2	.	.	8
China	19	.	.	.	.	19
Cuba	.	.	.	18	.	18
EC	.	15	.	.	.	15
Egypt	**42**	.	.	.	.	42
India	14	.	.	14	.	28
Iran	31	.	**40**	12	34	117
Iraq	17	.	.	12	.	29
Japan	3	.	.	.	.	3
Korea	3	**62**	38	.	.	103
Mexico	30	.	28	17	.	75
Morocco	**40**	.	14	.	.	54
Pakistan	34	.	30	.	.	64
Peru	.	**49**	**51**	.	.	100
USSR	.	.	.	.	.	.
Venezuela	**43**	.	7	10	.	60
Total	354	139	210	92	34	

Dots denote a value of zero
The nine highest values are emboldened.

more from Argentina than elsewhere which have low marginal costs, whereas in the basic model of chapter 8 Canada held this position (paragraph 40). Thus, although in competitive equilibrium Canada has a greater potential to capture trade than other exporters, the effect of protectionism is to make Argentina the exporter with the most to gain from small changes in freight rates or other equivalent price changes.

12. In chapter 8, (paragraph 39) it was suggested that we might expect those importers with high sensitivity matrix scores to change more readily with alterations to the model. Thus we might expect those importers with high scores in table 13.ii (Iran, Korea, Peru etc.) to have moved down the country ranking of model 13.1 when compared to that of the basic model. This is not the case, indicating that although most of the major distortions in the wheat market have been modelled, small distortions which cause a change in trade pattern but not much change in total transport costs have not been modelled as well.

Table 13.iii: Predicted and observed flows (D4, 1987/8)
('000 tons) (predicted columns followed by observed)

	Exporters									
	Arg		Aus		Can		EC		USA	
Alg	0	0	0	0	0	154	0	222	1634	1258
Ban	0	0	838	191	114	220	524	721	510	854
Bra	986	986	0	0	633	633	5	343	407	69
Chl	55	10	0	0	0	0	0	44	5	6
Chn	0	300	40	2170	10845	7807	40	62	3910	4496
Cub	80	91	0	0	0	937	1321	373	0	0
Egy	0	0	2044	2044	115	115	2436	1576	2484	3344
EC	1309	7	0	0	0	864	0	0	51	489
Ind	0	0	0	0	30	30	0	0	203	203
Irn	0	763	4109	2257	0	988	0	101	0	0
Irq	0	0	800	942	1168	823	0	0	782	985
Jap	0	0	993	993	1367	1367	0	0	3191	3191
Kor	0	21	0	168	1339	712	0	1476	3123	2085
Mex	0	0	0	59	0	309	0	39	678	271
Mor	0	0	0	0	22	22	750	108	1103	1745
Pak	0	0	20	20	54	54	132	132	429	429
Per	455	455	0	0	0	312	3	14	602	279
USSR	604	604	298	298	3377	3377	2582	2582	12582	12582
Ven	0	252	0	0	0	340	0	0	884	292

13. From table 13.iii, an example for 1987/8 of expected and observed flow matrices, it can be seen that out of 95 routes in the matrix, 46 are predicted correctly, and a further 9 are predicted within 100,000 tons of the observed flow. However, 19 flows are at least 500,000 tons awry, of which 6 are more than 1,000,000 tons out. These larger errors are the most unsatisfactory - 19 flows out of 95 represents significant distortion as yet unmodelled. Similar figures for earlier years are better, as shown in table 13.iv. The numbers of non-zero predicted flows for the five years are successively 54, 59, 55, 53 and 51 which compare with 67, 65, 67, 70 and 69 observed non-zero flows.

Table 13.iv: Model 13.1 analysis of differences between observed and expected flows

Number of Differences	1983/4	1984/5	1985/6	1986/7	1987/8
> 1000*	0	0	4	4	6
> 500	7	4	12	10	19
> 100	26	27	27	25	40
= 0	48	54	53	55	46

* '000 tons

MODELLING WHEAT HETEROGENEITY AND SEASONALITY

14. Our next specification includes, besides the constraints in model 13.1, the heterogeneity and seasonality constraints from model 11.6. We label this model 13.2. This yields λ results using the same data sets as in 13.1 of -0.71, -0.02, -2.16, 0.46 and 1.65 for the five years. These compare favourably with the corresponding figures for 13.1 (table 13.i) but, as discussed in chapter 11, the data on heterogeneity and seasonality are poor, and the results are unreliable. Comparing in more detail expected and observed flows, prediction is worse than model 13.1 for more routes than better. For example, in 1983/4 the difference between observed and expected flows was significantly greater than in 13.1 for Algerian, Brazilian, Chilean, EC, Indian and Iranian imports; but significantly less only for

Cuban and Iraqi imports. There is consistent improvement only for Cuba (where a quantity constraint has been imposed). Thus we would not want to use model 13.2 where we can use 13.1 instead.

The relative importance of protectionism, heterogeneity and seasonality

15. By subtracting constraints in turn from model 13.2 we can make an assessment of the relative importance of the removal of protectionism, wheat heterogeneity and seasonality features from the observed global wheat market. Models 13.3 and 13.4, allow market distortions caused by protectionism back into λ by excluding constraints developed to capture protectionist behaviour. In chapter 11 quantity constraints were introduced to model heterogeneity, but this was not necessary where quantity constraints were already included to model protectionism. As a result, in addition to those quantity constraints newly-added in chapter 11, Japanese imports remain constrained to observed levels (reflecting data on Japanese preferences). The difference between 13.3 and 13.4 is that model 13.3 retains constraints to model food aid separately and 13.4 does not. Model 13.5 similarly excludes heterogeneity constraints from model 13.2, and model 13.6 excludes seasonality constraints from 13.2. If both heterogeneity and seasonality constraints are excluded model 13.1 is obtained. The λ results are presented in table 13.v below.

Table 13.v: Models 13.2-13.6 and 13.1 λ values

Year	13.2	13.3	13.4	13.5	13.6	13.1
1983/4	-0.71	8.44	11.22	2.20	-0.71	2.32
1984/5	-0.02	5.23	8.74	2.31	-0.02	2.62
1985/6	-2.16	2.39	5.38	3.41	-2.08	4.34
1986/7	0.46	9.11	12.30	3.24	0.39	3.66
1987/8	1.65	4.06	4.74	1.92	1.82	1.32
Average	-0.16	5.85	8.48	2.61	-0.12	2.85

16. The first conclusion to be drawn from table 13.v is that protectionism is the most significant factor causing distortion in the international wheat

market. The removal of constraints modelling government policies (whilst still constraining Japanese exports to those observed) raises average λ from approximately zero (model 13.2) to an average of 8.48 (13.4). Removing heterogeneity and seasonality constraints together raises average λ only to 2.85 (13.1).

17. The second finding is that heterogeneity a is more important influence of trade patterns in wheat than are seasonal variations in supply and demand - the difference between 13.2 and 13.5 λ values is greater than the difference between 13.2 and 13.6 λ values.

18. Thirdly, the λ values for model 13.6 in 1986/7 and for model 13.1 in 1987/8 are lower than those for model 13.2 in those years. This may mean that seasonality in 1986/7 and a combination of heterogeneity and seasonality in 1987/8 counter slightly the market distortion caused by protectionism. Such an effect is more likely the more protectionism there is in the market. Alternatively, such a result may be caused by mispecification of heterogeneity and seasonality constraints.

19. Fourthly, when constraints capturing protectionism are removed the constraints remaining reduce λ from the average basic (chapter 8) model value of 25.88 to 8.48. This is a reduction of 67%. It is generally true that the introduction of a constraint will have less impact in reducing λ when there are many existing constraints in a model than when there are just a few (as the model is more tightly bound by constraints). Notwithstanding this, it appears from this 67% reduction that although the removal of behaviour caused by seasonality and heterogenity from the historically-observed wheat market has limited effect, the effect of introducing such behaviour to a counter-factual world of competitive equilibrium is far more marked. One feature of preference data which makes this result more understandable is that countries describe the products they actually purchase as the ones they prefer, even though their choice is influenced by protectionist policies. This produces heterogeneity constraints which mirror protectionist constraints.

The relative importance of different protectionist policies

20. For a more detailed analysis of the relative importance of some protectionist policies we can revert to specification 13.1, rather than 13.2. Models 13.7 to 13.13 include the constraints of 13.1, but each drops one set of constraints corresponding to a different set of protecionist policies. Thus comparing each model to 13.1 provides a partial equilibrium analysis of the effect of liberalization of the relevant set of protectionist policies. Model 13.7 drops constraints accounting for non-commercial flows, 13.8 credit, 13.9 long-term agreements, 13.10 the EEP, 13.11 geographically-differentiated EC restitutions, 13.12 Japanese import policy and 13.13 Argentine concessionary sales to Peru. The effect of constraining Soviet flows to those observed is seen by comparing 13.1 with 10.10. The λ results of all these models are presented in table 13.vi.

Table 13.vi: Models 13.1, 13.7-13.13 and 10.10 λ values

Year	13.1	13.7	13.8	13.9	13.10	13.11	13.12	13.13	10.10
1983/4	2.32	3.62	6.26	3.45	2.32	2.32	2.35	2.34	8.48
1984/5	2.62	4.92	4.63	3.62	2.62	2.62	2.71	2.67	7.93
1985/6	4.34	6.57	6.55	5.17	4.88	4.34	5.11	4.36	7.73
1986/7	3.66	3.87	5.37	3.67	3.66	3.66	3.71	3.66	9.76
1987/8	1.32	1.78	1.32	3.39	1.21	5.58	1.39	1.32	3.78
Average	2.85	4.15	4.83	3.86	2.94	3.71	3.05	2.87	7.54

21. The larger the difference from the 13.1 λ values, the greater the effect of liberalization of the set of policies captured by the omitted constraints. Thus from table 13.vi we can see that after constraining Soviet imports to those observed (10.10), credit (13.8) is the most significant of the modelled sets of protectionist policies in terms of distorting the pattern of trade. Non-commercial flows (13.7) come next in importance, followed by long-term agreements (13.9), EC restitutions (13.11), Japanese import policy (13.12), the EEP (13.10) and finally (and with a very small impact) the concessionary flows from Argentina to Peru (13.13).

22. Comparing model 13.11 with 13.1, the geographical differentiation of EC restitutions effects the pattern of trade in only 1987/8 (by looking at expected flow matrices it can be seen that all predicted flows in other years are unchanged). In contrast, λ values show that the EEP starts as a distortionary policy in 1985/6 (as the λ for 13.10 is higher than that for 13.1), becomes neutral in 1986/7 and redresses other protectionist distortion in 1987/8 (λ being lower than in 13.1).

23. In the five years 1983/4 to 1987/8 λ peaks in 1985/6. In other words unmodelled distortion peaks. We know that protectionism increased after this date (see the PSE and CSE figures of table 10.ii). It is possible that the price effects of protectionist policies captured by model constraints became more dominant in the last two years studied than distortions not captured by the model in any year. As the result, unmodelled distortions become less significant in altering trade. This possibly explains why λ dropped after 1985/6 although the total levels of protection increased.

24. Aside from λ, the other statistics produced for models 13.7-13.13 and 10.10 hold few surprises. The total run variations, which measure the ability to predict importers' main import sources correctly, are equal to or less than for 13.1 (indicating that taking constraints out reduces predictive power) with two exceptions. In 1987/8 models 13.9 and 13.11 both produce total run variations one point higher than for 13.1, principally in the former case due to better prediction of EC imports. Looking at the country ranking (which ranks importers by unmodelled distortion in their trade flows), one interesting feature is that for all but one model the EC is top - i.e. its imports are least well explained. The exception is 13.7, where the EC is ranked 2nd.

25. Analysing expected flow matrices and comparing with those of 13.1, models 13.7, 13.8 and 13.9 demonstrate that inclusion of constraints capturing non-commercial flows, credit sales and long-term agreements improve all round predictability, with no countries being consistently worse predicted by model 13.1. Models 13.12, 13.13 and 10.10 show that inclusion of constraints capturing Japanese import policy, Argentine-Peru trade and Soviet

imports improves the modelling of Japanese, Peruvian and Soviet imports, but has no consitent impact on other countries' trade flows.

26. The expected flows of model 13.10 reveal that the lower λ than the 13.1 λ in 1987/8 is explained by a better prediction of Egyptian imports from the EC and US in 13.10. As Egypt is an EEP-targetted country this suggests that the EEP is anti-distortionary with the main effect of countering EC protectionism.

27. In the first four years the geographical differentiation of restitutions had no effect on the pattern of trade. In 1987/8 restitutions caused distortions from observed flows to Cuban, Egyptian, Iranian and Korean imports, but redressed other distortion in Algeria, China, Mexico and particularly Morocco - i.e. the EC has some justification in claiming that additional subsidies to North Africa are in retaliation for the EEP. The effect on other countries is neutral.

The effect of the C.A.P. on Latin America

28. The research in this thesis was originally prompted by the question: what is the effect of the Common Agricultural Policy on Latin America? The question can now be answered by considering what trade flow patterns would have occured without C.A.P. We call this simulation model 13.14. The only long-term agreements between the EC and importers in the five year period 1983/4-1987/8 were with Egypt. None of the constraints to model these are binding - the flows predicted without the constraints are greater than the amounts specified in the agreements. However, some credit flow constraints (to Morocco and Cuba) and those representing restitutions are binding. Simulation of the unilateral removal of EC protectionism is obtained with their removal from 13.1. EC food aid is assumed not to be reduced, and so non-commercial flow constraints remain intact.

29. The radical nature of our counter-factual - the abolition of the C.A.P. - makes it appropriate to use the SWOPSIM elasticities introduced in chapter

10 (paragraph 6 ff) rather than the coefficients estimated in chapter 9 to represent price responsiveness. In other words, we assume that C.A.P. abolition is a sufficient departure from historical market conditions (the environment in which the chapter 9 coefficients were estimated) to affect import and export volumes. Accordingly, a 2-stage approach is employed with price responsiveness assumed (the first stage is not required in less radical simulations as we can assume countries to be non-price-responsive and national trade volumes fixed). The effect of liberalizing the C.A.P. on prices and national import and export totals is first calcuated using SWOPSIM elasticities and the PSE and CSE figures for the EC. The second stage of the model minimizes transport costs given these trade totals, and the remaining constraints of the full model bar EC credit and restitution constraints.

30. The 13.14 λ results, adjusted for volume changes, are shown in table 13.vii below, together with 13.1 λ values. The 13.14 λ values are significantly higher than those for models 13.7-13.13 and on average higher than 10.10 values. The effect of assumed liberalization is particularly marked in 1987/8.

Table 13.vii: Models 13.14* and 3.1 λ values

Year	13.14	13.1
1983/4	7.45	2.32
1984/5	7.27	2.62
1985/6	9.78	4.34
1986/7	8.71	3.66
1987/8	10.69	1.32
Average	8.78	2.85

* 13.14 values adjusted for volume changes (see chapter 10, paragraph 55)

31. The effect of C.A.P. liberalization on international price is shown in table 13.viii by comparing predicted prices with those observed. Prices predicted with global liberalization are also shown (from model 10.11). It can be seen that the price effect of the C.A.P. becomes significant from

1985/6 onwards, but that in 1987/8 the effect of the C.A.P. relative to the combined effect of other protectionist measures is less than in 1986/7.

Table 13.viii: Observed and liberalization prices

Year	Observed	EC Lib.	Global Lib.
1983/4	129	130	154
1984/5	125	125	141
1985/6	113	118	138
1986/7	89	100	137
1987/8	94	101	156

32. The effect of EC liberalization on export volumes is shown in table 13.ix, and on the import volumes of Latin American countries in 13.x. Argentine exports rise in the simulation by 0.6%, 0.2%, 2.7%, 7.5% and 4.7% for the five years. The percentage decreases in demand by the Latin American importers are all below 1% for 1983/4 and 1984/5; the highest percentage is that for Brazil in 1986/7 at 5.7%.

Table 13.ix: Changes in export supply with EC liberalization
('000 tonnes)

Year	Arg	Aus	Can	EC	USA
1983/4	+53	+85	+91	-507	+162
1984/5	+15	+40	+28	-199	+60
1985/6	+113	+501	+296	-1698	+374
1986/7	+283	+1316	+1041	-5033	+1218
1987/8	+166	+651	+755	-4016	+1547

Table 13.x: Changes in LA imports with EC liberalization
('000 tonnes)

Year	Bra	Chl	Cub	Mex	Per	Ven
1983/4	-21	-3	-7	-2	-3	-2
1984/5	-8	-1	-2	-1	-1	-1
1985/6	-51	-6	-24	-1	-13	-8
1986/7	-162	-6	-66	-17	-42	-28
1987/8	-74	-1	-44	-16	-25	-17

33. Lastly, comparing the expected flow matrices of 13.14 with those of 13.1 we can draw some conclusions about the spatial effects of C.A.P. liberalization on Latin America. Argentine exports would have been higher to India in 1983/4, to the EC in 1984/5, to Brazil and Chile in 1985/6, to the EC and Bangladesh in 1986/7 and to Cuba in 1987/8. However, they would have been lower to the EC in 1987/8 (because of increased US exports to the EC). The effect on Latin American importers is as follows. Cuban imports from the EC would have increased at the expense of Canada in 1984/5. In 1985/6 Brazil would have imported more from Argentina and less from the US, Chile more from Argentina and less from the EC and Cuba more from Canada and less from the EC. In 1987/8 Cuba would have imported more from Argentina and less from the EC. Otherwise the pattern of Latin American trade would have remained the same, except for some small volume changes.

PART III

Extensions and Conclusions

CHAPTER 14: EXTENSIONS AND A COMPARISON: THE CASE OF SOYA

1. The main purpose of this chapter is to demonstrate the flexibility and wider application of the spatial equilibrium model developed in Part II. This is done by first adding more countries to the the model already developed, and secondly by creating a similar linear programming model for international soya bean trade. By adding East European and Newly Industrialised Country (NIC) importers to the wheat model we can draw some conclusions about the effects of these increasingly important regions on the international wheat market. By building a model for international soya bean trade we can compare the degree of distortion in the wheat market with that in the soya market.

Increasing the number of countries in the wheat model

2. It is of interest to know in what ways the opening up of the economies of Eastern Europe may affect the international wheat market. It could, for example, enable significant distortion-creating policies in East European wheat trade to be dispensed with. Thus it is useful to analyse the nature of distortion in East European import patterns. The importing countries not already analysed that can be included are Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Romania and Yugoslavia. East European countries produce and export wheat as well as import it (although the region is a net importer). The most significant exporter is Hungary. However, whereas data on East European wheat imports exist for the 10 years of the chapter 8 wheat model (1978/9-1987/8), suitable IWC data on East European exports exist only for Hungary, and then only for the three years 1985/6, 1986/7 and 1987/8. Another problem is a lack of freight rate data from Hungary.

3. Another group of countries of particular interest to a medium-term view of the world economy are the Newly Industrialised Countries of South-East Asia (NICs). South Korea imports sufficient quantities of wheat to be already included in the basic model. The other S.E. Asian NICs are Hong Kong,

Singapore and Taiwan.

4. Model 14.1 includes no constraints to capture distortions. It simply repeats the basic model presented in chapter 8 with an additional 10 importers - the seven East European countries and three NICs mentioned above. Table 14.i presents the λ values for this model together with the corresponding results from the chapter 8 basic model:

Table 14.i: Model 14.1 and basic model λ values

	Model 14.1		Basic model	
Year	D4	D13	D4	D13
1978/9	18.52	26.95	17.72	27.57
1979/80	26.54	22.69	26.54	23.37
1980/1	17.63	13.85	17.13	14.31
1981/2	16.92	14.92	17.89	15.61
1982/3	34.09	25.13	34.14	25.97
1983/4	29.22	26.98	29.90	27.01
1984/5	28.09	25.54	28.17	26.03
1985/6	29.13	27.12	29.43	27.00
1986/7	29.63	30.92	28.82	30.49
1987/8	15.35	12.23	13.83	11.25
Average	24.51	22.63	24.36	22.86

5. Table 14.i shows that for five out of seven years up to 1984/5 (the exceptions being 1978/9 and 1980/1 using D4) there is less distortion (lower λ values) in model 14.1 than the basic model. In 1986/7 and 1987/8 the λ values indicate the opposite, and in 1985/6 the position is less clear. This pattern suggests that in the late 1980s distortions affecting Eastern European and NIC imports became more significant.

6. Comparing the flow matrices of model 14.1 with those of the basic model we can analyse the effect on other countries' import patterns of introducing Eastern European countries and NICs into the model. Four countries are perceptibly affected. Soviet and Japanese imports are slightly better predicted when Eastern European countries and NICs are introduced. Chinese and Egyptian imports are less well predicted.

7. Comparison between the observed and predicted trade flows of the newly added importing countries in model 14.1 also reveals that observed NIC imports (for Hong Kong, Singapore and Taiwan) are less than predicted from Australia, more on average than predicted from Canada, slightly more from the EC and a lot more from the US. There may be political reasons why these small countries wish to buy from the US. However, the seven new Eastern European countries also import less than predicted from Australia, more (on average) than predicted from the US and a lot more from Canada. On average they import slightly less than predicted from the EC.

8. Model 14.2 also includes a new exporter: Hungary. The data sets for the three years computed are those used in the full model in chapter 13: D13 for 1985/6 and 1986/7 and D4 for 1987/8. The λ results for the three years are 27.89, 32.56 and 15.95. These figures are greater than those corresponding in the basic model and model 14.1, suggesting significant distortion in Hungarian exports. Looking at the flow matrices, both observed and predicted Hungarian exports are mainly to Eastern Europe. The most significant point is that Hungarian exports to the USSR are not predicted.

9. It is useful to assess the degree to which these newly-included countries are price responsive. Thus, as in chapter 9, econometric techniques were used to determine whether domestic and international price are co-integrated (see chapter 9, footnote 3), and to build regression equations to explain national imports and exports. The results for importers are presented in tables 14.ii and 14.iii, together with Japan, Korea and the USSR (see chapter 9, paragraph 15 ff for the details of the techniques used).

10. The low R^2 values (for time series) shown in table 14.iii indicate that we are unable to explain import patterns particularly well with the chosen variables. Table 14.iv shows the signs of international price coefficients where international price does not drop out of the regression analysis. From this table it appears that for none of the newly-included importers is the level of imports determined by international price (price is insignificant as an explanatory variable or the coefficients have the wrong sign). It is thus not necessary to consider the magnitudes of the coefficients.

Table 14.ii: NIC and E. Europe importers: Local and international price co-integration results

Importer	Price Co-I
HGK	.
JAP	X
KOR	.
SIN	.
TAI	.
NIC	.
BUL	.
CZE	.
GDR	.
HUN	
POL	.
ROM	
USR	.
YUG	
EEUR	.

A dot . denotes no test possible. An X indicates that local and international price are co-integrated C(1).

Table 14.iii: NIC and E. Europe importers: regression results

Importer	Initial[a] variables	Final[b] vars.	Coefficient	Std. Error	t-value	Partial r^2	R^2	DW
HGK	I	I	.08	.39	.20	.002	.466	2.12
		I1	.11	.38	.29	.005		
		M1	.68	.19	3.54	.410		
		Const.	45.83	39.46	1.16	.070		
JAP	I,G,N,O, P,S,Y	I1	3.67	1.73	2.12	.200	.856	1.86
		O	-1.33	.22	-6.11	.675		
		P1	1.15	.21	5.55	.631		
		Const.	5139.74	195.69	26.26	.975		
KOR	I,N,O,S	I	-9.14	3.19	-2.87	.302	.760	1.43
		N1	229.74	30.29	7.58	.752		
		Const.	-5244.69	954.89	-5.49	.614		
SIN	No Import data							
TAI	I,O,S	M1	.62	.14	4.53	.507	.507	2.45
		Const.	267.98	89.98	2.98	.307		
NIC	I,O,S	I1	12.58	4.07	3.09	.374	.919	1.86
		M1	.73	.11	6.78	.742		
		O	-.53	.12	-4.54	.563		
		O1	.53	.11	4.94	.604		
		S1	-2.18	.30	-7.15	.762		
		Const.	928.63	470.54	1.97	.196		
BUL	No import data							
CZE	No import data							
GDR	I,O	M1	.60	.15	4.04	.462	.748	2.15
		O	-.32	.12	-2.68	.274		
		Const.	1370.82	483.44	2.83	.297		

Table 14.iii (continued): NIC and E. Europe importers: regression results

Importer	Initial[a] variables	Final[b] vars.	Coefficient	Std. Error	t-value	Partial r^2	R^2	DW
HUN	I,G,N,O,	N1	-577.09	122.57	-4.71	.649	.728	1.98
	P,Y	O1	.020	.006	3.47	.501		
		P	4.96	.90	5.52	.717		
		Y	-115.74	34.34	-3.37	.486		
		Y1	109.87	35.91	3.06	.438		
		Const.	5660.29	1215.62	4.66	.644		
POL	No import data							
ROM	I,B,N,O,	I1	3.07	1.23	2.49	.267	.646	2.19
	P,S	M1	.59	.15	3.83	.463		
		O	-.16	.04	-3.80	.459		
		S1	-.77	.34	-2.22	.225		
		Const.	757.38	241.62	3.13	.366		
USR	I,O,S	M1	.87	.10	9.02	.780	.800	2.23
		O	-.29	.06	-4.66	.486		
		O1	.29	.06	4.70	.490		
		S1	-.30	.10	-2.96	.276		
		Const.	2238.45	5246.81	.43	.008		
YUG	I,B,G,N,	I	5.12	1.49	3.43	.370	.500	2.16
	O,P,S,Y	O	-.30	.08	-3.58	.390		
		Const.	1406.35	424.60	3.312	.354		
EEUR	I,O,S	M1	.32	.18	1.79	.144	.513	1.75
		O	-.12	.03	-3.45	.385		
		Const.	7209.84	1646.09	4.38	.502		

key to variables

B	Balance of payments (MUS$)
C	Consumption of wheat ('000 tons)
G	GNP (GDP where not available) (MUS$)
I	International price (US$/ton)
M	Imports ('000 tons)
N	Population (millions)
O	Output of wheat ('000 tons)
P	Domestic Price (US$/ton)
S	Stocks of wheat ('000 tons)
X	Exports ('000 tons)
Y	GNP per capita (or GDP per capita) (US$)

notes

a The dependent variable is M. One period lags are included in addition to the variables listed.

b This list comprises the explanatory variables in the model, in addition to a constant, once all insignificant variables have been eliminated. As in the analysis in chapter 9, to make certain international price is not significant I and I1 may be re-introduced at several points in the elimination process. (One period lagged variables are represented by a 1 after the variable symbol, e.g. I1 is lagged international price.)

Table 14.iv: Signs of international price coefficients in regressions to explain imports

Importer	I	I1
JAP		+
KOR	-	
NIC		+
ROM		+
YUG	+	

11. Similar to tables 14.ii and 14.iii, tables 14.v and 14.vi show the co-integration and regression results for Eastern European exports. None of the final models include international price as an explanatory variable. This is consistent with the findings of chapter 9, concerning the lack of price responsiveness of imports and exports (but not route price responsiveness), and suggests that it is appropriate to continue to use a linear program.

Table 14.v: E. Europe exporters: local and international price co-integration results

Exporter	Price Co-I
HUN	
ROM	
USR	.
YUG	
EEUR	.

A dot . denotes no test possible. An X indicates that local and international price are co-integrated C(1).

12. A remarkable feature of table 14.vi is the R^2 value of 1 obtained for Hungarian exports. Statisticians are typically well advised to be suspicious of such a perfect fit. On closer inspection of the data it was discovered that the identity X+C=M+O holds for all years except 1987-89. Similarly the same identity was found to exist for the Romanian data for all years except 1981-88.

Table 14.vi: E. Europe exporters: regression results

Exporter	Initial[a] variables	Final[b] vars.	Coefficient	Std. Error	t-value	Partial r^2	R^2	DW
HUN	I,C,M,O,	C	-1.00	.00	-471.35	1.000	1.000	2.03
	P	C1	27.82	.28	100.73	.998		
		M	1.00	.01	141.36	.999		
		M1	-27.82	.28	-100.71	.998		
		O	1.00	.00	515.55	1.000		
		O1	-27.82	.28	-100.70	.998		
		X1	27.82	.28	100.95	.998		
		Const.	2.69	4.62	.58	.017		
ROM	I,C,M,O,	C	-1.02	.05	-20.33	.954	.979	1.88
	P,S	C1	-.99	.17	-5.77	.625		
		M	1.06	.08	12.55	.887		
		M1	.90	.15	6.14	.654		
		O	1.01	.04	22.36	.961		
		O1	.98	.16	6.13	.653		
		X1	-.98	.17	-5.72	.621		
		Const.	52.26	90.91	.57	.016		
USR	I,C,M,O,	C1	-.66	.16	-4.09	.432	.800	1.83
	S	M	-.19	.04	-4.33	.460		
		M1	.77	.20	3.86	.403		
		O1	.67	.16	4.09	.432		
		S1	-.66	.16	-4.08	.431		
		Const.	1206.23	1656.05	.73	.023		
YUG	I,C,M,O,	P	-4.22	.61	-6.93	.716	.763	1.52
	P,S	P1	4.63	.60	7.73	.759		
		Const.	29.25	59.11	.49	.013		
EEUR	I,C,M,O,	C	.40	.10	-3.89	.377	.847	1.94
	S	M	.34	.15	2.25	.169		
		O	.44	.09	4.74	.473		
		Const.	96.63	695.76	.14	.001		

key and notes as for table 14.iii
Imports (M) replaced by Exports (X) as dependant variable.

13. Having decided to continue to use a linear program we can now insert constraints to identify some protectionist policies. This is done in models 14.3 to 14.6. Models 14.3 and 14.4 include the 10 new importers but do not include Hungarian exports. Model 14.3 contains all the constraints featured in model 10.10, including constraints relevant to the new countries in the model - although data for creating such new constraints are limited, consisting predominantly of a few EEP sales. Thus constraints are imposed to reflect non-commercial flows, credit, long-term agreements, the EEP, EC restitutions, Japanese import policy and Argentine exports to Peru. Model 14.4 additionally includes a constraint on Soviet imports (as in model 13.1). Models 14.5 and 14.6 cover the three years 1985/6-1987/8. They are identical

to 14.3 and 14.4 respectively, except that Hungarian exports are now included. All four models 14.3-14.6 use the data sets selected by the full model 13.1: D4 for 1983/4,1984/5 and 1987/8 and D13 for 1985/6 and 1986/7.

14. Table 14.vii presents the λ results for the first two of these models, and compares these with the corresponding values for models 10.10 and 13.1. From the table it can be seen that λ has generally increased with the inclusion of the extra countries. This implies that unexplained distortion is greater than average for the new countries.

Table 14.vii: Models 14.3,10.10,14.4 and 13.1 λ values

	Model			
Year	14.3	10.10	14.4	13.1
1983/4	8.64	8.48	2.65	2.32
1984/5	9.78	7.93	3.14	2.62
1985/6	8.77	7.73	5.39	4.34
1986/7	10.81	9.76	4.99	3.66
1987/8	4.32	3.78	1.78	1.32
Average	8.46	7.54	3.59	2.85

15. Comparing the expected trade flow matrices of 14.3 and 10.10, the four importers whose trade patterns are chiefly affected by the inclusion of the Eastern European and East Asian countries are China and the USSR, and to a lesser extent Iran and Korea. The clearest difference is that Soviet imports are predicted less well with the new countries included. When Soviet imports are constrained to their observed quantities (model 14.4) λ is significantly reduced. Comparing the expected flows of 14.4 with those of 13.1 most difference occurs for China (as in 14.3), followed by Algeria and Korea and then the EC. Of these four countries, only Korea's flows are on average over the five years better predicted in model 14.4 than in model 13.1, and then not consistently over time. Comparing the trade flows of the newly included countries, model 14.4 predicts East European imports better than 14.3.

16. Table 14.viii presents the λ results for models 14.5 and 14.6 (the same

as 14.3 and 14.4 except with Hungarian exports). The λ values for model 14.5 are higher than the corresponding values for 14.3 and 10.10. However, although 14.6 values are higher than 13.1 values, they are slightly less than those for 14.4; though not significantly. Indeed, examination of the expected flow matrices reveal that there are a greater number of worse predictions than better ones in model 14.6 as compared with 14.4. We can conclude that Hungarian exports are more distorted than the global average as their inclusion raises λ.

Table 14.viii: Models 14.5 and 14.6 λ values and comparisons

	Model					
Year	14.5	14.3	10.10	14.6	14.4	13.1
1985/6	9.05	8.77	7.73	5.34	5.39	4.34
1986/7	11.41	10.81	9.76	4.90	4.99	3.66
1987/8	4.41	4.32	3.78	1.77	1.78	1.32

17. Prediction of Hungarian exports is fairly good in models 14.5 and 14.6, especially in the latter. However, no predictions of Hungarian sales outside Eastern Europe are made by either model. Two such sales were made in the three-year time period, one to the EC and the other to Pakistan.

18. The first conclusion we can draw from these efforts to extend the Part II model is that the basic predictive structure and conclusions presented in previous chapters remain unaltered. As indicated in table 14.i, model 14.1 is very similar to the basic model of chapter 8.

19. Secondly, we can attempt some inferences about distortions from simple competitive trade patterns in the new countries. We have not explained such distortions as well as for the original countries. Predicted flow patterns are not significantly altered simply by adding (or subtracting) constraints designed to capture protectionism in the newly-added countries, as we have limited data on the distortion-creating policies. Comparing models 14.3-14.6 with observed flows, we can deduce that most distortion in Hungarian exports

affects trade only within Eastern Europe. We could expect Hungary (assuming no decline in its total exports) to sell more to Algeria (the only non-regional importer predicted in model 14.1), and less to the USSR in a less distorted global market. In comparison, the differences between observed and predicted flow matrices for Eastern European importers varies from year to year to the extent that it is impossible to determine the effect of East European distortions on East European imports without more data. However, the analysis of model 14.1 tentatively suggests that targetted protectionism or some other geographically differentiated factors have the effect of reducing imports from the EC and Australia and increasing them from Canada. There is more clarity about NIC distortions. NIC imports are more oriented to the US than predicted. This may change in the future in Australia's favour if strategic and political reasons for favouring US exports diminish.

<u>A comparison: the case of soya</u>

20. A linear programming model for international soya bean trade was constructed in order to compare the degree of distortion in the international wheat and soya bean markets. The intention here is to try and build no more than a basic model similar to that for wheat presented in chapter 8. Again by way of comparison, this time with the results of chapter 9, a brief consideration of the price-responsiveness of soya bean importers and exporters is included at the end of the section.

21. The basic soya bean model covers the 7 largest exporters and 23 largest importers. US exports are dominant, accounting for between 70% and 90% of exports to the 23 importers modelled in the period 1978/9-1987/8. Freight rates are calculated on the same basis as in chapter 8. Table 14.ix presents the λ results of the basic model, and compares these to the results for wheat.

22. In most years the degree of distortion in the wheat market is significantly greater than in the soya bean market, the two exceptions being 1980/1 and 1987/8. In both cases this reflects below-average distortion in

Table 14.x: Observed and expected soya bean flows 1987/8 (D4)

('000 tons) (expected columns followed by observed)

	Exporters													
Importers	Argentina		Brazil		Canada		China		EC-10		Paraguay		USA	
Brazil	0	0	357	0	0	0	0	0	0	0	0	0	0	357
Canada	0	0	0	0	0	0	0	0	0	0	0	0	236	236
China	0	0	0	33	0	0	441	0	0	0	0	0	0	408
EC-10	0	605	0	1948	0	29	0	2	0	0	0	328	10614	7702
Colombia	0	0	0	0	0	0	0	0	0	0	0	0	178	178
Finland	0	13	152	20	0	0	0	0	0	1	0	3	0	115
Indonesia	287	0	0	0	0	0	0	238	0	0	0	0	0	49
Israel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jamaica	0	0	0	0	0	0	0	0	0	0	0	0	59	59
Japan	0	0	0	307	0	35	286	290	0	0	0	63	4509	4100
S. Korea	0	0	0	18	0	0	0	0	0	0	0	5	1107	1084
Malaysia	0	0	164	24	0	21	0	197	0	0	0	0	95	17
Mexico	0	19	0	25	0	0	0	0	0	0	0	0	1078	1034
Norway	0	30	0	36	0	0	0	0	0	0	0	3	319	250
Poland	44	0	0	44	0	0	0	0	0	0	0	0	0	0
Portugal	908	25	0	212	0	0	0	0	0	3	0	47	0	621
Romania	0	21	454	45	0	0	0	0	0	0	0	0	0	388
Spain	0	14	1899	456	0	63	0	0	0	2	887	431	0	1820
Switzerland	0	5	79	18	0	3	0	0	7	1	0	7	0	52
Taiwan	0	0	0	0	0	0	0	0	0	0	0	0	0	0
USSR	0	638	0	5	166	15	0	0	0	0	0	0	702	210
Venezuela	0	0	0	0	0	0	0	0	0	0	0	0	223	223
Yugoslavia	131	0	86	0	0	0	0	0	0	0	0	0	0	217

Table 14.ix: Soya bean and wheat basic model λ values

Year	Soya bean D4	Soya bean D13	Wheat D4	Wheat D13
1978/9	11.79	8.07	17.72	27.57
1979/80	19.88	15.11	26.54	23.37
1980/1	18.68	15.84	17.13	14.31
1981/2	15.93	13.61	17.89	15.61
1982/3	23.85	17.57	34.14	25.97
1983/4	11.29	18.31	29.90	27.01
1984/5	13.94	10.45	28.17	26.03
1985/6	20.51	13.41	29.43	27.00
1986/7	7.48	8.68	28.82	30.49
1987/8	14.64	11.55	13.83	11.25
Average	15.80	13.26	24.36	22.86

the wheat market rather than above-average distortion in the soya bean market. We may recall that this feature was noted in chapter 8, and is more probably due to some protectionist policies countering the distortionary effects of others rather than to any overall reduction in protectionism (which in any case would only be temporary). On average over the 10-year period, market distortion as measured by λ is 54% higher for wheat than for soya beans using D4, and 72% higher using D13.

23. An example of the observed and predicted flows in the soya bean model is presented in table 14.x. Observe that in the year shown, 1987/8, Israel and Taiwan import nothing and EC exports are very low. In any given year in the sample period (1978/9-1987/8) up to four of the included importers may import nothing. Four of the countries feature as both importers and exporters: Brazil, Canada, China and the EC. An obvious inaccuracy is the prediction of positive flows for Brazil-Brazil and China-China, which with fixed national import totals in the transportation model affect other predicted Brazilian and Chinese flows. Brazilian exports are poorly predicted to the EC. In fact, EC imports appear generally to be severely distorted. The flows of four countries with non-zero total imports (Canada, Colombia, Jamaica and Venezuela) are correctly predicted as all coming from the US. Generally US export predictions are good.

24. Although soya beans are more homogenous than wheat, they are highly substitutable with other commodities (viz. other oilseeds and feedgrains). As a result we might expect greater price responsiveness than for wheat. A complication is that soya beans yield two distinct products: soya cake and soya oil, each with a separate market. The price of soya beans is determined by the prices of these two products and crushing costs. Further, demands and supplies of soya beans are determined by soya cake, oil and bean prices in that processing can be carried out before or after shipment. As in chapter 9 co-integration tests were carried out and regression analysis used to measure responsiveness to international price. The results of this analysis are presented in tables 14.xi-14.xvi.

Table 14.xi: Soya bean local and international price co-integration results

Importer	Price Co-I	Exporter	Price Co-I
BRA		ARG	
CAN		BRA	
CHN		CAN	
COL		CHN	
EC	.	EC	
FIN	.	PAR	
IDO		USA	N/A
ISR	.		
JAM	.		
JAP	X		
KOR	X		
MAY			
MEX			
NOR	.		
POL	.		
POR	.		
ROM			
SPA	X		
SWI	.		
TAI	.		
USR	.		
VEN			
YUG			

A dot . denotes no test possible. An X indicates that local and international price are co-integrated C(1).

Table 14.xii: Soya bean importers: regression results

Importer	Initial[a] variables	Final[b] vars.	Coefficient	Std. Error	t-value	Partial r^2	R^2	DW
BRA	I,IC,IO,	I	-3.88	1.24	-3.14	.354	.731	1.75
	B,N,P	IC1	9864.79	1594.42	6.19	.680		
		IO	-1441.26	477.15	-3.02	.336		
		B	-3.88	1.46	-2.66	.282		
		Const.	-218.94	135.58	-1.62	.126		
CAN	I,IC,IO,	IC1	1490.27	415.96	3.58	.368	.659	2.08
	G,N,P,Y	M1	.28	.16	1.65	.110		
		N	-61.90	13.39	-4.62	.493		
		Const.	1413.62	283.32	4.99	.531		
CHN	I,IC,IO,	I	-.87	4.29	-.20	.008	.398	1.96
	P	I1	2.88	6.52	.44	.038		
		IC	-5654.72	9931.89	-.57	.061		
		IC1	4249.99	6614.70	.64	.076		
		IO	-1428.44	1874.01	-.76	.104		
		IO1	-786.20	1123.88	-.70	.089		
		P	7.69	6.26	1.23	.232		
		P1	-5.35	5.25	-1.02	.172		
		Const.	907.92	1770.43	.51	.050		
COL	I,IC,IO,	I1	-.50	.18	-2.71	.328	.731	2.05
	G,N,P,Y	N	20.55	3.22	6.38	.731		
		Const.	-376.06	76.01	-4.95	.620		
EC	I,IC,IO	M1	.90	.06	14.08	.892	.892	2.23
		Const.	960.55	531.42	1.81	.120		
FIN	I,IC,IO,	I1	-1.14	.22	-5.12	.607	.845	2.14
	G,N,Y	IC	669.33	165.96	4.03	.489		
		IO	247.21	56.36	4.39	.531		
		M1	.91	.18	4.96	.591		
		Const.	-16.41	13.81	-1.19	.077		
IDO	I,IC,IO,	M1	.57	.13	4.45	.474	.819	2.28
	G,N,P,Y	Y	-1205.40	425.34	-2.83	.267		
		Y1	1524.87	434.46	3.51	.359		
		Const.	11.92	18.65	.64	.018		
ISR	I,IC,IO,	IO	401.94	129.31	3.11	.279	.279	1.23
	N	Const.	135.35	62.79	2.15	.157		
JAM	I,IC,IO,	M1	.51	.18	2.87	.247	.624	2.03
	G,N,Y	N1	50.10	26.80	1.87	.123		
		Const.	-85.96	50.24	-1.71	.105		
JAP	I,IC,IO,	IC1	-5337.46	1717.02	-3.11	.305	.969	1.97
	B,G,N,P,Y	G	-.37	.17	-2.22	.183		
		N	189.88	19.04	9.97	.819		
		Const.	-16377.87	1792.97	-9.13	.791		
KOR	I,IC,IO,	M1	1.03	.04	23.49	.958	.958	1.49
	B,N,P	Const.	26.65	19.38	1.37	.073		
MAY	I,IC,IO,	I1	-.55	.18	-3.09	.335	.846	2.03
	G,N,P,Y	Y1	1.71	.19	9.15	.815		
		Const.	18.39	25.54	.72	.027		
MEX	I,IC,IO,	G	111.04	33.26	3.34	.336	.785	2.11
	G,N,P,Y	Y	-12486.06	4050.28	-3.08	.302		
		Const.	309.13	204.91	1.51	.094		
NOR	I,IC,IO,	I1	.81	.24	3.36	.386	.645	1.48
	N	N	4265.14	1869.64	2.28	.224		
		N1	-4024.75	1806.66	-2.23	.216		
		Const.	-941.98	513.31	-1.83	.158		
POL	I,IC,IO,	I	1.18	.27	4.37	.577	.762	2.09
	N	I1	-.91	.40	-2.23	.263		
		IC1	1131.42	503.61	2.25	.265		
		M1	.44	.18	2.39	.290		
		N	-680.41	281.54	-2.42	.294		
		N1	648.55	277.66	2.34	.280		
		Const.	1095.45	345.80	3.17	.417		

Table 14.xii (continued): Soya bean importers: regression results

Importer	Initial[a] variables	Final[b] vars.	Coefficient	Std. Error	t-value	Partial r^2	R^2	DW
POR	I,IC,IO,	M1	.91	.09	10.31	.855	.855	1.50
	G,N,Y	Const.	53.16	38.75	1.37	.095		
ROM	I,IC,IO,	IO	-374.81	150.62	-2.49	.246	.795	1.83
	B,N,P	P	-.73	.23	-3.08	.333		
		N1	130.37	18.36	7.10	.726		
		Const.	-2269.73	340.81	-6.66	.700		
SPA	I,IC,IO,	I	3.56	1.67	2.13	.185	.815	2.03
	G,N,P,Y	M1	.63	.12	5.15	.570		
		Const.	72.53	239.06	.30	.005		
SWI	I,IC,IO,	M1	.94	.07	13.44	.883	.883	2.17
	G,N,Y	Const.	5.36	4.13	1.30	.066		
TAI	I,IC,IO	M1	.97	.08	12.70	.885	.885	2.79
		Const.	82.92	58.59	1.41	.087		
USR	I,IC,IO	IC	7627.66	1410.99	5.41	.594	.852	1.94
		IO	-2220.32	553.58	-4.01	.446		
		IO1	2638.36	476.51	5.54	.605		
		Const.	-789.13	131.78	-4.48	.501		
VEN	I,IC,IO,	I	-.25	.12	-2.02	.185	.811	2.54
	B,G,N,P,Y	B	.005	.002	2.72	.291		
		G	-3.03	.72	-4.17	.492		
		N1	35.40	4.92	7.19	.742		
		Const.	-234.58	45.29	-5.18	.598		
YUG	I,IC,IO,	M1	.25	.21	1.18	.096	.890	1.95
	B,G,N,P,Y	G1	143.52	40.74	3.52	.488		
		Y1	-1538.90	436.79	-3.52	.488		
		Const.	190.61	57.67	3.30	.457		

key to variables

B	Balance of payments (MUS$)
G	GNP (GDP where not available) (MUS$)
I	International price of soya beans (US$/ton)
IC	International price of soya cake (US$/ton)
IO	International price of soya oil (US$/ton)
M	Imports ('000 tons)
N	Population (millions)
P	Domestic Price (US$/ton)
Y	GNP per capita (or GDP per capita) (US$)

notes

a The dependent variable is M. In addition to the possible explanatory variables listed here are all one period lags.

b This list consists of explanatory variables in the model, in addition to a constant, once all insignificant variables have been eliminated. Prices may be re-introduced at several points in the elimination process.

25. Table 14.xi records that the domestic soya bean price was found to be co-integrated (see chapter 9, footnote 3) with international (US) price for only three importers (Japan, Korea and Spain), and for no (non-US) exporters.

Table 14.xiii: Soya bean exporters: regression results

Importer	Initial[a] variables	Final[b] vars.	Coefficient	Std. Error	t-value	Partial r^2	R^2	DW
ARG	I,P,PC,PO	None						
BRA	I,P,PC,PO	I	109.86	80.01	1.37	.105	.4831	2.02
		I1	85.09	107.29	.79	.038		
		P	-93859.73	89988.46	-1.04	.064		
		P1	-38431.34	72881.26	-.53	.017		
		Const.	-2118.99	7200.69	-.29	.005		
CAN	I,P,PC,PO	X1	.96	.13	7.10	.668	.669	2.32
		Const.	8220.43	11440.34	.72	.020		
CHN	I,P,PC	I	-.98	.33	-2.95	.303	.866	2.17
		X1	.61	.11	5.35	.589		
		Const.	278.61	90.40	3.08	.322		
EC	I,P,PC,PO	I	1.17	.31	3.78	.405	.405	1.30
		Const.	-80.36	60.90	-1.32	.077		
PAR	I,P,PC,PO	X1	1.16	.08	14.87	.898	.898	3.04
		Const.	13.44	26.84	.50	.010		
USA	I	I	-37.76	16.44	-2.30	.227	.864	2.15
		I1	70.46	14.89	4.73	.554		
		X1	.60	.12	4.94	.576		
		Const.	1681.79	1937.99	.87	.040		

key and notes as for table 14.xii
Imports (M) replaced by Exports (X) as dependant variable.

Table 14.xiv: Signs of international price coefficients in regressions to explain soya bean imports

Importer	I	I1	IC	IC1	IO	IO1
BRA	-			+	-	
CAN				+		
COL		-				
FIN		-	+		+	
JAP				-		
MAY		-				
NOR		+				
POL	+	-		+		
ROM					-	
SPA	+					
USR			+		-	+
VEN	-					

Data series used for the regression analyses were, unfortunately, even shorter than wheat series, reducing our confidence in the regression results presented. In any event, the explanatory power of some of the equations can be seen to be quitepoor, as witness the generally low R^2 values (especially for Canada, China, Israel, Jamaica and Norway). Tables 14.xiv and 14.xv summarize the signs of price coefficients for importers and exporters respectively. Table 14.xvi records the coefficients of those countries which are candidates for a direct relationship between the international soya bean price, or cake price or oil price and soya bean demand or supply (others have been eliminated as price is insignificant as an explanatory variable or the coefficients have the wrong sign).

Table 14.xv: Signs of international price coefficients in regressions to explain soya bean exports

Exporter	I	I1
CHN	-	
EC	+	
USA	-	+

Table 14.xvi: Coefficients showing price responsiveness

Country	Importer(M) Exporter(X)	Coefficient	t-value
BRA	M	-3.88*	-3.14
COL	M	-0.496	-2.71
FIN	M	-1.14	-5.12
MAY	M	-0.552	-3.09
POL	M	-0.906	-2.23
VEN	M	-0.250	-2.02
EC	X	1.17	3.78
USA	X	70.46	4.73

* This coefficient is for soya beans not soya oil, which in the case of Brazil is also significant.

26. The majority of countries modelled are not included in table 14.xiii and are assumed to be not significantly price-responsive. The conclusion we

can draw from this analysis is that a similar proportion of importers and exporters of soya beans are non-price-responsive to international soya bean price as wheat importers and exporters are to wheat price. Five out of nineteen wheat importers were found to be price-responsive, and one exporter out of five (see table 9.vii). This compares with six out of twenty three importers and two out of seven exporters for soya beans. The only importer found to be price responsive in both markets is Venezuela. The United States is similarly price responsive in both markets as an exporter (which is less surprising as US price is used in both cases as the international price). However, it is also observed from table 14.xi that three importers (Japan, Romania and the USSR) are responsive to either cake or oil price but not bean price.

CHAPTER 15: THESIS FINDINGS AND CONCLUSIONS

A critique of the methodology used

1. In the international wheat market, as in other international agricultural commodity markets, price changes affect spatial flow patterns more than aggregate national trade volumes. Also, there are few easily identifiable econometric relationships between prices and quantities demanded and supplied. In any case, it is not possible to measure price relationships accurately with the help of time series data, because of the protectionist influences to which agricultural commodity trade has long been subject.

2. Along with imperfect international price transmission caused principally by government intervention, several other factors cause distortion from the textbook supply-demand framework. These are rigidities of flow patterns over time (e.g. as a result of political ties, strategic considerations or importer preferences); imperfectly competitive freight markets; stock management; structural changes in demand patterns (such as changes in feed demand for wheat); the immobility of factors of production; and supply irreversibilities (planting occuring months before harvest and shipment).

3. As a result, price relationships are less prominent and identifiable than those searched for by simple regression analysis. Orcutt's (1950) list of reasons why elasticities may be under-estimated, and Magee's (1970) list why they might be over-estimated together help explain why estimates of the same elasticity may vary widely (see chapter 2, paragraph 11). Certain protectionist measures in particular may frustrate attempts to measure demand and supply elasticities. A leading motivation for protectionist policy is normally to reduce domestic price volatility (which may in turn reduce the responsiveness of producers and consumers to international price), and protectionist policies themselves may be adjusted in response to international price movements (as are the EC's variable levies) to achieve this.

4. In addition to an absence of price transmission, international agricultural commodity markets also often lack a single international price. This has effectively been the case even for wheat (a relatively well-developed market) since the birth of the US Export Enhancement Program (EEP) in 1985.

5. In the context of the foregoing characteristics of agricultural commodity markets, spatial equilibrium modelling was chosen as the means of studying the international wheat market. The spatial approach has in the past been criticised for various shortcomings, some of which have been overcome in the present study.

6. The first criticism, which also applies to most non-spatial equilibrium and econometric approaches, is that general equilibrium effects are not modelled. The second is that with countries' import and export volumes exogenous, the model is of limited value for forecasting. However, it is precisely the difficulty of predicting these volumes (from price and other variables) which has, in part, led to the choice of technique. Were such volumes more predictable (and insofar as they are predictable) a two-stage linear programme or a non-linear programme could (can) be used for forecasting. The principal use of the linear model is in understanding the historical wheat market and in analysing the effects of policy change. It remains true that price effects of policy change cannot be captured in a simple linear model - a two-stage or non-linear model is necessary for this.

7. Thirdly, spatial equilibrium modelling is less able than econometrics to take into account historical and political ties, and the costs to importers of switching exporters. On the other hand, the "automatic" modelling of historical and political ties implicit in time series econometric analysis may hide them from the modeller. Such ties are not obscured from the researcher using spatial equilibrium modelling, since they are manifested as departures of observed flows from the expected flow matrix. A historical trend can be observed as a repeated difference between observed and expected flows on a particular route. For example, Argentina's concessionary exports to Peru were highlighted in this way (see chapter 10,

paragraph 52).

8. Fourthly, Thompson (1981) identifies four types of behaviour presenting problems for spatial price equilibrium models: product heterogeneity; harvests that occur at varying times of year; quotas on trade flows imposed by importers; and the diversification by importers to spread risks. Devices to model all four of these types of behaviour have been discussed in this thesis. In addition, it has been suggested how strategic behaviour could be incorporated using game theory.

9. Fifthly, Thompson (1981) also comments on all international agricultural trade models that "the generally weak empirical content [is] the principle deficiency of all the trade models reviewed". In other words, the empirical problems faced in this thesis are also experienced by researchers using other methodologies. Thus, data deficiency and (in modelling heterogeneity) mis-specification have been major problems for this research; but they do not necessarily lessen the attractiveness of the methodology, because the same problems are faced using other approaches.

10. Sixthly, the lambda statistic λ can be criticised for being a defective indicator of inefficiency in an international market, and also of being difficult to interpret. It is recognised that a single value of λ is not of analytical use on its own. However, it is useful in comparison with other values and also in concert with other statistics and analytical techniques employed throughout the thesis. It needs therefore to be interpreted carefully and with reference to other figures, in particular predicted and observed flow matrices. One weakness is that λ is not able to pick up changes in flows which are associated with small or zero changes in total transport cost. However, this is not a defect if what is being sought is a measure of market efficiency and not an explanation of observed flows.

11. Seventhly, spatial equilibrium modelling is open to the criticism that constraints are added simply to eliminate failures of explanation. This is particularly the case when quantity constraints are added. By forcing a predicted flow to equal some or all of an observed flow, λ is normally

reduced whether or not there is justification for the constraint. Because of this feature care needs to be taken to ensure that constraints are meaningful and justified.

12. Lastly, there are limited numbers of countries in the models of this thesis (24 in the basic wheat model, 34 in the extended wheat model of chapter 14; 30 in the soya model). However, the trade of all other countries is far less significant in volume terms, and their inclusion is not expected to change the main conclusions significantly. In any event, the adding of countries of interest (as in chapter 14) is always possible. Many previous studies have included the entire world, but at the cost of modelling regions rather than individual countries - an approach open to criticism considering the lack of homogeneity between countries of the same region found in this study. As price elasticities are not generally used in the models developed in this thesis (and world price is not determined simultaneously with global trade volume) the inclusion of a 'rest-of-the-world' region is not seen as a necessity (and was not included).

13. So much for various criticisms. The methodology used also offers a number of distinct advantages. Firstly, focus on the spatial aspects of international trade (the alternative being to model countries' overall trade balances) is a significant advantage. As mentioned above, price changes in the wheat market (including those initiated by protectionist policies) have more significant spatial than volume effects.

14. Secondly, the non-mechanistic character of the approach (theoretical analysis at each stage of model building being possible)and the spatial nature of the model provides transparency of the modelling operation. This transparency assists the researcher in the analysis of causality. Particularly useful is the constant monitoring of the model as it is being built.

15. Thirdly, flexibility is provided. Constraints may readily be added or removed, and so may countries.

16. Fourthly, the model does not depend on elasticity estimates of questionable appropriateness. EC wheat output seems quite independent of world market conditions, and for many other countries the responsiveness to international price of imports and exports is not significant. The distortions in agricultural commodity market make price relationships difficult to measure and estimates inaccurate.

17. Fifthly, the spatial nature of the model allows for more realistic inclusion of constraints to model non-price-responsive variables - in particular geographically differentiated protectionist instruments. If for whatever reason f.o.b. prices vary across space, the resulting non-minimization of global transport costs is picked up by λ.

18. Sixthly, although a usable game-theoretic model was not parameterised, it was shown in chapter 12 how reaction functions capturing US and EC strategic behaviour could be incorporated into a spatial equilibrium model. The advantage of a spatial model in this context is that targeted markets and non-targeted markets can be differentiated, and geographically differentiated levels of export subsidy included.

19. Validation of the models has been carried out in previous chapters by three methods (see in particular chapters 8, 10 and 13). Firstly, using different data sets and then observing differences in model results (expected flow matrices and 'data set variation' statistics) provided sensitivity analyses. Secondly, the marginal transport cost matrices produced by the mathematical programs were analysed to investigate specific flows and to provide more general measures of the sensitivity of models by constructing and analysing 'sensitivity matrices'. Thirdly, the expected flow matrices were compared with the observed flow matrices to locate comparative errors.

The international wheat market: findings

20. Having appraised the merits and limitations of the methodology, we now

summarize the main findings concerning the international wheat market. The first conclusion is that distortion in the wheat market causes total transport costs to exceed the level that would prevail in a perfectly competitive homogenous product market without seasonal supply and demand variations (i.e. what we have been referring to as competitive equilibrium) by some 23% - 25% over the period 1978/9 to 1987/8. The figure varies from year to year due to changes in distortion levels and in supply and demand. Total distortion declines in 1980/1 and 1987/8.

21. The 2-stage model presented in chapter 10 using SWOPSIM elasticities shows that when price effects on national import demand and export supply totals are taken into account, the level of distortion in 'competitive equilibrium' is much the same as in the chapter 8 basic model which did not take such price effects into consideration.

22. In chapter 9 price responsiveness was estimated for importers and exporters. Bangladeshi, Chinese and EC imports appear to have a one-year lagged response to international (US) price. Only Korean and Venezuelan imports appear to be responsive to current prices (the relationship for Korea being in some doubt). Of the exporters, only US trade was found dependent on US price. Where possible responsiveness to US price was found (even though not significant), it was usually to the undeflated US dollar price. Two exceptions to this were imports to Cuba (which is subject to a US embargo for most tradable goods) and to Bangladesh. The former were responsive to US price adjusted for fluctuations in the dollar. The latter were responsive to wheat purchasing power (US price adjusted for dollar fluctuations and deflated) - possibly a reflection of US policy to give away food aid when the purchasing power of wheat is low.

23. In chapters 10, 11 and 13 constraints were added to the basic model to capture protectionism, wheat heterogeneity and seasonality. In this way two full models were developed in chapter 13 - one (13.2) which included constraints to capture protectionism, heterogeneity and seasonality, and one (because of the poor performance of the heterogeneity and seasonality constraints) with constraints to capture protectionism only (13.1).

Concerning the effects of protectionism, model 10.10 constraints reflecting non-commercial flows, credit sales, long-term agreements, EEP sales, EC restitutions, Japanese purchasing power and Argentine concessionary sales to Peru in the five years 1983/4 to 1987/8, explained between 68% and 72% (depending on the year) of the distortion identified in the basic model. Of the distortion remaining an average of 62% is identified with the trade of the USSR. These Soviet flows were constrained to the observed levels for the full models (13.1 and 13.2). The number of large differences between expected and observed flows was significantly greater in the last of the five years of the full model, 1987/8, indicating greater unmodelled distortions.

24. By subtracting constraints or sets of constraints one at a time from a full model (subtracting from the full model each time) partial analyses of their relative importance is obtained. In other words, we can gauge what the wheat market would be like without the behaviour captured by each particular constraint. In this way protectionism was found to be more significant than heterogeneity or seasonality. Removing protectionist constraints from model 13.2 increased λ from about zero to an average of 8.48, whereas the subtraction of heterogeneity and seasonality constraints together raised λ only to an average of 2.85. Even so, the constraints modelling protectionism under-estimate rather than over-estimate the effects of protectionism. This is because the degree of overlap of different protectionist policies (such as EEP and US credit programs) was assumed greater than that which exists (necessitated by a lack of data on overlaps).

25. The effect of protectionism on prices and national import and export volumes was examined in chapter 10 with the aid of a 2-stage linear model incorporating USDA's SWOPSIM elasticities (see chapter 10, paragraphs 7 and 53 ff). This suggested that the dramatic fall in world price in the 1980s was largely attributable to the increase in protectionism. One interesting result is that the EC would have exported slightly more with global liberalization in 1983/4 and 1984/5 (in the three later years modelled EC exports are far less than observed).

26. Subtracting constraints from the full model 13.1 was a method of policy

simulation of various specific types of trade liberalization (i.e. removal of protectionist supports). The group of protectionist policies with the greatest distortionary impact was found to be credit (offered mostly by Canada and the US). Non-commercial flows were found to be next in importance, then long-term agreements, EC restitutions and lastly the EEP.

27. In 1987/8 the EEP was found to be anti-distortionary in that it countered EC protectionism in trade with Egypt. EC restitutions, on the other hand, are not normally geographically differentiated, and had no impact on the pattern of flows between 1983/4 and 1986/7. In 1987/8, although mostly distortionary, EC restitutions seem anti-distortionary in some countries, notably Morocco (probably countering the EEP).

28. Turning to distortions specific to individual importers, the least-well explained trade pattern in the full model is that of the EC, which both as an importer and as an exporter seems more isolated from international market conditions than any other country. The USSR, the largest importer, is also difficult to model and is an important source of unexplained distortion. Constraining Soviet imports to those observed model 10.10 λ values are decreased by an average of 62% (the adding of such constraints to 10.10 yields the full model 13.1). The difficulty in predicting USSR and EC imports may be related: when Soviet imports are constrained to observed levels, EC imports are predicted better.

29. Japan has a clear and identifiable import policy - to import from the US, Canada and Australia in roughly the same proportions every year. Partial analysis from the full model indicates that this policy is more distortionary to trade patterns than the EEP.

30. Another worthwhile discovery is that the US embargo on Cuba, despite spatial proximity, appears to be non-binding because of concessions extended by other exporters. In other words, the lifting of the US embargo (provided the policies of other exporters did not change) would be expected to result in no change to Cuban import patterns. It is possible that voluntary withdrawal of the US from the market has encouraged other exporters to

compete more vigorously. By the same token, however, the lifting of the US embargo might cause other exporters to reduce concessions offered to Cuba, thus making US sales more likely.

31. Difficulty has been encountered in modelling wheat heterogeneity because of poor data on preferences and trade by type of wheat and because of mis-specification of utility functions. Examination of expected flow matrices suggests that the heterogeneity constraints are not accurate - imports of countries modelled in greater detail to reflect wheat preferences are not necessarily better predicted. However, some behaviour is fairly well predicted, such as Mexican and Chilean imports. Notwithstanding these difficulties, heterogeneity seems clearly less important in affecting trade patterns than protectionism, but more important than seasonality. Seasonality is better specified than heterogeneity, but its importance appears to be small. One apparent feature discovered is that protectionism to some extent counters the spatial effects of seasonality in 1986/7 and a combination of seasonality and heterogeneity in 1987/8. Another feature is that when protectionist constraints are excluded from the full model (13.2), the heterogeneity and seasonality constraints remaining nevertheless reduce the basic model λ by 67%. This feature is likely to be due in part to the fact that preferences for wheat reported in the IWC questionnaire reflected types and quantities of wheat actually imported, and hence influenced by protectionist measures, rather than true underlying tastes.

32. The modelling of strategic behaviour with a game-theoretic framework (iteratively solved in a spatial equilibrium model) was discussed, and a formulation of EC and US reaction curves presented. Such an approach gives added insight into protectionist policies and could make the spatial equilibrium framework more powerful as a policy simulation and forecasting tool.

33. The original motivation of the research was to try to assess the impact of the C.A.P. on Latin America. Analysis is hampered by the small scale of EC-Latin American trade, as well as the lack of freight data for Chile and Cuba and the scarcity of freight rates to Peru. Nevertheless, some additional

relevant conclusions for Latin America (not already mentioned above) were reached. Firstly, the full model over-predicts Argentine exports to the EC. This may be explained by EC consumer preferences for North American wheat. Secondly, whereas in the competitive equilibrium environment of the chapter 8 basic model 'exporter sensitivity' was highest for Canada, in the full model Argentina holds this position. In other words, small changes in freight rates or protectionist policies are on average likely to benefit Argentine exports more than those of other countries, and Argentina has more to gain than other exporters from partial liberalization of wheat trade.

34. Thirdly, the 2-stage model simulating C.A.P. wheat liberalization in chapter 13 (model 13.14) yields several conclusions. The effect on Latin America (and elsewhere) is limited in 1983/4 and 1984/5 but more significant in the next three years. The effect peaks in 1986/7, with Argentine exports increasing under liberalization by 7.5%. The reduction in Latin American imports caused by higher global prices is less pronounced, the largest effect being to reduce Brazilian imports by 5.7%, again in 1986/7. No consistent change in Latin American import patterns are recorded, apart from a general shift from EC to Argentine (and Canadian) supplies.

35. In chapter 14 NICs and Eastern European countries were added to the analysis. None of the new countries are price-responsive. Their trade patterns are on average more distorted than those of the original countries. Turning first to the three NIC importers added to the model - Hong Kong, Singapore and Taiwan - more imports were predicted than observed from Australia and less from the EC and the US. With liberalization and a lessening of political dependence on the United States, we would expect these NICs to import more from Australia at the expense of the US.

36. On the assumption of competitive equilibrium the addition of East European importers increases the predictability of Soviet imports (and also Japanese imports); but in the full model Soviet trade is worse predicted. Imports to the rest of Eastern European are predicted more from the EC and Australia than observed, and less from Canada, indicating possible export gains from East European liberalization for the EC and Australia.

Liberalization in Eastern Europe would also have affected Hungarian exports in 1985/6-1987/8. Assuming total Hungarian export volumes unchanged, we would still expect the majority of Hungarian exports to go to other Eastern European countries. However, no sales to the Soviet Union are predicted, and occasional sales to Algeria are.

37. A comparison was undertaken between the international soya bean and wheat markets. Distortion from competitive trade flows was found significantly more severe in wheat than in soya beans, with average transport costs over 10 years between 54% and 72% higher. Two other conclusions from the brief study made of the soya market are that EC imports are heavily distorted, and that a similar proportion of countries are price-responsive to international soya bean price as countries are to wheat price in the wheat market. However, soya bean demands and supplies are also influenced by soya cake and oil prices as well as prices of substitute oilseed and feedgrain products.

38. Lack of freight data has been a problem in this research. Regression-estimated rates were finally chosen to fill in gaps in freight matrices, but doubts about their accuracy remain. One interesting discovery is that distance data tend to explain large flows relatively well. This may be a reflection of a more competitive freight market on major routes. Other data deficiencies include data on trade by wheat type, data on preferences for wheat types, seasonal trade data, and data on the overlap between various export subsidies and credits.

Conclusion: protectionism in the international wheat market

39. Using the data sets finally selected for the years 1983/4 - 1987/8 (D4 for 1983/4, 84/5, 87/8, and D13 for 85/6, 86/7) observed transport costs were 26% greater than would have been the case in a perfectly competitive market. Of this figure, 23% was explained by protectionism (including distortions to Soviet imports). A rough calculation using the observed US prices reported in table 10.xii can be made to gauge the significance of this relative to total

wheat import costs: the observed transport costs ascribed to protectionism divided by the sum of countries' wheat import bills, $X.T^{o}/P.V$ (where X is the percentage of observed transport costs ascribed to protectionism, and P is the US price), has an average over the five years 83/4 - 87/8 of 3.3 per cent.

40. This figure may not seem particularly high. It is dwarfed by the price changes estimated using the SWOPSIM elasticities (see table 10.xii). However, a more dramatic figure is that on average, over the five years, only 32% of the volume of total non-durum trade which occurred between the countries under investigation was unaffected by protectionism. In other words, an average of 68% of trade which occurred was routed differently in the spatial matrix of flows as a result of protectionism. (This figure was calculated by comparing the non-durum flows from models 13.1 with those of the chapter 8 model.) Protectionism thus not only alters the quantity of wheat traded, but also drastically changes the pattern of trade.

41. This gives strength to the argument that protectionism has a major impact on world wheat trade not fully captured by investigating import and export totals and prices alone. Quantification of the costs of protectionism is difficult. The contribution of this thesis is that it sheds light on the extent of spatial distortions. This is a significant addition to the contribution furnished by non-spatial models which only analyze countries' total import and export volumes.

Further research

42. In addition to the data shortcomings just mentioned, possible extensions to the research concern mostly the product range and forecasting. Domestic export supply and import demand equations could be included, possibly on a seasonal basis, to aid forecasting power. Also, estimation of credit premiums (i.e. the price changes which would leave importers and exporters just content with loss of special credit terms) would be useful.

43. The development of game-theoretic reaction curves in spatial equilibrium models is a promising area of research. Problems arise in assessing government motivations, which may be constantly changing and affected by various sorts of political lobbying. Rent-seeking and economy-wide effects of protectionism could usefully be taken into account. Additional possible developments from the reaction curves presented in chapter 12 are the inclusion of motivations for food aid, differentiation between various protectionist measures, and the endogenous specification of target countries. Also, more game players could be included: more countries but also private grain traders and ship owners.

44. The methodology used in this research can be used for products apart from wheat. It could also be extended to a multi-commodity framework, using substitution elasticities. Durum wheat could be added to the existing model, and/or soya and beef (which both have specific technological and economic relationships with wheat). A fully comprehensive analysis of the effect of the C.A.P. on Latin America would also cover sugar and the food processing industry.

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