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STRATEGIC AGRICULTURAL TRADE POLICY INTERDEPENDENCE AND THE EXCHANGE RATE: A GAME THEORETIC ANALYSIS*

by

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Strategic Agricultural Trade Policy
Interdependence and the Exchange Rate:
A Game Theoretic Analysis

EXECUTIVE SUMMARY

In most countries, agriculture has become increasingly open, as evidenced by the dramatic increase in the volume of international trade since the end of World War II. One of the consequences of the growing openness of agriculture is a growing international interdependence of agricultural trade policy. Since agricultural trade policies are affected by linkages of the agricultural sector to world markets, any large country's agricultural trade decisions may lead to other countries' policy adjustments. Section 1 reviews the determination of agricultural producer price support and describes how the growing international interdependence has made unilateral policy reform a politically unattractive option.

In section 2 the effect of the exchange rate on the measurement of agricultural protection is discussed. Although a particular country may decrease price support, an appreciation of its domestic currency combined with world market changes may result in an increase in its Nominal Protection Coefficient (NPC).

Section 3 develops a multi-commodity model of agriculture which analyzes how welfare effects of various actions are taken into account by the government. Policy-makers behave as though they are using a weighing system to compare the gains of certain groups versus the losses of others. A Political Payoff Function (PPF) is used to represent this behavior. In modelling the policy decision process of interdependent

countries, a Nash equilibrium occurs where each country chooses policy which maximizes its PPF given the policy choice of the other.

Section 4 is based on Modele International Simplifie de Simulation (MISS), a simplified world trade model. MISS allows the analysis of various policy strategies for the United States and the European Community. First, using MISS the various sectoral weights are approximated. Then, a two-player, normal-form, noncooperative game is employed to analyze various policy strategies: across-the-board trade liberalization and liberalization based on proposals made in the Uruguay Round. Game simulations are conducted with and without compensation of losers. In addition, alternative exchange rate levels are incorporated in the analysis. Without compensatory payments to those with the highest political influence, the results suggest that only modest reform is possible. With compensation, liberalization occurs but free trade is not obtained.

Section 5 concludes the paper with a discussion of the problem that policy alternatives which are politically acceptable are typically a small or null subset of outcomes which are Pareto superior. The approach utilized here narrows the policy set to the level of reform that seems politically acceptable, and then shows the sensitivity of this set to compensatory payments from budget savings, and to fluctuations in the value of the U.S. dollar relative to the ECU. In light of the concerns expressed by EC negotiators these results are not surprising; clearly, the linkage between the value of the dollar and the influence of special interests serves to link broader economic policy to possibilities for reform at the sectoral level.

Strategic Agricultural Trade Policy Interdependence and the Exchange Rate: A Game Theoretic Analysis

Abstract: Strategic Agricultural Trade Policy Interdependence is modeled using a game theoretic framework. The model distinguishes between the European Community, the United States and a politically passive rest-of-the-world. Particular emphasis is placed on the effect of the exchange rate on the equilibrium outcome of this game.

(Key words: international trade policy reform; game theory; U.S.; EC)

1. Introduction: International Agricultural Trade Policy Interdependence

In most countries, agriculture has become increasingly open, as evidenced by the dramatic increase in the volume of international trade since the end of World War II. One of the consequences of the growing openness of agriculture is a growing international interdependence. Around the globe, agricultural trade policies are determined by the polity which in turn are influenced by the linkage of their agricultural sectors to world markets, and hence to the polity in other major trading nations. Any large country's agricultural trade decisions can affect world market prices and international trade flows and thus other countries' agriculture. This in turn may lead to changes in other countries' policy adjustments.

It has been shown that in many countries, including the United States (U.S.) and the European Community (EC), the level of agricultural producer price support is determined to a large extent by agricultural incomes and budgetary expenditures caused by farm programs (e.g., Riethmueller and Roe, 1986; von Witzke, 1986, 1990). Typically, the functional relationship is such that relatively low (high) agricultural incomes, and relatively low (high) budgetary expenditures result in relatively high (low) levels of price support.

In the 1980s, the budgetary expenditures of farm programs skyrocketed in many countries, inducing political demands for agricultural and trade policy reform. However, the growing international interdependence had made unilateral reform a politically unattractive option. Under these circumstances policy makers face a classical Prisoners' Dilemma as they have to expect that unilateral policy reform would be counteracted by other countries' endogenous policy adjustments.

To illustrate this, consider a world of two large countries, the U.S. and the EC. Suppose that the U.S. discontinued agricultural price support. Of course, this would lead to price increases on the world markets. This, in turn, would reduce EC budgetary expenditures, as it reduces the export subsidies the EC pays to dispose of its surplus production. The budgetary savings would be used by the EC to further increase agricultural price support. This would result in growing EC exports which would reduce world market prices, all other things being equal, and lead to additional structural adjustment of U.S. agriculture.

To model this international strategic agricultural policy interdependence, we will develop a non-cooperative game of a three-country world consisting of the U.S., the EC, and a politically passive rest of the world. In our model each country chooses its policy strategies based on a political payoff function (PPF). Particular emphasis is placed on the role of the exchange rate between the two countries in determining policy strategies. First, we discuss the role of the exchange rate in determining the choice of policy strategies. Then the theoretical framework is outlined, and third, we discuss the empirical results of the game. Comments on the stability of international agreements on

agricultural and trade policy reform in the presence of exchange rate fluctuations conclude the paper.

2. The Role of the Exchange Rate

The measurement of the extent of agricultural trade protection has been a popular area of agricultural economic research in recent years, and it has played an important role in the multilateral trade negotiations in the Uruguay Round of the General Agreement on Tariffs and Trade. One of the problems involved is that measures of trade protection, such as the Nominal Protection Coefficient (NPC) or the Producer Subsidy Equivalent are influenced not only by domestic price support and international price levels but also by exchange rates which have the tendency to fluctuate over time.

Consider the ECU/US$ exchange rate and price support in wheat. During the mid-1980s the US$ was rather strong relative to the currencies that form the ECU. In 1985, when the ECU/US$ exchange rate peaked the ECU world market price of wheat was at about the same level as EC support prices. Consequently, the NPC of wheat in the EC approached one and the EC could export at zero or very low export subsidies.

By 1992 the value of the US$ had declined relative to the ECU to 0.76 ECU/US$ (Commission of the EC, 1992). Although wheat price support in the EC had declined by about 30 percent since 1985, the change in the exchange rate together with world market changes had resulted in an NPC in the EC of 1.94 (OECD, 1993).

This phenomenon has a number of implications. For instance, in 1985 it was difficult for the U.S. to claim that the EC's Common Agricultural Policy (CAP) was

protectionist and distorting international agricultural trade. But it was not a change in the CAP towards a more liberal policy that had resulted in such a low NPC; it was a temporarily high value of the US$ relative to the ECU. Likewise the growing NPC in the EC since 1985 was not the consequence of more protectionist tendencies in EC agriculture. Quite the opposite, real support prices have declined considerably since then. For the most part the growing NPC was the consequence of a declining value of the US$.

3. Theoretical Framework

This analysis is based on a multi-commodity model of agriculture. The initial model was developed by Mahé, et al. (1988). Subsequently a political economic submodel was added (Johnson, 1990; Johnson, Mahé and Roe, 1993) and other modification were made (Kennedy, 1994).

In the model, N commodities are produced, consumed, and traded by two main countries and the rest of the world. Vectors of supply, demand, and excess demand are used to describe the levels of aggregate production, consumption, and trade for each country. The supply sector in country k produces some combination of the N commodities in order to maximize profits given prices, technology, and endowments. Aggregate production of the N commodities is described by the vector of supply functions,

$$(1) \quad S_k(P_k^S ; X_k^S) = [S_{1k}(P_k^S ; X_k^S), S_{2k}(P_k^S ; X_k^S), \ldots , S_{Nk}(P_k^S ; X_k^S)],$$

where $P_k^S = (P_{1k}^S, P_{2k}^S, \ldots , P_{Nk}^S)$ is the vector of prices observed by the supply sector and

X_k^S is a vector of exogenous variables, such as technology, input prices, and endowments for the supply sector of country k . Aggregate consumption of the N commodities is described by the vector of demand functions

$$(2) \quad Q_k(P_k^Q ; X_k^Q) = [Q_{1k}(P_k^Q ; X_k^Q), Q_{2k}(P_k^Q ; X_k^Q), \ldots , Q_{Nk}(P_k^Q ; X_k^Q)],$$

where $P_k^Q = (P_{1k}^Q, P_{2k}^Q, \ldots , P_{Nk}^Q)$ is the vector of prices observed by the final demand sector and X_k^Q is a vector of exogenous variables for country k. The aggregate level of trade in the N commodities for country k is described by the excess demand functions

$$(3) \quad M_k(P_k^S, P_k^Q ; X_k^S, X_k^Q) = Q_k(P_k^Q ; X_k^Q) - S_k(P_k^S ; X_k^S)$$

where $M_k = (M_{1k}, M_{2k}, \ldots , M_{Nk})$ and $M_{ik} > 0$ indicates net imports and $M_{ik} < 0$ indicates net exports of commodity i for i = 1,2, ... , N.

Governments intervene in domestic markets either through the use of price (π) or supply/demand shift (θ) instruments. Price instruments, denoted as $A_{ik}^{\pi S}$ for producers and $A_{ik}^{\pi Q}$ for consumers of commodity i in country k, affect the prices observed by the supply and final demand sectors. With the world price of commodity i represented as P_i^W the domestic price functions for country k are:

$$(4) \quad P_{ik}^S = P_{ik}^S (A_{ik}^{\pi S}, P_i^W) \text{ and } P_{ik}^Q = P_{ik}^Q (A_{ik}^{\pi Q}, P_i^W), \text{ for i = 1,2, ... , N.}$$

Supply/demand shift instruments, shown as $A_{ik}^{\theta S}$ for producers and $A_{ik}^{\theta Q}$ for consumers of commodity i in country k, are implicit elements of vectors X_k^S and X_k^Q which shift supply and demand functions by modifying non-price elements of the producers or consumers

decision process. Supply/demand shift instruments include policy such as acreage reduction programs, subsidization schemes, and food stamp/giveaway programs. In order to make these instruments explicit the vectors X_k^S and X_k^Q are defined as follows,

(5) $X_k^S = X_k^S(A_k^{\theta S}; \tilde{X}_k^S)$ and $X_k^Q = X_k^Q(A_k^{\theta Q}; \tilde{X}_k^Q)$.

The aggregate supply (1), demand (2) and excess demand (3) equations are expressed as functions of world price, policy instruments, and exogenous variables by substituting the domestic price functions (4) and the function of explicit variables (5), thus obtaining;

$$(1^*)\quad S_k[P_k^S(A_k^{\pi S}, P^W), A_k^{\theta S}; \tilde{X}_k^S] = \{S_{1k}[P_k^S(A_k^{\pi S}, P^W), A_k^{\theta S}; \tilde{X}_k^S], S_{2k}[P_k^S(A_k^{\pi S}, P^W), A_k^{\theta S}; \tilde{X}_k^S], \dots, S_{Nk}[P_k^S(A_k^{\pi S}, P^W), A_k^{\theta S}; \tilde{X}_k^S]\},$$

$$(2^*)\quad Q_k[P_k^Q(A_k^{\pi Q}, P^W), A_k^{\theta Q}; \tilde{X}_k^Q] = \{Q_{1k}[P_k^Q(A_k^{\pi Q}, P^W), A_k^{\theta Q}; \tilde{X}_k^Q], Q_{2k}[P_k^Q(A_k^{\pi Q}, P^W), A_k^{\theta Q}; \tilde{X}_k^Q], \dots, Q_{Nk}[P_k^Q(A_k^{\pi Q}, P^W), A_k^{\theta Q}; \tilde{X}_k^Q]\}$$

and

$$(3^*)\quad M_k[P_k^Q(A_k^{\pi Q}, P^W), P_k^Q(A_k^{\pi Q}, P^W), A_k^{\theta S}, A_k^{\theta Q}; \tilde{X}_k^S, \tilde{X}_k^Q] = \{M_{1k}[P_k^Q(A_k^{\pi Q}, P^W), P_k^Q(A_k^{\pi Q}, P^W), A_k^{\theta S}, A_k^{\theta Q}; \tilde{X}_k^S, \tilde{X}_k^Q], M_{2k}[P_k^Q(A_k^{\pi Q}, P^W), P_k^Q(A_k^{\pi Q}, P^W), A_k^{\theta S}, A_k^{\theta Q}; \tilde{X}_k^S, \tilde{X}_k^Q], \dots, M_{Nk}[P_k^Q(A_k^{\pi Q}, P^W), P_k^Q(A_k^{\pi Q}, P^W), A_k^{\theta S}, A_k^{\theta Q}; \tilde{X}_k^S, \tilde{X}_k^Q]\}$$

where $P^j(A_k^{\pi S}, P^W) = [P_1^j(A_1^{\pi S}, P^W), P_2^j(A_2^{\pi S}, P^W), \dots, P_N^j(A_N^{\pi S}, P^W)]$ for $j = S,Q$.

Let the main countries be denoted as countries 1 and 2 and the rest of the world as country 3. The vector of excess demand functions for the rest of the world is shown as $M_3(P^W; X_3)$ where X_3 is the vector of exogenous variables for the rest of the world. Through the adjustment of world prices, world markets are assumed to clear, i.e. world markets are competitive. Therefore,

$$(6) \quad M_1[P_1^S(A_1^{\tau S}, P^W), P_1^Q(A_1^{\tau Q}, P^W), A_1^{\theta S}, A_1^{\theta Q}; \tilde{X}_1^S, \tilde{X}_1^Q] +$$
$$M_2[P_2^S(A_2^{\tau S}, P^W), P_2^Q(A_2^{\tau Q}, P^W), A_2^{\theta S}, A_2^{\theta Q}; \tilde{X}_2^S, \tilde{X}_2^Q] + M_3(P^W; X_3) = 0$$

where the right-hand side of the equation is an $N \times 1$ vector of zeros. In order for the game to be well defined it is necessary that world prices be defined as functions of the actions of the two main countries. Therefore, the world price vector is shown as the function

$$(7) \quad P^W = P^W(A_1^{\tau S}, A_1^{\tau Q}, A_1^{\theta S}, A_1^{\theta Q}, A_2^{\tau S}, A_2^{\tau Q}, A_2^{\theta S}, A_2^{\theta Q}; \tilde{X}_1^S, \tilde{X}_1^Q, \tilde{X}_2^S, \tilde{X}_2^Q, X_3)$$

Throughout the process of agricultural policy formulation the welfare effects of various actions are taken into account by the government. Policy-makers behave as though they are using a weighing system to compare the gains of certain groups versus the losses of others. In order to model this behavior, a political payoff function (PPF) is used. The PPF, a weighted, additive function of producer quasi-rents, consumer utility and budget costs, is the objective function which, through their policy choices, policy-makers behave as though they seek to maximize. The weights are determined empirically in the model, based on observed policies.

Let $-k$ denote the other main country and $A_k = (A_k^{\pi S}, A_k^{\pi Q}, A_k^{\theta S}, A_k^{\theta Q})$ represent the actions of country k. In addition, let exogenous factors $X = (\tilde{X}_1^S, \tilde{X}_1^Q, \tilde{X}_2^S, \tilde{X}_2^Q, X_3)$ be suppressed. Producers are grouped according to commodities with their welfare defined as the profit obtained through the production and marketing of that commodity. Assuming differentiability, the welfare of the group producing commodity i is shown as the line integral:

$$(8) \quad \Pi_{ik}(P_k^S ; X_k^S) = \int_0^{P_i} S_k(P_k^S ; X_k^S)\, dP_i.$$

The vector,

$$(9) \quad \Pi_k(P_k^S ; X_k^S) = [\Pi_{1k}(P_k^S ; X_k^S), \Pi_{2k}(P_k^S ; X_k^S), \ldots , \Pi_{Nk}(P_k^S ; X_k^S)]$$

signifies quasi-rents over the N producer groups. In addition, the utility function is shown as:

$$(10) \quad U_k(P_k^Q ; X_k^Q) = \int_{P_i}^{\infty} Q_k(P_k^Q ; X_k^Q)\, dP_i.$$

In order to express producer quasi-rents (9) as a function of government policies, equation (4) is substituted for P_k^S, equation (5) is substituted for the exogenous variable X_k^S, and equation (7) replaces the world price P^W, thus obtaining,

$$(11) \quad \tilde{\Pi}_k(A_k, A_{-k}) = \Pi_k\{P_k^S[A_k^{\pi S}, P^W(A_k, A_{-k})], A_k^{\theta S}\}.$$

In the same manner, by substituting equations (4), (5) and (7) into equation (10) consumer utility is expressed as a function of government policies, obtaining

(12) $\tilde{U}_k(A_k, A_{-k}) = U_k\{P_k^Q[A_k^{\pi Q}, P^W(A_k, A_{-k})], A_k^{\theta Q}\}.$

In order to express the budget function let a transpose of an N × 1 vector be denoted by T. Producer receipts are $P_k^S \cdot S_k^T$, consumers spend $P_k^Q \cdot Q_k^T$, and excess demand (supply) is purchased (sold) in the world market at price P^W for a total monetary value of $P^W \cdot M_k^T$. Using equations (1), (2) and (3) the budget is shown as:

(13) $B_k(P_k^S, P_k^Q, P^W; X) = (P_k^Q - P^W) \times Q_k^T(P_k^Q; X_k^Q) - (P_k^S - P^W) \times S_k^T(P_k^S; X_k^S).$

Substituting for P_k^S, P_k^Q and P^W and suppressing X as before, the budget of country k, as a function of government policies, is shown as:

(14) $\tilde{B}_k(A_k, A_{-k}) = B_k\{P_k^S[A_k^{\pi S}, P^W(A_k, A_{-k})], P_k^Q[A_k^{\pi Q}, P^W(A_k, A_{-k})],$
$P^W(A_k, A_{-k}), A_k^{\theta S}, A_k^{\theta Q}\}.$

Having expressed producer quasi-rents, consumer utility and the budget as functions of government policies, the budget weight is normalized to one and the PPF, as a function of government policies, is shown as:

(15) $V_k(A_k, A_{-k}) = \tilde{\Pi}_k(A_k, A_{-k}) \cdot \lambda_{Sk} + \tilde{U}_k(A_k, A_{-k}) \cdot \lambda_{Qk} + \tilde{B}_k(A_k, A_{-k})$

where λ_{Sk} is a strictly positive N × 1 vector which represents the relative political weights of the producer groups in country k and λ_{Qk} is a strictly positive scaler representing the relative political weight of the consumer group in country k.

If the policy decision process of interdependent countries is to be modelled, a Nash equilibrium occurs where each country chooses the policy which maximizes its PPF

given the policy choice of the other. This equilibrium is defined using a best response correspondence. For a given A_{-k}, government k chooses A_k^*, one possible best response to A_{-k}, such that

$$(16) \quad V_k(A_k^*, A_{-k}) \geq V_k(A_k, A_{-k}), \text{ for all } A_k \in \mathbf{A}_k,$$

where $\mathbf{A}_k$ is the set of all possible actions which can be employed by government k. Every A_{-k} element of $\mathbf{A}_{-k}$ has at least one A_k^* element of $\mathbf{A}_k$ which is a best response for country k. A Nash equilibrium is defined as the set of actions (A_k^*, A_{-k}^*) where A_k^* is a best response to A_{-k}^* for country k, and A_{-k}^* is a best response to A_k^* for country -k.

Differentiating eq. (15) with respect to A_k^S and A_k^Q, the first order necessary conditions for a maximum are

$$(17) \quad \begin{bmatrix} \frac{\delta V_k}{\delta A_k^S} \\ \frac{\delta V_k}{\delta A_k^Q} \end{bmatrix} = \begin{bmatrix} \frac{\delta \tilde{\Pi}_k}{\delta A_k^S} & \frac{\delta \tilde{U}_k}{\delta A_k^S} \\ \frac{\delta \tilde{\Pi}_k}{\delta A_k^Q} & \frac{\delta \tilde{U}_k}{\delta A_k^Q} \end{bmatrix} \cdot \begin{bmatrix} \lambda Sk \\ \lambda Qk \end{bmatrix} + \begin{bmatrix} \frac{\delta \tilde{B}_k}{\delta A_k^S} \\ \frac{\delta \tilde{B}_k}{\delta A_k^Q} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}.$$

Under the assumption that V_k is concave in A_k given A_{-k} any A_k^* which solves equation (16) maximizes V_k. Thus, by definition, A_k^* is a best response to A_{-k}. (A_k^*, A_{-k}^*) is a Nash equilibrium if

$$(18) \quad \begin{bmatrix} \frac{\delta V_k}{\delta A_k^S} \\ \frac{\delta V_k}{\delta A_k^Q} \end{bmatrix} \Big| (A_k^*, A_{-k}^*) = \begin{bmatrix} 0 \\ 0 \end{bmatrix}.$$

In the situation where the two main countries negotiate with one another, no agreement will be reached or kept unless both countries are made at least as well off as they were prior to the agreement. A necessary condition for a treaty is that there exist at least one pair of actions (A_k^+, A_{-k}^+) which satisfy

$$(19) \quad V_k(A_k^+, A_{-k}^+) \geq V_k(A_k^*, A_{-k}^*) \text{ and } V_{-k}(A_k^+, A_{-k}^+) \geq V_{-k}(A_k^*, A_{-k}^*).$$

Actions (A_k^+, A_{-k}^+) satisfying equation (19) are called treaty actions. The treaty action space is the set of all treaty actions. In order to achieve an agreement in which both governments are made at least as well off as prior to negotiations, the settlement must lie within the treaty action space.

4. Empirical Analysis

The base year for the empirical analysis is 1990. We distinguish seven commodity groups consisting of cereals, oilmeals, feed grain substitutes, beef, pork and poultry, milk, and sugar. The PPFs for the U.S. and EC were generated through the evaluation of incremental changes in the observed policies from their base year levels. These changes are then used to approximate the partial derivatives in eq. (7). When eq. (7) is solved for λ_{Sk} and λ_{Qk} one obtains approximations of the PPF weights. These weights are normalized such that the budget weight is one. They are presented in Table 1.

In this two-player, normal-form, noncooperative game, defined by $G = \{A_{US}, A_{EC}; P_{US}, P_{EC}\}$, each country k chooses some action $A_k \in A_k$ in order to maximize its PPF given the action choices of the other country. The policy strategies analyzed here are

Table 1. Political Payoff Function Weights and Their Ranking by Interest Group for the United States and the European Community, Based on 1990 Data.

Interest Group	United States		European Community	
	Rank	Weight	Rank	Weight
Sugar	1	1.32	1	1.49
Milk	2	1.31	2	1.41
Cereals	3	1.15	3	1.37
Oilmeals	4	1.04	4	1.35
Budget	5	1.00	7	1.00
Beef	6	0.89	5	1.29
Consumers	7	0.85	8	0.90
Pork & Poultry	8	0.84	6	1.01

Source: Kennedy (1994).

several different degrees of across-the-board trade liberalization and liberalization proposals made in the Uruguay Round of multilateral trade negotiations under the General Agreement on Tariffs and Trade. For games involving across-the-board trade liberalization, the action space $A_k = \{SQ_k, 75_k, 50_k, 25_k, FT_k\}$ for k = U.S.,EC, where SQ_k denotes status quo policies; 75_k denotes protection at 75% of the status quo level; 50_k denotes protection at 50% of the status quo level; 25_k denotes protection at 25% of the status quo level; and FT_k denotes free trade (FT).

Game simulations are conducted in which compensation is not allowed (NC) and where governments provide budget compensation (BC). In the NC scenario the political payoff function reflects changes in producer and consumer welfare and budget savings resulting from policy changes. The PPF is modified in the BC scenario, allowing each

government to provide compensation from budget savings to those sectors of the economy made worse off due to the policy liberalization. The rules used for budget compensation specify that only those sectors of the economy which experience a decrease in welfare as a result of the policy action are compensated. Budget compensation given to a sector cannot exceed the amount of that sector's welfare loss. Because the weight of budget savings in the political payoff function is one, a sector must have a PPF weight greater than one in order to receive compensation. Budget compensation is given in descending order of welfare weights. Finally, total budget compensation cannot exceed total budget savings.

The base solution using across-the-board trade liberalization without direct compensation of producers is presented in Table 2. The Nash equilibrium in this as well as in all other scenarios analyzed here is unique. It is marked by a star (*). As can be seen, without use of budgetary savings to compensate producers, only limited liberalization can be expected in both the U.S. and the EC. If budget savings are used to compensate producers, both countries are willing to liberalize more (Table 3). However, the U.S. is willing to reduce trade protection more than the EC. This is consistent in principle with the strategies both countries have pursued in the GATT negotiations.

Table 4 depicts the Nash equilibria at alternative exchange rates. We use the maximum and minimum US$/ECU exchange rate since the introduction of the ECU in 1978 (1.39 US$/ECU in 1980; 0.76 US$/ECU in 1985). This implies that compared with 1990 (1.27 US$/ECU) we simulate the effect of a 9.4% devaluation and a 40.2% revaluation of the dollar. A devaluation of the dollar results in the same Nash

Table 2. PPF Values for U.S. and EC Protection Reductions Using Across-the-Board Liberalization Without Budget Compensation, 1990.

US Actions	EC Actions				
	SQ_{EC}	75_{EC}	50_{EC}	25_{EC}	FT_{EC}
SQ_{US}	0,0	97,120	210,-441	323,-1716	461,-4174
75_{US}	434,168	545,242*	683,-335	854,-1662	1093,-4181
50_{US}	132,359	239,453	378,-150	548,-1469	791,-4004
25_{US}	-521,577	-442,680	-320,116	-151,-1238	56,-3772
FT_{US}	-1675,844	-1552,957	-1486,392	-1384,-915	-1216,-3479

The pair (P_{US},P_{EC}) are the PPF for the US and EC respectively.
* The Unique Nash Equilibrium occurs at $(75_{US},75_{EC})$.

Table 3. PPF Values for U.S. and EC Protection Reductions Using Across-the-Board Liberalization With Budget Compensation, 1990.

US Actions	EC Actions				
	SQ_{EC}	75_{EC}	50_{EC}	25_{EC}	FT_{EC}
SQ_{US}	0,0	101,2235	221,3331	341,2911	490,493
75_{US}	1522,191	1463,2287	1383,3455	1320,2969	1354,479
50_{US}	2112,409	2182,2306	2203,3557	2178,3169	2129,1636
25_{US}	2280,657	2348,2343	2399,3681*	2495,3339	2610,853
FT_{US}	1745,961	1852,2399	1915,3856	1989,3532	2087,1112

The pair (P_{US},P_{EC}) are the PPF for the US and EC respectively.
* The Unique Nash Equilibrium occurs at $(25_{US},50_{EC})$.

equilibrium for NC^D as that found for the actual 1990 exchange rate, NC^A. However, BC^D occurs at a point where the U.S. chooses free trade while the EC once again picks a 50% reduction of its protection levels. The results of a revaluation of the dollar show both countries retaining the status quo in NC^R, while the solution BC^R finds the U.S.

Table 4. Nash Equilibrium Solutions to Games Based on Across-the Board Liberalization Using Various Exchange Rate Levels.

US Actions	EC Actions				
	SQ_{EC}	75_{EC}	50_{EC}	25_{EC}	FT_{EC}
SQ_{US}	NC^R		BC^R		
75_{US}		NC^A,NC^D			
50_{US}					
25_{US}			BC^A		
FT_{US}			BC^D		

Game solutions with No Budget Compensation and with Budget Compensation are represented by NC^E and BC^E respectively, for E=A,R,D, where A denotes actual exchange rate, R denotes a revalued dollar, and D denotes a devalued dollar.

choosing the status quo and the EC reducing its protection levels by 50%.

When across-the-board trade liberalization is simulated a depreciation of the dollar induces the EC and the U.S. to choose policies at or near the status quo without compensation. If compensation is allowed, the EC reduces its protection levels by fifty percent regardless of the exchange rate. Solutions involving compensation indicate that the U.S. loses incentive to reduce protection given a revaluation of the dollar, while incentive to liberalize trade policies increases as the dollar is devalued, due to the relative change in prices of traded goods.

Games simulating proposals made in the Uruguay Round utilize the action space $A_k = \{SQ_k, EX_k, PF_k, FT_k\}$ for k=U.S.,EC.[1] Each country k has action choices which are; status quo (SQ_k); no export related subsidies (EX_k); partial free trade (PF_k); and

[1]A more complete overview of proposals made in the Uruguay round of GATT can be found in Hine, et. al., (1989) and Guyomard, et. al., (1993).

free trade (FT_k). For the U.S., SQ_{US} denotes status quo policies; EX_{US} denotes free trade in cereals, oilmeals, cereal substitutes, and pork and poultry, status quo in beef and sugar, and uniform reductions of dairy prices to autarky; PF_{US} denotes free trade in cereals, oilmeals, cereal substitutes, beef, and pork and poultry, and status quo dairy and sugar policies; and FT_{US} denotes free trade.

In the case of the EC; SQ_{EC} denotes status quo policies; EX_{EC} denotes a uniform reduction of cereal, beef, pork and poultry, dairy, and sugar prices to autarky, and status quo oilmeal producer policies; PF_{EC} denotes twenty percent ad valorem tariffs on cereals and beef, twenty percent oilmeal producer subsidy above world price, free trade in pork, and status quo dairy and sugar policies; and FT_{EC} denotes free trade.

The base solution for scenarios using liberalization based on proposals made in the Uruguay Round without direct compensation is presented in Table 5. Without the use of budgetary savings to compensate producers, no liberalization can be expected in either country. As can be seen in Table 6, if budget savings are used to compensate producers, both countries are willing to liberalize to some extent, although complete free trade is not achieved.

Similar to the scenarios using across-the-board trade liberalization, simulations based on Uruguay Round proposals indicate that a devaluation of the dollar will induce the U.S. and EC to select policies which do not involve trade liberalization without budget compensation. If compensation is allowed, the EC chooses the elimination of export related subsidies regardless of the exchange rate as shown in table 7. However, solutions involving compensation indicate that the U.S. gains incentive to reduce protection given

Table 5: PPF Values for U.S. and EC Protection Reductions Using Uruguay Round Proposals Without Budget Compensation, 1990.

US Actions	EC Actions			
	SQ_{EC}	EX_{EC}	PF_{EC}	FT_{EC}
SQ_{US}	0,0*	122,-578	514,-773	461,-4174
EX_{US}	-345,365	-246,-465	134,-384	38,-3743
PF_{US}	-486,321	-340,-464	67,-458	174,-3748
FT_{US}	-1632,843	-1564,-363	-1143,137	-1174,-3478

The pair (P_{US},P_{EC}) are the PPF for the US and EC respectively.
* The Unique Nash Equilibrium occurs at (SQ_{US},SQ_{EC}).

Table 6: PPF Values for U.S. and EC Protection Reductions Using Uruguay Round Proposals With Budget Compensation, 1990.

US Actions	EC Actions			
	SQ_{EC}	EX_{EC}	PF_{EC}	FT_{EC}
SQ_{US}	0,0	122,2202	563,1312	490,493
EX_{US}	1857,444	1923,2362*	2243,1674	2134,907
PF_{US}	1474,399	1580,2366	1922,1582	1987,847
FT_{US}	1795,961	1804,2449	2315,2385	2135,1113

The pair (P_{US},P_{EC}) are the PPF for the US and EC respectively.
* The Unique Nash Equilibrium occurs at (EX_{US},EX_{EC}).

Table 7. Nash Equilibrium Solutions to Games Based on Uruguay Round Proposals Using Various Exchange Rate Levels.

US Actions	EC Actions			
	SQ_{EC}	EX_{EC}	PF_{EC}	FT_{EC}
SQ_{US}	NC^A, NC^D, NC^R	BC^R		
EX_{US}		BC^A		
PF_{US}				
FT_{US}		BC^D		

Game solutions with No Budget Compensation and with Budget Compensation are represented by NC^E and BC^E respectively, for E=A,R,D, where A denotes actual exchange rate, R denotes a revalued dollar, and D denotes a devalued dollar.

a devaluation of the dollar, while incentive to liberalize trade policies decreases as the dollar is revalued, due to the relative change in the prices of traded goods.

5. Conclusion

Knowledge of the state of economic policy is typically sufficient for economists to suggest numerous policy alternatives that, even in the presence of second best, can lead to Pareto superior outcomes. The problem of course is that the policy alternatives which are politically acceptable are typically a small or a null subset of those that lead to these outcomes. The approach utilized here narrows the policy set to the level of reform that seems politically acceptable, and then shows the sensitivity of this set to compensatory payments from budget savings, and to fluctuations in the value of the U.S. dollar relative to the ECU. Without compensatory payments to those with the highest political influence, the results suggest that only modest reform is possible. With compensation, liberalization occurs but free trade is not obtained.

These results are not surprising in light of the concerns expressed by EC negotiators; clearly, the linkage between the value of the dollar and the influence of special interests serves to link broader economic policy to possibilities for reform at the sectoral level. The GATT plays a unique role in this regard because bringing agriculture under its discipline leads to pressures for macroeconomic stability as well.

We suggest that as the world moves in the direction of regional trading blocks, more in-depth and sophisticated analysis of the type presented here will be needed in order to focus attention on those reforms that are politically feasible and Pareto superior. Included in this concern is the tendency for numerous small countries (such as countries with a comparative advantage in the production of sugar) to face a free rider problem so that no individual country in this group is willing to incur the cost of pressuring the large countries to reform. Economists will need to analyze the design of various institutional mechanisms that can minimize the tendencies for prisoners dilemma outcomes.

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