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

Abstract: International strategic agricultural trade policy interdependence is modelled using a game theoretical 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.

INTRODUCTION

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 political processes 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 USA 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 programmes (e.g., Riethmueller and Roe, 1986; and 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 programmes 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 'prisoner's 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 USA and the EC. Suppose that the USA 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 increase agricultural price support further. 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 US agriculture.

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To model this international strategic agricultural policy interdependence, we will develop a non-co-operative game of a three-country world consisting of the USA, the EC, and a politically passive rest-of-the-world. In our model each country chooses its policy strategies based on a *political pay-off 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.

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 unity 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 USA 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, the real support price has declined considerably. For the most part it was the consequence of a declining value of the US$.

THEORETICAL FRAMEWORK

Our analysis is based on a multi-commodity model of agriculture. The initial model was developed by Mahé, Tavèra and Trochet (1988). Subsequently a political economic sub-model was added (Johnson, 1990; and Johnson, Mahé and Roe, 1993) and other modifications were made (Kennedy, 1994).

In our model, N commodities are produced, consumed, and traded by two main countries, the EC and the USA, and the rest-of-the-world. 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:

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

Supply/demand shift instruments, denoted as $A_{ik}^{\theta S}$ for producers and $A_{ik}^{\theta Q}$ for consumers of commodity i in country k, are implicit elements of exogenous variable vectors X_k^S and X_k^Q.

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 behaviour, a political pay-off 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 while the actions of country k are represented by $A_k = \{A_k^{\pi S}, A_k^{\pi Q}, A_k^{\theta S}, A_k^{\theta Q}\}$. Producers are grouped according to commodities with their welfare defined as the profit obtained through the production and marketing of that commodity. Producer quasi-rents, consumer utility, and the budget of country k are expressed as functions of government policies in the following equations:

$$(2)\quad \tilde{\Pi}_k(A_k, A_{-k}) = \Pi_k\{P_k^S[A_k^{\pi S}, P^W(A_k, A_{-k})], A_k^{\theta S}\}$$

$$(3)\quad \tilde{U}_k(A_k, A_{-k}) = U_k\{P_k^Q[A_k^{\pi Q}, P^W(A_k, A_{-k})], A_k^{\theta Q}\}$$

$$(4)\quad \tilde{B}_k(A_k, A_{-k}) = B_k\{P_k^S[A_k^{\pi S}, P^W(A_k, A_{-k})], P_k^Q[A_k^{\pi Q}, P^W(A_k, A_{-k})], P^W(A_k, A_{-k})], A_k^{\theta S}, A_k^{\theta Q}\}$$

The budget weight is normalized to one and the PPF, expressed as a function of government policies, is shown as:

$$(5)\quad V_k(A_k, A_{-k}) = \tilde{\Pi}_k(A_k, A_{-k}) \cdot \lambda_{Sk} + \tilde{U}_k(A_k, A_{-k}) \cdot \lambda_{Qk} + \tilde{B}_k(A_k, A_{-k})$$

where λ_{Sk} is a strictly positive, N x 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 its 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:

(6) $V_k(A_k^*, A_{-k}) \geq V_k(A_k, A_{-k})$, 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 Equation (5) with respect to A_k^S and A_k^Q, the first-order necessary conditions for a maximum are

$$(7) \quad \begin{bmatrix} \frac{\delta V_k}{\delta A_k^S} \\ \\ \frac{\delta V_k}{\delta A_k^Q} \end{bmatrix} = \begin{bmatrix} \frac{\delta \tilde{\Pi}_k}{\delta A_k^S} \frac{\delta \tilde{U}_k}{\delta A_k^S} \\ \\ \frac{\delta \tilde{\Pi}_k}{\delta A_k^Q} \frac{\delta \tilde{U}_k}{\delta A_k^Q} \end{bmatrix} \cdot \begin{bmatrix} \lambda_{Sk} \\ \\ \lambda_{Qk} \end{bmatrix} + \begin{bmatrix} \frac{\delta \tilde{B}_k}{\delta A_k^S} \\ \\ \frac{\delta \tilde{B}_k}{\delta A_k^Q} \end{bmatrix} = \begin{bmatrix} 0 \\ \\ 0 \end{bmatrix}$$

Under the assumption that V_k is concave in A_k given A_{-k}, any A_k^*which solves Equation (7) maximizes V_k. Thus, by definition, A_k^* is a best response to A_{-k}. In the situation where the two 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}^+)satisfying

(8) $V_k(A_k^+, A_{-k}^+) \geq V_k(A_k^*, A_{-k}^*)$ and $(V_{-k}(A_k^+, A_{-k}^+) \geq V_{-k}(A_k^*, A_{-k}^*)$

Actions (A_k^+, A_{-k}^+) satisfying Equation (8) 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.

EMPIRICAL ANALYSIS

This analysis is based on 1990 as the base year. We distinguish 7 commodity groups consisting of cereals, oilmeals, feed grain substitutes, beef, pork and poultry, milk, and sugar. The PPFs for the USA and EC were generated through the evaluation of small changes in the observed policies from their base year levels. These changes were then used to approximate the partial derivatives in Equation (7). When Equation (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, non-co-operative game, defined by $G = \{\mathbf{A_{US}}, \mathbf{A_{EC}}; \mathbf{P_{US}}, \mathbf{P_{EC}}\}$ each country k chooses some action $A_k \in \mathbf{A_k}$in order to maximize its PPF, given the action choices of the other country. The policy strategies analyzed here are several different degrees of across-the-board trade liberalization. The action space $A_k = \{SQ_k, 75_k, 50_k, 25_k, FT_k\}$ for k = USA, EC. Actions of the USA and

EC are status quo (SQ), protection at 75 percent of the status quo level (75), protection at 50 percent of the status quo level (50), protection at 25 percent of the status quo level (25), and free trade (FT). Game simulations are conducted in which compensation is not allowed (NC) and in which governments provide compensation to losers (BC).

In the BC scenarios, government budget savings, resulting from liberalization, are transferred to producers. In order to receive this transfer, the PPF weight of a sector must be greater than one.

Table 1 *Political Pay-Off Function Weights and Their Ranking by Interest Group for the USA and the EC, Based on 1990 Data*

	United States		European Community	
Interest group	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 and poultry	8	0.84	6	1.01

Source: Kennedy (1993).

Table 2 *PPF Values for US and EC Protection Reductions without Budget Compensation, 1990*

	EC actions				
US actions	SQ_{EC}	75_{EC}	50_{EC}	25_{EC}	FT_{EC}
SQ_{US}	0, 0	97, 120	210, –441	323, –1 716	461, –4 174
75_{US}	434, 168	545, 242*	683, –335	854, –1 662	1093, –4 181
50_{EC}	132, 359	239, 453	378, –150	548, –1 469	791, –4 004
25_{US}	–531, 577	–442, 680	–320, 116	–151, –1 238	56, –3 772
FT_{US}	–1675, 844	–1552, 957	–1486, 392	–1384, –915	–1216, –3 479

Notes: The pair (P_{US}, P_{EC}) are the PPF for the USA and EC respectively. * The unique Nash equilibrium occurs at $(75_{US}, 75_{EC})$.

The base solution for 1990 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 USA and the EC. If budget savings are used to compensate producers, both countries are willing to liberalize more (Table 3). However, the USA 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 percent devaluation and a 40.2 percent revaluation of the dollar. A devaluation of the dollar results in the same Nash equilibrium for NC^D as that found for the actual 1990 exchange rate, NC^A. However, BC^D occurs at a point where the USA chooses free trade while the EC once again picks a 50 percent 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 USA choosing the status quo and the EC reducing its protection levels by 50 percent.

Table 3 *PPF Values for US and EC Protection Reductions with Budget Compensation, 1990*

	EC actions				
US 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

Notes: The pair (P_{US}, P_{EC}) are the PPF for the USA and EC respectively. *The unique Nash equilibrium occurs at $(25_{US}, 50_{EC})$.

Table 4 *Nash Equilibrium Solutions to Games Using Various Exchange Rate Levels*

	EC Actions				
USA 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		

Note: 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.

Without budget compensation, both countries are induced to choose policies at or near the status quo regardless of the exchange rate. If compensation is allowed, the EC reduces its protection levels by 50 percent. Solutions involving compensation indicate that the USA 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.

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 US$ 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. Economists will need to analyze the design of various institutional mechanisms that can minimize the tendencies for prisoners dilemma outcomes.

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DISCUSSION OPENING — Stephan von Cramon-Taubadel *(Institut für Agrarökonomie, Christian-Albrechts-Universität, Germany)*

Kennedy, von Witzke and Roe are to be congratulated for producing a very concise, topical and interesting paper. Along with their focus on interdependence, their explicit consideration of the exchange rate is particularly pertinent. Recall that the first agricultural market organization in the EU was completed in mid-1967. As a consequence, intra-EU agricultural trade was liberalized — at the cost of much trade diversion — and EU farm prices were exposed to exchange rate movements. Due to Bretton Woods, this exposure seemed harmless. However, less than two years later, as Bretton Woods began to crumble and exchange rate fluctuations increased, EU policy makers were scrambling to reinstate barriers to intra-EU trade. The resulting agri-monetary system (AMS) of tariffs spelled the end of the EU's common agricultural market. Any agricultural trade liberalization that would expose EU farm prices to exchange rate induced fluctuations like those that would have resulted from the US$'s gyrations during the 1980s, would likely be just as short lived as the EU's common agricultural market. Hence, Kennedy, von Witzke and Roe are right to stress the link between agricultural liberalization and macroeconomic stability.

The AMS continues to play an important role in EU agriculture. Because of the 'green' ECU, a particularly byzantine aspect of the AMS that is designed to keep the strength of the DM from depressing German farm prices, EU agricultural prices in US$ are actually 21 percent higher than the US$/ECU exchange rate would suggest. Kennedy, von Witzke and Roe do not mention the green ECU in their paper, but I assume that their calculations account for this hidden protectionism.

Several aspects of the paper merit closer examination. First, the empirical analysis is based on 1990 data. Since 1990, the EU and the USA have come to terms on agriculture and the EU has reformed its cereals and oilseeds market organizations. Do Kennedy, von Witzke and Roe feel that these developments bear out the results of their model? I suspect that the answer to this question would hinge on the fact that they analyze across-the-board liberalization while the EU's recent changes are product specific. The authors stress that economists should pay more attention to politically feasible alternatives; given the differences in the PPF weights reported in Table 1, across-the-board liberalization does not appear to be such an alternative.

Second, while Kennedy, von Witzke and Roe refer to the prisoner's dilemma in their paper, I do not see a classic prisoner's dilemma in their results. There is a strategy available to each country that maximizes its PPF regardless of the other's action. For example, in Table 3, the USA should move to 25 percent of status quo protection no matter what the EU does. Of course, each would like to see the other liberalize more, but this is not a prisoner's dilemma outcome in which strategic behaviour precludes a solution that both would prefer.

Indeed, my first reaction to Tables 2 and 3 was: why haven't we seen the suggested solutions? Is it because politicians haven't been asking economists for advice on how to increase political pay-offs? Note that this also casts doubt on the derivation of the PPF weights in Table 1. If the US PPF increases following a move to 75 percent of status quo protection regardless of the EU's action (Table 2), the status quo cannot represent an optimum. In this case, the PPF has not been maximized, and the first order conditions used to derive PPF weights do not hold. Combined with other problems surrounding the estimation and use of PPF weights — for example, that they are endogenous and may

vary with major policy changes such as total liberalization, or that they are conditional on the stochastic elasticity estimates used to derive them — this suggests that Kennedy, von Witzke and Roe's empirical results must be considered illustrative and preliminary.