Trade Wars and Trade Negotiations in Agriculture

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EXECUTIVE SUMMARY

We employ a numerical general equilibrium model to evaluate the payoffs to agricultural and non-agricultural interests in the EC and the US. A government objective function for each region is calibrated as a weighted sum of the payoffs to the two interest groups with weights corresponding to the benchmark political influence. The objective function is employed by each government to determine the level of agricultural support. The influence weights on agricultural interests that would rationalize the existing protection system with these objective functions are 72% in the EC and 61% in the US. A negotiated outcome which fulfills certain economic efficiency criteria with this disagreement point could result in partial liberalization of the CAP by 75% while simultaneously allowing US agriculture to gain an additional 50% protection.

There are, however, alternatives to direct negotiations that could result in partial CAP liberalization. A marginal change in the political influence weights of European interest groups would also result in a 75% liberalization of the CAP.

A complete liberalization of the CAP would, nonetheless, require substantial changes in these political weights. Even if the EC were indifferent to income distributional aspects of the outcome, corresponding to 50:50 weights, there would be an efficiency argument in favor of unilaterally keeping some endogenous protection in place. Complete liberalization would therefore, to some extent, require a reversal of the bias in income distributional considerations that now favor agricultural interests.

Some attention should be directed to the possibility of an escalating trade war. A very small increase in the EC agricultural influence weight would lead to increases in protection for both the US and the EC. Avoiding these alterations in the political structure can therefore be of some importance. Similarly, a marginal increase in the weight for US agriculture would increase US agricultural protection, but the strategic response from the EC in this case would be a reduction in protection. However, the cost of this policy change would be carried by the US nonagricultural interests.

There is therefore some cause for optimism with regard to achieving partial CAP liberalizations simply through a minor political change in the EC, even if a complete liberalization would require quite drastic steps.

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1. INTRODUCTION

Agriculture has been a sensitive issue in the current round of multilateral trade negotiations. It threatens to be one of the major stumbling blocks to an acceptable agreement. Why has agricultural liberalization generated such controversy? What is needed in order to achieve significant reform of agricultural policies?

We approach these two questions from a very specific point of view. We assume that the currently observed levels of agricultural support are the outcome of a trade war in which the major participants have been agricultural and non-agricultural interests in the European Communities (EC) and the United States (US).

The historic opposition to reform is explained in these terms by agricultural interest groups having a stronger political influence than non-agricultural interest groups. This insight provides a consistent basis for the quantitative evaluation of these political influence weights.

Once the model is calibrated with these benchmark[1] weights we can determine how much the structure of political influence would have to change in the EC or the US so as to bring about a new political equilibrium in which reform has occurred. Analysis of the means of influencing this political structure is beyond the scope of this study, but it is easy to imagine how informing politicians, bureaucrats, and the electorate about the costs of agricultural support could change the political influence structure.

The central concept of equilibrium in our model of a trade war is **Nash Equilibium** (NE). This equilibrium is simply a set of policies for the EC and US such that neither country would want to change their policies unilaterally. We consider a trade war in which the payoffs to each country depend on the values of two variables. The first variable is **the real return to domestic agricultural interests** and the second is **national welfare net of this return to agriculture**. This situation could be viewed as the result of a behind-the-scenes lobbying game in which agricultural interests have managed to convince their government that one of the objectives of agricultural trade policy should be to protect domestic agricultural interests, rather than to worry

[1] The notion of a "benchmark equilibrium" is standard in GE modelling. It refers to an equilibrium of the system in which all of the essential microeconomic features of the base year are replicated as solution values. GE models are calibrated, or estimated, so that they replicate a benchmark equilibrium in this way. We will be referring to several alternative base years, so we prefer to use the term "benchmark equilibrium" rather than "benchmark year."

solely about the general welfare effects of that policy.

What are the relative weights that governments attach to these two objectives? A set of political influence weights are derived that are consistent with our model. Specifically, we can determine the weight that must be given to agricultural interests in the benchmark equilibrium of the model so as to rationalize the protection for agriculture that is assumed in the model to apply in that year. The political process that is implicit in this rationalization exercise is a simple lobbying model in which agricultural interests compete with the rest of the economy for policies that favor one or other group. This process is not explicitly modelled here.

We find that agricultural groups in the EC must have had considerably more influence over the determination of EC agricultural policies than non-agricultural groups. Specifically we calculate political influnce weights of 72% and 28%, respectively. The same result is true for the US, albeit to a lesser extent with weights of 61% and 39%.

We then vary these political weights in order to investigate the sensitivity of the level of agricultural support with respect to the structure of political influence. This exercise is undertaken so as to assess the possibility of attaining agricultural reform even in the absence of a satisfactory negotiated settlement. This reform would be the result of influencing the perceptions of the electorate and politicians. The Nash Equilibrium of the agricultural trade war would then be realized at lower levels of agricultural support.

Our results show that partial liberalization of the CAP could be achieved by relatively modest changes in the political structure. Complete elimination would require more radical changes in political influence.

However, we also consider the implications of our trade war results for the outcome of a negotiated agreement on agriculture between the US and the EC. This agreement would be the outcome of cooperative negotiations, such as are occurring on a multilateral basis under the auspices of the GATT, rather than the outcome of a noncooperative trade war. Nonetheless, the outcome of the trade war can have a dramatic impact on the former negotiated agreement by determining the relative threats that each nation can credibly bring to the bargaining table.

We emphasize at the outset that the game-theoretic concepts and computations that we undertake are extremely stylized, in the sense that they should be qualified before our results are applied to policy-making. This is more than the natural reticence of scholars to take responsibility for the use or abuse of their research: we identify throughout a number of dimensions in which our specific results might properly be questioned. In section 6 we explicitly consider several alternative formulations of the strategic agricultural trade issue. However, the main contribution of our results is to propose and illustrate a conceptual and quantitative approach to strategic trade issues which can be readily extended to deal with such qualifications.

The paper is structured as follows. In section 2 we provide a gentle introduction to the game-theoretic concepts employed throughout. The key idea here is that one cannot, in general, define the "self-interest" of one country independently of the range of policies available to other countries. In section 3 we explain in detail the methodology that we employ to model agricultural trade wars. The key concept here is the estimation of model-consistent political influence weights for agricultural and non-agricultural interests. In section 4 we present the numerical results of applying this methodology. Section 5 is a discussion of a number of questions that arise when attempting to assess how general our results are.

2. STRATEGIC SELF-INTEREST

The Idea of Nash Equilibrium

Imagine that some policy action that would improve the well-being of all of its citizens was available to the US. Forget, for the moment, the unbridled self-interest of sectional lobby groups or the alleged myopia of politicians. Let us assume that transparency reigns such that the political actors can see what is best and have the political willpower to act accordingly if they want to. Should the US pursue this policy action?

Before answering this question we need to know one more piece of information. Will this action lead to any retaliatory policy action from any other nation that could "hurt" the citizens of the US? Assume that the citizens of the EC would be hurt by this action of the US if it were carried out. In other words, the citizens of the EC are assumed to be worse off if the US implements this policy than if it does not. The next question, then, is whether or not the EC has any policy of its own that can be used to retaliate against the US (or to threaten to retaliate).

Assume that the EC does have such a policy. Will they use it? That depends on whether or not the EC is better off using it. And if they use it, it will influence and possibly change the initial US policy decision. Thus the self-interest of each nation is linked necessarily to the actions that it expects other nations to take. It is simply impossible to define the self-interest of one nation independently of the self-interest of other nations, unless the actions of one nation have no impact at all on the well-being of other nations, or if the other nations have no retaliatory threat that would lead the first nation to choose one action over another.

Game theory provides a framework that enables us to untangle this apparent infinite regress of semantics. Specifically, the **Nash Equilibrium** (NE) concept is a way of predicting what the outcome will be if each and every nation pursues its own self-interest while expecting the other nations to do the same. The NE concept does not describe a process of retaliation, but the outcome of such a process.

To illustrate the importance of accounting for strategic retaliation in trade policy, consider the two simple games with payoff matrices shown in Table 1. In each case we have taken the payoffs from policy simulations generated by the global general equilibrium (GE) model of Whalley [1985] [1986] and reported in

Harrison, Rutström and Wigle [1989]. Two agents are considered: the US and the EC. Each agent has just two pure strategies in each game. In game 1 each agent can do nothing (N) or can abolish (A) agricultural trade barriers. In game 2 the EC can increase agricultural protection by 100 percent or 200 percent and the US can increase protection by 150 or 200 percent. We shall consider much more detailed policy options later in a more realistic model, but the essential ideas can be understood with just two strategies.

In each game in Table 1 the abolition strategy refers to all tariff and non-tariff barriers, abolished on a nondiscriminatory basis. In other words, we are allowing each nation to remove all agricultural protection against imports from all other nations (the alternative would be to have them remove protection only against imports coming from particular nations). The payoffs shown in the two games are the annual welfare impact, as measured by the Equivalent Variation in income in billions of 1977 U.S. dollars.

Consider game 1 first. The NE of this game is extremely simple to compute; in fact, it can be read directly from the payoff matrix. If the EC does nothing, the US has two policy choices available to it with payoffs of 0 and -3.64, respectively. Clearly it is in the self-interest of the US to choose the first policy, which involves it doing nothing. Note that this policy choice is conditional on the assumed behavior of the EC.

If the EC were to abolish protection, the US again has two policy choices available to it. This time, however, the payoffs to the US from these two actions are 1.53 and -2.15, respectively. Although the values of the payoffs are quantitatively different to the US (depending on what the EC does), the predicted outcome for the US is the same in each case: to do nothing. Thus the US can be counted on by the EC to follow the policy of doing nothing. This is called a **dominant strategy** for the US. It is always in the best interest of a country to follow a dominant strategy, irrespective of the actions of the other country.[2]

Now consider the self-interest of the EC. If the US were to do nothing, it has two policy choices open, leading to payoffs of 0 and -6.97, respectively. In this case it would choose to do nothing. If the US were to abolish agricultural protection, the EC's two policy choices provide it with payoffs of 0.96 and -6.03, respectively. The EC would choose to do nothing in this case as well. Thus the EC also has a dominant strategy to do nothing

[2] In this case we have a strongly dominant strategy, since the payoffs to the United States for the alternative action are strictly lower. Weakly dominant strategies are defined in an obvious manner.

in this particular game. Even if the EC did not have this dominant strategy, we could have restricted our analysis to the first set of choices for the EC, since the EC could be safe in assuming that the US would do nothing (irrespective of what it, the EC, decided to do).

In game 1, therefore, the NE is simply for each country to do nothing. Because each country had a dominant strategy available to it, the self-interest of each country could indeed be defined independently of the conjectured retaliation of the other nation. This is a very special case.

The NE outcome in game 2 is not quite as simple. The best strategy for the US depends on the strategy chosen by the EC. If the EC increases protection by 100 percent, the US would prefer to increase protection by 150 percent; conversely, if the EC increases protection by 200 percent, the US would prefer to increase its protection by 200 percent. Which policy is in the self-interest of the US to follow? Fortunately, the EC will choose to increase protection levels by 200 percent irrespective of the US' choice here, so it is in the self-interest of the US to do likewise and increase protection by 200 percent (this is the NE of game 2). Our point, however, is that one could not define the self-interest of the US in game 2 without making some conjecture about the behavior of the EC.

We shall see below that the payoff structure for trade policy games is not always so simple as in games 1 and 2. If a country does not have a dominant strategy available to it, it will need to form some conjecture as to the likely strategy choice of the other country. We do not explain or analyze this process of conjecture and counter-conjecture. Instead we focus on a set of strategies that are consistent with correct conjectures: a Nash Equilibrium.

Some Qualifications

We would like to stress three obvious but important qualifications to this result and our approach, even at this simple illustrative level.

First, the welfare or production impacts shown may not be robust to variations in the parameters (or underlying structure) of the GE model. Even at a casual level we can see that the equilibrium point of game 2 might alter with relatively small changes in the welfare impacts for either the US or the EC. These small changes in welfare may, in turn, be generated by small perturbations of key elasticities in the underlying model (e.g., see Harrison, Jones, Kimbell and Wigle [1991]). Thus the robustness of the GE results are essential to the robustness of the game. We will employ procedures for the systematic sensitivity analysis of GE models developed by Harrison and Vinod [1991] to allow for a statistical treatment of the robustness problem.[3]

The second qualification is that we are considering extreme pure strategies in these two examples. It is quite possible that there exist intermediate pure strategies, involving something less than the total abolition of agricultural trade barriers, such that some US-EC liberalization would occur in a noncooperative equilibrium. The operationalization of a response to this qualification involves taking finer grids of pure strategies. We are able to do this with our approach, subject to familiar constraints on computational expense.

The final qualification is that our analysis of game 1 implies only the absence of a welfare-improving noncooperative outcome. Such a result may therefore point the way towards the necessity of cooperative solutions to the US-EC agricultural trade policy problem. More importantly, it provides one starting point, the disagreement outcome, in a subsequent analysis of the cooperative game in the sense of Nash [1950] [1953]. We illustrate this point in the next section.

The Nash Solution to Cooperative Bargaining Games

Nash [1951] proposed a "solution" to a class of cooperative bargaining problems. The solution is obtained as the unique outcome that satisfies a series of plausible axioms involving, among other things, economic efficiency. Agents are assumed to be able to communicate and write down some binding agreement to implement this solution, which is widely referred to as the Nash Solution (NS).[4] In the absence of an agreement each agent faces a specified **disagreement outcome**. The particular disagreement outcome that is selected can have dramatic consequences for the negotiated agreement, which is intuitive enough. This turns out not to be the case in our

[3] Appendix B provides a brief description of these procedures.

[4] Readers that are not familiar with game theory should take some care to distinguish the notions of Nash Equilibrium and the Nash Solution. The fact that they were developed by the same John Nash leads many readers to confuse them. To add to the risk of confusion, Nash [1953] demonstrates that the NE and the NS coincide for certain classes of non-cooperative games. Many game theorists sniff at the direct use of axiomatic solution concepts such as the NS unless they can be shown to emerge as NE of interesting classes of non-cooperative bargaining models. Binmore, Rubinstein and Wolinsky [1986] develop this general point.

study, however.

Computationally, the NS is straightforward to calculate. One simply evaluates the product of the utility gains of each agent, where a "gain" is measured by the difference between the utility that the agent receives at the tentative agreement point and the fixed disagreement outcome. The strategy combinations that generate a maximum for this "Nash Product" constitute the agreement point.[5]

[5] Appendix A presents these cooperative solution concepts in greater technical detail for the interested reader.

3. METHODOLOGY

We consider a bilateral[6] trade war between the US and the EC with respect to agricultural protection using a computable GE trade model to generate payoffs to each government. Each of the US and EC adopts policies that operate in a non-discriminatory fashion.[7]

There are three important steps in generating the payoff matrices which form the basis of our trade wars. The first step is to define the **objective function of the governments** of the EC and US, taking into account the relative political influence weights of agricultural and non-agricultural interests. The second step is to define the **policy instruments** that may be used as strategies. The third step is to allow for the **uncertainty** underlying any particular numerical simulation model, using techniques of sensitivity analysis and expected utility theory. Each of these steps is considered in sections 3.1, 3.2, and 3.3, respectively. We then proceed to evaluate the trade war outcomes in section 3.4.

3.1 Payoffs to Trade Wars

We assume that each of the governments in the US and EC have an objective function that they use to decide when a policy change is an improvement or not. These objective functions have just two arguments: the welfare of sectional agricultural interests, and the welfare of the rest of society (i.e., the non-agricultural interests). The key issue to be resolved here is how the government weights these two factors.

Before addressing this issue, however, we should note how we measure the welfare of each of these groups. The welfare of society as a whole is given by changes in welfare of the consumers of the country. This is measured in terms of the Equivalent Variation (EV) in benchmark dollar terms (the base year is 1980 in this model, and the benchmark monetary measure is the U.S. dollar). This is a standard measure of changes in welfare for models where consumers are homogeneous within each country.

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[6] All other nations are assumed to be strategically passive in these policy experiments. It would be straightforward to relax this assumption in later work.

[7] That is, the EC might increase protection against imports from all sources (rather than just against imports from the United States, for example). The effects of a geographically discriminatory trade war might be quite different, and could also be evaluated in later work.

The welfare of agricultural interests is measured by looking at the change in the real income of a household that derives it's income solely from agriculture. Specifically, let agricultural land and capital be specific to agriculture with no useful employment in any other sector. Whenever there is some policy change there will be some change in the return to this factor, invariably reflecting the fate of the sector to which it is specific. Thus a decline in agricultural production will typically result in a decline in the relative price of factors specific to agriculture. The real income of the household owning this factor is then calculated by deflating with the change in the cost of living.[8] It is perfectly possible for the return to the factor to decline but for the real income of the household owning the factor to increase (this would occur if the cost of living dropped by a greater percentage than the return to the factor).

In the model that we employ there are two sectors that are "agricultural" in the broad sense used here. One is called AGR and refers to primary agricultural production. The other sector is called FOO and refers to food products. It is appropriate to consider these two jointly since much of the trade in agricultural goods occurs after they have been processed to some extent and hence are treated statistically as food products. In effect we are assuming that these two sectors coordinate their political lobbying activities perfectly. Given that we change the levels of protection afforded their sectors equally, this assumption is plausible enough.[9]

Given that we know how any set of trade policies affects the welfare of agricultural interests and the welfare of the economy as a whole, it is a straightforward matter to net out the former from the latter to obtain the change in the welfare of non-agricultural interests. Our governments are then assumed to apply relative political weights to these two welfare changes in order to evaluate the overall affect of the policy change in a linear objective function.

To derive the political weights on agricultural and non-agricultural interests, we assume that the

[8] In our model there is only one consumer in each country, thus there is only one cost of living index in each country. Note that the change in the price of the specific factor, as well as the cost of living, are denominated in terms of some (arbitrary) numeraire good.

[9] In the concluding section we mention how our results could be extended to consider different trade policies for each of these sectors. We assume away issues of the "endogenous structure" of trade policies. If such issues were addressed it would not be appropriate to assume that the interests of the two sectors coincide perfectly. Our calculation of political weights would then need to be extended to account for three lobby groups instead of two, necessitating the use of a formal non-linear programming approach presented in Rutström [1991; Chapter 8] in the place of the back-of-the-envelope arithmetic used here. In all other respects our approach generalizes easily to allow for more than two lobbying groups.

benchmark equilibrium policies in our model are the outcome of a political lobbying process. Specifically, allow the US government to consider two alternative policy options: maintaining the status quo in terms of agricultural support, or complete (unilateral) abolition of agricultural support. We consider more than one alternative to the status quo, but for illustrative purposes just assume that there is one liberalization alternative.

Assume that our lobbying groups have opposite interests in the policy being considered. This is always the case for the policies being considered in this study. Agricultural interests prefer more agricultural support and non-agricultural interests less.

A minimal weight on agricultural payoffs in the objective function is calculated such that none of the alternatives to status quo that are preferred by the non-agricultural interest groups would be chosen. For our illustrative example it would imply that the weighted payoffs to the government from complete (unilateral) abolition of agricultural support is less than that in the status quo.

Similarly, a maximal weight for agricultural payoffs will have to be calculated when allowing for alternatives with higher levels of support than status quo.[10] These alternatives would be preferred by agricultural groups. The weighted payoff to the government from this higher support alternative must be less than their weightred payoff in the status quo.

The interpretation of these weights is straightforward. They tell us the range of weights within which lies the weight that one lobby group must receive in terms of the government's objective function so as to rationalize the fact that the GE model has a support level equal to the value assumed. No empirical rabbit is being pulled out of the air, since we are not claiming that we have estimated these weights. Rather, we are just taking a particular model that represents the support policies that were assumed or observed to be in effect in the benchmark year, and asking how one could explain that using a simple model of government behavior.[11] As constructed, the weights that we employ are best described as being model-consistent rather than being

[10] Note that if the policy variables were modelled as being continuous rather than discrete then the minimal and maximal weights would coincide.

[11] The political lobbying process underlying this model of government behavior is not part of our GE model. Recent developments in GE modelling now allow one to incorporate such political equilibrium models simultaneously with the economic model: see Rutherford and Winer [1990]. The calibration of such political economy GE models can be delicate, however, and it is well beyond the scope of the present study to undertake such an exercise. Our approach has the disadvantage of appending a political model to a (calibrated) GE model, but has the advantage of simplicity and transparency.

empirical estimates.[12]

Further, we make no attempt at explaining the political lobbying process that leads to the establishment of these weights. We simply take them as given in the benchmark. The benchmark is therefore assumed to be in both economic and political equilibrium.

3.2 Policy Instruments of a Trade War

The policy instruments considered here are directly related to the agricultural support policies in the two countries.

The Common Agricultural Policy in the EC is modelled as a threshold price constraint on the import price of goods in agriculture and food that is enforced through a variable import levy. The levy in 1985, the benchmark year in our model, caused a 4% difference between the domestic and the international price.

In addition there is an intervention price constraint on domestic goods, above the threshold price, that is supported by intervention purchases and export subsidies. This constraint forces domestic prices up by an additional 1% in the benchmark. The share of intervention purchases that is exported is fixed at 82% for agriculture and 87% for food. The export subsidy is determined such that these excesses can be sold on the international market; these benchmark subsidies are 28% and 17%, respectively, for agriculture and food. The fraction of the intervention purchases that is not exported is simply treated as waste to the economy (i.e., it is stockpiled and does not enter any agent's consumption). The final instrument of the CAP is an exogenously determined production subsidy, averaging about 1%.

In any one simulation all three of these instruments (the threshold price, the intervention price, and the production subsidy) are manipulated simultaneously and to the same extent. That is, if we scale the CAP down by 25% then all three are lowered by this percentage.

The agricultural policies of the US are simply exogenously determined import tariffs (1% to 2%), export subsidies (1% or less), and production subsidies (3% and 1% for agriculture and food, respectively). Again they

[12] There is an uninteresting philosophical issue here. To the extent that the GE model is "estimated" or "calibrated" from observed data, then one might try to argue that the political weights are indirectly estimated. We much prefer the simpler interpretation, advanced in the text, of these being "model consistent" weights.

are manipulated simultaneously and with equal percentage changes in any one simulation.

The simulations we investigate involve independently changing the EC and the US protection levels from -100% to +100% in steps of 25%. All bilateral combinations are evaluated.

The instruments that are varied in our simulations do not include Non-Tariff Barriers (NTB's). We believe that NTB's should be treated differently to more direct forms of assistance when considering trade negotiation options. The reason that they should be treated differently is simply that there is always some credible doubt as to whether they are intended as a trade barrier or not, at least from the necessarily legalistic perspective of international trade diplomacy. All of our results could be extended to include NTB's.

There is one aspect of our further interpretation of the policy instruments that must be addressed at this point: the treatment of the CAP as a set of endogenous policies. The issue arises when we compare the payoffs to countries under a zero-CAP scenario to the payoffs for the same countries under an epsilon-CAP scenario. In the first case it is natural in terms of the economics of the policy to "turn off" the endogenous features of the CAP, whereas in the latter case the CAP does remain endogenous albeit at a tiny level. The issue here is the possibility for some discontinuity in payoffs to countries as we make an arbitrarily small change in the CAP scenario.

If the U.S. engages in some agricultural support program that causes world prices as perceived by the EC to increase above unity (the benchmark value), then it would make a difference if the zero-CAP scenario were implemented as a set of exogenous or endogenous polices. If the policies were endogenous then there would be some variable import levy set up to insulate EC domestic agents; if the policies were exogenous there would be no such response. The discontinuity arises when we study an epsilon-CAP scenario in which the EC sets threshold prices at one millionth of a penny above the benchmark prices. For all substantive purposes this may seem like the zero-CAP option, but it is not since it calls for endogenous variations in the import levy.

From the perspective of game theory this type of discontinuity is bothersome if one insists on interpreting the strategy space as continuous. We are not so restricted in our numerical work, preferring to deal with finite numbers of discrete pure strategies. As such there is no formal problem in allowing the CAP to be exogenous in the zero-CAP scenario and yet endogenous in the epsilon-CAP scenario.

More important than the potential problems of formal interpretation, we believe that the economics of the CAP require that one recognize the discontinuity inherent in moving from an endogenous policy to an exogenous policy, even if the benchmark values (which are ceteris paribus the policy values of other countries) are identical. As such we would defend our approach as being more natural than the alternative of studying a zero-CAP scenario in which the import levy and export subsidy remained endogenous.

In the event this problem does not arise in our numerical simulations, since we do not examine epsilon-CAP scenarios that are all that close to the zero-CAP scenario. But it is important to be aware of this possibility in any further work.

3.3 Uncertainty About Payoffs

Like any numerical simulation model, our GE model is calibrated to particular values of certain parameters that may or may not be reliable estimates of the "true value". Recognizing this fact, it is becoming common in policy applications of such models to undertake a systematic sensitivity analysis of results, at least with respect to the elasticity specifications adopted. We conduct a sensitivity analysis using the statistical procedures developed by Harrison and Vinod [1991]. Appendix B details the particular distributional assumptions that we have made in this analysis.

The upshot of running such a sensitivity analysis is that we generate a **distribution of solution values** for any particular counter-factual policy simulation. In other words, if the EC dismantles the CAP we would be able to say something such as "the mean change in agricultural payoffs in the EC is -8.3%, with a standard deviation of 0.6%". We can also make statements as to the reliability of a qualitative result. For example, we can say such things as "the probability of a decrease in agricultural payoffs in to the EC from dismantling the CAP is 0%". Such statements reflect the intrinsic uncertainty about the particular empirical model underlying the simulations.

A natural question arises for the conduct of our trade war. We are assuming that this is a game in which all agents know the relevant payoffs to every agent. In effect we are assuming that all agents might agree on the basic empirical model being used to generate the payoffs of alternative strategy combinations, even if neither side thinks that the model is "true" in any deeper sense. For present purposes we suppose that the agents adopt the GE model we use here.

If this is so, then how are we to deal with the uncertainty over the model's results? Expected utility theory provides a natural answer to this question. We know how to evaluate the utility (or payoffs) to each agent given that they agree on the model and the particular set of elasticities used in any counterfactual policy simulation. This was discussed above in section 3.1. Now we must extend that calculation to allow for the fact that different elasticities will result in the same model giving different payoffs for the same counterfactual policy simulation. Expected utility theory assumes that the expected utility of some uncertain outcome is just the probability-weighted average utility of the utilities associated with each outcome.

To be specific, assume that we just try two sets of elasticities, called High and Low for convenience, and one counterfactual policy simulation, such as the dismantling of the CAP and US farm support policies. Assume hypothetically that the payoff to the EC is 1.44 if elasticities are Low and 2.22 if they are High. If there is a 65% chance of the elasticities being Low and only a 35% chance of them being High, then the expected utility of this uncertain prospect to the EC is just $0.65(1.44)+0.35(2.22) = 0.936+0.777 = 1.713$.

Our sensitivity analysis undertakes a calculation of this kind over more than two sets of elasticities. In fact our sample sizes for **each cell of the payoff matrices** used here are equal to 500. The simple logic of the above expected payoff calculation is just the same, however.

Table 2 summarizes our analysis of the robustness of these results. In Table 2a the robustness of both unilateral and bilateral elimination of agricultural support policies is illustrated. Our results are very robust to variations in elasticity values. Standard deviations are consistently low and the qualitative results[13] are certain to 100% with only two exceptions -- the change in the weighted payoffs to the US government's objective function has approximately a 5% chance of being of the opposite sign. Table 2b illustrates partial and full bilateral liberalizations with equally robust results. Qualitative results always hold with 100% certainty with respect to variations in elasticity values.

It should be noted that we employ prior probabilities for the different sets of elasticities that reflect our

[13] The qualitative result refers to the sign of the change.

knowledge about these estimates, rather than always assuming diffuse priors. As such the sensitivity analysis does involve greater weight being given to elasticity values that are "a priori" more likely to be observed. We thereby constrain the range of counterfactual policy results to be consistent with elasticity values that are **uncertain but not unrealistic.**

For example, our sensitivity analysis is much more likely to pick a value for an elasticity drawn from a Normal distribution within one standard deviation of the mean than it is to pick a value between one and two standard deviations from the mean. The objective is not to "let anything happen", but just to provide an honest assessment of the intrinsic uncertainty surrounding numerical calculations such as those employed here.[14]

[14] This may seem to be a minor point, but we are aware of many instances in policy applications of models such as these in which authors have not constrained their elasticity specifications to realistic values, and managed to find that a given policy can have virtually any qualitative effect. Such analyses have led many people to avoid the use of sensitivity analysis on the false grounds that it necessarily involves drawing indeterminate policy conclusions.

4. RESULTS

4.1 The Model-Consistent Political Weights

Complete and unilateral liberalization of the CAP in 1985 results in reductions in the real income of agricultural interests in the EC of 8.34 billion 1980 U.S. dollars[15], and overall welfare gains to non-agricultural interests in the EC of 12.35 billion.[16] The minimal political weight on agricultural interests consistent with the CAP being in place in our benchmark equilibrium is therefore 0.597 (=12.35/20.69). Thus one does not have to give agricultural interests much more than half-weight in order to rationalize the existence of the CAP in this model, at least in relation to complete liberalization as the alternative.

A similar calculation for complete and unilateral liberalization of agricultural support by the US results in reductions in real income of agricultural interests of 4.71 billion[17] and increases in the real income of the non-agricultural US interests of 6.81 billion. Thus the minimal political weight on agricultural interests in the US is 0.591 (=6.81/11.52). This weight is coincidentally quite close to the weight found for the EC.

It should be noted that each of these weights are based on the average changes in real income over 500 simulations, reflecting our sensitivity analysis with respect to key elasticities and parameters in the underlying empirical model.[18]

How do the political weights change as we consider alternatives to the status quo other than complete liberalization? Figures 1 and 2 display the results of comparable calculations for a wide range of unilateral policy alternatives by the EC and US. Table 3 lists the corresponding values in these figures.

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[15] This figure is composed of losses to three distinct groups. Land and Capital that are specific to AGR in the EC each lose 3.7012% of their real income with CAP liberalization, and Capital specific to FOO in the EC loses 8.3813% of it's real income. The endowments of each of these factors, in billions of dollars, are 64.0213, 28.7632, and 58.4979, respectively. The total loss of 8.34 is therefore computed as 0.037012(64.0213+28.7632) + 0.083813(58.4979).

[16] Each of these amounts is the average value of a distribution of solution values generated from the sensitivity analysis described in an Appendix. Note that we could have generated a distribution of values for the political weights, but choose not to in order to keep this calculation as transparent as possible.

[17] This is also composed of losses to three factor groups. Capital and Land specific to AGR in the US each lose 7.51% of their real income due to the removal of support, and Capital specific to FOO in the US loses 2.76% of its real income. These factors have initial endowments of 12.1979, 27.1501, and 63.6760 billion, respectively. Weighted by the percentage changes in real income, these endowments add up to the overall loss of 4.71 billion reported in the text.

[18] As was seen in Table 2 the results are quite robust with respect to uncertainties in these elasticities and parameters.

It is apparent from these results that agricultural interests in each of the EC and US would lobby against liberalization of agricultural support and in favor of increases in that support. Conversely, non-agricultural interests would have diametrically opposed lobbying activities. These qualitative results are quite intuitive. They do, however, imply that one must take a little care in interpreting the political weights.

Consider the political weights within the EC first. In order to rationalize the status quo as compared to 100% liberalization of the CAP we found that agricultural interests needed a weight of at least 0.597 in the objective function of the EC "government". For all other reductions in the CAP this weight must be higher, around 0.71 or 0.72 depending on the precise alternative to the status quo.

Now consider the alternative of increasing the CAP by 100%. In this case agricultural interests gain by 4.6760 billion as compared to the status quo and non-agricultural interests lose by 12.3811 billion. The political weight of 0.274139 is calculated as the minimal weight required on **non-agricultural** interests so as to rationalize why the status quo was the benchmark in this model. This means that one minus this weight, or 0.725861, is the **maximal feasible** weight on agricultural interests that is consistent with the status quo being preferred by the EC "government".

We therefore find that there is a reasonably tight bound on the political weights for agricultural interests that is consistent with the status quo. Specifically, this weight can lie between 0.719766 and 0.722099 for the EC, and between 0.601696 and 0.611874 for the US.[19] Any lower weight than given by these bounds would result in the gains to non-agricultural interests outweighing the losses to agricultural interests in the government's "eyes", and the alternative to the status quo being chosen by the government. Similarly, any higher weight would result in the gains to agricultural interests outweighing the losses to non-agricultural interests.[20]

Why are these weights so stable for all of the alternatives other than complete liberalization? The reason is that the ratio of the change in real income of agricultural interests and non-agricultural interests is relatively

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[19] We could evaluate policy alternatives that are arbitrarily close to the status quo and obtain even tighter bounds, but these intervals are more than adequate for present purposes. Moreover, it is not obvious that such marginal changes in policies are feasible from a negotiating perspective, notwithstanding the nihilistic rhetoric commonplace in the GATT bargaining process.

[20] To see this point transparently, consider the effects of having weights of zero and one on agricultural interests. In the first case the government would completely ignore agricultural interests and fully liberalize unilaterally, whereas in the second case the government would completely ignore non-agricultural interests and expand agricultural support (to the maximal level of +100% considered here).

constant. The absolute level of these changes in real income vary significantly with the different alternative policies, but the ratio of the two does not for all but complete liberalization.

It is particularly noteworthy that there is a difference when we consider complete liberalization rather than just a scaling up or down of the CAP. This indicates that it will be much easier to get the EC to engage in partial liberalizations than it will be to get them to engage in complete liberalizations in the sense that the political influence weight for agriculture only has to be lowered by a small fraction to remove enough opposition to full liberalization[21]. This may seem like a trivial conclusion until one notices that in terms of the political weights we have calculated it will be just as easy to get the EC to engage in a 75% liberalization as in a 25% liberalization. Our analysis as to the political ease of alternative reforms have nothing to do with the absolute size of the real income changes that they imply for any group of agents, but rather with their effect on their relative lobbying influence.

Given this range of political weights we determine the objective function weights on agricultural interests used in our simulations for the EC and US to each want to adopt the status quo. For the EC this weight is roughly 0.72 and for the US it is roughly 0.61, comfortably within the bounds noted earlier.

4.2 The Trade War

We conduct the agricultural trade war by evaluating the economic effects of each country adopting values for their agricultural support policies that are -100%, -75%, -50%, -25%, 0%, +25%, +50%, +75%, or +100% of the status quo values. This trade war therefore involves 81 (=9×9) policy combinations, or 81 distinct policy simulations.

Each of these 81 policy simulations is solved repeatedly as part of our sensitivity analysis, with every major elasticity being randomly perturbed each time we solve it. In each cell we conduct a sensitivity analysis with a sample size of 500, implying a total of 40,500 (=81×500) solutions of our model. From this sensitivity analysis for each cell we determine the average changes in the real income of agricultural and non-agricultural

[21] Recall our earlier discussion of why there is a difference between partial and full liberalizations of the CAP. The latter involves a fundamental "regime change" in relation to the variables that are endogenous and exogenous (e.g., the import levy is no longer variable, but fixed).

interests.

Tables 4 and 5 report these unweighted changes in real income (in billions of dollars, per annum). The first line of Table 4 is read as follows. When the EC adopts a policy of -100% liberalization (complete abolition of the CAP) and the US does likewise, agricultural real income in the EC goes down by 7.231 billion relative to the status quo and by 1.717 billion in the US relative to the status quo. The second line shows that when the EC maintains it's policy of full liberalization but the US only liberalizes by 75%, agricultural real income in the EC goes down by 7.427 billion and goes up in the US by 0.020 billion.

Similar interpretations apply to the payoff reported in Table 5. The first and second lines there correspond to the same policy packages as discussed above. In this case we see from the first line that complete liberalization by the EC and US results in a 10.068 billion gain in real income for non-agricultural interests in the EC and a gain of 3.085 billion in the US.

These payoffs are unweighted in the sense that we have not yet applied the political weights to each interest group to determine the payoff in the "government" objective function in each country. When we use the weights of 0.72 and 0.61 for the EC and US discussed earlier, we obtain the weighted payoffs shown in Table 6. Consider the first line again. The weighted payoff to the EC "government" is -2.388 billion, which is the sum of the weighted loss of 5.206 (= 0.72 × 7.231) to agricultural interests and the weighted gain of 2.818 (= 0.28 × 10.068) to non-agricultural interests.

4.3 The Retaliatory Nash Equilibrium of the Trade War

Given the payoffs to each government shown in Table 6, it is a straightforward matter to verify that the status quo is a Nash Equilibrium (NE) of this trade war. This follows by the way that we have constructed the political weights for each agent: neither has any unilateral incentive to choose a policy that differs from the status quo.[22]

To see this, examine the line in the payoff matrix that corresponds to both players choosing the status quo. Each player receives a payoff of zero, since there is obviously no change in the real income of any interest

[22] Indeed, verifying that the status quo is a NE is a useful consistency check on the way that we have computed the political weights.

group.[23] Now evaluate the alternative policies that the US could adopt, assuming that the EC maintains its status quo polices. Any such unilateral deviation by the US results in it receiving a loss relative to the status quo. Hence the US has no incentive to unilaterally deviate from the status quo, given that the EC is at the status quo. Similarly, by comparing the lines of the payoff table corresponding to the US adopting the status quo[24] we see that the EC does not gain by unilaterally deviating from the status quo. This verifies that the status quo is a NE.

It does not follow that this is the only NE. Our political weights have only been constructed to ensure that the status quo is a best-response given that the other player is choosing the status quo also. They do not ensure that the status quo is a best-response if the other agent is deviating from the status quo. For example, if the EC completely liberalizes the CAP then the best-response for the US would be to increase agricultural support by 75%.

Nonetheless, it turns out that the status quo is indeed the only NE of this game.

4.4 The Cooperative Nash Solution

Given the policy alternatives considered thus far we can determine the unique negotiation outcome using the Nash Solution (NS) with the NE as the disagreement outcome in the event of a breakdown in negotiations. For the calibrated political weights the NS is for the EC to liberalize the CAP by 75% and for the US to increase agricultural support by 50%. This generates losses to EC agricultural interests of 3.443 billion, gains to US agricultural interests of 3.364 billion, gains to EC non-agricultural interests of 9.383 billions, and losses to US non-agricultural interests of 4.953 billion.

It is impossible to conceive of a NS where no one loses relative to the status quo as the effects on agricultural and non-agricultural groups, both in the EC and the US, are diametrically opposite. If an agricultural group gains the corresponding non-agricultural group loses. All that we can conclude therefore is that with the existing political influence weights in the government planning function a cooperative NS exists such that the EC would completely eliminate the CAP and the US would augment its agricultural protection program with net

[23] Strictly speaking the minimal political weight on agricultural interests is zero at this point, but this is a mere technicality.

[24] These lines are in the middle of each block of payoffs, and are not contiguous.

gains in both countries objective functions (15% for the EC and 12% for the US).

4.5 Varying the Political Weights

It is of some interest to investigate possible non-cooperative and cooperative outcomes from changing the political weights in the government objective function. This will be done in order to determine how much the structure of political influence would have to change in the EC or the US so as to bring about a new political equilibrium in which reform has occurred. Table 7 summarizes our results.

The first point to notice is how sensitive the EC position is to very small changes in its own political weights. This is partly brought out by Table 3 where we saw, conditional on the US remaining in Status Quo, that the weights were very stable across strategy changes. The only major change was brought about by the complete liberalization of CAP. We therefore would expect that marginal changes in relative weights would result in large, but not complete, liberalization of the CAP. Table 3 does not take US retaliatory actions into consideration, however, so we therefore need to construct a NE.

Lowering the EC weight on agricultural interests marginally by 1% results in the same liberalization for the EC as a negotiated NS outcome. As there is no retaliatory action from the US in this equilibrium, this directly confirms our conclusion drawn above based on Table 3 only. It can therefore be concluded that a fairly small effort in lowering this influence weight can have quite dramatic liberalization effects.

Increasing the weight by a marginal 1%, on the other hand, would be expected to cause quite a dramatic increase in agricultural protection. In this case, however, the US retaliatory action reduces the amount of protection escalation and it halts at +50%. The US retaliation is quite modest, however, at only +25%. Again the conclusion is that a fairly small effort of avoiding an increase in agricultural influence can have significant impacts in terms of avoiding a potential trade war.

A natural question here would be what action would be needed to get the EC to perform a complete liberalization of the CAP. Looking at Table 3 it would appear that if there is no retaliatory action from the US lowering the weight to just slightly below 60% would give the desired result. As it turns out, however, the best response for the US in this case is a large increase in agricultural protection by +75%. This somewhat surprising response follows from the fact that the relation between the benefits to agriculture and to nonagriculture shifts when CAP is eliminated. It is important to notice, however, that the payoffs to the US government form a rather flat surface, implying that there is a degree of indifference on behalf of the US government across a wide range of policy choices. Due to this retaliatory response from the US, however, the influence weight for agriculture in the EC needs to be decreased below 50% that marks the value where distributional concerns do not enter the EC government objective function. A weight of 45% will generate a complete elimination of the CAP program in the non-cooperative Nash equilibrium outcome.

Because of the flatness of the payoff surface to the US government there is a possibility of multiple equilibria at these weights. The alternative equilibrium is simply equivalent to the one we obtained when marginally lowering the EC weight.[25] There is an obvious solution to this immediate problem, however, and that is to reduce the agricultural weight even further. This eliminates the alternative NE leaving (-100%, +75%) as the unique single-stage equilibrium.

In addition either this NE from the marginally lower weight or the Status Quo could serve as disagreement outcomes in cooperative negotiations leading to a NS where CAP is eliminated. Again, however, this equilibrium involves a high US protection level of +100%.

If instead the US agricultural influence weight was to decrease, it would have no appreciable effect on the EC as it would remain in the Status Quo. The agricultural protection systems in the US would be eliminated at a weight of 0.57, which is not far from the benchmark weight. By increasing the influence of agricultural interests in the US and thereby increasing US protection, the CAP would be liberalized. We do not see a complete elimination of the CAP within the limited strategies available to the US, however.

In summary then it is possible to liberalize, or even eliminate, the CAP by changing the political influence structure in either the EC or the US. Partial liberalization can be achieved reasonably easily by changing the influence weight of agriculture in the EC. An increased weight to US agriculture is an alternative instrument to achieve partial CAP liberalization. This latter alternative is more costly for the nonagricultural

[25] This possibility of multiple equilibria causes problems when analyzing agricultural relations as a repeated game. This will be discussed in section 5.3.

groups in the US, however, as it involves a larger increase in US protection. A complete elimination of the CAP would require a dramatic change in the political structure of the EC. The agricultural weight would need to be lowered past the point where the government is indifferent with respect to distributional concerns and instead imposes a bias in favor of nonagricultural interests.

5. DISCUSSION

There are many conceptual and practical issues that underlie our analysis of an agricultural trade war between the U.S. and EC. In this section we address some of these, indicating how they could be addressed in subsequent research if they were considered important enough.

5.1 The Scope of an Agricultural Trade War

The battle lines of the trade war considered so far have been limited in geographic and sectoral terms. Only the EC and the US are assumed to engage in retaliatory trade policy actions, and the only actions they consider are with respect to agricultural protection. The possibility that such a trade war will escalate is a serious one in the eyes of many commentators, and has clearly added a note of urgency to the need for multilateral consideration of agricultural policies in the Uruguay Round. Hathaway [1987; p.4] argues this point convincingly:

> The experience of the 1980s has shown the extent to which agricultural trade tensions can erupt into wider arenas and other areas of international cooperation. This is not new. Many still remember the famous chicken war between the United States and the European Community (EC) in the 1960s, which threatened all trade and political cooperation among NATO allies. During the 1980s, Japan-U.S. relations have been increasingly strained over agricultural trade issues. In the 1980s we have seen a steady escalation in policy actions designed to offset the actions of others that are asserted to be unfair. Countries too small or too weak economically to engage in trade wars have seen their export earnings plummet and their economies crumble from the side effects of two years of guerrilla trade warfare between the United States and the EC in international grain markets. Unless some kind of permanent settlement can be reached, prospects are that these actions will increase.
>
> However unimportant agricultural trade issues appear to many persons, especially in industrial economies, such chronic difficulties on these issues erode cooperation on other international problems. Australia has questioned its continued commitment to U.S. defence installations because of U.S. agricultural subsidies. U.S. credibility on Caribbean Basin development has been undermined by the U.S. sugar import policy. Just as war is too important to be left to generals, agricultural policy -- especially as it affects trade -- has become too important to be left to ministers of agriculture. The importance of completing a successful trade round that disarms trade disputes in agriculture extends beyond agriculture.

Hathaway [1987; p.21] also argues that the possibility of such an agricultural trade war escalation is one of three major reasons that the new round of GATT negotiations attempts some fundamental reform in the area of agriculture. What would be the effects of a full-blown trade war conducted with across-the-board protection on all imports as the policy variable?

5.2 Individual Rationality and Social Inefficiency.

With our trade war simulations we have addressed the following question: If countries noncooperatively try to improve their own objectives, and are not subject to GATT bindings, what levels of agricultural protection could emerge in a strategic equilibrium under different assumptions regarding political structure? As we know from elementary games such as Prisoner's Dilemma, there is absolutely no presumption that noncooperative strategic (Nash) equilibria lead to efficient outcomes. It is possible for countries to change the rules of the trade liberalization game so as to encourage such efficient outcomes, but those types of changes are not considered here. Indeed one can interpret many of the provisions of the GATT as crude attempts to develop such rules; see, for example, McMillan [1986]. Changing the rules of a game so as to bring about certain outcomes that are (socially) preferred is a different question from determining what outcomes could emerge from a certain specified set of rules.

It is also important to realize that we are not modeling the way that countries negotiate now. There are many types of constraints on the propensity of countries to engage in the type of retaliatory policy-making that is implied by our trade war. These constraints range from the most mundane of legalities (e.g., GATT bindings) to grander geo-political considerations.

5.3 Repeated Games

We have deliberately chosen to model a very simple game. One feature of the game that might cause some concern about the general validity of our results is the fact that we have analyzed a one-shot or static game that is not repeated. How would our results change if we viewed the game analyzed here as just one stage (one year) in a repeated game between the same players over several stages (multiple years)? The theory of repeated games is much more complicated than the theory of single stage games, and the possible equilibria of the repeated game typically much larger: see Benoit and Krishna [1985], Fudenberg and Maskin [1986], and Abreu [1988] for important contributions.

The so-called Folk Theorem of repeated games says that many possible equilibrium outcomes are possible in the repeated game that may not be equilibria of the single-stage game. The essential idea behind this is that players can devise "punishment rules" to impose on any player that deviates from any prescribed equilibrium path of the repeated game. The only paths that cannot be protected with these sorts of punishments are paths in which one player gets worse than he could even if all of the other plays cooperated in punishing him the most (the player's "minimax outcome").

The reason that this result is important, in the present context, is that it provides one possible way in which efficient multilateral liberalization strategies might come about even if they are not NE in a single stage game. If one country deviates from this liberalization strategy, the other players enact punishments that make the would-be deviant worse off than if he deviated without any such punishments being invoked. It can be argued that many of the provisions of the GATT can be interpreted in this way -- as prescribed punishment rules for nations that deviate in certain ways.

Is this another case in which game theory allows one to prove any results one likes, without any possibilities being ruled out? Not quite. For simplicity we concentrate on the case in which the game is to be repeated a finite number of times; this number may be arbitrarily large, but it must be finite.

First it should be noted that one of the equilibria of the repeated game will always be just to repeat the single stage NE. This is called "the trivial equilibrium" by game theorists, not because it is uninteresting, but because it is stationary and perhaps an obvious equilibrium. However, even though it is obvious from a formal point of view it provides a natural benchmark for analysis.

Second, if the single stage NE is unique then the only equilibrium of the repeated game is this trivial equilibrium. This is a very important result, emphasized by Benoit and Krishna [1985; p.910] and Moreaux [1985]. The simple logic behind this result is as follows. In the last period the players will not deviate from the single stage NE, since the only reason to deviate from a NE (in earlier periods) and forego some expected payoff is to punish some other player for deviating. That is, to threaten to punish someone by undertaking an action that causes me to forgo some expected payoff in the final period is not credible. When we actually get to the last period you will not expect me actually to undertake my threat, since the game ends in that period. (Formally, we are evaluating perfect equilibria of the repeated game).

Now consider the next-to-last period of the repeated game. What can I use as a threat to stop you deviating in this period? I cannot threaten to punish you in the final period by the above logic, and you are aware of that! All I can credibly threaten you with is that I will play my NE strategy in the final period. Hence nobody can be punished if they deviate in the next-to-last period, since it is in nobody else's best interest to punish them in the last period. If no player can be punished for a deviation in the NE, each player will do what is in his best interest to do in each period. That is just a definition of the single stage NE. So we have proved the result that the only equilibrium of the repeated game is in fact the trivial NE of the single stage game.

The reason that this argument is so important here is that virtually all of the games that we have studied had unique NE in their single stages. Hence we know that the only equilibrium of the repeated game is the outcome we found as the NE of the single stage game. (Note that the NE only has to be unique in terms of the payoffs it generates for all players; there could be any number of NE strategy combinations as long as they all generate the same unique payoff vector.)

We do not want to claim that the only repeated game of interest is the finite horizon complete-information game we study here. If the time horizon is infinite or there exists some uncertainty about the payoffs (for example), the Folk Theorem does indeed open up a Pandora's box of possible equilibrium outcomes over time. The empirical relevance of these possibilities is not yet established, however, and they provide a flimsy basis for rationalizing a multilateral liberalization strategy as the equilibrium of some repeated game.

APPENDIX A:

COOPERATIVE SOLUTION CONCEPTS FROM GAME THEORY

Nash [1950] characterized a cooperative negotiation situation in terms of a bargaining environment and a bargaining process. The environment is a pair (S,d) defined over a set of outcomes $x = \{x_1, x_2\}$, where x_i denotes the outcome to agent i, S is the set of feasible outcomes, and d is the disagreement outcome. We require that S be compact and convex, and that there exists at least one point $x \in S$ s.t. $x > d$ (i.e., $x_1 > d$ and $x_2 > d$). The first two requirements on S are satisfied by allowing mixed strategy combinations of all pure strategies in S, for x finite. The third requirement on S is readily verified by inspection of S. It is assumed that the pair (S,d) is common knowledge.

We will interpret S as consisting of the set of outcomes attainable by mixtures of the pure strategy combinations evaluated in each payoff matrix we generate.

Two possible disagreement outcomes d can be considered. One is the Status Quo, and corresponds to zero welfare improvements for each country. An alternative disagreement point is the non-cooperative NE for the (non-cooperative) game generated by the same sets of pure strategies. This has the natural interpretation of a "threat point", in the spirit (if not the letter) of Nash [1953]. Harrison and Rutström [1991a] demonstrate in the context of several trade war simulations that the choice of either of these interpretations of the disagreement point can have a major quantitative impact on the outcome of the bargaining process.

The bargaining process is modelled as a function f(S,d) that selects a solution $z = f(S,d)$ for $z \in S$. This solution must possess four properties:

(1) Pareto Optimality: if $f(S,d) = z$ then there does not exist an $x \in S$, $x \neq z$, s.t. $x > z$.

(2) Symmetry: if $x_1 = x_2$, for all x, and $d_1 = d_2$ then $z_1 = z_2$.

(3) Independence of Irrelevant Alternatives: if $T \subset S$ and if $f(S,d) \in T$, then $f(T,d) = f(S,d)$.

(4) Independence of Equivalent Utility Representations: if ' denotes a given positive affine transformation, and if $z = f(S,d)$ and $y = f(S',d')$, then $y = z'$.

Nash [1950] established the remarkable result that there exists a (unique) solution that possesses these four properties and that it can be computed as the set of feasible outcomes that maximize the product of the gains relative to d. Formally, z is the solution to

$$\max_{x_1,\, x_2} \quad (x_1 - d_1)\,(x_2 - d_2).$$

This solution generalizes naturally to n-person negotiation situations, providing one does not permit coalitions or sidepayments.

Note that no particular "extensive form" bargaining process is modelled by the NS.[26] However, there is an implicit requirement buried in the definition of the bargaining environment that if S does not contain any feasible outcome that (strictly) Pareto-dominates d then each player has a final "veto power" over any proposed agreement. Viewing this as a final sub-game in the overall negotiation game, one is naturally led to adopt the non-cooperative NE as the only credible outcome of this "disagreement sub-game".

We make one simplification when actually computing the NS. Rather than evaluate the set of mixed strategies to determine the unique NS, we evaluate only the set of pure strategies. This discrete approximation to the true NS should be satisfactory for our purposes.

[26] There are many alternative ways to "solve" bargaining games. We have selected the NS as the obvious and popular choice for present purposes, although we do discuss one important alternative below. An axiomatic solution, such as the NS, has the advantage of attempting to characterize the outcome of a wide range of distinct bargaining processes. Strategic approaches to bargaining games are typically very sensitive to the exact extensive-form representation of the process. Moreover, there are numerous non-cooperative "strategic rationalizations" of the outcome predicted by the NS; see, for example, Nash [1953; pp.130-136], Harsanyi [1977], Binmore, Rubinstein and Wolinsky [1986] and van Damme [1986].

APPENDIX B:

SYSTEMATIC SENSITIVITY ANALYSIS PROCEDURES

The procedures that we use to undertake a systematic sensitivity (SS) analysis of our general equilibrium model was developed by Harrison and Vinod [1991]. It essentially involves a controlled Monte Carlo series of simulations of the model, with each simulation involving some random change in the values that elasticities take. To undertake this analysis we use the MPSS software devloped by Harrison [1991b] to undertake SS analyses of models written in the MPS/GE programming language for general equilibrium models (see Rutherford [1989] for documentation of that language).

The most important aspect of such a sensitivity analysis is the choice of distributional assumptions on each of the important elasticities. By and large we follow the specifications and values detailed in Harrison, Rutherford and Wooton [1991; p.101, 115]. The major exception is the use of a "high" import trade elasticities, specifically a value of 10.0 for the import-source nest (this is the point at which domestic agents choose between alternative sources of imports). This value reflects our strong prior beliefs as to the plausible values for these elasticities, largely ignoring a large empirical literature that generates much lower estimates.[27]

We can be even more precise as to the assumptions that are used in our sensitivity analysis by listing the "configuration file" developed for MPSS. There are actually two versions opf this file. The one displayed below is based on the model structure in which the CAP is completely liberalized (EC policy choice of -100%, in terms of the payoff matrices). This file was used for the first nine models.[28] A slightly different format is required for a model in which the CAP is operative, due to differences in which variables are declared to be endogenous or not.[29] There is no difference between the sensitivity analyses performed in each case, just a

[27] This empirical literature is not naive to the priors that these elasticities should be "high", and has attempted to correct for many sources of bias. Our elasticities choice was made using the default elasticities option in the program ECPOL. Any interested reader can use lower elasticities, or simply alternative priors, by using the other options from that menu. (ECPOL is discussed in Appendix C below).

[28] Denoted TMP1 through TMP9 in Appendix C.

[29] It is a trivial matter to generate these configuration files using the "setup" option of MPSS.

difference in how variables are ordered. Hence all of the relevant information is shown in the following file[30]:

```
$SAMPLE: 500
$MPS: up mps
$MAPMEM: NUL
$SAVE:
$INTEGRATE: 0
$HISTOGRAM: 15
$CINTERVALS: 50 55 60 65 70 75 80 85 90 95 100
$PERCENT: FALSE
PRODUCTION *** U-EEC    r:  1.000  s 0.5 1.0 1.5
PRODUCTION ... U-EEC    a:  0.000
PRODUCTION ... U-EEC    b:  0.000
PRODUCTION ... U-EEC    c:  0.000
PRODUCTION ... U-EEC    d:  0.000
PRODUCTION ... U-EEC    t:  0.000
PRODUCTION *** U-USA    r:  1.000  s 0.5 1.0 1.5
PRODUCTION ... U-USA    a:  0.000
PRODUCTION ... U-USA    b:  0.000
PRODUCTION ... U-USA    c:  0.000
PRODUCTION ... U-USA    d:  0.000
PRODUCTION ... U-USA    t:  0.000
PRODUCTION *** U-JAP    r:  1.000  s 0.5 1.0 1.5
PRODUCTION ... U-JAP    a:  0.000
PRODUCTION ... U-JAP    b:  0.000
PRODUCTION ... U-JAP    c:  0.000
PRODUCTION ... U-JAP    d:  0.000
PRODUCTION ... U-JAP    t:  0.000
PRODUCTION *** U-ROW    r:  1.000  s 0.5 1.0 1.5
PRODUCTION ... U-ROW    a:  0.000
PRODUCTION ... U-ROW    b:  0.000
PRODUCTION ... U-ROW    c:  0.000
PRODUCTION ... U-ROW    d:  0.000
PRODUCTION ... U-ROW    t:  0.000
PRODUCTION ... Y-AGR01  r:  0.000  s 0.0 0.5 1.0
PRODUCTION ... Y-AGR01  a:  0.950  n 0.041 3
PRODUCTION ... Y-AGR01  b:  0.000
PRODUCTION ... Y-AGR01  c:  0.000
PRODUCTION ... Y-AGR01  d:  0.000
PRODUCTION ... Y-AGR01  t:  0.000
PRODUCTION ... Y-FOO01  r:  0.000  s 0.0 0.5 1.0
PRODUCTION ... Y-FOO01  a:  0.950  n 0.041 3
PRODUCTION ... Y-FOO01  b:  0.000
PRODUCTION ... Y-FOO01  c:  0.000
PRODUCTION ... Y-FOO01  d:  0.000
PRODUCTION ... Y-FOO01  t:  0.000
PRODUCTION ... Y-E+M01  r:  0.000  s 0.0 0.5 1.0
PRODUCTION ... Y-E+M01  a:  0.920  n 0.144 3
PRODUCTION ... Y-E+M01  b:  0.000
PRODUCTION ... Y-E+M01  c:  0.000
PRODUCTION ... Y-E+M01  d:  0.000
PRODUCTION ... Y-E+M01  t:  0.000
PRODUCTION ... Y-MAN01  r:  0.000  s 0.0 0.5 1.0
PRODUCTION ... Y-MAN01  a:  1.05  n 0.086 3
PRODUCTION ... Y-MAN01  b:  0.000
PRODUCTION ... Y-MAN01  c:  0.000
PRODUCTION ... Y-MAN01  d:  0.000
PRODUCTION ... Y-MAN01  t:  0.000
PRODUCTION ... Y-T+T01  r:  0.000  s 0.0 0.5 1.0
PRODUCTION ... Y-T+T01  a:  1.50  n 0.426 3
PRODUCTION ... Y-T+T01  b:  0.000
PRODUCTION ... Y-T+T01  c:  0.000
PRODUCTION ... Y-T+T01  d:  0.000
PRODUCTION ... Y-T+T01  t:  0.000
PRODUCTION ... Y-SER01  r:  0.000  s 0.0 0.5 1.0
PRODUCTION ... Y-SER01  a:  2.11  n 0.496 3
PRODUCTION ... Y-SER01  b:  0.000
PRODUCTION ... Y-SER01  c:  0.000
PRODUCTION ... Y-SER01  d:  0.000
PRODUCTION ... Y-SER01  t:  0.000
PRODUCTION ... Y-AGR02  r:  0.000  s 0.0 0.5 1.0
PRODUCTION ... Y-AGR02  a:  0.950  n 0.041 5
```

[30] To avoid confusion, this is the file CAP.SSA and not the file TMP.SSA.

```
PRODUCTION ... Y-AGR02   b:  0.000
PRODUCTION ... Y-AGR02   c:  0.000
PRODUCTION ... Y-AGR02   d:  0.000
PRODUCTION ... Y-AGR02   t:  0.000
PRODUCTION ... Y-FOO02   s:  0.000   s 0.0 0.5 1.0
PRODUCTION ... Y-FOO02   a:  0.950   n 0.102 5
PRODUCTION ... Y-FOO02   b:  0.000
PRODUCTION ... Y-FOO02   c:  0.000
PRODUCTION ... Y-FOO02   d:  0.000
PRODUCTION ... Y-FOO02   t:  0.000
PRODUCTION ... Y-E+M02   s:  0.000   s 0.0 0.5 1.0
PRODUCTION ... Y-E+M02   a:  1.09    n 0.105 5
PRODUCTION ... Y-E+M02   b:  0.000
PRODUCTION ... Y-E+M02   c:  0.000
PRODUCTION ... Y-E+M02   d:  0.000
PRODUCTION ... Y-E+M02   t:  0.000
PRODUCTION ... Y-MAN02   s:  0.000   s 0.0 0.5 1.0
PRODUCTION ... Y-MAN02   a:  1.06    n 0.041 5
PRODUCTION ... Y-MAN02   b:  0.000
PRODUCTION ... Y-MAN02   c:  0.000
PRODUCTION ... Y-MAN02   d:  0.000
PRODUCTION ... Y-MAN02   t:  0.000
PRODUCTION ... Y-T+T02   s:  0.000   s 0.0 0.5 1.0
PRODUCTION ... Y-T+T02   a:  1.88    n 0.077 5
PRODUCTION ... Y-T+T02   b:  0.000
PRODUCTION ... Y-T+T02   c:  0.000
PRODUCTION ... Y-T+T02   d:  0.000
PRODUCTION ... Y-T+T02   t:  0.000
PRODUCTION ... Y-SER02   s:  0.000   s 0.0 0.5 1.0
PRODUCTION ... Y-SER02   a:  2.73    n 0.027 5
PRODUCTION ... Y-SER02   b:  0.000
PRODUCTION ... Y-SER02   c:  0.000
PRODUCTION ... Y-SER02   d:  0.000
PRODUCTION ... Y-SER02   t:  0.000
PRODUCTION ... Y-AGR03   s:  0.000   s 0.0 0.5 1.0
PRODUCTION ... Y-AGR03   a:  0.950   n 0.041 5
PRODUCTION ... Y-AGR03   b:  0.000
PRODUCTION ... Y-AGR03   c:  0.000
PRODUCTION ... Y-AGR03   d:  0.000
PRODUCTION ... Y-AGR03   t:  0.000
PRODUCTION ... Y-FOO03   s:  0.000   s 0.0 0.5 1.0
PRODUCTION ... Y-FOO03   a:  0.290   n 0.102 5
PRODUCTION ... Y-FOO03   b:  0.000
PRODUCTION ... Y-FOO03   c:  0.000
PRODUCTION ... Y-FOO03   d:  0.000
PRODUCTION ... Y-FOO03   t:  0.000
PRODUCTION ... Y-E+M03   s:  0.000   s 0.0 0.5 1.0
PRODUCTION ... Y-E+M03   a:  0.430   n 0.105 5
PRODUCTION ... Y-E+M03   b:  0.000
PRODUCTION ... Y-E+M03   c:  0.000
PRODUCTION ... Y-E+M03   d:  0.000
PRODUCTION ... Y-E+M03   t:  0.000
PRODUCTION ... Y-MAN03   s:  0.000   s 0.0 0.5 1.0
PRODUCTION ... Y-MAN03   a:  0.950   n 0.041 5
PRODUCTION ... Y-MAN03   b:  0.000
PRODUCTION ... Y-MAN03   c:  0.000
PRODUCTION ... Y-MAN03   d:  0.000
PRODUCTION ... Y-MAN03   t:  0.000
PRODUCTION ... Y-T+T03   s:  0.000   s 0.0 0.5 1.0
PRODUCTION ... Y-T+T03   a:  0.900   n 0.077 5
PRODUCTION ... Y-T+T03   b:  0.000
PRODUCTION ... Y-T+T03   c:  0.000
PRODUCTION ... Y-T+T03   d:  0.000
PRODUCTION ... Y-T+T03   t:  0.000
PRODUCTION ... Y-SER03   s:  0.000   s 0.0 0.5 1.0
PRODUCTION ... Y-SER03   a:  1.000   n 0.027 5
PRODUCTION ... Y-SER03   b:  0.000
PRODUCTION ... Y-SER03   c:  0.000
PRODUCTION ... Y-SER03   d:  0.000
PRODUCTION ... Y-SER03   t:  0.000
PRODUCTION ... Y-AGR04   s:  0.000   s 0.0 0.5 1.0
PRODUCTION ... Y-AGR04   a:  0.950   n 0.041 5
PRODUCTION ... Y-AGR04   b:  0.000
PRODUCTION ... Y-AGR04   c:  0.000
PRODUCTION ... Y-AGR04   d:  0.000
PRODUCTION ... Y-AGR04   t:  0.000
PRODUCTION ... Y-FOO04   s:  0.000   s 0.0 0.5 1.0
PRODUCTION ... Y-FOO04   a:  0.290   n 0.102 5
```

PRODUCTION	_ Y-FOO04	b:	0.000	
PRODUCTION	_ Y-FOO04	c:	0.000	
PRODUCTION	_ Y-FOO04	d:	0.000	
PRODUCTION	_ Y-FOO04	t:	0.000	
PRODUCTION	_ Y-E+M04	s:	0.000	s 0.0 0.5 1.0
PRODUCTION	_ Y-E+M04	a:	0.430	n 0.105 5
PRODUCTION	_ Y-E+M04	b:	0.000	
PRODUCTION	_ Y-E+M04	c:	0.000	
PRODUCTION	_ Y-E+M04	d:	0.000	
PRODUCTION	_ Y-E+M04	t:	0.000	
PRODUCTION	_ Y-MAN04	s:	0.000	s 0.0 0.5 1.0
PRODUCTION	_ Y-MAN04	a:	0.950	n 0.041 5
PRODUCTION	_ Y-MAN04	b:	0.000	
PRODUCTION	_ Y-MAN04	c:	0.000	
PRODUCTION	_ Y-MAN04	d:	0.000	
PRODUCTION	_ Y-MAN04	t:	0.000	
PRODUCTION	_ Y-T+T04	s:	0.000	s 0.0 0.5 1.0
PRODUCTION	_ Y-T+T04	a:	0.900	n 0.077 5
PRODUCTION	_ Y-T+T04	b:	0.000	
PRODUCTION	_ Y-T+T04	c:	0.000	
PRODUCTION	_ Y-T+T04	d:	0.000	
PRODUCTION	_ Y-T+T04	t:	0.000	
PRODUCTION	_ Y-SER04	s:	0.000	s 0.0 0.5 1.0
PRODUCTION	_ Y-SER04	a:	1.000	n 0.027 5
PRODUCTION	_ Y-SER04	b:	0.000	
PRODUCTION	_ Y-SER04	c:	0.000	
PRODUCTION	_ Y-SER04	d:	0.000	
PRODUCTION	_ Y-SER04	t:	0.000	
DEMAND	_ EEC	s:	0.000	
DEMAND	_ EEC	a:	0.000	
DEMAND	_ EEC	b:	0.000	
DEMAND	_ EEC	c:	0.000	
DEMAND	_ EEC	d:	0.000	
DEMAND	_ USA	s:	0.000	
DEMAND	_ USA	a:	0.000	
DEMAND	_ USA	b:	0.000	
DEMAND	_ USA	c:	0.000	
DEMAND	_ USA	d:	0.000	
DEMAND	_ JAP	s:	0.000	
DEMAND	_ JAP	a:	0.000	
DEMAND	_ JAP	b:	0.000	
DEMAND	_ JAP	c:	0.000	
DEMAND	_ JAP	d:	0.000	
DEMAND	_ ROW	s:	0.000	
DEMAND	_ ROW	a:	0.000	
DEMAND	_ ROW	b:	0.000	
DEMAND	_ ROW	c:	0.000	
DEMAND	_ ROW	d:	0.000	
DEMAND	_ TAXAGT	s:	0.000	
DEMAND	_ TAXAGT	a:	0.000	
DEMAND	_ TAXAGT	b:	0.000	
DEMAND	_ TAXAGT	c:	0.000	
DEMAND	_ TAXAGT	d:	0.000	
PRODUCTION	_ M-AGR01	s:	1.474	m 1.0 2.0 3.0 4.0 5.0
PRODUCTION	_ M-AGR01	a:	9.999	
PRODUCTION	_ M-AGR01	b:	0.000	
PRODUCTION	_ M-AGR01	c:	0.000	
PRODUCTION	_ M-AGR01	d:	0.000	
PRODUCTION	_ M-AGR01	t:	0.000	
PRODUCTION	_ M-FOO01	s:	2.398	m 1.0 2.0 3.0 4.0 5.0
PRODUCTION	_ M-FOO01	a:	9.999	
PRODUCTION	_ M-FOO01	b:	0.000	
PRODUCTION	_ M-FOO01	c:	0.000	
PRODUCTION	_ M-FOO01	d:	0.000	
PRODUCTION	_ M-FOO01	t:	0.000	
PRODUCTION	_ M-E+M01	s:	0.956	m 1.0 2.0 3.0 4.0 5.0
PRODUCTION	_ M-E+M01	a:	9.999	
PRODUCTION	_ M-E+M01	b:	0.000	
PRODUCTION	_ M-E+M01	c:	0.000	
PRODUCTION	_ M-E+M01	d:	0.000	
PRODUCTION	_ M-E+M01	t:	0.000	
PRODUCTION	_ M-MAN01	s:	0.879	m 1.0 2.0 3.0 4.0 5.0
PRODUCTION	_ M-MAN01	a:	9.999	
PRODUCTION	_ M-MAN01	b:	0.000	
PRODUCTION	_ M-MAN01	c:	0.000	
PRODUCTION	_ M-MAN01	d:	0.000	
PRODUCTION	_ M-MAN01	t:	0.000	
PRODUCTION	_ M-T+T01	s:	1.992	m 1.0 2.0 3.0 4.0 5.0

PRODUCTION _ M-T+T01 a: 9.999
PRODUCTION _ M-T+T01 b: 0.000
PRODUCTION _ M-T+T01 c: 0.000
PRODUCTION _ M-T+T01 d: 0.000
PRODUCTION _ M-T+T01 t: 0.000
PRODUCTION _ M-SER01 s: 1.341 m 1.0 2.0 3.0 4.0 5.0
PRODUCTION _ M-SER01 a: 9.999
PRODUCTION _ M-SER01 b: 0.000
PRODUCTION _ M-SER01 c: 0.000
PRODUCTION _ M-SER01 d: 0.000
PRODUCTION _ M-SER01 t: 0.000
PRODUCTION _ M-AGR02 s: 1.474 m 1.0 2.0 3.0 4.0 5.0
PRODUCTION _ M-AGR02 a: 9.999
PRODUCTION _ M-AGR02 b: 0.000
PRODUCTION _ M-AGR02 c: 0.000
PRODUCTION _ M-AGR02 d: 0.000
PRODUCTION _ M-AGR02 t: 0.000
PRODUCTION _ M-FOO02 s: 2.398 m 1.0 2.0 3.0 4.0 5.0
PRODUCTION _ M-FOO02 a: 9.999
PRODUCTION _ M-FOO02 b: 0.000
PRODUCTION _ M-FOO02 c: 0.000
PRODUCTION _ M-FOO02 d: 0.000
PRODUCTION _ M-FOO02 t: 0.000
PRODUCTION _ M-E+M02 s: 0.956 m 1.0 2.0 3.0 4.0 5.0
PRODUCTION _ M-E+M02 a: 9.999
PRODUCTION _ M-E+M02 b: 0.000
PRODUCTION _ M-E+M02 c: 0.000
PRODUCTION _ M-E+M02 d: 0.000
PRODUCTION _ M-E+M02 t: 0.000
PRODUCTION _ M-MAN02 s: 0.879 m 1.0 2.0 3.0 4.0 5.0
PRODUCTION _ M-MAN02 a: 9.999
PRODUCTION _ M-MAN02 b: 0.000
PRODUCTION _ M-MAN02 c: 0.000
PRODUCTION _ M-MAN02 d: 0.000
PRODUCTION _ M-MAN02 t: 0.000
PRODUCTION _ M-T+T02 s: 1.992 m 1.0 2.0 3.0 4.0 5.0
PRODUCTION _ M-T+T02 a: 9.999
PRODUCTION _ M-T+T02 b: 0.000
PRODUCTION _ M-T+T02 c: 0.000
PRODUCTION _ M-T+T02 d: 0.000
PRODUCTION _ M-T+T02 t: 0.000
PRODUCTION _ M-SER02 s: 1.341 m 1.0 2.0 3.0 4.0 5.0
PRODUCTION _ M-SER02 a: 9.999
PRODUCTION _ M-SER02 b: 0.000
PRODUCTION _ M-SER02 c: 0.000
PRODUCTION _ M-SER02 d: 0.000
PRODUCTION _ M-SER02 t: 0.000
PRODUCTION _ M-AGR03 s: 1.474 m 1.0 2.0 3.0 4.0 5.0
PRODUCTION _ M-AGR03 a: 9.999
PRODUCTION _ M-AGR03 b: 0.000
PRODUCTION _ M-AGR03 c: 0.000
PRODUCTION _ M-AGR03 d: 0.000
PRODUCTION _ M-AGR03 t: 0.000
PRODUCTION _ M-FOO03 s: 2.398 m 1.0 2.0 3.0 4.0 5.0
PRODUCTION _ M-FOO03 a: 9.999
PRODUCTION _ M-FOO03 b: 0.000
PRODUCTION _ M-FOO03 c: 0.000
PRODUCTION _ M-FOO03 d: 0.000
PRODUCTION _ M-FOO03 t: 0.000
PRODUCTION _ M-E+M03 s: 0.956 m 1.0 2.0 3.0 4.0 5.0
PRODUCTION _ M-E+M03 a: 9.999
PRODUCTION _ M-E+M03 b: 0.000
PRODUCTION _ M-E+M03 c: 0.000
PRODUCTION _ M-E+M03 d: 0.000
PRODUCTION _ M-E+M03 t: 0.000
PRODUCTION _ M-MAN03 s: 0.879 m 1.0 2.0 3.0 4.0 5.0
PRODUCTION _ M-MAN03 a: 9.999
PRODUCTION _ M-MAN03 b: 0.000
PRODUCTION _ M-MAN03 c: 0.000
PRODUCTION _ M-MAN03 d: 0.000
PRODUCTION _ M-MAN03 t: 0.000
PRODUCTION _ M-T+T03 s: 1.992 m 1.0 2.0 3.0 4.0 5.0
PRODUCTION _ M-T+T03 a: 9.999
PRODUCTION _ M-T+T03 b: 0.000
PRODUCTION _ M-T+T03 c: 0.000
PRODUCTION _ M-T+T03 d: 0.000
PRODUCTION _ M-T+T03 t: 0.000
PRODUCTION _ M-SER03 s: 1.341 m 1.0 2.0 3.0 4.0 5.0

```
PRODUCTION _ M-SER03   a:  9.999
PRODUCTION _ M-SER03   b:  0.000
PRODUCTION _ M-SER03   c:  0.000
PRODUCTION _ M-SER03   d:  0.000
PRODUCTION _ M-SER03   t:  0.000
PRODUCTION _ M-AGR04   e:  1.474   m  1.0 2.0 3.0 4.0 5.0
PRODUCTION _ M-AGR04   a:  9.999
PRODUCTION _ M-AGR04   b:  0.000
PRODUCTION _ M-AGR04   c:  0.000
PRODUCTION _ M-AGR04   d:  0.000
PRODUCTION _ M-AGR04   t:  0.000
PRODUCTION _ M-FOO04   e:  2.398   m  1.0 2.0 3.0 4.0 5.0
PRODUCTION _ M-FOO04   a:  9.999
PRODUCTION _ M-FOO04   b:  0.000
PRODUCTION _ M-FOO04   c:  0.000
PRODUCTION _ M-FOO04   d:  0.000
PRODUCTION _ M-FOO04   t:  0.000
PRODUCTION _ M-E+M04   e:  0.956   m  1.0 2.0 3.0 4.0 5.0
PRODUCTION _ M-E+M04   a:  9.999
PRODUCTION _ M-E+M04   b:  0.000
PRODUCTION _ M-E+M04   c:  0.000
PRODUCTION _ M-E+M04   d:  0.000
PRODUCTION _ M-E+M04   t:  0.000
PRODUCTION _ M-MAN04   e:  0.879   m  1.0 2.0 3.0 4.0 5.0
PRODUCTION _ M-MAN04   a:  9.999
PRODUCTION _ M-MAN04   b:  0.000
PRODUCTION _ M-MAN04   c:  0.000
PRODUCTION _ M-MAN04   d:  0.000
PRODUCTION _ M-MAN04   t:  0.000
PRODUCTION _ M-T+T04   e:  1.992   m  1.0 2.0 3.0 4.0 5.0
PRODUCTION _ M-T+T04   a:  9.999
PRODUCTION _ M-T+T04   b:  0.000
PRODUCTION _ M-T+T04   c:  0.000
PRODUCTION _ M-T+T04   d:  0.000
PRODUCTION _ M-T+T04   t:  0.000
PRODUCTION _ M-SER04   e:  1.341   m  1.0 2.0 3.0 4.0 5.0
PRODUCTION _ M-SER04   a:  9.999
PRODUCTION _ M-SER04   b:  0.000
PRODUCTION _ M-SER04   c:  0.000
PRODUCTION _ M-SER04   d:  0.000
PRODUCTION _ M-SER04   t:  0.000
COMMODITY *** EEC-U
COMMODITY *** USA-U
COMMODITY *** JAP-U
COMMODITY *** ROW-U
COMMODITY _ LAB01
COMMODITY _ LAB02
COMMODITY _ LAB03
COMMODITY _ LAB04
COMMODITY *** F_020101
COMMODITY *** F_020201
COMMODITY _ F_020301
COMMODITY _ F_020401
COMMODITY _ F_020501
COMMODITY _ F_020601
COMMODITY *** F_020102
COMMODITY *** F_020202
COMMODITY _ F_020302
COMMODITY _ F_020402
COMMODITY _ F_020502
COMMODITY _ F_020602
COMMODITY *** F_020103
COMMODITY *** F_020203
COMMODITY _ F_020303
COMMODITY _ F_020403
COMMODITY _ F_020503
COMMODITY _ F_020603
COMMODITY *** F_020104
COMMODITY *** F_020204
COMMODITY _ F_020304
COMMODITY _ F_020404
COMMODITY _ F_020504
COMMODITY _ F_020604
COMMODITY *** LND01
COMMODITY *** LND02
COMMODITY *** LND03
COMMODITY *** LND04
COMMODITY _ AGR01-O
```

```
COMMODITY ... AGR02-O
COMMODITY ... AGR03-O
COMMODITY ... AGR04-O
COMMODITY ... FOO01-O
COMMODITY ... FOO02-O
COMMODITY ... FOO03-O
COMMODITY ... FOO04-O
COMMODITY ... E+M01-O
COMMODITY ... E+M02-O
COMMODITY ... E+M03-O
COMMODITY ... E_M04-O
COMMODITY ... MAN01-O
COMMODITY ... MAN02-O
COMMODITY ... MAN03-O
COMMODITY ... MAN04-O
COMMODITY ... T+T01-O
COMMODITY ... T+T02-O
COMMODITY ... T+T03-O
COMMODITY ... T+T04-O
COMMODITY ... SER01-O
COMMODITY ... SER02-O
COMMODITY ... SER03-O
COMMODITY ... SER04-O
COMMODITY ... AGR01-I
COMMODITY ... AGR02-I
COMMODITY ... AGR03-I
COMMODITY ... AGR04-I
COMMODITY ... FOO01-I
COMMODITY ... FOO02-I
COMMODITY ... FOO03-I
COMMODITY ... FOO04-I
COMMODITY ... E+M01-I
COMMODITY ... E+M02-I
COMMODITY ... E+M03-I
COMMODITY ... E_M04-I
COMMODITY ... MAN01-I
COMMODITY ... MAN02-I
COMMODITY ... MAN03-I
COMMODITY ... MAN04-I
COMMODITY ... T+T01-I
COMMODITY ... T+T02-I
COMMODITY ... T+T03-I
COMMODITY ... T+T04-I
COMMODITY ... SER01-I
COMMODITY ... SER02-I
COMMODITY ... SER03-I
COMMODITY ... SER04-I
COMMODITY ... CUTRNSFR
```

Although the format of this file may appear to be quite cryptic to readers not familiar with MPS/GE or MPSS, it is relatively easy to decipher the exact form of the sensitivity analysis from the information provided.

The first few lines, starting with a dollar sign, are options that are not essential. The first field in the remainder of the file defines the type of variable being listed, allowing MPSS to find the variable in the corresponding MPS/GE file. The second field consists of either three dots ("...") or three asterisks ("****"). If the asterisks appear then the solution value of the vartiable will be retained after each solution. Given the large sample sizes being run it is inefficient to save all solution variables.

The third field defines the MPS/GE variable to which the elasticity applies. The fourth field, if it appears, defines the particular elasticity to be varied. MPS/GE allows up to four nests of substitution, denoted by "a:", "b:", "c:" or "d:", as well as two top-level elasticities of substition ("s:") or transformation ("t:"). The fifth field defines the point estimate of the elasticity, which is generally the set of values selected via ECPOL.

Finally we come to the specification of the random disturbance. From the wide range of distributional assumption permitted in MPSS, we use three. The first is to "specify" a set of alternative elasticities which will be selectected at random with equal probability. Thus to write "s 0.5 1.0 1.5" would result in a discrete distribution taking on three values, with each value being selected one-third of the time. It is possible to repeat certain values, so as to generate virtually any odd distribution one likes (e.g., "s 1.0 1.5 1.5" would generate the value 1.0 with probability one-third and the value 1.5 wioth probability two-thirds). Up to 20 such values can be specified.

The second distributional assumption, used when we have Gaussian estimates of elasticities such as the factor-substitution elasticities, is to request a "normal" distribution. Thus to write "n 0.3 5" would generate a random deviate from a normal distribution with the mean given by the point estimate (already specified in an earlier field in this line) and standard deviation 0.3. This distribution would be carefully partitioned into five equi-probable intervals, and the (weighted) mean of each of those intervals used as the elasticity perturbation.

The third distributional assumption is to simply scale the point estimate by some "multiplicative" factor. Thus to write "m 0.5 1.0 1.5" would mean selecting three values that are 50%, 100% and 150% of the already-specified point estimate. This is just a slightly more convenient form of the first distributional assumption.

The sample size for each sensitivity analysis was 500. In each case we stored the variables of interest in "level form", rather than converting to percentage deviations from the benchmark (the $PERCENT option controls this).

APPENDIX C:

COMPUTER SOFTWARE

In this appendix we document the new computer programs that have been developed to undertake the numerical calculations reported in the text. Our objective is to provide specific technical descriptions of how our calculations were performed, to assist any reader interested in replicating or extending our results.

Detailed documentation for several background programs mentioned below may be obtained separately. For the **ECMODEL** software suite[31] used to estimate and generate the basic model see Harrison, Rutherford and Wooton [1991]. For the **ECPOL** software used to generate the policy simulations with ECMODEL see Harrison, Rutherford, Rutström and Tarr [1991]. For the **MPS/GE** software used to solve the general equilibrium model see Rutherford [1989]. For the **MPSS** software used to undertake the sensitivity analysis described in Appendix B see Harrison [1991b]. Finally, for the **PURE** and **NASH** software used to compute Nash Equilibria (in pure or mixed strategies) and the Nash Solution, see Harrison and Rutström [1986] [1991]. The reader is assumed to have access to the documentation for these programs or to be familiar with their use.

The first step in our calculations was to use ECPOL to generate all of the 81 policies that make up our trade war. This step is conducted automatically by ECPOL, which is largely menu-driven. The "configuration file" AGWARS.CNF that was used to generate these simulations is as follows:

```
* This is an Agricultural Trade War POL file for use in ECPOL.

[title]
TW

[objective]  'region' 'name' 'field identifier' 'LEVEL or CHANGE or PERCENT'
   EEC  WELFARE  EEC   Percent
   USA  WELFARE  USA   Percent

* 'sector' 'region' IN <integer> STEPS FROM <%> TO <%> 'LEVEL or CHANGE'
[Protection]
   AG*  EEC  in 9 steps from -100 to 100 change
   AG*  USA  in 9 steps from -100 to 100 change tariffs esubsidies psubsidies

[cap]     ' YES or NO for endogenous CAP
yes

[solve]   ' name of MPSGE solver to use
nul

[mixed NE]    ' TRUE or FALSE' for computation of mixed-strategy NE
```

[31] This suite consists of many programs, but only one is relevant here. This program is ECGEN.EXE, which generates counter-factual policy cases.

There are three features of this file that are not described in the existing ECPOL documentation, since they were developed for the present project. The first is the use of the sectoral identifier AG* to indicate that all policy changes are to apply to the sectors AGR and FOO jointly. The second is the use of additional fields in the [policy] section when describing US agricultural policies. The user may choose to change any combination of three sets of pre-existing policies: tariffs, export subsidies ("esubsidies"), and production subsidies ("psubsidies"). We elected to scale all of these equally, as described in the text, but have the capability of running a trade war in which the US only uses a subset of these instruments (e.g., an export subsidy war). The third feature is the use of the "nul" command for the [solve] delimiter. This instructs ECPOL to generate the case files for processing by ECGEN but not to proceed to solve them.[32] We do this so as to undertake the sensitivity analysis of each policy using a separate program, MPSS.

The model used in these simulations is the "4x6" alternative in which there are 4 regions (the EC, the US, Japan, and a residual Rest of World) and 6 sectors (Agriculture, Food Products, Mining & Energy, Manufacturing, Construction, and Services). We use the latest available year for the model, 1985. The version of the model that is selected in ECPOL assumes that capital is sector-specific (the Ricardo-Viner assumption) and that there is full employment of labor with flexible real wages.

Once the 81 case files have been generated by ECPOL, we use the program ECGEN (from the ECMODEL suite of programs) to generate the MPS/GE file representing the general equilibrium model with the counter-factual policy.

The sensitivity analysis of each of the 81 policy cells was performed with a program MPSS, described in Appendix B.

The solution of each model was found using the powerful general-purpose modelling program MPS/GE. We employed a 32-bit version of this program, using three 80386 PC's. One was a 16mhz laptop, and the other

---

[32] If the user enters a valid instruction to call the MPS/GE program instead of "nul" then ECPOL will solve all 81 policy simulations automatically, collate the results in a payoff matrix and generate the NE and NS for the trade war. However, ECPOL will only solve the general equilibrium model using benchmark values for all elasticities, rather than repeatedly using perturbations of these elasticities as generated by the MPSS program. For computational efficiency we did not have ECPOL call MPSS, since this would have tied up one of our PC's continuously for a week or two. Instead we were able to "farm out" groups of the MPSS runs to several PC's and schedule them to run over-night when computing resources are otherwise lying idle.

two were 25mhz desktops. Each machine had over 3mb of RAM, and the laptop used 2mb of it's total 6mb as a fast RAM-drive[33]. The dimensionality of the general equilibrium problem varied between 250 and 280, which is to say that the algorithm was required to find solutions for that many variables. Each solution was found in a matter of 3 or 4 seconds, with the benchmark solution values being used to initialize each run. It is difficult to understate the dramatic improvement in technology that MPS/GE represents for exercises such as ours.[34]

Each of the 81 sensitivity analyses consisted of 500 solutions obtained with carefully perturbed elasticities. These solutions were contained in a series of 81 "results files", called TMP1.RES through TMP81.RES. The benchmark solution, in which all elasticities are set to their benchmark values, each region adopts the status quo set of policies, and the sample size is one, is stored in a comparable file called TMP0.RES. These files store only the variables needed to construct our payoffs.

A program called POOL.EXE was written for the purpose of "pooling" all of these solutions and generating the payoff matrices and tables reported in the text. Specifically, POOL (i) reads in the benchmark values for all of the relevant variables, (ii) reads in the 500 solution values for each of the 81 policy alternatives, (iii) converts all endogenous variables to represent changes relative to the status quo, (iv) computes the maximal contribution that each interest group would make to move away from the status quo, (v) computes the political weights discussed in the text, and (vi) generates output files for subsequent game-theoretic analysis (described below).

The program POOL requires two "configuration files" to describe the way in which the data is to be pooled (this is apart from the 81 results files and TMP0.RES, as just described). These files are the way in which the user can instruct POOL to parametrically vary political weights, as illustrated in the text. Specifically, the first file is called AGWARS.CNF and describes the payoff matrix of the underlying game:

```
==> AGWARS.CNF  _ configuration file for POOL

[agents]   'define the agents by ID in one line
EC  US
```

[33] Existing laptops have notoriously slow hard-disk drives, which will slow down IO for large jobs such as these that involve considerable reading and writing of DOS-level files. Overall performance is dramatically enhanced by using extra memory as a RAM-drive for all scratch files.

[34] All of our calculations could be conducted on 80286 or 8086 machines, with or without math co-processors, that have no extended memory.

```
'Define the Status Quo as SQUO in the next few lines in order to have
'Pool compute the political weights needed to ensure that SQUO is a NE.

[strategies]  'define the strategies for each player (each one is a string)
-100% -75% -50% -25% SQUO +25% +50% +75% +100
-100% -75% -50% -25% SQUO +25% +50% +75% +100%

[files]  ' file name, the agents and their strategy numbers
tmp1.res  ec 1  us 1
tmp2.res  ec 1  us 2
tmp3.res  ec 1  us 3
tmp4.res  ec 1  us 4
tmp5.res  ec 1  us 5
tmp6.res  ec 1  us 6
tmp7.res  ec 1  us 7
tmp8.res  ec 1  us 8
tmp9.res  ec 1  us 9
tmp10.res ec 2  us 1
tmp11.res ec 2  us 2
tmp12.res ec 2  us 3
tmp13.res ec 2  us 4
tmp14.res ec 2  us 5
tmp15.res ec 2  us 6
tmp16.res ec 2  us 7
tmp17.res ec 2  us 8
tmp18.res ec 2  us 9
tmp19.res ec 3  us 1
tmp20.res ec 3  us 2
tmp21.res ec 3  us 3
tmp22.res ec 3  us 4
tmp23.res ec 3  us 5
tmp24.res ec 3  us 6
tmp25.res ec 3  us 7
tmp26.res ec 3  us 8
tmp27.res ec 3  us 9
tmp28.res ec 4  us 1
tmp29.res ec 4  us 2
tmp30.res ec 4  us 3
tmp31.res ec 4  us 4
tmp32.res ec 4  us 5
tmp33.res ec 4  us 6
tmp34.res ec 4  us 7
tmp35.res ec 4  us 8
tmp36.res ec 4  us 9
tmp37.res ec 5  us 1
tmp38.res ec 5  us 2
tmp39.res ec 5  us 3
tmp40.res ec 5  us 4
tmp41.res ec 5  us 5
tmp42.res ec 5  us 6
tmp43.res ec 5  us 7
tmp44.res ec 5  us 8
tmp45.res ec 5  us 9
tmp46.res ec 6  us 1
tmp47.res ec 6  us 2
tmp48.res ec 6  us 3
tmp49.res ec 6  us 4
tmp50.res ec 6  us 5
tmp51.res ec 6  us 6
tmp52.res ec 6  us 7
tmp53.res ec 6  us 8
tmp54.res ec 6  us 9
tmp55.res ec 7  us 1
tmp56.res ec 7  us 2
tmp57.res ec 7  us 3
tmp58.res ec 7  us 4
tmp59.res ec 7  us 5
tmp60.res ec 7  us 6
tmp61.res ec 7  us 7
tmp62.res ec 7  us 8
tmp63.res ec 7  us 9
tmp64.res ec 8  us 1
tmp65.res ec 8  us 2
tmp66.res ec 8  us 3
tmp67.res ec 8  us 4
tmp68.res ec 8  us 5
tmp69.res ec 8  us 6
tmp70.res ec 8  us 7
```

```
tmp71.res ec 8  us 8
tmp72.res ec 8  us 9
tmp73.res ec 9  us 1
tmp74.res ec 9  us 2
tmp75.res ec 9  us 3
tmp76.res ec 9  us 4
tmp77.res ec 9  us 5
tmp78.res ec 9  us 6
tmp79.res ec 9  us 7
tmp80.res ec 9  us 8
tmp81.res ec 9  us 9
```

The format of this file is self-explanatory from the comments in it. Note that the free-format features of all of the configuration files described in ECPOL and MPSS apply here also. The only substantive restriction is that once the [files] delimiter appears the next set of non-blank lines must contain all of the files to be pooled. In other words, do not add anything to the bottom of the file unless it is another set of RESults files to be processed by POOL. Although this file may appear to be somewhat cryptic, it does provide POOL with the information needed to generate intelligible tabular reports such as presented in the main text.

The second configuration file is called WEIGHTS.CNF and contains the basic data on the endowments of each of the potential lobby groups in the EC and the US, as well as the political weights that are to be used in pooling agricultural and non-agricultural interests in the government objective function. It has the following format:

```
Agr_Lnd_EC       64.0213    0.0
Agr_Lnd_US        0.0      27.1501
Agr_Lnd_Japan     0.0       0.0
Agr_Lnd_ROW       0.0       0.0
Agr_K_EC         28.7632    0.0
Agr_K_US          0.0      12.1979
Agr_K_Japan       0.0       0.0
Agr_K_ROW         0.0       0.0
Food_K_EC        58.4979    0.0
Food_K_US         0.0      63.6760
Food_K_Japan      0.0       0.0
Food_K_ROW        0.0       0.0
EV_EC          2799.65      0.0
EV_US             0.0    3103.71
EV_Japan          0.0       0.0
EV_ROW            0.0       0.0
Pol_weight        0.7200    0.6100

*               EC        US

* In this file enter on each row the name of the lobbyist, then the
* ENDOWMENT weights for each of the lobbyists. Finally, in the last row
* enter the POLITICAL weight for the agricultural lobbyist (alpha).
* Enter zeroes for all other lobbyists. Each column refers to a country
* in which lobbying is occuring. This format allows much more general
* lobbying games than we are analyzing for the first USTR study.
```

Again, the comment lines at the bottom of the file explain the format adequately. In order to find the weights 0.72 and 0.61 we initially ran POOL with arbitrary weights 0.5 and 0.5, studied the output file AGWARS.TAB to see the information shown in the text in Table ??, and then re-ran POOL using the calibrated weights.

POOL generates two output files. One is called AGWARS.TAB, and contains all of the basic data underlying the construction of the political weights and the payoff matrices. These tables are reproduced in the text, with some descriptive column headings added. The second output file is AGWARS.DAT, which reproduces the payoff matrix in a format that can be processed by the game-theory software described below. Specifically, AGWARS.DAT has the following format:

```
==> AGWARS.DAT _ payoff matrix for trade war

{title}
AGWARS

{number of players}
 2

{gridsize}
 100

{corner}
1

{loop}
yes

{restart}
no

{trace}
no

{disagreement payoffs}
 0.00
 0.00

{number of strategies}
 9
 9

* The following weights are being used to generate payoffs:
* Lobbyist Agr_Lnd_EC      _    64.0213     0.0000
* Lobbyist Agr_Lnd_US      _     0.0000    27.1501
* Lobbyist Agr_Lnd_Japan   _     0.0000     0.0000
* Lobbyist Agr_Lnd_ROW     _     0.0000     0.0000
* Lobbyist Agr_K_EC        _    28.7632     0.0000
* Lobbyist Agr_K_US        _     0.0000    12.1979
* Lobbyist Agr_K_Japan     _     0.0000     0.0000
* Lobbyist Agr_K_ROW       _     0.0000     0.0000
* Lobbyist Food_K_EC       _    58.4979     0.0000
* Lobbyist Food_K_US       _     0.0000    63.6760
* Lobbyist Food_K_Japan    _     0.0000     0.0000
* Lobbyist Food_K_ROW      _     0.0000     0.0000
* Lobbyist EV_EC           _  2799.6499     0.0000
* Lobbyist EV_US           _     0.0000  3103.7100
* Lobbyist EV_Japan        _     0.0000     0.0000
* Lobbyist EV_ROW          _     0.0000     0.0000
* These weights are being used in lobbying activities for regions
* EC, US, respectively.
* Agricultural lobbyists have political weight of 0.7200000 in EC
* Agricultural lobbyists have political weight of 0.6100000 in US
*  EC -100%  US -100%  ==>  payoffs of -2.388 and  0.156  (sample 500)
*  EC -100%  US  -75%  ==>  payoffs of -2.403 and  0.422  (sample 500)
*  EC -100%  US  -50%  ==>  payoffs of -2.440 and  0.648  (sample 500)
*  EC -100%  US  -25%  ==>  payoffs of -2.479 and  0.860  (sample 500)
*  EC -100%  US  SQUO  ==>  payoffs of -2.546 and  1.025  (sample 500)
*  EC -100%  US  +25%  ==>  payoffs of -2.571 and  1.141  (sample 500)
*  EC -100%  US  +50%  ==>  payoffs of -2.639 and  1.176  (sample 500)
*  EC -100%  US  +75%  ==>  payoffs of -2.720 and  1.201  (sample 500)
*  EC -100%  US +100%  ==>  payoffs of -2.744 and  1.151  (sample 500)
*  EC  -75%  US -100%  ==>  payoffs of -0.400 and -0.009  (sample 500)
*  EC  -75%  US  -75%  ==>  payoffs of -0.305 and  0.059  (sample 500)
```

* EC -75% US -50% ==> payoffs of -0.241 and 0.119 (sample 500)
* EC -75% US -25% ==> payoffs of -0.129 and 0.158 (sample 500)
* EC -75% US SQUO ==> payoffs of -0.047 and 0.172 (sample 500)
* EC -75% US +25% ==> payoffs of 0.055 and 0.161 (sample 500)
* EC -75% US +50% ==> payoffs of 0.149 and 0.120 (sample 500)
* EC -75% US +75% ==> payoffs of 0.223 and 0.049 (sample 500)
* EC -75% US +100% ==> payoffs of 0.348 and -0.087 (sample 500)
* EC -50% US -100% ==> payoffs of -0.378 and -0.077 (sample 500)
* EC -50% US -75% ==> payoffs of -0.281 and -0.002 (sample 500)
* EC -50% US -50% ==> payoffs of -0.200 and 0.054 (sample 500)
* EC -50% US -25% ==> payoffs of -0.112 and 0.093 (sample 500)
* EC -50% US SQUO ==> payoffs of -0.015 and 0.111 (sample 500)
* EC -50% US +25% ==> payoffs of 0.061 and 0.100 (sample 500)
* EC -50% US +50% ==> payoffs of 0.166 and 0.062 (sample 500)
* EC -50% US +75% ==> payoffs of 0.250 and -0.014 (sample 500)
* EC -50% US +100% ==> payoffs of 0.327 and -0.123 (sample 500)
* EC -25% US -100% ==> payoffs of -0.356 and -0.153 (sample 500)
* EC -25% US -75% ==> payoffs of -0.258 and -0.072 (sample 500)
* EC -25% US -50% ==> payoffs of -0.175 and -0.008 (sample 500)
* EC -25% US -25% ==> payoffs of -0.085 and 0.033 (sample 500)
* EC -25% US SQUO ==> payoffs of -0.001 and 0.050 (sample 500)
* EC -25% US +25% ==> payoffs of 0.086 and 0.043 (sample 500)
* EC -25% US +50% ==> payoffs of 0.167 and 0.010 (sample 500)
* EC -25% US +75% ==> payoffs of 0.251 and -0.066 (sample 500)
* EC -25% US +100% ==> payoffs of 0.335 and -0.167 (sample 500)
* EC SQUO US -100% ==> payoffs of -0.339 and -0.221 (sample 500)
* EC SQUO US -75% ==> payoffs of -0.254 and -0.134 (sample 500)
* EC SQUO US -50% ==> payoffs of -0.168 and -0.072 (sample 500)
* EC SQUO US -25% ==> payoffs of -0.084 and -0.026 (sample 500)
* EC SQUO US SQUO ==> payoffs of 0.000 and 0.000 (sample 500)
* EC SQUO US +25% ==> payoffs of 0.082 and -0.006 (sample 500)
* EC SQUO US +50% ==> payoffs of 0.164 and -0.042 (sample 500)
* EC SQUO US +75% ==> payoffs of 0.244 and -0.107 (sample 500)
* EC SQUO US +100% ==> payoffs of 0.325 and -0.221 (sample 500)
* EC +25% US -100% ==> payoffs of -0.342 and -0.277 (sample 500)
* EC +25% US -75% ==> payoffs of -0.263 and -0.201 (sample 500)
* EC +25% US -50% ==> payoffs of -0.170 and -0.129 (sample 500)
* EC +25% US -25% ==> payoffs of -0.090 and -0.084 (sample 500)
* EC +25% US SQUO ==> payoffs of -0.009 and -0.058 (sample 500)
* EC +25% US +25% ==> payoffs of 0.071 and -0.039 (sample 500)
* EC +25% US +50% ==> payoffs of 0.144 and -0.094 (sample 500)
* EC +25% US +75% ==> payoffs of 0.218 and -0.164 (sample 500)
* EC +25% US +100% ==> payoffs of 0.305 and -0.268 (sample 500)
* EC +50% US -100% ==> payoffs of -0.353 and -0.342 (sample 500)
* EC +50% US -75% ==> payoffs of -0.271 and -0.256 (sample 500)
* EC +50% US -50% ==> payoffs of -0.202 and -0.186 (sample 500)
* EC +50% US -25% ==> payoffs of -0.124 and -0.136 (sample 500)
* EC +50% US SQUO ==> payoffs of -0.029 and -0.112 (sample 500)
* EC +50% US +25% ==> payoffs of 0.049 and -0.111 (sample 500)
* EC +50% US +50% ==> payoffs of 0.111 and -0.142 (sample 500)
* EC +50% US +75% ==> payoffs of 0.199 and -0.199 (sample 500)
* EC +50% US +100% ==> payoffs of 0.262 and -0.311 (sample 500)
* EC +75% US -100% ==> payoffs of -0.387 and -0.399 (sample 500)
* EC +75% US -75% ==> payoffs of -0.310 and -0.312 (sample 500)
* EC +75% US -50% ==> payoffs of -0.227 and -0.243 (sample 500)
* EC +75% US -25% ==> payoffs of -0.155 and -0.191 (sample 500)
* EC +75% US SQUO ==> payoffs of -0.069 and -0.160 (sample 500)
* EC +75% US +25% ==> payoffs of -0.008 and -0.158 (sample 500)
* EC +75% US +50% ==> payoffs of 0.068 and -0.182 (sample 500)
* EC +75% US +75% ==> payoffs of 0.140 and -0.251 (sample 500)
* EC +75% US +100% ==> payoffs of 0.207 and -0.349 (sample 500)
* EC +100 US -100% ==> payoffs of -0.411 and -0.461 (sample 500)
* EC +100 US -75% ==> payoffs of -0.355 and -0.364 (sample 500)
* EC +100 US -50% ==> payoffs of -0.258 and -0.294 (sample 500)
* EC +100 US -25% ==> payoffs of -0.192 and -0.242 (sample 500)
* EC +100 US SQUO ==> payoffs of -0.100 and -0.208 (sample 500)
* EC +100 US +25% ==> payoffs of -0.053 and -0.206 (sample 500)
* EC +100 US +50% ==> payoffs of 0.019 and -0.229 (sample 500)
* EC +100 US +75% ==> payoffs of 0.111 and -0.296 (sample 500)
* EC +100 US +100% ==> payoffs of 0.153 and -0.384 (sample 500)

[payoffs}

-2.388
-2.403
-2.440
-2.479
-2.546
-2.571

-2.639
-2.720
-2.744
-0.400
-0.305
-0.241
-0.129
-0.047
0.055
0.149
0.223
0.348
-0.378
-0.281
-0.200
-0.112
-0.015
0.061
0.166
0.250
0.327
-0.356
-0.258
-0.175
-0.085
-0.001
0.086
0.167
0.251
0.335
-0.339
-0.254
-0.168
-0.084
0.000
0.082
0.164
0.244
0.325
-0.342
-0.263
-0.170
-0.090
-0.009
0.071
0.144
0.218
0.305
-0.353
-0.271
-0.202
-0.124
-0.029
0.049
0.111
0.199
0.262
-0.387
-0.310
-0.227
-0.155
-0.069
-0.008
0.068
0.140
0.207
-0.411
-0.355
-0.258
-0.192
-0.100
-0.053
0.019
0.111
0.153
0.156
0.422
0.648

0.860
1.025
1.141
1.176
1.201
1.151
-0.009
0.059
0.119
0.158
0.172
0.161
0.120
0.049
-0.087
-0.077
-0.002
0.054
0.093
0.111
0.100
0.062
-0.014
-0.123
-0.153
-0.072
-0.008
0.033
0.050
0.043
0.010
-0.066
-0.167
-0.221
-0.134
-0.072
-0.026
0.000
-0.006
-0.042
-0.107
-0.221
-0.277
-0.201
-0.129
-0.084
-0.058
-0.059
-0.094
-0.164
-0.268
-0.342
-0.256
-0.186
-0.136
-0.112
-0.111
-0.142
-0.199
-0.311
-0.399
-0.312
-0.243
-0.191
-0.160
-0.158
-0.182
-0.251
-0.349
-0.461
-0.364
-0.294
-0.242
-0.208
-0.206
-0.229
-0.296
-0.384

Again, this file is reasonably self-documenting. Any line beginning with an asterisk is just a "remark" line to explain what assumptions have been used to generate the payoff matrix. The payoff matrix values are listed in a particularly ordered manner which is far less transparent than the tabular format of AGWARS.TAB, but which is easy for the subsequent software to read in.

Finally, the AGWARS.DAT file is used as an input file for the programs PURE.EXE and NASH.EXE. They generate output files which summarize the NE and the NS that are found. For each NE that is found a NS is computed assuming that the NE is the disagreement point. Also, if the AGWARS.DAT file contains payoff values under the [disagreement payoffs] delimiter, the NS using these as a disagreement point will be computed. The benchmark output file from PURE is called AGWARS.PNE and is as follows:

File AGWARS.DAT contains the payoff matrix for this game.

Number of pure strategy combinations: 81

Pure Strategy Nash Equilibrium 1:

Agent	Strategy	Payoff
1	5	0.000000
2	5	0.000000

Nash Cooperative Solution with this NE as the disagreement outcome:

Agent	Strategy	Payoff
1	2	0.149000
2	7	0.120000

Nash Cooperative Solution with the specified disagreement outcome:

Agent	Strategy	Payoff
1	2	0.149000
2	7	0.120000

The strategies are numbered here, so some reference back to the AGWARS.CNF file may be needed to ascertain what these numbers refer to. Recall that strategy number 5 was the status quo (called SQUO in AGWARS.CNF), hence we see that the only NE in pure strategies is indeed the status quo. The output of the program NASH is more specialized, but should not be needed for most readers since we are able to find all NE in pure strategies.

TABLE 1
Two Simple Trade Games

Game 1

	US PAYOFFS			EC PAYOFFS	
	EC^N	EC^A		EC^N	EC^A
US^N	0.0	0.85	US^N	0.0	-3.85
US^A	-3.31	1.46	US^A	1.06	0.62

Source: Harrison and Rutström [1991; Table 1, p. 421].

Game 2

	US PAYOFFS			EC PAYOFFS	
	EC^{100}	EC^{200}		EC^{100}	EC^{200}
US^{150}	0.23	-0.37	US^{150}	1.16	1.33
US^{200}	0.21	-0.36	US^{200}	1.06	1.22

Source: Harrison, Rutström and Wigle [1989; Table 11.1, p. 335].

TABLE 2a
Sensitivity Analysis and Results

EC Strategy	US Strategy	Description	EC	US	EC	US	EC	US
-100%	-100%	Mean	-2.388	0.156	-7.231	-1.717	10.068	3.085
		Std. Dev.	0.197	0.100	0.421	0.356	0.388	0.307
		Prob. of Gain	0.0	0.950	0.0	0.0	1.0	1.0
-100%	SQ	Mean	-2.546	1.025	-8.339	5.862	12.351	-6.540
		Std. Dev.	0.285	0.167	0.633	0.568	0.618	0.463
		Prob. of Gain	0.0	1.0	0.0	1.0	1.0	0.0
SQ	+100%	Mean	-0.339	-0.221	0.007	-4.713	-1.230	6.805
		Std. Dev.	0.014	0.081	0.002	0.280	0.053	0.232
		Prob. of Gain	0.0	0.961	1.0	0.0	0.0	1.0

TABLE 2b
Additional Sensitivity Analysis

EC Strategy	US Strategy	Mean	Standard Deviation	Probability of Gain
		Agriculture in EC		
-100%	SQ	-8.339	0.633	0.0
-100	SQ	-8.339	(0.633)	0.0
-75	SQ	-3.439	(0.008)	0.0
-50	SQ	-2.299	(0.005)	0.0
-25	SQ	-1.153	(0.002)	0.0
+25	SQ	+1.159	(0.003)	1.0
+50	SQ	+2.325	(0.005)	1.0
+75	SQ	+3.497	(0.009)	1.0
+100	SQ	+4.676	(0.011)	1.0
		Non-Agriculture in EC		
-100%	SQ	12.351	(0.618)	1.0
-75	SQ	8.677	(0.731)	1.0
-50	SQ	5.859	(0.477)	1.0
-25	SQ	2.962	(0.240)	1.0
+25	SQ	-3.011	(0.248)	0.0
+50	SQ	-6.081	(0.248)	0.0
+75	SQ	-9.240	(0.739)	0.0
+100	SQ	-12.381	(1.049)	0.0
		Agriculture in US		
-100%	SQ	-4.713	(0.280)	0.0
-75	SQ	-3.592	(0.218)	0.0
-50	SQ	-2.455	(0.148)	0.0
-25	SQ	-1.250	(0.080)	0.0
+25	SQ	1.315	(0.091)	1.0
+50	SQ	2.678	(0.183)	1.0
+75	SQ	4.114	(0.297)	1.0
+100	SQ	5.570	(9.423)	1.0
		Non-Agriculture in US		
-100%	SQ	6.805	(0.232)	1.0
-75	SQ	5.274	(0.178)	1.0
-50	SQ	3.654	(0.120)	1.0
-25	SQ	1.888	(0.066)	1.0
+25	SQ	-2.074	(0.075)	0.0
+50	SQ	-4.296	(0.145)	0.0
+75	SQ	-6.709	(0.238)	0.0
+100	SQ	-9.279	(0.350)	0.0

TABLE 3
The Political Weights

All payoffs are measured in billions of US dollars.

		Payoffs from not being in the Status Quo		Political Weight	Check-Sum Net
Country	Strategy	Ag.	Non-Ag.	for Ag.	Contribution
EC	-100%	-8.3392	12.3511	0.596951	0.000000
	-75%	-3.4392	8.6774	0.716156	-0.000000
	-50%	-2.2995	5.8592	0.718155	0.000000
	-25%	-1.1532	2.9618	0.719766	-0.000000
	+25%	1.1588	-3.0111	0.722099	0.000000
	+50%	2.3247	-6.0808	0.723436	0.000000
	+75%	3.4972	-9.2397	0.725429	-0.000000
	+100%	4.6760	-12.3811	0.725861	0.000000
US	-100%	-4.7134	6.8053	0.590805	-0.000000
	-75%	-3.5925	5.2744	0.594842	0.000000
	-50%	-2.4548	3.6537	0.598134	0.000000
	-25%	-1.2495	1.8876	0.601696	0.000000
	+25%	1.3154	-2.0737	0.611874	0.000000
	+50%	2.6779	-4.2959	0.616004	-0.000000
	+75%	4.1145	-6.7094	0.619869	-0.000000
	+100%	5.5696	-9.2794	0.624916	-0.000000

TABLE 4: The Unweighted Payoffs to Agricultural Interests

All payoffs are measured in billions of US dollars.

EC Policy	US Policy	EC Payoff	US Payoff
-100%	-100%	-7.231	-1.717
	-75%	-7.427	0.020
	-50%	-7.695	1.816
	-25%	-7.979	3.791
	SQUO	-8.339	5.862
	+25%	-8.644	8.045
	+50%	-9.066	10.287
	+75%	-9.532	12.815
	+100%	-9.902	15.478
-75%	-100%	-3.431	-4.050
	-75%	-3.433	-2.957
	-50%	-3.435	-1.789
	-25%	-3.437	-0.581
	SQUO	-3.439	0.676
	+25%	-3.441	1.994
	+50%	-3.443	3.364
	+75%	-3.445	4.809
	+100%	-3.447	6.224
-50%	-100%	-2.291	-4.257
	-75%	-2.293	-3.156
	-50%	-2.295	-2.015
	-25%	-2.298	-0.816
	SQUO	-2.299	0.442
	+25%	-2.301	1.749
	+50%	-2.303	3.118
	+75%	-2.306	4.539
	+100%	-2.308	6.036
-25%	-100%	-1.145	-4.500
	-75%	-1.147	-3.389
	-50%	-1.149	-2.233
	-25%	-1.151	-1.035
	SQUO	-1.153	0.219
	+25%	-1.155	1.519
	+50%	-1.157	2.899
	+75%	-1.159	4.308
	+100%	-1.161	5.819
SQUO	-100%	0.007	-4.713
	-75%	0.006	-3.592
	-50%	0.004	-2.455
	-25%	0.002	-1.250
	SQUO	0.000	0.001
	+25%	-0.002	1.315
	+50%	-0.004	2.678
	+75%	-0.006	4.114
	+100%	-0.008	5.570
+25%	-100%	1.167	-4.887
	-75%	1.165	-3.816
	-50%	1.163	-2.653
	-25%	1.161	-1.461
	SQUO	1.159	-0.208
	+25%	1.157	1.101
	+50%	1.155	2.457
	+75%	1.153	3.862
	+100%	1.151	5.339
+50%	-100%	2.333	-5.096
	-75%	2.331	-3.995
	-50%	2.329	-2.851
	-25%	2.327	-1.652
	SQUO	2.325	-0.408
	+25%	2.323	0.894
	+50%	2.321	2.251
	+75%	2.319	3.696
	+100%	2.317	5.139
+75%	-100%	3.505	-5.276
	-75%	3.503	-4.184
	-50%	3.501	-3.051
	-25%	3.499	-1.854
	SQUO	3.497	-0.601
	+25%	3.496	0.702
	+50%	3.493	2.074
	+75%	3.492	3.465
	+100%	3.490	4.953
+100%	-100%	4.683	-5.472
	-75%	4.683	-4.354
	-50%	4.680	-3.227
	-25%	4.678	-2.043
	SQUO	4.676	-0.789
	+25%	4.674	0.508
	+50%	4.674	1.876
	+75%	4.671	3.270
	+100%	4.669	4.783

TABLE 5: The Unweighted Payoffs to Non-Agricultural Interests

All payoffs are measured in billions of US dollars.

EC Policy	US Policy	EC Payoff	US Payoff
-100%	-100%	10.068	3.085
	-75%	10.517	1.050
	-50%	11.073	-1.179
	-25%	11.662	-3.724
	SQUO	12.351	-6.540
	+25%	13.044	-9.658
	+50%	13.888	-13.075
	+75%	14.797	-16.966
	+100%	15.661	-21.258
-75%	-100%	7.394	6.311
	-75%	7.737	4.776
	-50%	7.974	3.103
	-25%	8.377	1.314
	SQUO	8.677	-0.615
	+25%	9.045	-2.705
	+50%	9.383	-4.953
	+75%	9.657	-7.397
	+100%	10.107	-9.958
-50%	-100%	4.542	6.461
	-75%	4.891	4.932
	-50%	5.188	3.291
	-25%	5.508	1.516
	SQUO	5.859	-0.408
	+25%	6.137	-2.479
	+50%	6.514	-4.719
	+75%	6.824	-7.13
	+100%	7.102	-9.756
-25%	-100%	1.674	6.647
	-75%	2.027	5.115
	-50%	2.329	3.472
	-25%	2.658	1.704
	SQUO	2.962	-0.213
	+25%	3.278	-2.266
	+50%	3.572	-4.509
	+75%	3.877	-6.907
	+100%	4.181	-9.529
SQUO	-100%	-1.230	6.805
	-75%	-0.921	5.274
	-50%	-0.610	3.654
	-25%	-0.303	1.888
	SQUO	0.000	-0.001
	+25%	0.300	-2.074
	+50%	0.597	-4.296
	+75%	0.888	-6.709
	+100%	1.184	-9.279
+25%	-100%	-4.222	6.934
	-75%	-3.933	5.453
	-50%	-3.598	3.818
	-25%	-3.306	2.069
	SQUO	-3.011	0.177
	+25%	-2.722	-1.874
	+50%	-2.457	-4.084
	+75%	-2.187	-6.460
	+100%	-1.870	-9.037
+50%	-100%	-7.260	7.093
	-75%	-6.963	5.593
	-50%	-6.711	3.981
	-25%	-6.426	2.236
	SQUO	-6.081	0.352
	+25%	-5.797	-1.682
	+50%	-5.570	-3.884
	+75%	-5.252	-6.291
	+100%	-5.023	-8.834
+75%	-100%	-10.394	7.229
	-75%	-10.115	5.745
	-50%	-9.814	4.147
	-25%	-9.552	2.410
	SQUO	-9.240	0.529
	+25%	-9.017	-1.502
	+50%	-8.739	-3.711
	+75%	-8.478	-6.062
	+100%	-8.235	-8.642
+100	-100%	-13.509	7.378
	-75%	-13.309	5.878
	-50%	-12.956	4.294
	-25%	-12.716	2.574
	SQUO	-12.381	0.700
	+25%	-12.207	-1.324
	+50%	-11.949	-3.523
	+75%	-11.613	-5.874
	+100%	-11.459	-8.466

TABLE 6: The Weighted Payoffs to Government

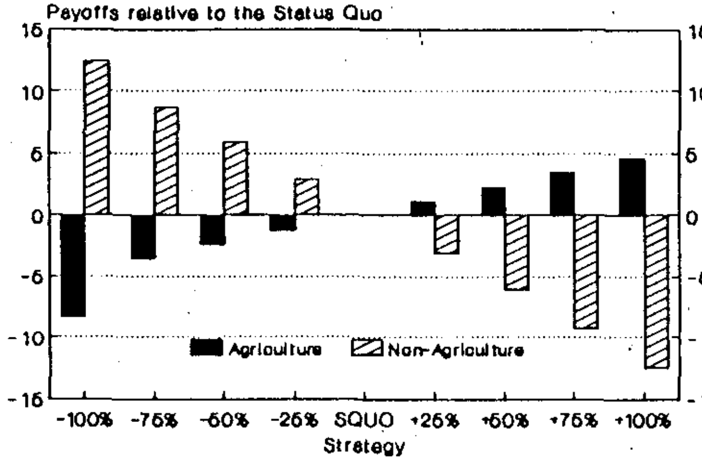
All payoffs are measured in billions of US dollars.

EC Policy	US Policy	EC Payoff	US Payoff
-100%	-100%	-2.388	0.156
	-75%	-2.403	0.422
	-50%	-2.440	0.648
	-25%	-2.479	0.860
	SQUO	-2.546	1.025
	+25%	-2.571	1.141
	+50%	-2.639	1.176
	+75%	-2.720	1.201
	+100%	-2.744	1.151
-75%	-100%	-0.400	-0.009
	-75%	-0.305	0.059
	-50%	-0.241	0.119
	-25%	-0.129	0.158
	SQUO	-0.047	0.172
	+25%	0.055	0.161
	+50%	0.149	0.120
	+75%	0.223	0.049
	+100%	0.348	-0.087
-50%	-100%	-0.378	-0.077
	-75%	-0.281	-0.002
	-50%	-0.200	0.054
	-25%	-0.112	0.093
	SQUO	-0.015	0.111
	+25%	0.061	0.100
	+50%	0.166	0.062
	+75%	0.250	-0.014
	+100%	0.327	-0.123
-25%	-100%	-0.356	-0.153
	-75%	-0.258	-0.072
	-50%	-0.175	-0.008
	-25%	-0.085	0.033
	SQUO	-0.001	0.050
	+25%	0.086	0.043
	+50%	0.167	0.010
	+75%	0.251	-0.066
	+100%	0.335	-0.167
SQUO	-100%	-0.339	-0.221
	-75%	-0.254	-0.134
	-50%	-0.168	-0.072
	-25%	-0.084	-0.026
	SQUO	0.000	0.000
	+25%	0.082	-0.006
	+50%	0.164	-0.043
	+75%	0.244	-0.107
	+100%	0.325	-0.221
+25%	-100%	-0.342	-0.277
	-75%	-0.263	-0.201
	-50%	-0.170	-0.129
	-25%	-0.090	-0.084
	SQUO	-0.009	-0.058
	+25%	0.071	-0.059
	+50%	0.144	-0.094
	+75%	0.218	-0.164
	+100%	0.305	-0.268
+50%	-100%	-0.353	-0.342
	-75%	-0.271	-0.256
	-50%	-0.202	-0.186
	-25%	-0.124	-0.136
	SQUO	-0.029	-0.112
	+25%	0.049	-0.111
	+50%	0.111	-0.142
	+75%	0.199	-0.199
	+100%	0.262	-0.311
+75%	-100%	-0.387	-0.399
	-75%	-0.310	-0.312
	-50%	-0.227	-0.243
	-25%	-0.155	-0.191
	SQUO	-0.069	-0.160
	+25%	-0.008	-0.158
	+50%	0.068	-0.182
	+75%	0.140	-0.251
	+100%	0.207	-0.349
+100	-100%	-0.411	-0.461
	-75%	-0.355	-0.364
	-50%	-0.258	-0.294
	-25%	-0.192	-0.242
	SQUO	-0.100	-0.208
	+25%	-0.053	-0.206
	+50%	0.019	-0.229
	+75%	0.111	-0.296
	+100%	0.153	-0.384

TABLE 7
Predicted Outcomes of Trade Negotiations

		Non-cooperative NE		Cooperative NS with NE=d		Cooperative NS with SQ=d	
EC Weight	US Weight	EC Strategy	US Strategy	EC Strategy	US Strategy	EC Strategy	US Strategy
0.72	0.61	SQ	SQ	-75%	+50%	SQ	SQ
0.71	0.61	-75%	SQ	---	---	-75%	+50%
0.73	0.61	+50%	+25%	-25%	+75%	-50%	+50%
0.45	0.61	-100%	+75%	---	---	-100%	+100%
0.45	0.61	-75%	SQ	-100%	+100%	-100%	+100%
0.72	0.60	SQ	-25%	-75%	+25%	-75%	+75%
0.72	0.57	SQ	-100%	-75%	-50%	---	---
0.72	0.0001	SQ	-100%	---	---	---	---
0.72	0.62	-25%	+50%	-75%	+75%	-75%	+75%
0.72	0.71	-75%	+100%	---	---	-75%	+75%

Figure 1a
PAYOFFS TO INTEREST GROUPS IN THE EC



Payoffs are measured in billions of 1985 U.S. dollars. Detailed results are displayed in Table 3.

Figure 1b
POLITICAL WEIGHTS IN THE EC

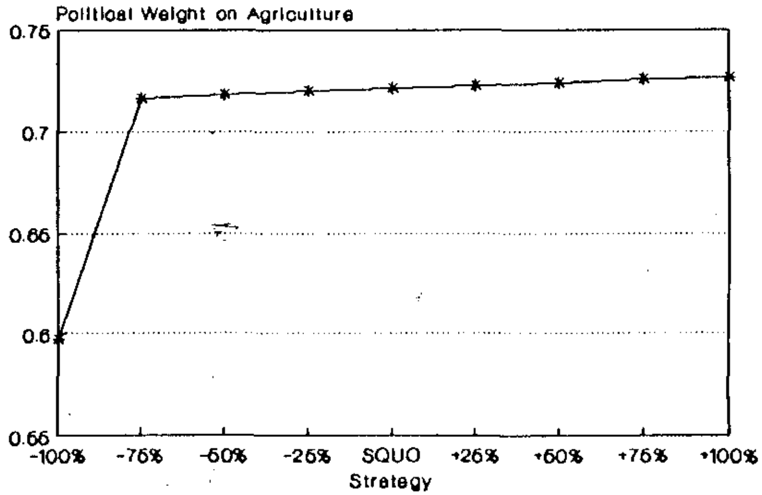
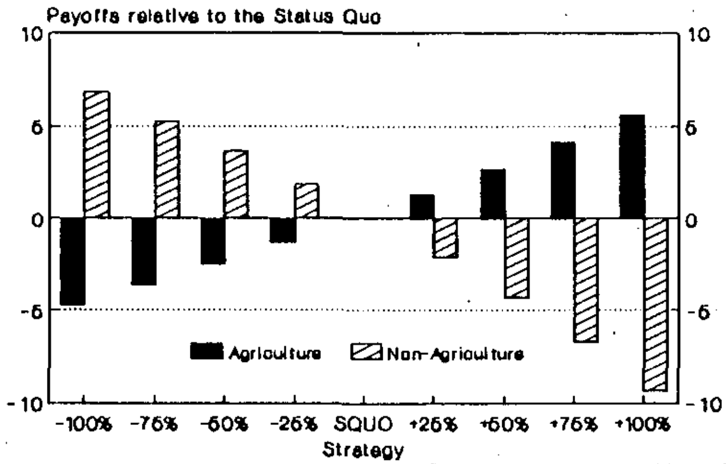
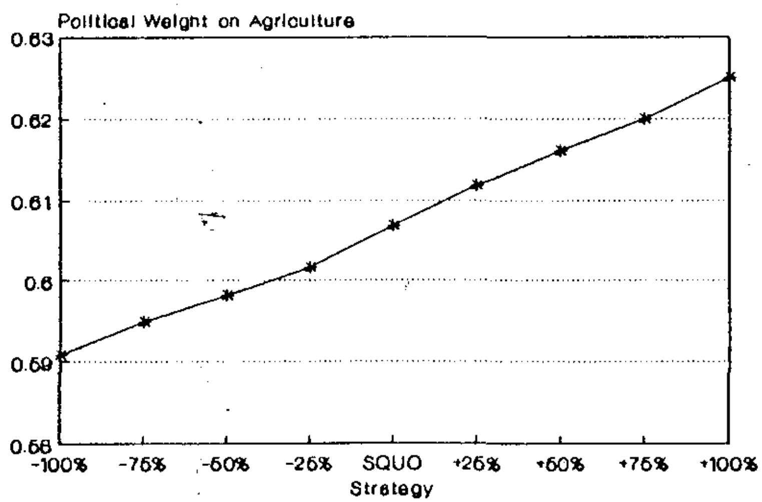


Figure 2a
PAYOFFS TO INTEREST GROUPS IN THE U.S.



Payoffs are measured in billions of 1985 U.S. dollars. Detailed results are displayed in Table 3.

Figure 2b
POLITICAL WEIGHTS IN THE U.S.



REFERENCES

Abreu, Dilip, "On the Theory of Infinitely Repeated Games With Discounting", **Econometrica**, v. 56, 1988, pp. 383-396.

Baldwin, Robert E., and Clarke, Richard N., "Game Modelling the Multilateral Trade Negotiations", **Journal of Policy Modelling**, v. 9, 1987, pp. 257-284.

Benoit, J.P., and Krishna, V., "Finitely Repeated Games", **Econometrica**, v. 55, 1985, pp. 905-922.

Binmore, Ken; Rubinstein, Ariel, and Wolinsky, Asher, "The Nash Bargaining Solution in Economic Modelling", **Rand Journal of Economics**, v. 17, Summer 1986, pp. 176-188.

Brooke, Anthony; Kendrick, David, and Meeraus, Alexander, **GAMS: A User's Guide** (Redwood City, CA: Scientific Press, 1988).

Brown, Drusilla K., "Tariffs, the Terms of Trade and National Product Differentiation", **Journal of Policy Modelling**, v. 9, 1987, pp. 503-526.

Brown, Fred, and Whalley, John, "General Equilibrium Evaluations of Tariff-Cutting Proposals in the Tokyo Round and Comparisons With More Extensive Liberalization of World Trade", **Economic Journal**, v. 90, December 1980, pp. 838-866.

Fudenberg, Drew, and Maskin, Eric, "The Folk Theorem in Repeated Games With Discounting Or With Incomplete Information", **Econometrica**, v. 54, 1986, pp. 533-554.

Gasiorek, Michael; Smith, Alasdair, and Venables, Anthony J., "Tariffs, Subsidies and Retaliation", **European Economic Review**, v. 33, 1989, pp. 480-489.

Gately, Dermot, "Sharing the Gains From Customs Unions Among Less Developed Countries", **Journal of Development Economics**, v. 1, 1974, pp. 213-233.

Hamilton, Bob, and Whalley, John, "Optimal Tariff Calculations in Alternative Trade Arrangements", Journal of **International Economics**, v. 15, 1983, pp. 323-348.

Hansen, Terje, "On the Approximation of Nash Equilibrium Points in an N-Person Noncooperative Game", SIAM **Journal of Applied Mathematics**, v. 26, 1974, pp. 622-637.

Harrison, Glenn W., "A General Equilibrium Analysis of Tariff Reductions", in T.N. Srinivasan and John Whalley (eds.), **General Equilibrium Trade Policy Modelling** (Cambridge, MA: MIT Press, 1986).

Harrison, Glenn W., "Rational Expectations and Experimental Methods", in B.A. Goss (ed.), **Rational Expectations and Efficiency in Futures Markets** (London: Routledge, 1991a).

Harrison, Glenn W., "The Sensitivity Analysis of Applied General Equilibrium Models With MPSS: User Guide", **Unpublished Manuscript**, Department of Economics, College of Business Administration, University of South Carolina, 1991b.

Harrison, Glenn W.; Jones, Richard; Kimbell, Larry J., and Wigle, Randall, "How Robust is Applied General Equilibrium Analysis?", **Journal of Policy Modelling**, v. 13, 1991, forthcoming.

Harrison, Glenn W.; Rutherford, Thomas F.; Rutström, E.E.; and Tarr, David, "The ECPOL Trade Policy Generator: User Guide", **Unpublished Manuscript**, Department of Economics, College of Business Administration, University of South Carolina, March 1991.

Harrison, Glenn W.; Rutherford, Thomas F.; and Wooton, Ian, "The Economic Impact of the European Community", **American Economic Review (Papers & Proceedings)**, v. 79, May 1989, pp. 288-294.

Harrison, Glenn W.; Rutherford, Thomas F., and Wooton, Ian, "Liberalizing Agriculture in the European Community", **Economics Working Paper B-90-03**, Division of Research, College of Business Administration, University of South Carolina, October 1990.

Harrison, Glenn W.; Rutherford, Thomas F.; and Wooton, Ian, "An Empirical Database for a General Equilibrium Model of the European Communities", in J. Piggott and J. Whalley (eds.), **Applied General Equilibrium** (Heidelberg: Physica Verlag, 1991).

Harrison, Glenn W., and Rutström, E.E., "Computing Nash Equilibria in General Equilibrium Trade Models", **Invited Paper**, IIASA Conference on Applied General Equilibrium Modelling, August 1986.

Harrison, Glenn W., and Rutström, E.E., "Trade Wars, Trade Negotiations, and Applied Game Theory", **The Economic Journal**, v. 101, May 1991a, pp. 420-435.

Harrison, Glenn W., and Rutström, E.E., "Who Are The Friends and Enemies of The Common Agricultural Policy?", **Unpublished Draft Manuscript**, Department of Economics, College of Business Administration, University of South Carolina, April 1991b.

Harrison, Glenn W.; Rutström, E.E.; and Wigle, Randall, "The Costs of Agricultural Trade Wars", in A. Stoeckel, D. Vincent and S. Cuthbertson (eds.), **Macroeconomic Consequences of Farm Support Policies** (Durham: Duke University Press, 1989).

Harrison, Glenn W., and Vinod, H.D., "The Sensitivity Analysis of Applied General Equilibrium Models: Completely Randomized Factorial Sampling Designs", **The Review of Economics and Statistics**, v.73, 1991, forthcoming.

Harsanyi, John C., **Rational Behavior and Bargaining Equilibrium in Games and Social Situations** (Cambridge: Cambridge University Press, 1977).

Hathaway, Dale E., **Agriculture and the GATT: Rewriting the Rules** (Washington, DC: Institute for International Economics, 1987).

Johnson, H.G., "Optimum Tariffs and Retaliation", **Review of Economic Studies**, v. 21, 1954, pp. 142-153; reprinted with revisions in H.G. Johnson, **International Trade and Economic Growth** (Cambridge: Harvard University Press, 1958).

Kennan, John, and Riezman, Raymond, "Do Big Countries Win Tariff Wars?", **International Economic Review**, v. 29, February 1988, pp. 81-85.

Kuga, Kiyoshi, "Tariff Retaliation and Policy Equilibrium", **Journal of International Economics**, v. 3, 1973, pp. 351-366.

Markusen, James R., and Wigle, Randall M., "Nash Equilibrium Tariffs for the United States and Canada: The Roles of Country Size, Scale Economies, and Capital Mobility", **Journal of Political Economy**, v. 97, April 1989, pp. 368-386.

McMillan, John, **Game Theory in International Economics** (Chur: Harwood, 1986).

Moreaux, M., "Perfect Nash Equilibria in Finite Repeated Games and Uniqueness of Nash Equilibrium in the Constituent Game", **Economics Letters**, v. 17, 1985, pp. 317-320.

Nash, John F., "The Bargaining Problem", **Econometrica**, v. 18, 1950, pp. 155-162.

Nash, John F., "Noncooperative Games", **Annals of Mathematics**, v. 54, 1951, pp. 286-295.

Nash, John F., "Two-Person Cooperative Games", **Econometrica**, v. 21, 1953, pp. 128-140.

Riezman, Raymond, "Customs Unions and the Core", **Journal of International Economics**, v. 1, 1985, pp. 355-365.

Roth, Alvin E., and Malouf, Michael W.K., "Game-Theoretic Models and the Role of Information in Bargaining", **Psychological Review**, v. 86, 1979, pp. 574-594.

Rutherford, Thomas F., "General Equilibrium Modelling With MPS/GE", **Unpublished Monograph**, Department of Economics, University of Western Ontario, 1989.

Rutherford, Thomas F., and Winer, Stanley L., "Endogenous Policy in a Computational General Equilibrium Framework", **Research Report 9007**, Department of Economics, University of Western Ontario, Canada, May 1990.

Rutström, E.E., **The Political Economy of Protectionism in Indonesia** (Stockholm: Economic Research Institute, Stockholm School of Economics, 1991).

Stoeckel, Andrew R.; Vincent, David; and Cuthbertson, Sandy (eds.), **Macroeconomic Consequences of Farm Support Policies** (Durham: Duke University Press, 1989).

Tower, Edward; Sheer, Alain; and Baas, Hessell J., "Alternative Optimum Tariff Strategies as Devices for Transferring Real Incomes", **Southern Economic Journal**, v. 44, July 1978, pp. 18-31.

van Damme, Eric, "The Nash Bargaining Solution Is Optimal", **Journal of Economic Theory**, v. 38, 1986, pp. 78-100.

Whalley, John, **Trade Liberalization Among Major World Trading Areas** (Cambridge: MIT Press, 1985).

Whalley, John, "Impacts of a 50% Tariff Reduction in an Eight-Region Global Trade Model", in T.N. Srinivasan and J. Whalley (eds.), **General Equilibrium Trade Policy Modelling** (Cambridge: MIT Press, 1986).