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Does Arbitraging Matter?
Spatial Trade and Discriminatory Trade Policies

by

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Executive summary

Does Arbitraging Matter?
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When modeling discriminatory trade policies -- such as targeted embargoes, selective quotas, targeted export or import subsidies, or preferential trading agreements -- failure to explicitly include assumptions about arbitraging behavior may yield to misleading results.

Quadratic programming (QP), Non Linear Programming (NLP), and Vector Sandwich (VS) models *implicitly* set the rules regarding the possibility of simultaneous exporting and importing. The result is that many analysis using these models may lead to poor results because the models contain implicit limits on arbitraging which may be at variance with the actual policies and/or country behavior.

The paper introduces an alternative spatial model. Its main features are that countries are allowed to switch from one side of the market to the other as prices change, and that the researcher is allowed to *explicitly* incorporate her own assumptions about arbitraging and/or obtain different possible solutions as a function of different policy constraints or different levels of effectiveness in enforcing such constraints. Two numerical examples, one addressing the 1980 US embargo to USSR, the other, constructed, involving preferential trading, show how the results obtained using the proposed model compare with those obtained by applying the most frequently used spatial trade models.

Key words: Trade, spatial models, arbitraging, discriminatory trade policy, embargo, preferential tariff.

Does Arbitraging Matter? Spatial Trade Models and Discriminatory Trade Policies*

Failure to explicitly include assumptions about arbitraging behavior causes traditional spatial trade models to yield misleading results. The issue becomes important when economists attempt to model discriminatory national trade policies intended to benefit friends and/or punish enemies. Examples of such policies abound in the real world such as GSP preferences, Lome' Convention preferences, targeted export subsidies, PL 480, selective quotas and targeted embargoes. These policy approaches necessarily create multiple prices and generate possibilities to simultaneously export and import to take advantage of price spreads. Almost all of these discriminatory trade policies, frequently pursued by developed countries, attempt to prohibit arbitraging by targeted countries. Yet most frequently used trade models do not explicitly address the arbitraging question. The result is that many analyses using these models lead to poor results because the models contain implicit limits on arbitraging which may be at variance with the actual policy.

This paper argues that unless trade models explicitly incorporate assumptions about the possibility of simultaneous exporting and importing, the selection of the trade model implicitly sets the rules on arbitrage behavior. For example spatial trade models using reduced form trade equations generally exclude by assumption the possibility of switching or of simultaneously exporting and importing. This paper reviews often used models, then presents an alternative model and concludes with two numerical examples.

Specifically, the first part of the paper discusses the role played by arbitraging in the design and management of discriminatory agricultural trade policies. The implications for empirical trade policy analysis of different assumptions about the possibility of arbitraging are briefly addressed.

In the second part, the implicit hypotheses about arbitraging associated with three classes of spatial models - Quadratic Programming (QP) models, Non Linear Programming (NLP) models and Vector Sandwich (VS) models - are discussed in detail.

An alternative model is presented in the third part of the paper. Its main features are that countries are allowed to switch from one side of the market to the other as prices change, and that the user is allowed to incorporate her assumptions about the possibility of arbitraging. The model presented represents an improvement over the other spatial trade models when the policy issues addressed include, for example, trade liberalization when preferential trade agreements exist, an embargo, or a targeted export subsidy. Two numerical examples, one addressing the 1980 US embargo to USSR, the other, constructed, involving preferential trading, show how the results obtained using the proposed model compare with those obtained by applying the three classes of models mentioned above.

Discriminatory Agricultural Trade Policies and Arbitraging

World agricultural markets abound in discriminatory trade policies. These include preferential tariffs, targeted export subsidies, embargoes, customs unions, food aid and preferential import quotas. In all of these types of policies the granting country must be concerned with preventing the recipient country from re-exporting subsidized imports, or exporting under preferential agreements imports from non-preferred countries. In this section several examples are reviewed to determine how countries attempt to deal with the problem of arbitrage.

The United States has many preferential agricultural tariff reduction agreements including its Generalized System of Preferences (G.S.P.), the Caribbean Basin Initiative, the Israeli free trade agreement and the recently concluded US-Canada Free Trade Agreement. Other discriminatory trade policies include the Agricultural Trade Development and Assistance Act of 1954 (PL 480), the Export Enhancement Program (EEP) and a series of targeted embargoes including those against the USSR in 1974, 1975 and 1980-81.

In all of these cases additional policy instruments are necessary. On preferential imports (GSP) the United States applies a "rule of origin" which requires at least 35% (50% if two preferred countries involved) of the value of the article to have been added in the developing country. The definitions of qualified LDC "production and/or processing" take several pages. The same constraints apply to duty free treatment under the Caribbean Basin Initiative (Organization of American States). The United States-Canada free trade agreement contains a substantial set of rules of origin to prevent reexport when different third country tariffs apply in the two countries. PL 480 contains language and rules to prevent concessional shipments from disrupting (lowering prices) commercial markets and seeks "commitment from participatory countries that will prevent resale or transhipment to other countries, or use, for other than domestic purposes, of surplus agricultural commodities purchased under the act" (sect. 101). The rules attempt to prevent arbitraging and try to freeze other trade flows of the beneficiary country.

To enter the EEC under the preferential tariffs granted by the Lome' Convention, exports from the African, Caribbean, and Pacific (ACP) countries have to fulfill the conditions stated in Protocol 1 of the Convention, concerning the definition of the concept of "originating products."[1] Products originating in the ACP countries are defined, in simple terms, as products wholly obtained in one or more ACP countries, or products which have undergone *sufficient* working or processing within the ACP countries. Essentially, the entire Protocol deals with the definition of what sufficient means. A similar condition is contained in the EEC's GSP scheme (EEC). Borrmann, Borrmann and Stegger (p. 117-120) argue that the "rules of origin" may have strongly affected the volume of trade generated through the EEC's GSP scheme.

A "country of origin" constraint is contained in the ASEAN (Association of Southeast Asian Nations) agreement. The preferential tariffs apply to products wholly produced or obtained in ASEAN countries or to products for which non-ASEAN content does not exceed the 50% of the f.o.b. value (40% in case of Indonesia), and the final stage of manufacture must be performed in the ASEAN exporting country.

In all these preferential tariff reduction agreements, the inclusion of constraints to make sure that the exports are originating in the beneficiary country is dictated by the desire to avoid arbitraging and prevent third countries from taking advantage of the preferential policy. Constraints on the volume of exports which may be shipped under the preferential treatment are usually included as well. This reinforces the argument that limiting arbitraging is definitely an issue in the design of preferential tariff policies.

However, it should be noted that the various "rules of origin" still leave some space for arbitraging. The preferred country can still find it feasible and profitable to import and export at the same time, using low price imports for domestic consumption while exporting at a higher preferential price domestic production. In this case, if no binding ceiling is placed on the volume of the preferred country's exports, the quantity arbitraged is implicitly constrained by the "rules of origin" not to exceed domestic consumption.

As discussed later on in the paper, empirical simulations of the embargo's impact on world trade and on the availability of the embargoed commodities (and of their substitutes) in USSR critically depend on the assumptions made about the degree of cooperation of the other exporters and on the possibility for third countries to arbitrage (USDA).

In real world discriminatory trade policies arbitraging does matter. In many cases, failing to avoid its occurrence crucially affects the possibility of reaching the expected policy goals.

Modeling Discriminatory Trade Policies

When discriminatory trade policies are considered, the models which may be used in empirical analyses are restricted to the class of the spatial ones, those able to reproduce, in addition to the net trade positions of each of the regions considered, the flows between each pair of them. Because of the presence of discriminatory policies, each region may buy (sell) from (to) different regions at different prices, collecting (paying) different per unit tariffs (subsidies). As a result, the determination of the net trade positions needs to be based on a model capable of differentiating by origin the imports of each region.

Any discriminatory trade policy can be equivalently expressed in terms of a tariff or a subsidy. Targeted embargoes can be seen as the imposition of a country specific prohibitive export tariff. Country specific export (import) quotas may be translated into two export (import) taxes:

one, equal to zero, active up to the quota ceiling, the other, prohibitive, active above that ceiling. Food donations may be seen as volume constrained subsidized exports.

Any solution obtained by using a spatial trade model is such that, for each possible trade flow, say from country i to country j, the domestic prices (p_i and p_j , respectively), must satisfy the following relation (as long as no constraint is placed on the trade flow):

(1) $(p_j - p_i - t_{ij} + \sigma_{ij} - \pi_{ij}) \leq 0$;

(2) $(p_j - p_i - t_{ij} + \sigma_{ij} - \pi_{ij})\, x_{ij} = 0$;

where t_{ij} is the fixed transportation cost to ship one unit of the commodity from region i to region j, σ_{ij} is the export subsidy that country i pays to its producers for each unit exported to country j, π_{ij} is the import tariff that country j imposes on each unit it imports from country i, and x_{ij} is the non-negative trade flow from country i to country j. If there is a positive trade flow from country i to country j, then the per unit transportation cost plus the tariff minus the subsidy must give the wedge between the two domestic prices. If there are no shipments from country i to country j, then the difference between the two domestic prices must be smaller or, at the most, equal to the transportation cost plus the tariff minus the subsidy, implying that shipments from country i to country j are not profitable.

In absence of any intervention, the only possible wedges between domestic prices of trading countries are transportation costs. The matrix of the transportation costs may be said to be *consistent*, meaning that the minimum cost path to ship from region i to region j is *always* the one directly connecting the two regions. If this is the case, there is no rationality for arbitraging.[2] From the viewpoint of the conditions to be satisfied by the solution to the problem, transportation costs, subsidies and tariffs are undifferentiated. Given domestic demands and supplies, the only thing that matters in finding the market spatial equilibrium is, for each ordered pair[3] of countries, the net sum of the transportation cost plus the import tariff minus the export subsidy. This quantity can be thought of as a *generalized transportation cost.*

The addition and the subtraction to the transportation costs matrix of non-discriminatory tariffs and subsidies does not affect its consistency. However, this property may be disrupted by the existence of discriminatory trade policies. It can vanish as a result of the implementation of preferential tariffs, or targeted subsidies. It is lost when country specific embargos are imposed. The generalized transportation costs matrix being no longer consistent, is a necessary (but not sufficient) condition for arbitraging to be profitable.[4]

Most agricultural trade models are based on an a priori definition of the sets of the importing and exporting regions. Each country is represented through its excess demand or supply schedule. By doing so, the possibility of arbitraging, as well as the possibility of a country switching from one side of the market to the other as prices change, is assumed away.

When each country's position on the world market is not set a priori, the assumptions about the possibility of arbitraging are generally left to the structural characteristics of the specific model used. These assumptions may strongly affect the solutions obtained. For example, in a model with no transportation costs, when arbitraging is left free to occur the imposition of a tariff only on imports from a specific subset of countries leaves each region's net trade positions unchanged. Only trade flows change. However, a very different outcome is obtained if each region is constrained not to import and export at the same time.

Discriminatory Trade Policies and Most Commonly Used Trade Models

(a) Quadratic Programming Models;

The most commonly used spatial trade models are the ones developed by Takayama and Judge (Thompson, p. 28). This class of spatial trade models involves the maximization of a quadratic objective function subject to a set of linear constraints. Linear demand and supply functions, large countries and perfect competition, both on the domestic and the world markets, are assumed (Takayama and Judge 1964 and 1971, Bawden, Takayama).

Takayama and Judge (1971, chpt. 10) propose a framework to analyze trading when tariffs and subsidies are present. They suggest that this framework can also be used when discriminatory trade policies are active.[5] Two alternative modeling approaches, one based on domestic demand and supply functions (Takayama and Judge 1971, chpts. 7 and 8), the other based on excess supply/demand functions (Takayama and Judge 1971, chpt. 9), are proposed. They claim that in a very large spectrum of standard cases the two models are equivalent, and that the second one may be much more efficient. However, it is shown that, when discriminatory trade policies are considered, the equivalence of the two models may vanish. The *first* model - the one which uses domestic demand and supply functions - leaves each country free to import and export at the same time, but puts an implicit constraint on the imports, which cannot exceed domestic consumption. The *second* model leaves the possibility of arbitraging totally free.

Let's consider the approach based on domestic demand and supply functions first. Following Samuelson, the problem is solved maximizing an artificial net quasi-welfare function under a set of linear constraints. The quasi-welfare function may be seen as the sum of consumers' and producers' surpluses over all the regions considered. Using Takayama and Judge's notation, the model (in its quantity formulation)[6] may be stated as:

(3) $\max NW(y, x, X) = \lambda' y - \nu' x - 1/2\, y'\Omega y - 1/2\, x' H x - (T+\pi-\sigma)' X$

(4) s.t. $GX \geq \begin{bmatrix} y \\ -x \end{bmatrix}$

(5) $y \geq 0;\ x \geq 0;\ X \geq 0;$

where:

- y is the (nx1) vector of the quantities consumed in each country;
- x is the (nx1) vector of the quantities produced in each country;
- X is the (n^2x1) vector of the trade flows ($x_{11}, x_{12},.., x_{1n}, ...,x_{n1}, x_{n2},.., x_{nn}$);
- λ is the (nx1) vector of the constant terms in each region's inverse demand function;
- ν is the (nx1) vector of the constant terms in each region's inverse supply function;
- Ω is a (nxn) diagonal matrix of the absolute value of the slopes in each region's inverse demand function;
- H is the (nxn) diagonal matrix of the slopes in each region's inverse supply function;

- T is the (n^2x1) vector of the transportation costs ($t_{11}, t_{12}, ..., t_{1n}, ..., t_{n1}, t_{n2}, ..., t_{nn}$; where t_{ij} is the transportation cost to ship one unit of the commodity from region i to region j);
- π is the (n^2x1) vector of the import tariffs ($\pi_{11}, \pi_{12}, ..., \pi_{1n}, ..., \pi_{n1}, \pi_{n2}, ..., \pi_{nn}$; where π_{ij} is the per unit tariff imposed by country j on its imports from country i);
- σ is the (n^2x1) vector of the export subsidies ($\sigma_{11}, \sigma_{12}, ..., \sigma_{1n}, ..., \sigma_{n1}, \sigma_{n2}, ..., \sigma_{nn}$; where σ_{ij} is the subsidy paid by country i for each unit exported to country j);
- G is a ($2n$xn^2) matrix defined as follows:

(6) $$G = \begin{bmatrix} 1 & & & & 1 & & & & & 1 & & & \\ & 1 & & & & 1 & & & & & 1 & & \\ & & \ddots & & & & \ddots & & & & & \ddots & \\ & & & 1 & & & & 1 & \cdots & & & & 1 \\ -1 & -1 & \cdots & -1 & & & & & & & & & \\ & & & & -1 & -1 & \cdots & -1 & & & & & \\ & & & & & & & & \ddots & & & & \\ & & & & & & & & & -1 & -1 & \cdots & -1 \end{bmatrix}$$

To satisfy the Kuhn-Tucker conditions associated to this first model the solution to the problem must be such that [Takayama and Judge 1971, (7.2.9.d) p. 133]:[7]

(7) $\Sigma_j x^*_{ji} - y^*_i \geq 0$, and $[\Sigma_j x^*_{ji} - y^*_i] p^*_i = 0$, i=1,.., n;

(8) $- \Sigma_j x^*_{ij} + x^*_i \geq 0$, and $[- \Sigma_j x^*_{ij} + x^*_i] p^*_i = 0$, i=1,.., n;

where p_i is the domestic price in country i, and the * indicates values of the variables at the optimum. If domestic price is different from zero: (i) domestic consumption must be equal to the portion of the domestic production which is consumed domestically plus the sum of all the imports from the other countries, and (ii) domestic production must be equal to the portion which is consumed domestically plus the sum of all exports to the other regions. Each country may import and export at the same time, with the constraint that in each country imports cannot exceed domestic consumption. When domestic consumption is entirely satisfied through imports, the domestic production is entirely exported. This scenario can be described as one in which a constrained arbitraging can take place. When this model is used and the constraint on arbitraging is binding, the arbitraging country's consumption and production prices are not equal. The consumption price is linked to the low price prevailing in the region(s) where the imports come from, while the production price is linked to the high price prevailing in the region(s) exports are shipped to.

This implicit constraint limiting arbitraging not to exceed the volume of the actual domestic consumption, reproduces a condition similar to that imposed by the different types of "rules of origin" observed in real world preferential trade agreements.

When the second model, based on the use of excess supply/demand functions, is considered,[8] the following Kuhn-Tucker conditions apply [Takayama and Judge 1971, (9.1.27.d) p. 182; (9.3.4), p. 194]:

(9) $- y^*_i + x^*_i + \Sigma_{j \neq i} (- x^*_{ij} + x^*_{ji}) \geq 0 , i= 1, ..., n;$

(10) $[- y^*_i + x^*_i + \Sigma_{j \neq i} (- x^*_{ij} + x^*_{ji})] \, p^*_i = 0 , i= 1, ..., n.$

If the domestic price is different from zero, domestic production minus domestic consumption plus imports minus exports must be equal to zero. Arbitraging is now left totally unconstrained.

When discriminatory trade policies are present, by applying the two models to the same setting different results can be obtained. This will certainly happen whenever in the solution obtained by using the model based on excess demand and supply functions (a) at least one region acts at the same time as an exporter and an importer, and (b) its imports are larger than its domestic consumption.

Whenever QP models are used to analyze markets characterized by discriminatory policies such that the generalized transportation costs matrix is not consistent, strong assumptions about the possibility of arbitraging occurring are implicitly made. Such assumptions may have serious implications for the conclusions reached in terms of the trade policy analysis.

(b) Non Linear Programming Models;

Although QP models have been extensively used in agricultural trade analyses, the assumption regarding the linearity of the demand and supply functions they rely on is quite strong. Rowse, arguing that the availability of powerful nonlinear programming software is not a serious constraint any more, suggested a mathematical programming framework to solve problems involving nonlinear demand and supply functions.[9] His model, essentially, expands on the QP formulation. A quasi-welfare function is maximized under a set of linear constraints. Rowse's formulation of the problem allows for the specification of supplying and consuming regions. If each region is a priori defined either as a supplier or as a consumer, then, as mentioned earlier, an implicit no arbitraging constraint is imposed. However, in general, each country can be represented as both a consuming and producing region. In this case, keeping the notation used so far, the model may be described as follows:

(11) $\max NW(y, x, X) = \Sigma_i \theta_i(y_i) - \Sigma_i \phi_i(x_i) - (T + \pi - \sigma)'X;$

(12) s.t. : $GX \geq \begin{bmatrix} y \\ -x \end{bmatrix},$

(13) $y \geq 0, \quad x \geq 0, \quad X \geq 0,$

where $\theta_i(y_i)$ and $\phi_i(x_i)$ are the integrals under country i's inverse domestic demand between 0 and y_i, and country i's inverse domestic supply between 0 and x_i, respectively.

The QP model may be now seen as a particular specification of the general NLP formulation. The Kuhn-Tucker conditions of this problems are analogous to those of the QP formulation. In particular, the solution of Rowse's NLP model must satisfy (7) and (8). From the standpoint of handling discriminatory trade policies, what has been pointed out with respect to the QP approach applies to the general NLP formulation as well. When countries' positions on the world market are not set a priori, the use of NLP models as formulated by Rowse leaves arbitraging possible, but in each country imports cannot exceed domestic consumption.

(c) Vector Sandwich models;

MacKinnon (1975, 1976) proposed the use of a vector sandwich procedure, based on one of the algorithms developed to compute Kakutani fixed points, to solve spatial trade equilibrium problems.[10] The procedure allows for the inclusion of nonlinear demand and supply functions as well as transportation costs. Holland developed a microcomputer program based on MacKinnon's procedure to solve relatively small, single commodity, spatial equilibrium models. Holland's program is well documented and allows for great flexibility. It is capable of handling import and export tariffs, both ad valorem and per unit. Constraints may be imposed on specific flows as well as on individual countries' overall imports or exports. However, the possibility of the existence of discriminatory tariffs and subsidies is not considered. Even so, the user can include them, fooling the program by giving the generalized transportation costs when asked by the program to provide the transportation costs. Applications of the vector sandwich method in agricultural trade policy analyses include Holland and Sharples, and USDA (chpt. 11). Basically, the procedure searches for a solution which satisfies standard economic equilibrium conditions. Keeping the structure of the problem as close as possible to those discussed above, and allowing each country to be accounted for as a producer and a consumer at the same time, the model may be stated as follows:

Find p, x, y, and X

(14) such that

$$x_i(p_i) = \Sigma_j x_{ij}, \; i=1,.., n;$$

$$y_i(p_i) = \Sigma_j x_{ji}, \; i=1,.., n;$$

$$\Sigma_i x_i = \Sigma_i y_i;$$

(15) subject to:

$$yl_i \leq y_i \leq yu_i, \quad i=1,.., n;$$

$$xl_i \leq x_i \leq xu_i, \quad i=1,.., n;$$

$$xl_{ij} \leq x_{ij} \leq xu_{ij}, \quad i, j=1,.., n;$$

$$p_i \geq 0, \quad i=1, ..., n;$$

$$p_i = \min_j [\, L_i(p_j: xl_{ji} \leq x_{ji} \leq xu_{ji}) \,], \; i=1,.., n;$$

$$L_i(p_j) = [p_j + t_{ji} + \pi_{ji} - \sigma_{ji}], \; i, j=1,.., n.$$

If each country is considered as both consuming and producing, arbitraging is allowed but, again, it is constrained not to exceed domestic consumption. Each country may import and export at the same time, but imports may not be re-exported.

The Model

In this section a spatial trade model is presented. It should be used to analyze settings where discriminatory trade policies make the generalized transportation costs matrix inconsistent. The model is given in two forms, one based on domestic supply and demand functions, the other based on excess demand/supply functions. These functions do not have to be linear. The model has two main features: (a) each country is left free to move from one side of the market to the other as prices change, and (b) the user is allowed to explicitly specify assumptions on the possibility of arbitraging to occur through the input of two sets of parameters.

Table 1 and 2 synthesize the assumptions which are *implicitly* made when the models briefly reviewed above are used, and those which can be *explicitly* incorporated by the researcher when the model proposed in this paper is used. When each country is a priori defined as an importing or an exporting country -- as it is the case when NLP or VS models in which countries are represented either by an excess demand or an excess supply function are used -- arbitraging is simply ruled out. When QP, NLP and VS models in which each country is represented through both its domestic demand and supply functions are used, arbitraging is allowed, but it is constrained not to exceed the quantity which is consumed domestically. In this case the implicit constraint reproduces the "rules of origin" attached to many preferential trade agreements, whose intent is to prevent the re-exporting of imports from occurring. Finally, when the QP model in which each country is represented by its excess demand/supply function is used, arbitraging is allowed and left totally unconstrained (Table 1).

When the model proposed in this paper is used, the researcher is allowed to *explicitly* incorporate his own assumptions about arbitraging. The model based on domestic demand and supply functions can be constrained so that arbitraging (i) cannot occur, (ii) is allowed, but it is constrained not to exceed domestic consumption, or (iii) is allowed and left completely unconstrained. When the model in which each country is represented through its excess demand/supply function is used, only the first and the third scenarios can be implemented (Table 2).

In the model proposed only one commodity is considered. In addition, a partial equilibrium framework, fixed exchange rates, and perfect competition on both the domestic and the world markets are assumed.

Following Samuelson, Takayama and Judge, and Rowse the model maximizes an artificial quasi-welfare function (W) tied to the sum of consumers and producers surplus over all the regions.

Table 1 - Implicit assumptions about arbitraging of the QP, NLM and VS models.

Model	*Each country is represented through:*	*Implicit assumptions about arbitraging*
Quadratic Programming Models [Takayama and Judge 1964 and 1971, Bawden, Takayama]	linear domestic demand and supply functions	arbitraging allowed, but constrained not to exceed domestic consumption (imports cannot be re-exported)
	a continuous linear excess demand and supply function	arbitraging allowed and unconstrained
Non Linear Programming Models [Rowse]	non linear domestic demand and supply functions	arbitraging allowed, but constrained not to exceed domestic consumption (imports cannot be re-exported)
	a non linear excess demand *or* supply function	arbitraging not allowed
Vector Sandwich Models [MacKinnon 1975 and 1976; Holland]	linear or non linear domestic demand and supply functions	arbitraging allowed, but constrained not to exceed domestic consumption (imports cannot be re-exported)
	a linear or non linear excess demand *or* supply function	arbitraging not allowed

Table 2 - Assumptions about arbitraging which can be explicitly incorporated in the model proposed.

Model	*Each country is represented through:*	*Assumptions about arbitraging which can be explicitly incorporated*
Model proposed	linear or non linear domestic demand and supply functions	- arbitraging allowed and unconstrained - arbitraging allowed, but constrained not to exceed domestic consumption - arbitraging not allowed
	a linear or non linear continuous excess demand and supply function	- arbitraging allowed and unconstrained - arbitraging not allowed

When domestic demand and supply functions are considered, the quasi-welfare function is defined as the sum of the areas below the domestic demand functions, minus the areas below the domestic supply functions, minus the transportation costs, minus the tariff revenue plus the subsidy expenditure:

(16) $W = \Sigma_i \ \theta_i(y_i) - \Sigma_i \phi_i(s_i) - \ \Sigma_{ij} [(t_{ij} + \pi_{ij} - \sigma_{ij}) x_{ij}]$.

The model may be stated as follows:

(17) $\max_{x_{ij}} \ W$

subject to:

(18) $\xi_i^2 \{[1-(\xi_i - 1)/-2] [\Sigma_j x_{ji} - x_{ii}] + [(\xi_i - 1)/-2][\Sigma_j x_{ij} - x_{ii}]\} = 0$, $i= 1, .., n$;

(19) $\psi_i (\Sigma_j x_{ji} - x_{ii}) - y_i \leq 0$, $i= 1, .., n$;

(20) $x_i = \Sigma_j x_{ij} - \Sigma_j x_{ji}$, $i= 1, .., n$;

(21) $y_i = \max \{ x_{ii}, x_{ii} - x_i \}$, $i= 1, .., n$;

(22) $s_i = y_i + x_i$, $i= 1, .., n$;

(23) $x_{ij} \geq 0$; $i, j = 1, .., n$;

where:

- i and j denote the regions ($i , j = 1, 2,..., n$);
- y_i denotes the quantity consumed in country i;
- s_i denotes the quantity produced in country i;
- $\theta_i(y_i)$ denotes the integral under the inverse domestic demand of region i, $p^d{}_i(y_i)$, between 0 and y_i;
- $\phi_i(s_i)$ denotes the integral under the inverse domestic supply of region i, $p^s{}_i(s_i)$, between 0 and s_i;
- x_{ij} denotes the flow of commodity from region i to region j;
- x_i denotes the total exports (if positive) or the total imports with the sign changed (if negative) of region i;

- t_{ij} denotes the fixed per unit transportation cost for shipping the commodity from region i to region j;[11]
- π_{ij} denotes the per unit tariff imposed by region j on its imports from region i;
- σ_{ij} denotes the subsidy paid by region i for each unit exported to region j;
- ξ_i denotes a parameter controlling the possibility of the i-th region to arbitrage, and, if arbitraging is not allowed, the side of the market on which it may appear. This parameter may be set to be equal to -1, 0 or 1. It will be equal to 0 for the non-beneficiary regions, and for the beneficiary ones which are left free to arbitrage; to -1 for the beneficiary countries which are not allowed to arbitrage and may operate on the market as importers only, to 1 for those which may operate as exporters only;
- ψ_i denotes a parameter constraining arbitraging, when it has been allowed to occur, not to exceed domestic consumption. It will be equal to 1 when country i's imports must not exceed its domestic consumption, to 0 otherwise.

Constraints (20)-(23) are self-explanatory. When ψ_i in (19) is set equal to 1, arbitraging cannot exceed domestic consumption. When ψ_i is equal to 0 arbitraging is not constrained by (19). A more detailed discussion is needed to explain the rationale for (18). This constraint allows the user to impose that regions do not arbitrage. In addition, when arbitraging is not allowed, (18) imposes the position on the market (importer/exporter) that the region may take. This is needed to evaluate what its position on the market will be. In fact, if arbitraging is not allowed, each country may choose to appear on the world market either as an importer or as an exporter.

In the case of a preferential tariff, for example, this implies the imposition by each beneficiary country of a prohibitive tariff either on its imports or on its exports, and, hence, an explicit policy choice. Imports are taxed when the country wants to make use of the preference. Exports are taxed, to make arbitraging unprofitable, when it finds itself better off by importing. The decision is based on the maximization of the beneficiary country's welfare. In many cases, this choice may be easy, as it is the case when only one country is granted a preferential treatment and it is already exporting prior to the implementation of the preferential tariff. In other cases the choice may not be so obvious (Anania). A beneficiary country may find it, for example, more profitable to remain on the importers' side of the market even if the preferential treatment granted would make it possible for it to act as an exporter. When arbitraging is not allowed, the maximization of the world quasi-welfare may not be associated with the maximization of the welfare for each of the beneficiary regions. As a result, the solution obtained may not reproduce the world market equilibrium which would take place given the assumptions on which the model is based. When arbitraging is not allowed, the model has to be solved 2^m times (m is the number of the beneficiary countries which are not allowed to arbitrage), once for each possible set of the ξ_i's parameters. By doing so, all possible scenarios linked to the beneficiary countries' possible choices will be considered.

When more than one beneficiary country is present, to identify the market solution some sort of assumption is needed regarding the behavior of the beneficiary countries. The decision of each of them, in fact, affects the decision of the others, and a game structure needs to be assumed. In the second of the two numerical examples discussed below, the market solutions under two very simple different behavioral assumptions are presented: that the beneficiary countries collude, and that each of them makes its choice on the basis of its own welfare only. When a collusive behavior is assumed, the market solution will be given by the one among the 2^m associated with the highest value of the sum of the beneficiary countries' welfares. The underlying assumption is that by doing so each of the colluding regions will be made better off through a system of direct transfers among the countries entering the agreement. The market solution will be given by the one associated with the

(24) $\max_s [\, \Sigma_{k=1,..,m} W_k^s \mid s= 1,.., 2^m] ,$

where m is the number of the beneficiary countries, and W_k^s is country k's welfare associated with the s-th set of the ξ_i's parameters. When this behavior is assumed, a solution will always be found. The second approach leads to a more complex outcome. When each beneficiary region decides to act as an importer or as an exporter on the basis of its own welfare only, three possible results may be reached: (a) no market solution can be identified, (b) several possible market solutions can be identified, (c) one market solution can be identified. No market solution will be identified if at each of the solutions associated with the different sets of ξ_i's parameters, one or more of the beneficiary countries are better off by switching to the other side of the market. Several possible market solutions will be identified if more than one of the 2^m market solutions is such that no individual beneficiary region is better off by changing its position on the market. A unique market equilibrium will be obtained when only one of the 2^m solutions is such that no region is willing to switch to the other side of the market.

Once the model has been solved, equilibrium prices may be computed as:

(25) $p^d_i = p^d_i(y_i^*)$; i=1,.., n;

(26) $p^s_i = p^s_i(s_i^*)$; i=1,.., n.

Each country's producers' and consumers' welfare is here defined (Figure 1) as the area between the inverse demand function and the price[12] line, plus the area between the price[13] line and the horizontal axis or the inverse supply function, plus the tariff revenue (which is assumed to be redistributed to consumers and producers as a lump sum transfer):

$$(27)\ W_i = [\theta_i(y_i^*) - y_i^*\, p_i^d(y_i^*)] + [p_i^s(s_i^*)\, s_i^* - \int_{\max\,[0,S_i']}^{s_i^*} p_i^s(s_i)\, ds_i\,] + \Sigma_j\, \pi_{ji}\, x_{ji}\,,\ \ i = 1, .., n;$$

where S_i' is the intercept of the inverse supply function on the horizontal axis. In Figure 1 S'S is the inverse supply function, D'D is the inverse demand function, p is the equilibrium price, y* and s* are the quantities consumed and produced, respectively, and the cross-hatched areas sum up to the country's producers' and consumers' welfare.

Often estimates of the domestic supply and demand functions for each of the regions to be included in the model are not available, while estimates of the excess demand/supply functions are. In addition, the excess functions can be more easily estimated. For this reason, a formulation of the model which is based on excess functions is presented as well.

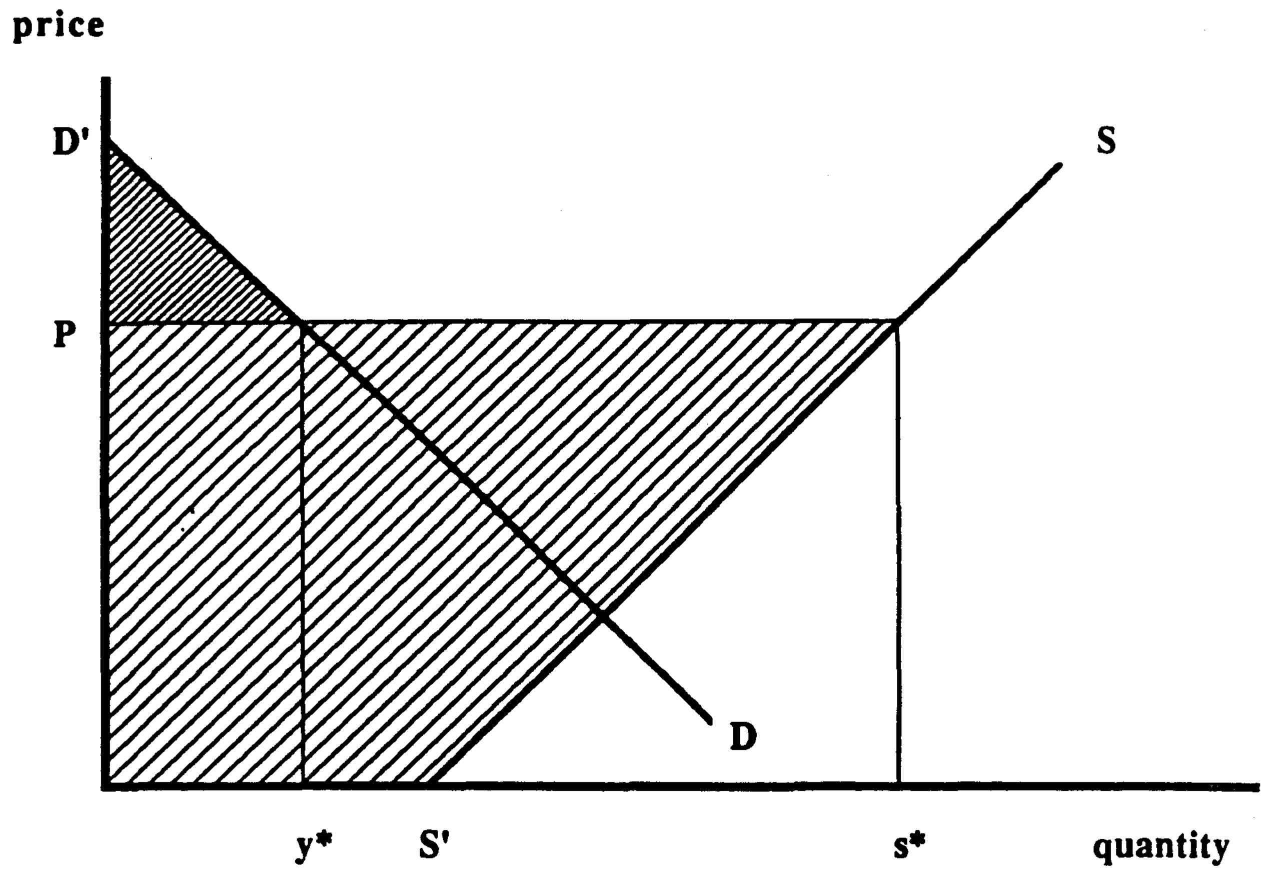

Figure 1 - Welfare components for an exporting country.

The structure of this model is essentially the same as the one based on the domestic demand and supply schedules. In Figure 2 a simple two country world market case is presented. S_aS_a and S_bS_b are the inverse excess demand/supply functions of countries A and B, respectively. The market equilibrium is such that region A imports $-X_a$ from region B ($-X_a$ is equal to X_b). The equilibrium prices in the two regions are P_a and P_b, respectively. The difference between the two prices is equal to the transportation cost of shipping one unit from B to A, plus the per unit import tariff imposed by country A, minus the per unit export subsidy paid by country B. The cross-hatched areas in Figure 2 represent the gains from trade, i.e. the increase of consumers' and producers' surplus in the two countries due to the international trading.

When excess supply/demand functions are used, W, the "artificial" welfare function, may be defined as:

(28) $W = \Sigma_i [- \chi_i(x_i)] - \Sigma_{ij} [(t_{ij} + \pi_{ij} - \sigma_{ij}) x_{ij}]$,

where $\chi_i(x_i)$ denotes the integral under the inverse excess supply/demand function of region i, $p_i(x_i)$, between 0 and x_i.

In Figure 2 the gains from trade of regions A and B are given by the sum of the areas CDP_a and P_bGF. These may be obtained by subtracting from the area $CDOX_a$ the areas FGX_b0 and CP_aP_bE. This is exactly what is given, for the n countries case, by expression (28). χ_i with the minus sign in front of it, in fact, gives, for each region, the area under the excess supply/demand function, positive if the region is importing ($x_i<0$), negative if it is exporting ($x_i>0$). From the quantity computed in this way, the net gains from trade are obtained by subtracting the transportation costs plus the tariff revenues minus the subsidy expenditure (the algebraic sum of tariff, subsidy and transportation costs is given in Figure 2 by the area CP_aP_bE).

When excess demand/supply functions are used, arbitraging cannot be constrained any more to not exceed domestic consumption.[14]

The problem may now be stated as:

(29) $\max_{x_{ij}} \quad W$

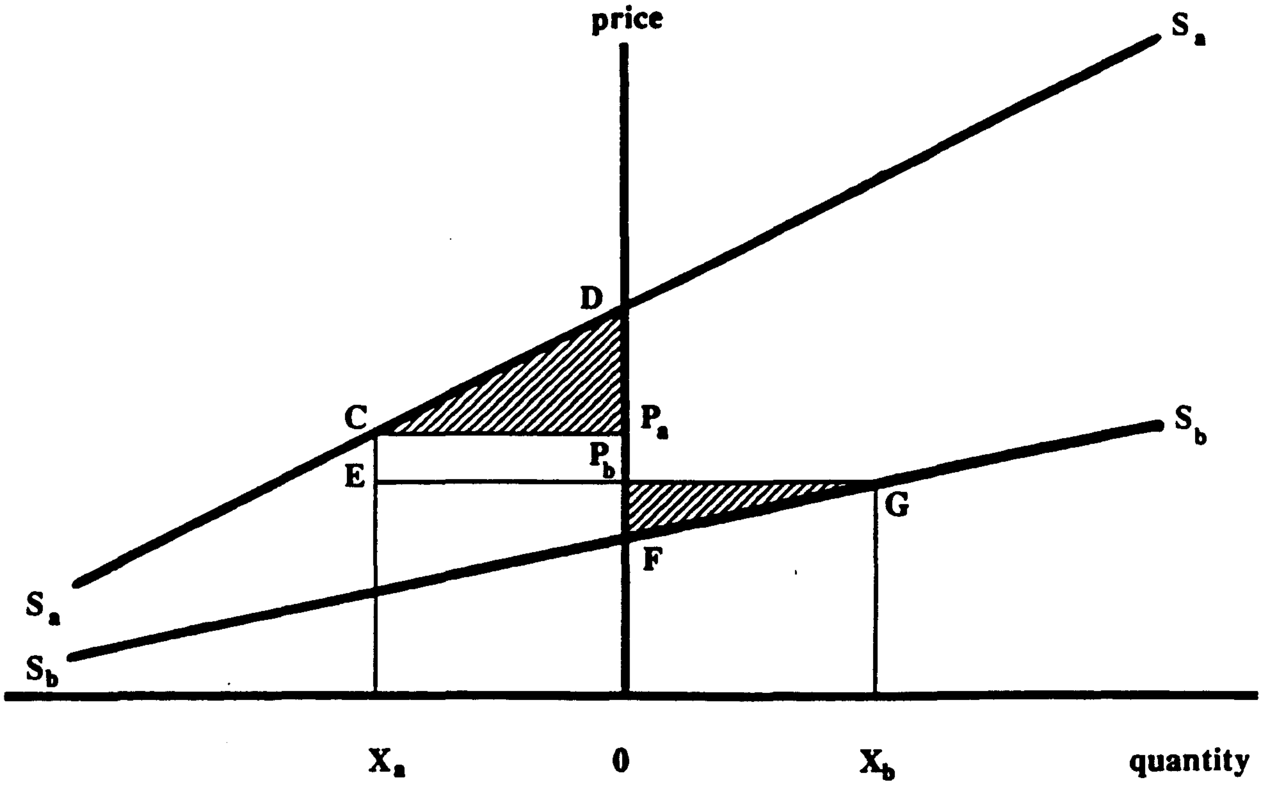

Figure 2 - Two country world trade equilibrium.

subject to:

(30) $\xi_i^2 \{[1 - (\xi_i-1)/-2] \Sigma_j x_{ji} + [(\xi_i-1)/-2] \Sigma_j x_{ij} \} = 0$, i= 1,.., n;

(31) $x_i = \Sigma_j x_{ij} - \Sigma_j x_{ji}$, i= 1,.., n;

(32) $x_{ij} \geq 0$; i, j = 1,.., n.

Equilibrium prices and individual countries gains from trade may now be computed as:

(33) $p_i = p_i(x_i^*)$, i= 1, ..., n;

(34) $W_i = [p_i(x_i^*) x_i^*] - \chi_i(x_i^*) + \Sigma_j (\pi_{ji} x_{ji}^*)$, i= 1,.., n.

Two Numerical Examples

In this section two simple numerical examples -- one addressing some of the trade policy issues of the 1980 US embargo on USSR, the other, constructed, involving preferential trading -- are presented to show how the proposed model works and how its results compare with those which may be obtained using the other spatial trade models discussed.

(a) The 1980 US embargo to the USSR;

The trade policy option analyzed in the first numerical example is an embargo. The focus is on the 1980 US embargo to the USSR. It lasted from January 4, 1980 to April 24, 1981 and covered several agricultural products, including wheat, feed grains, soybeans, meat and dairy products. The embargo was only partial, because the US fulfilled its commitment to the 1975 US-USSR trade agreement allowing the export to USSR of 8 million tons of grains in 1979/80 and 1980/81.

The embargo was motivated solely on the basis of a foreign policy concern, as a retaliation to protest the "USSR invasion of Afghanistan." The decision was taken on the basis of a Central Intelligence Agency (CIA) estimate that the embargo would have had a very strong impact on meat consumption in USSR (USDA). The CIA estimate assumed full cooperation of all other exporters. The actual short run impact of the embargo was substantially smaller than expected. It had a very small impact, if any, on meat consumption in the USSR. The USSR strategy was essentially based on: (a) replacing imports from the US by increased imports from other sources, (b) increasing imports of substitute goods, and (c) slightly reducing its stocks.

Even if the exercise performed provides some interesting insights with respect to the trade policy issues involved, assessing the actual effectiveness of the 1980 embargo is by no means the goal of this section. Its goal, instead, is to show, by using the model presented to predict the possible effects of an embargo, how very useful indications may be obtained on its possible different outcomes as a function of different scenarios with respect to the cooperation of the other actors active in the market.

The main source, both for background information and input data, is the comprehensive study mandated by the U.S. Congress (USDA). Consistent with the approach followed so far, only one commodity (wheat) is taken into account in a partial equilibrium framework. 27 regions are considered. Excess supply/demand functions (Table A1) are derived from base net trade positions, prices and trade elasticities used in USDA. The model is a short run model in nature, i.e. production is held fixed and only consumption, stocks and trade flows are assumed to change as a function of changes in prices. The reference time framework is the calendar year 1980, the only case where the embargo was in place for the entire year. Domestic policies as well as border ones have been incorporated by including price transmission elasticities in the computation of the trade price elasticities (USDA). The transportation costs matrix used is given in Table A2. It expands on the one used by Holland and Sharples.

The problem at hand is assumed to be that of an a priori evaluation of what the effects of a zero constraint on wheat exports from the US to USSR would be. Hence, the base scenario is the one in which no constraints exist on the trade flows. This solution is then compared with 5 different scenarios in which the embargo is active and different hypotheses regarding the cooperation of the other countries are assumed. In the *first* one it is assumed that no country cooperates, i.e. the only constraint imposed is the zero constraint on the US-USSR trade flow. The *second* scenario assumes that Canada, the European Community, Oceania and Argentina, i.e. all the other exporters in the base scenario, agree not to increase their exports to the USSR above the pre-embargo levels. Importers, however, are left free to arbitrage. In the *third* scenario all countries are cooperating, i.e. exporters agree not to increase their exports to the USSR, and importers agree not to arbitrage. The *fourth* and *fifth* scenario differ from the second and the third, respectively, only for the fact that Argentina is now assumed not to cooperate (In 1980 Canada, the European Community and Oceania agreed not to increase their exports to the USSR, even if their actual level of cooperation remains questionable, while Argentina announced that it was not going to cooperate).

Information about the trade flows and the net trade positions in the base solution is given in Table 3. In the pre-embargo scenario the US exports 33.7 million tons of wheat, and exports to the USSR equal 5.3 million tons. The other net exporters are Canada (17.5 million tons), the European Community (9.1), Oceania (12.2) and Argentina (4.9). Major importers are Japan (5.7 million tons), East Europe (5.4) USSR (14.4), China (12.2), Egypt (5.3) and Middle East (5.3).

The *first* embargo scenario assumes (a) that the US stops its exports to the USSR, and (b) that other countries do not cooperate (Table 4). When this is the case the impact of the embargo on the 27 regions net trade positions is negligible.[15] USSR wheat imports from US are replaced by increased imports from Canada and, as a result, USSR total wheat imports decline only by 59 thousand tons. The US, in turn, made up for the embargo on its exports to USSR by (a) increasing its exports toward regions they were already exporting to, and (b) exporting 2 million tons to East Europe and half a million tons to Egypt, two regions it was not trading with in the base scenario. Essentially, if the US imposes the embargo without obtaining any cooperation at all from the other actors active in the market its policy results in a complete failure. Trade net positions remain unchanged, and only some marginal welfare losses are experienced as a function of increased transportation costs due to the changes in the trade flows.

In the *second* scenario the US embargo receives full cooperation from all the regions exporting in the base solution (Canada, EC, Argentina and Oceania). They agree not to increase their exports to USSR above the base solution levels. Importers are assumed not to cooperate,

Table 3 - The embargo example.
Base solution.
Trade flows and net trade positions (million tons).

Destination	Source: US	Canada	EC	Oceania	Argentina	Net Trade Positions
Oth. West. Eur.	1.755					- 1.755
Japan	5.698					- 5.698
South Africa				.011		-.011
East Europe		5.351				- 5.351
USSR	5.282	9.090				- 14.373
China	9.395			2.792		- 12.187
Mexico	.793					- .793
Central America	2.129					- 2.129
Brazil	4.786					- 4.786
Venezuela	.744					- .744
South America	3.119					- 3.119
Sub-Saharan Africa		2.007			.297	- 2.305
Nigeria		.495			.510	- 1.006
Egypt		.554	4.729			- 5.283
North Africa			4.381			- 4.381
India				.067		- .067
South Asia					2.748	- 2.748
Indonesia				1.505		- 1.505
Thailand				.177		- .177
South-East Asia					1.345	- 1.345
East Asia				2.421		- 2.421
Middle East				5.275		- 5.275
Net Trade Positions	33.702	17.498	9.110	12.248	4.901	

Table 4 - The embargo example.
Scenario #1 (embargo active, no country cooperating).
Trade flows and net trade positions (million tons).

	Source					Net Trade
Destination	US	Canada	EC	Oceania	Argentina	Positions
Oth. West. Eur.	1.758					- 1.758
Japan	5.698					- 5.698
South Africa				.011		- .011
East Europe	2.073	3.255				- 5.328
USSR		14.314				- 14.314
China	11.941			.264		- 12.205
Mexico	.796					- .796
Central America	2.130					- 2.130
Brazil	4.787					- 4.787
Venezuela	.744					- .744
South America	3.122					- 3.122
Sub-Saharan Africa					2.306	- 2.306
Nigeria					1.006	- 1.006
Egypt	.532		4.746			- 5.278
North Africa			4.373			-4.373
India				.068		- .068
South Asia				2.024	.727	- 2.752
Indonesia				1.506		- 1.506
Thailand				.177		- .177
South-East Asia				.485	.862	- 1.347
East Asia				2.423		- 2.423
Middle East				5.284		- 5.284
Net Trade Positions	33.582	17.569	9.119	12.243	4.900	

which means that they are left free to arbitrage. This scenario actually seems to be very close to the one the US was trying to reach in 1980. However, the results of our simulations (Table 5) show that obtaining exporters cooperation is not enough to guarantee that effective results will be reached. In fact, USSR wheat imports are now predicted to decrease only by 400 thousand tons, a fall which cannot be expected to create any significant change in food availability in that country. USSR import price, on the other hand, goes up by 10.48 dollars due to the increased transportation costs (Table 9). USSR is able to substitute for its imports from the US thanks to arbitrage. It imports 3 and 1.8 million tons from East Europe and from the non EC western european countries, respectively. Both regions are net importers and arbitrage increased exports from the US (East Europe) and from Canada (Other West Europe). US exports decrease only by 272 thousand tons, while the price falls by 1.32 dollars. World wheat trade falls only by 271 thousand tons (Table 10). Hence, our simulation suggests that, even if the US would have obtained the cooperation requested to the other exporters, this would not have been sufficient to assure a significant impact of the embargo due to arbitraging. Arbitraging, however, does not seem to have been considered as a relevant issue during the policy design and implementation.

The *third* scenario (Table 6) has all countries cooperate, exporting countries by having their exports to USSR not exceeding the pre-embargo levels, importing countries by not arbitraging. The embargo impact is now significant. USSR wheat imports equal only 9.090 million tons, 5.3 million tons below the pre-embargo level. If we assume that Canada, which is the only country exporting to USSR, does not exploit market power, then USSR import price is now 13.49 dollars lower than the pre embargo one. US exports decrease by 2.8 million tons, export price by 13.69 dollars. World wheat trade decreases by 3.7 million tons. It should be noted that the US is not the only region paying a price for the US embargo. Canada's exports fall by almost 600 thousand tons and its export price by 13.49 US dollars. EC, Argentina and Oceania all experience lower exports and

Table 5 - The embargo example.
Scenario #2 (embargo active, all exporters cooperating).
Trade flows and net trade positions (million tons).

Destination	Source: US	Canada	EC	Oceania	Argentina	East Eur.	O.W.Eur.	Net Trade Positions
Oth. West. Eur.	3.594							- 1.762
Japan	5.699							- 5.699
South Africa				.011				- .011
East Europe		8.421						- 5.347
USSR		9.090				3.074	1.832	- 13.996
China	12.000			.228				- 12.228
Mexico	.799							- .799
Central America	2.131							- 2.131
Brazil	4.789							- 4.789
Venezuela	.745							- .745
South America	3.126							- 3.126
Sub-Saharan Africa					2.308			- 2.308
Nigeria					1.006			- 1.006
Egypt	.548		4.734					- 5.282
North Africa			4.379					- 4.379
India				.069				- .069
South Asia				1.174	1.584			- 2.758
Indonesia				1.508				- 1.508
Thailand				.177				- .177
South-East Asia				1.348				- 1.348
East Asia				2.426				- 2.426
Middle East				5.295				- 5.295
Net Trade Positions	33.430	17.511	9.113	12.236	4.898	- 5.347	- 1.762	

Table 6 - The embargo example.
Scenario #3 (embargo active, all countries cooperating).
Trade flows and net trade positions (million tons).

	Source					Net
Destination	US	Canada	EC	Oceania	Argentina	Trade Positions
Oth. West. Eur.	1.827					- 1.827
Japan	5.713					- 5.713
South Africa				.013		- .013
East Europe		5.547				- 5.547
USSR		9.090				- 9.090
China	11.575			1.043		- 12.618
Mexico	.850					- .850
Central America	2.146					- 2.146
Brazil	4.818					- 4.814
Venezuela	.762					- .762
South America	3.184					- 3.184
Sub-Saharan Africa		1.412			.928	- 2.340
Nigeria		.015			.993	- 1.008
Egypt			5.345			- 5.345
North Africa		.843	3.651			- 4.494
India				.083		- .083
South Asia				1.310	1.553	- 2.863
Indonesia				1.531		- 1.531
Thailand				.180		- .180
South-East Asia					1.381	- 1.381
East Asia				2.480		- 2.480
Middle East				5.480		- 5.480
Net Trade Positions	30.870	16.907	8.996	12.120	4.856	

prices. This is because of the increased competition from US exports they now face in their traditional markets.[16]

The *fourth* and *fifth* scenarios (Tables 7 and 8) show that the fact that Argentina stated explicitly that it was not going to cooperate was on its own a sufficient condition to make the US effort hopeless, no matter what the degree of cooperation of the other countries was. In fact, when all the exporters but Argentina are constrained to export to the USSR volumes not exceeding the pre-embargo levels, the impact of the embargo is very small. USSR imports decline only by 371 thousand tons when arbitraging is allowed (and some arbitrage occurs), and by 382 thousand tons when importing countries are assumed to fully cooperate (Table 10).

The third scenario, the one with all exporters cooperating and no arbitraging taking place is likely to be what the CIA had in mind when suggesting a strong embargo impact. The fourth scenario, on the other hand, the one in which arbitraging is left free to occur, Canada, Oceania and the EC keep their exports at the pre-embargo levels and Argentina does not cooperate, seems to represent the setting closest to the actual outcome.

If a model which defined the importing and the exporting regions a priori, or if a QP or a VS model would have been used, it would have been impossible to assess the impact of the embargo under different level of cooperation of the importing regions. The model proposed, on the contrary, provides the opportunity of easily incorporating different assumptions regarding arbitraging, allowing for a comparison of the different possible outcomes as a function of different hypotheses about the trade behavior of the countries involved.

If a policy conclusion can be reached on the basis of the exercise which has been conducted, it is that embargoes are policy tools that are very likely not to work. In order to have the embargo being effective one of the two following conditions must hold: (a) all countries cooperate (exporters by freezing their exports to the target country, importers by not arbitraging), or (b) all exporters agree to freeze at the pre-embargo levels their exports not only to the target country but to all importing regions. Both conditions appear to be very difficult to achieve.

Table 7 - The embargo example.
Scenario #4 (embargo active, all exporters but Argentina cooperating).
Trade flows and net trade positions (million tons).

Destination	Source: US	Canada	EC	Oceania	Argentina	O.W.Eur.	Net Trade Positions
Oth. West. Eur.	2.008						- 1.763
Japan	5.699						- 5.699
South Africa				.011			- .011
East Europe		5.347					- 5.347
USSR		9.090			4.668	.244	- 14.002
China	12.234						- 12.234
Mexico	.800						- .800
Central America	2.131						- 2.131
Brazil	4.789						- 4.789
Venezuela	.746						- .746
South America	3.126						- 3.126
Sub-Saharan Africa		2.146			.158		- 2.304
Nigeria		.929			.077		- 1.005
Egypt			5.282				- 5.282
North Africa	.552		3.829				- 4.380
India				.067			- .067
South Asia				2.748			- 2.748
Indonesia				1.506			- 1.506
Thailand				.177			- .177
South-East Asia				1.345			- 1.345
East Asia				2.422			- 2.422
Middle East		1.308		3.970			- 5.278
Net Trade Posit.	33.392	17.511	9.111	12.247	4.903	- 1.763	

Table 8 - The embargo example.
Scenario #5 (embargo active, all countries but Argentina cooperating).
Trade flows and net trade positions (million tons).

Destination	Source: US	Canada	EC	Oceania	Argentina	Net Trade Positions
Oth. West. Eur.	1.764					- 1.764
Japan	5.699					- 5.699
South Africa				.011		- .011
East Europe	.214	5.128				- 5.342
USSR		9.090			4.901	- 13.991
China	12.237					- 12.237
Mexico	.800					- .800
Central America	2.131					- 2.131
Brazil	4.789					- 4.789
Venezuela	.746					- .746
South America	3.127					- 3.127
Sub-Saharan Africa		2.303				- 2.303
Nigeria		1.003			.002	- 1.005
Egypt			5.283			- 5.283
North Africa	.554		3.827			- 4.381
India				.067		- .067
South Asia				2.749		- 2.749
Indonesia				1.506		- 1.506
Thailand				.177		- .177
South-East Asia				1.346		- 1.346
East Asia	1.312			1.110		- 2.422
Middle East				5.279		- 5.279
Net Trade Positions	33.373	17.525	9.110	12.246	4.904	

Table 9 - The embargo example.
Changes in import and export prices as a consequence of the imposition of the embargo (US $ per ton).

	Base solution	Scenarios				
		1	2	3	4	5
US	163.28	- .58	- 1.32	- 13.69	- 1.50	- 1.60
Canada	165.28	+ 1.62	+ .28	- 13.49*	+ .30	+ .60
EC	177.18	+ 1.02	+ .28	- 13.49	- .10	.00
Oth. W. Eur.	179.88	- .58	- 1.32	- 13.69	- 1.50	- 1.60
Japan	179.88	- .58	- 1.32	- 13.69	- 1.50	- 1.60
Oceania	166.98	- .58	- 1.32	- 13.69	- .20	- .30
South Africa	192.78	- .58	- 1.32	- 13.69	- .20	- .30
East Europe	181.28	+ 1.62	+ .28	- 13.49	+ .30	+ .60
USSR	183.08	+ 1.62	+ 10.48	- 13.49*	+ 10.30	+10.60
China	192.18	- .58	- 1.32	- 13.69	- 1.50	- 1.60
Mexico	177.08	- .58	- 1.32	- 13.69	- 1.50	- 1.60
Central Amer.	177.08	- .58	- 1.32	- 13.69	- 1.50	- 1.60
Brazil	178.28	- .58	- 1.32	- 13.69	- 1.50	- 1.60
Argentina	167.98	- .38	- 1.12	- 13.49	- .30	+ .60
Venezuela	179.78	- .58	- 1.32	- 13.69	- 1.50	- 1.60
South Amer.	179.78	- .58	- 1.32	- 13.69	- 1.50	- 1.60
Sub-Sah. Afr.	196.48	- .38	- 1.12	- 13.49	+ .30	+ .60
Nigeria	196.48	- .38	- 1.12	- 13.49	+ .30	+ .60
Egypt	191.78	+ 1.02	+ .28	- 13.49	- .10	.00
North Africa	191.78	+ 1.02	+ .28	- 13.49	- .10	.00
India	196.98	- .58	- 1.32	- 13.69	- .20	- .30
South Asia	194.78	- .38	- 1.12	- 13.49	.00	- .10
Indonesia	190.18	- .58	- 1.32	- 13.69	- .20	- .30
Thailand	188.18	- .58	- 1.32	- 13.69	- .20	- .30
South E. Asia	194.78	- .58	- 1.22	- 13.49	.00	- .10
East Asia	190.18	- .58	- 1.32	- 13.69	- .20	- .30
Middle East	189.98	- .58	- 1.32	- 13.69	- .20	- .30

*: assuming Canada does not exercise market power.

Table 10 - The embargo example.
Changes* in net trade positions as a consequence of the imposition of the embargo (thousand tons).

	Base Solution	Scenarios				
		1	2	3	4	5
US	33,702	- 120	- 272	- 2,832	- 310	- 329
Canada	17,498	+ 71	+ 31	- 591	+ 13	+ 25
EC	9,110	+ 9	+ 3	- 114	+ 1	0
Oth. W. Eur.	- 1,755	- 3	- 7	- 72	- 8	- 9
Japan	- 5,698	0	- 1	- 15	- 1	- 1
Oceania	12,248	- 5	- 12	- 128	- 1	- 2
South Africa	- 11	0	0	- 2	0	0
East Europe	- 5,351	+ 23	+ 4	+ 4	+ 4	+ 9
USSR	- 14,373	+ 59	+407	+ 5,283	+371	+382
China	- 12,187	- 18	- 41	- 431	- 47	- 50
Mexico	- 793	- 3	- 6	- 57	- 7	- 7
Centr. Amer.	- 2,129	- 1	- 2	- 17	- 2	- 2
Brazil	- 4,786	- 1	- 3	- 28	- 3	- 3
Argentina	4,901	+ 1	- 3	- 45	- 2	+ 3
Venezuela	- 744	0	- 1	- 18	- 2	- 2
South Amer.	- 3,119	- 3	- 7	- 65	- 7	- 8
Sub-S. Afr.	- 2,305	- 1	- 3	- 35	+ 1	+ 2
Nigeria	- 1,006	0	0	- 2	+ 1	+ 1
Egypt	- 5,283	+ 5	+ 1	- 62	- 1	0
North Africa	- 4,381	+ 8	+ 2	- 113	+ 1	0
India	- 67	- 1	- 2	- 16	0	0
South Asia	- 2,748	- 4	- 10	- 115	0	- 1
Indonesia	- 1,505	- 1	- 3	- 26	- 1	- 1
Thailand	- 177	0	0	- 3	0	0
South E. Asia	- 1,345	- 2	- 3	- 36	0	- 1
East Asia	- 2,421	- 2	- 5	- 59	- 1	- 1
Middle East	- 5,275	- 9	- 20	- 205	- 3	- 4
World Trade	65,211	- 44	- 271	- 3,710	- 299	- 303

*: note that for an importing country a positive change of its net trade position implies a reduction of its imports, while the opposite is true if a negative change occurs.

A last point to be made is that if all exporters agree to cooperate, they come out sharing part of the cost of the embargo, because the embargo imposing country's exports will now displace part of their pre-embargo exports. This implies that asking for cooperation in an embargo scheme should be supported by either a reimbursement for the costs, or by the guarantee that the embargo imposing country's exports would not exceed the pre-embargo level minus the volume exported to the country the embargo is imposed on.

(b) Assessing the impact of a preferential tariff;

The second case considered, while hypothetical, is representative of an increasingly prevalent policy of developed countries which provide preferential access to developing countries imports.

Six countries are considered. Countries A and B may be thought of as developed countries with high production costs, country C as a developed country with low production costs and countries D, E and F as developing countries with different costs of production. Country A is strongly interested, for general foreign policy reasons, to have the developing countries as allies (in particular it is interested in keeping a good relationship with country D, which is hosting military installations crucial for its security). On the other hand, country A strongly opposes country C.

Each country's domestic demand and supply and inverse excess demand/supply functions are given in Table A3 in Appendix. Even though the proposed model does not need demand and supply schedules to be linear, they are assumed to be linear in the example. This allows for a comparison of the results obtained by using the model proposed in the previous section with those obtained using the QP model.

In the starting scenario, countries A and B impose a non-discriminatory import tariff. The hypothetical policy issue to be addressed is the impact of country A granting tariff-free access to exports from countries D, E and F (the developing countries), while imposing a discriminatory tariff (left unchanged) on its imports from countries B and C. Transportation costs and per unit import tariffs are given in Table A4 in Appendix. When preferential tariffs are in place the generalized transportation costs matrix is no longer consistent. The minimum generalized cost path to ship one unit of the commodity from country C to country A is no longer the direct one (the generalized transportation cost associated with this path is equal to $t_{ca} + \pi_{ca} = 1 + 2 = 3$), but the path going from C to F and from F to A (the generalized transportation cost now being $t_{cf} + \pi_{cf} + t_{fa} + \pi_{fa} = .5 + 0 + 1 + 0 = 1.5$).

In the starting scenario countries A, B, E and F are importing, C and D are exporting (Table 11). Because the generalized transportation costs matrix is consistent, this solution may be obtained using any of the four classes of models considered.

However, when the hypothetical preferential trade policy option is taken into account, the projected scenario crucially depends on the model used (and on the assumptions it implicitly makes about arbitraging).

The first solution considered is the one obtained using the QP[17] and the VS[18] models based on domestic demand and supply functions, and the model presented in this paper setting $\xi_{A,B,C,D,E,F} = \psi_{A,B,C} = 0$, and $\psi_{D,E,F} = 1$. All of them assume, implicitly or explicitly, that arbitraging is allowed but constrained not to exceed domestic consumption. Country A's production decreases sharply. Domestic production is replaced by increased imports from D (which more than doubles its exports to A) (Table 12). Country E is slightly worse off. It does not trade in the preferential trading scenario, while it was importing in the starting one (Table 11). Country F is made better off by the preference granted by country A. It was importing in the non-discriminatory tariff scenario, and it is exporting in the preferential trade policy one. This switch from being an importer to being an exporter as a result of country A's policy change would not have been caught if a model setting a priori the positions of the countries on the market would have been used. Country C is strongly penalized, even if the nominal level of the tariff faced by its exports to A did not change. The QP and VS models implicitly constrain each country's arbitraging to not exceed domestic consumption. The model proposed here is explicitly constrained in the same way. Country C now ships to A both directly and, indirectly, through F, which is arbitraging, partially bypassing country A's discriminatory tariff. Country F's constraint on arbitraging is binding. Its

Table 11 - The preferential tariff example. Production, consumption, volume traded, prices and welfare.

	Consumption	Production	Net trade position	Demand price	Supply price	Welfare
Base solution (non discriminatory tariff).						
A	293.556	154.648	- 138.908	8.444	8.444	43,864
B	16.056	13.944	- 2.112	8.944	8.944	218
C	2.278	113.369	111.090	5.444	5.444	267
D	3.686	35.140	31.455	3.944	3.944	39
E	3.057	2.944	- 0.113	4.944	4.944	9
F	12.478	11.066	- 1.412	5.944	5.944	1,559
Solution obtained using the Quadratic Programming and the Vector Sandwich models based on domestic demand and supply functions, and the model proposed (constraining arbitraging not to exceed domestic consumption).						
A	294.501	131.980	- 162.520	7.499	7.499	43,870
B	17.001	12.999	- 4.002	7.999	7.999	225
C	2.750	90.230	87.478	4.499	4.499	174
D	3.334	69.973	66.639	4.999	4.999	91
E	3.000	3.000	0.000	5.000	5.000	9
F	12.525	24.929	12.404	4.999	6.499	1,581
Solution obtained using the Quadratic Programming model based on excess demand and supply functions and the model proposed (leaving arbitraging unconstrained).						
A	294.868	123.157	- 171.711	7.132	7.132	43,790
B	15.868	14.131	- 1.737	9.132	9.132	217
C	2.184	117.970	115.786	5.632	5.632	288
D	3.456	57.833	54.377	4.632	4.632	69
E	3.000	3.000	0.000	5.000	5.000	9
F	12.468	15.753	3.285	6.132	6.132	1,560
Solution obtained using the model proposed when no arbitraging can occur. Scenario #2 (D and E allowed to export, F allowed to import).						
A	294.215	138.827	- 155.389	7.785	7.785	43,840
B	16.715	13.284	- 3.431	8.285	8.285	222
C	2.608	97.220	94.612	4.785	4.785	200
D	3.238	79.389	76.150	5.285	5.285	111
E	2.716	3.284	0.569	5.284	5.284	9
F	12.511	0.000	- 12.511	5.283	5.500	1,565
Solution obtained using the model proposed when no arbitraging can occur. Scenario #4 (D allowed to export, E and F allowed to import).						
A	294.208	138.987	- 155.221	7.792	7.792	43,839
B	16.709	13.291	- 3.418	8.291	8.291	222
C	2.604	97.382	94.778	4.791	4.791	200
D	3.236	79.382	76.371	5.291	5.291	112
E	3.000	3.000	0.000	5.000	5.000	9
F	12.510	0.000	- 12.510	5.291	5.500	1,565

Table 12 - The preferential tariff example. Trade flows.

Base solution (non discriminatory tariff).

Source	Destination					
	A	B	C	D	E	F
A	154.648					
B		13.944				
C	107.566	2.112	2.278			1.412
D	31.342			3.686	0.113	
E					2.944	
F						11.066

Solution obtained using the Quadratic Programming and the Vector sandwich models based on domestic demand and supply functions, and the model proposed (constraining arbitraging not to exceed domestic consumption).

Source	A	B	C	D	E	F
A	131.980					
B		12.999				
C	70.953	4.002	2.750			12.525
D	66.639			3.334		
E					3.000	
F	24.929					

Solution obtained using the Quadratic Programming model based on excess demand and supply functions and the model proposed (leaving arbitraging unconstrained).

Source	A	B	C	D	E	F
A	123.157					
B		14.131				
C		1.737	2.184			114.049
D	54.377			3.456		
E					3.000	
F	117.334					12.468

Solution obtained using the model proposed when no arbitraging can occur.
Scenario #2 (D and E allowed to export, F allowed to import).

Source	A	B	C	D	E	F
A	138.827					
B		13.284				
C	78.670	3.431	2.608			12.511
D	76.150			3.238		
E	0.569				2.716	
F						

Solution obtained using the model proposed when no arbitraging can occur.
Scenario #4 (D allowed to export, E and F allowed to import).

Source	A	B	C	D	E	F
A	138.987					
B		13.291				
C	78.850	3.418	2.604			12.510
D	76.371			3.236		
E					3.000	
F						

consumers pay 4.999 for one unit of the commodity, while its producers receive 6.499 for each unit shipped. Exports equal domestic production and imports equal domestic consumption.

The third solution presented is the one obtained when the QP model based on excess supply/demand functions and the model presented here, with both the ξ_i's and ψ_i's parameters set equal to 0, are used. Now arbitraging is left completely unconstrained. All of country C's exports to A now go through F, completely bypassing country A's import tariff (Table 12). Country C, which country A opposes, is now even better off with respect to the non discriminatory trade scenario! Country D's exports to A fall. Countries D and F are worse off with respect to the solution which allowed a constrained arbitraging, while country E's welfare is not affected (Table 11).

The use of the model proposed in this paper when arbitraging is not allowed implies the solution of 8 different models corresponding to the 2^3 possible sets of the ξ_i's parameters.

Individual and joint beneficiary countries' welfares associated to each of the 8 solutions are given in Table 13.

If the preferred countries do not collude, but each of them tries to maximize its own gains from trade, the only equilibrium in this hypothetical example is the one labeled as scenario number 2. In this scenario, no beneficiary country would gain from moving to the other side of the market. In addition, if each of the remaining 7 scenarios is considered, it is easy to verify that if countries D, E and F change their position on the market trying to maximize their gains from trade, then they always eventually move to scenario number 2. Hence, in this particular case, the solution suggested by the model when it is assumed that no arbitraging can take place is *unique* and *stable*. In this solution (Table 11), countries D and E export. Country F, which is constrained not to export, is an importer. It does not produce at all. Its domestic consumption is entirely satisfied by imports at a price lower than the minimum price needed to have a positive domestic supply.

If the preferred countries collude, the solution is given by scenario number 4. This particular case - in which country D exports, country F imports (and, again, finds unprofitable to produce) and

Table 13 - The preferential tariff example.
Solutions obtained using the model proposed when no arbitraging can occur.
Welfare results.

Scenario #	ξ_D	ξ_E	ξ_F	W_D	W_E	W_F	$W_D+W_E+W_F$
1	1	1	1	90.810	9.000	1,562.483	1,662.293
2	1	1	-1	111.225	9.081	1,565.215	1,685.521
3	1	-1	1	90.811	9.000	1,562.476	1,662.287
4	1	-1	-1	111.730	9.000	1,565.108	1,685.838
5	-1	1	1	24.242	9.708	1,581.881	1,615.831
6	-1	1	-1	24.243	11.140	1,559.371	1,594.754
7	-1	-1	1	24.241	8.998	1,582.618	1,615.857
8	-1	-1	-1	24.292	9.000	1,559.376	1,592.668

Table 14 - The preferential tariff example.
Welfare impact of country A implementing the preferential trade policy.

	Constrained arbitraging	Free arbitraging	------ No arbitraging ------ (a)	(b)
W_A	+ 0.01%	- 0.17%	- 0.06%	- 0.06%
W_B	+ 3.21%	- 0.54%	+ 1.83%	+ 2.29%
W_C	- 34.82%	+ 7.86%	- 25.09%	- 25.09%
W_D	+ 133.33%	+ 76.92%	+ 184.62%	
W_E	- 0.06%	- 0.06%	- 0.06%	
W_F	+ 1.41%	+ 0.06%	+ 0.38%	
$W_D+W_E+W_F$	+ 4.60%	+ 1.93%	+ 4.85%	+ 4.92%
$\frac{\Delta W_A}{\Delta(W_D+W_E+W_F)}$	+ 0.08	- 2.39	- 0.31	- 0.32

(a): beneficiary countries not colluding (scenario #2);
(b): beneficiary countries colluding (scenario #4).

country E does not trade - is associated with the highest possible level of the sum of the gains from trade of the three colluding beneficiary countries (Table 13). Country D compensates countries E and F in such a way that they are better off with respect to the gains from trade that they would obtain trying to maximize their own gains from trade individually.

Table 14 synthesizes the estimates of the welfare impact of country A's preferential trade policy option obtained by using the different models. The most relevant differences concern countries D and C (respectively the country A is more interested in favoring, and the country A opposes). When arbitraging is implicitly (QP models based on excess demand and supply functions) or explicitly left free to occur, country C's welfare is actually increased by country A granting preferential market access to its imports from D, E and F. Country D's welfare is the lowest among those reachable under the different hypotheses made regarding arbitraging. When arbitraging is implicitly (QP model based on domestic supplies and demands, VS model) or explicitly constrained to not exceed domestic consumption, country C is strongly negatively affected by country A's policy, while country D strongly benefits from it. When arbitraging is not allowed, the beneficiary countries experience the highest welfare increase. Country C is negatively affected, but less than under the hypothesis that a constrained arbitraging can take place.

In addition, if the efficiency (from country A's viewpoint) of the welfare transfer induced by the donor preferential tariff is considered, the results are very different. In Table 14 the ratio between the change in country A's welfare and the change in the sum of the beneficiary countries' welfares $[\Delta W_A/\Delta(W_D+W_E+W_F)]$ for each of the scenarios considered is given. This ratio is an index of the efficiency of the transfer (it is equal to the number of units of welfare country A is giving up to induce a one unit increase in the sum of the beneficiary countries' welfares). When constrained arbitraging can take place country A slightly increases its welfare while making the beneficiary countries better off. When arbitraging is left free to occur, not only the smallest beneficiary countries welfare increase takes place, but the efficiency ratio is much smaller than -1 (it is, in fact, equal to -2.39), i.e. A would be much better off by inducing the same welfare increase in countries D, E and F through a *direct* resources transfer (which, under the assumptions made, would have an efficiency ratio equal to -1). On the contrary, when arbitraging cannot take place, the beneficiary countries' welfare reaches its highest value and the efficiency ratio is close to -.30, i.e. country A's welfare is decreasing only by three tenths of one unit for each unit increase in the sum of countries D, E and F welfares.

As discussed before, arbitraging is definitely an issue in real world preferential trading. Clearly, the hypotheses regarding arbitraging (or, more often, the apparently "neutral" choice among alternative models thought to be equivalent) may produce very different projections of the effects of the trade policy option considered. In this second example the results of the analysis show that failure by country A to prevent the possibility of arbitraging occurring may turn the preferential trade policy in a very inefficient and costly option. The model which has been proposed gives the option of investigating the impact of the policy under a full spectrum of different trade behavior assumptions regarding arbitraging. This option is neglected when QP, NLP or VS models are used.

The hypotheses that have been made about the behavior of the beneficiary countries are very simple. Much more complex game structures in the international trade context are available and can be adapted to the specific problems discussed here.

Conclusions

Arbitraging is definitely an issue in real world discriminatory trade policy design and implementation, as confirmed, for example, by the "rules of origin" attached to all the active preferential tariff agreements. In this paper the limits involved in using Quadratic Programming, Non Linear Programming as proposed by Rowse, and Vector Sandwich models when discriminatory trade policies are present have been discussed. It has been shown that all these models implicitly make strong assumptions regarding the possibility of arbitraging to occur. In addition, the non-equivalence of the Takayama and Judge models based on domestic demand and supply functions and on excess demand/supply functions when discriminatory trade policies are present has been addressed.

A framework designed to model policy scenarios when discriminatory policies are active, allowing (a) each country to move from one side of the market to the other as the equilibrium prices change, and (b) the researcher to impose her assumptions about the possibility of arbitraging to occur and about countries' behavior, has been proposed.

Two numerical examples have been used to show how relevant the proposed model's features may be in terms of the implications for agricultural trade policy analysis.

Even if arbitraging is definitely a serious concern in designing and managing real world discriminatory trade policies, the most popular spatial trade models fail to effectively take it into account. The model proposed allows the researcher to properly specify his own assumptions about arbitraging and/or to obtain different possible solutions as a function of different policy constraints or different levels of effectiveness in enforcing such constraints.

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Footnotes

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1: Third ACP-EEC Convention, signed in Lome', Togo on December 8th 1984.

2: Throughout the paper arbitraging is defined in a broad sense as countries exporting and importing at the same time, without implying the existence of arbitraging gains.

3: I.e. pairs (i, j) and (j, i) are different.

4: The structure of the problem somehow resemble that of a generalized transportation model in which transshipment in permitted (as in Dantzig, chpt. 16). There, however, linear transportation costs are minimized, here the optimization involves a non-linear objective function.

5: "In this example we use the same demand and supply functions and transportation costs as in chapters 7 and 8, but assume that $\pi_{21}=1$ and $\pi_{31}=1$. It is not necessary to assume that $\pi_{1j}=\pi_{2j}=...=\pi_{nj}$ for all j; that is, the tariff may be discriminatory," (Takayama and Judge 1971,

p. 201).

6: The equivalence of the price and the quantity formulations of the model is proven in Takayama and Woodland.

7: The analogous conditions for the price formulation of the model are given in (8.3.7.a) and (8.3.7.b), p. 159 .

8: For a complete description of the structure of this model see Takayama and Judge 1971, chpt. 10.

9: Non linear transportation costs may be included as well. However, to keep the model presentation as close as possible to the QP framework discussed above, linear transportation costs are assumed. This does not affect anyhow the results of the analysis.

10: A good introduction to fixed point theory as a tool in finding economic equilibrium solutions is Zangwill and Garcia, chpts. 5, 6 and 7.

11: Non linear transportation costs may be easily included. They are assumed to be linear to maintain the discussion as close as possible to the standard QP setting.

12: The consumers price if consumers and producers prices are not equal.

13: The producers price if consumers and producers prices are not equal.

14: However, in this formulation of the problem, as well as in the one based on domestic demand and supply functions, each country's arbitraging may be easily constrained not to exceed a specific amount by inserting an ad hoc constraint.

15: A summary of the impact of the embargo in the different scenarios is given in Tables 9 and 10.

16: The same argument is in Paddock.

17: Clearly, in this case the NLP formulation collapse to the QP one.

18: The VS solution has been obtained by specifying in Holland's program the generalized transportation costs matrix as if it was the transportation costs one.

Appendix

Table A1 - The embargo example.
Excess demand/supply functions.
(prices in US $ per ton; quantities in million tons)

US	p	=	0.349	+	4.834	q
Canada	p	=	- 233.871	+	22.811	q
EC	p	=	- 898.258	+	118.046	q
Oth. West. Eur.	p	=	518.015	+	192.622	q
Japan	p	=	5450.136	+	924.969	q
Oceania	p	=	-1134.499	+	106.256	q
South Africa	p	=	267.002	+	6700.168	q
East Europe	p	=	550.109	+	68.928	q
USSR	p	=	582.966	+	27.823	q
China	p	=	579.342	+	31.769	q
Mexico	p	=	369.280	+	242.269	q
Central America	p	=	1945.634	+	830.684	q
Brazil	p	=	2493.845	+	483.827	q
Argentina	p	=	-1275.145	+	294.427	q
Venezuela	p	=	735.519	+	747.364	q
South America	p	=	838.890	+	211.297	q
Sub-Sah. Africa	p	=	1072.458	+	380.087	q
Nigeria	p	=	5451.160	+	5225.823	q
Egypt	p	=	1344.111	+	218.125	q
North Africa	p	=	716.457	+	119.753	q
India	p	=	254.311	+	854.092	q
South Asia	p	=	518.286	+	117.706	q
Indonesia	p	=	997.061	+	536.080	q
Thailand	p	=	984.791	+	4495.407	q
South East Asia	p	=	704.528	+	378.873	q
East Asia	p	=	746.552	+	229.840	q
Middle East	p	=	542.459	+	66.821	q

Table A2 - The embargo example.
Transportation costs matrix.
(US $ per ton)

	US	CAN	EC	OWEU	JAP	OCE	SAF	EEUR	USSR	CHI	MEX	CAME	BRA	ARG	VEN
US	0	10	16	16.6	16.6	32	34.5	20.2	19.8	28.9	13.8	13.8	15	16.5	16.5
CAN	10	0	17	16.2	20.3	35	35.4	16	17.8	28.2	19.3	19.3	21	23	23
EC	16	17	0	12	26.8	33.2	35	12.3	15	30	20	20	20	21.7	21.7
OWEU	16.6	16.2	12	0	30	39.6	35	12.5	15	35	25	25	25	25	25
JAP	16.6	20.3	26.8	30	0	18.2	20	25	26	14	18	18	24	26.1	26.1
OCE	32	35	33.2	39.6	18.2	0	25.8	28	19.7	25.2	27.5	27.5	27.5	25.8	25.8
SAF	34.5	35.4	35	35	20	25.8	0	35	35	30	34	34	33	32.1	32.1
EEUR	20.2	16	12.3	12.5	25	28	35	0	12	22	18	18	27	25.6	25.6
USSR	19.8	17.8	15	15	26	19.7	35	12	0	20	25	25	25	25.1	26
CHI	28.9	28.2	30	35	14	25.2	30	22	20	0	28	28	30	35.2	35.2
MEX	13.8	19.3	20	25	18	27.5	34	18	25	28	0	12	25	25.1	25.1
CAME	13.8	19.3	20	25	18	27.5	34	18	25	28	12	0	25	25.1	25.1
BRA	15	21	20	25	24	27.5	33	27	25	30	25	25	0	15	15
ARG	16.5	23	21.7	25	26.1	25.8	32.1	25.6	25.1	35.2	25.1	25.1	15	0	12
VEN	16.5	23	21.7	25	26.1	25.8	32.1	25.6	26	35.2	25.1	25.1	15	12	0
SAME	16.5	23	21.7	25	26.1	25.8	32.1	25.6	26	35.2	25.1	25.1	15	12	12
SSAA	40	31.2	31.6	30	24	32.9	20	30	30	30	40	40	30	28.5	28.5
NIG	40	31.2	31.6	30	24	32.9	20	30	30	30	40	40	30	28.5	28.5
EGY	30.1	26.5	14.6	15	28	32.3	25	18	16	35	35	35	28	27	27
NAFR	30.1	26.5	14.6	15	28	32.3	25	18	16	35	35	35	28	27	27
IND	44.2	37	39	39	30	30	28	30	39	30	40	40	44	44	44
SAS	44.2	37	39	40	16	28	26	40	40	20	30	30	26	26.8	26.8
INDO	28.2	26.6	30	35	13	23.2	30	40	35	18	35	35	30	34	34
THA	48.2	38.8	35.1	40	16	21.2	26	40	25	20	35	30	28	27.5	27.5
SEAS	44.2	37	39	40	15	28	30	40	40	18	35	35	30	26.8	26.8
EAS	28.2	26.6	30	35	13	23.2	30	40	35	18	35	35	30	34	34
ME	28	26.4	28.8	34	18	23	29	40	34	25	34	34	29	33	33

(Table A2 continues on the next page)

(Table A2, continued from the previous page)

	SAME	SSAA	NIG	EGY	NAFR	IND	SAS	INDO	THA	SEAS	EAS	ME
US	16.5	40	40	30.1	30.1	44.2	44.2	28.2	48.2	44.2	28.2	28
CAN	23	31.2	31.2	26.5	26.5	37	37	26.6	38.8	37	26.6	26.4
EC	21.7	31.6	31.6	14.6	14.6	39	39	30	35.1	39	30	28.8
OWEU	25	30	30	15	15	39	40	35	40	40	35	34
JAP	26.1	24	24	28	28	30	16	13	16	15	13	18
OCE	25.8	32.9	32.9	32.3	32.3	30	28	23.2	21.2	28	23.2	23
SAF	32.1	20	20	25	25	28	26	30	26	30	30	29
EEUR	25.6	30	30	18	18	30	40	40	40	40	40	40
USSR	26	30	30	16	16	39	40	35	25	40	35	34
CHI	35.2	30	30	35	35	30	20	18	20	18	18	25
MEX	25.1	40	40	35	35	40	30	35	35	35	35	34
CAME	25.1	40	40	35	35	40	30	35	30	35	35	34
BRA	15	30	30	28	28	44	26	30	28	30	30	29
ARG	12	28.5	28.5	27	27	44	26.8	34	27.5	26.8	34	33
VEN	12	28.5	28.5	27	27	44	26.8	34	27.5	26.8	34	33
SAME	0	28.5	28.5	27	27	44	26.8	34	27.5	26.8	34	33
SSAH	28.5	0	12	20	20	30	30	36	36	36	36	35
NIG	28.5	12	0	20	20	30	30	36	36	36	36	35
EGY	27	20	20	0	12	35	20	28	25	27	28	27
NAFR	27	20	20	12	0	35	20	28	25	27	28	27
IND	44	30	30	35	35	0	12	25	25	25	25	25
SAS	26.8	30	30	20	20	12	0	20	14	20	20	20
INDO	34	36	36	28	28	25	20	0	15	15	12	15
THA	27.5	36	36	25	25	25	14	15	0	15	15	15
SEAS	26.8	36	36	27	27	25	20	15	15	0	15	15
EAS	34	36	36	28	28	25	20	12	15	15	0	15
ME	33	35	35	27	27	25	20	15	15	15	15	0

Table A3 - The preferential tariff example.
Domestic demand and supply functions, excess demand/supply functions.

	domestic demands	domestic supplies
country A:	$q_a = 302 - p^d_a$	$q_a = -48 + 24\ p^s_a$
country B:	$q_b = 25 - p^d_b$	$q_b = 5 + p^s_b$
country C:	$q_c = 5 - .5\ p^d_c$	$q_c = -20 + 24.5\ p^s_c$
country D:	$q_d = 5 - .333\ p^d_d$	$q_d = -95 + 33\ p^s_d$
country E:	$q_e = 8 - p^d_e$	$q_e = -2 + p^s_e$
country F:	$q_f = 12.775 - .05\ p^d_f$	$q_f = -137.225 + 24.95\ p^s_f$

corresponding inverse excess supply/demand functions

country A:	$p_a = 14 + .04\ x_a$
country B:	$p_b = 10 + .5\ x_b$
country C:	$p_c = 1 + .04\ x_c$
country D:	$p_d = 3 + .03\ x_d$
country E:	$p_e = 5 + .05\ x_e$
country F:	$p_f = 6 + .04\ x_f$

Table A4 - The preferential tariff example.
Transportation costs and tariffs.

transportation costs matrix

	A	B	C	D	E	F
A	0	1	1	2.5	2.5	1
B	1	0	1.5	3	3	1.75
C	1	1.5	0	2	2	0.5
D	2.5	3	2	0	1	2
E	2.5	3	2	1	0	2
F	1	1.75	0.5	2	2	0

tariff matrix*

	A	B	C	D	E	F
A	0	2	0	0	0	0
B	2	0	0	0	0	0
C	2	2	0	0	0	0
D	2 (0)	2	0	0	0	0
E	2 (0)	2	0	0	0	0
F	2 (0)	2	0	0	0	0

*: (the numbers in parenthesis represents the changes in the tariff matrix when the preferential trade policy is implemented)

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