

MEMORANDUM

RM-4297-ISA

OCTOBER 1966

## AN ECONOMIC THEORY OF ALLIANCES

Mancur Olson, Jr. and Richard Zeckhauser

PREPARED FOR:

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PREFACE

This Memorandum presents a new theoretical model of military alliances and other international organizations. The model, if correct, has important policy implications, but these implications are discussed only briefly here. Hopefully this presentation will stimulate further study of the model's application to specific policy problems.

The study was sponsored jointly by the Center of International Studies of Princeton University, and by The RAND Corporation as part of its continuing program of research for the Office of the Assistant Secretary of Defense, International Security Affairs (ISA). The Memorandum has been greatly improved by the efforts of many perceptive critics. Of these, Klaus Knorr of Princeton University, Malcolm Hoag and James Schlesinger of The RAND Corporation, Richard Musgrave and Thomas Schelling of Harvard University, and Gerald Garvey of the Department of Defense deserve special thanks. The sponsors and critics of this study do not, however, share the responsibility for the views it expresses.

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### SUMMARY

Many writers in the United States, and even some in other countries, have argued that this country bears a disproportionately large share of the costs of various ventures in international cooperation. There is some concern about the proportions of the expenses of the United Nations and the costs of economic aid to the less developed countries that are borne by the United States, but the most notable complaint is about the American share of the burden of the common defense under the North Atlantic Treaty Organization. Some observers contend that America's allies, especially the smaller ones, have simply been unfair in not bearing larger shares of the common burdens, and hope that moral suasion can induce the smaller members of the Western Alliance to bear a more nearly proportional share of these costs. Others say that the disappointingly small contributions of the smaller allies are due to a considerable and increasing degree of divergence of purpose among the allies and hope that political discussion can bring about the full agreement that will make every ally want to do its share.

This study assumes that any nation's decision about the amount of resources to devote to a military alliance, or any other international organization, is determined by what the nation's government conceives to be its national interest. It then develops a formal model based on this assumption. This model indicates that in an alliance or other international organization composed of nations acting in their national interests, there will be a general tendency for the larger nations to bear disproportionately large shares of the costs, and for the smaller nations to make little or no contribution to the common cause. The model also implies that the individual allies will usually fail to provide the organization with as large an amount of resources as it would be in their common interest to provide. Statistical tests of some of the model's implications show that there is a positive and statistically significant relationship between the size of NATO nations as measured by the Gross National Product and the percentage of their resources that they devote to the common defense. The tests also show

that in subscriptions to the United Nations and in the provision of foreign aid there appear to have been similar tendencies for larger nations to make disproportionately greater efforts than smaller nations.

If the model developed here is correct, and the disproportionately large contributions of the larger allies, and the less than proportional contributions of the smaller allies, can be explained in terms of their respective national interests, then it follows that the large share of alliance burdens that falls upon the United States should not be explained in strictly moral or political terms. When the different levels of alliance contribution of larger and smaller members are securely grounded in their individual national interests, moral suasion and political discussion are not likely to be effective, and American attempts to persuade her allies to bear larger shares of the common burden are apt to do nothing more than breed division and resentment.

There are, however, two types of institutional arrangements that tend to prevent disproportionality and suboptimality in the support given to international undertakings: (1) greater unification, either of all alliance members, or even of only the smaller alliance members; (2) arrangements for sharing costs of additional forces on a percentage basis. A sharing arrangement would give each of the members of an alliance an incentive to keep contributing to the alliance until that alliance receives an optimal level of support. Whatever disadvantages such arrangements may have, they are still of practical interest, for if special incentives such as these are not provided, it will normally be impossible for alliances or other international organizations composed of states acting in their own national interests to obtain adequate levels of support or to avoid a disproportional and arbitrary sharing of costs.

Finally, our model shows that, in the absence of any such institutional arrangements, the tendency toward suboptimality and disproportionality is, paradoxically, stronger the more complete the unity of purpose among the allies. This finding suggests that even fairly considerable divergences of purpose among alliance members need not



necessarily be fatal to an alliance. Though there is obviously a point beyond which differences of purpose will destroy an alliance, the model suggests there are also circumstances in which limited disagreement among members can increase the effectiveness of an alliance.



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## I. INTRODUCTION

The United States participates with other countries in a number of international organizations designed to achieve some common goal or purpose. The North Atlantic Treaty Organization, to which the United States contributes a substantial military force, is the most costly of these joint ventures and, in terms of the model that will be developed here, perhaps the most interesting. The main focus of this Memorandum will therefore be on NATO, but the model also fits the United Nations or any other international organization or alliance equally well.

There are some important respects in which the United States is not satisfied with NATO or most other U.S. ventures in international cooperation. For one thing, it is argued that the United States is bearing a disproportionate share of the burden of the common defense of the NATO countries,\* since the smaller members of NATO devote smaller percentages of their national incomes to defense than does the United States.\*\* There is also some concern about the fact that the NATO alliance has systematically failed to provide the number of divisions that the NATO nations have themselves proclaimed (rightly or wrongly) are necessary; it has failed to provide the level of defense that it has itself defined as the optimal or appropriate level.\*\*\* Similarly, many nations, especially smaller nations, have failed to fulfill their

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\* Hedley Bull, Strategy and the Atlantic Alliance: A Critique of United States Doctrine, Center of International Studies, Princeton University, Princeton, New Jersey, 1964, p. 42; Edward S. Mason, "The Equitable Sharing of Military and Economic Aid Burdens," Proceedings of the Academy of Political Science, Vol. XXVII, May 1963, pp. 256-269, especially p. 264; John A. Pincus, Sharing the Costs of Military Alliance and International Economic Aid, The RAND Corporation, RM-3249-ISA, August 1962, and Economic Aid and International Cost Sharing, The Johns Hopkins Press, Baltimore, Maryland, 1965; Bernard Brodie, "What Price Conventional Capabilities in Europe," The Reporter, Vol. XXXVIII, May 23, 1963, p. 27; "How Helpful Are U.S. Allies?" U.S. News and World Report, September 13, 1965, pp. 50-55.

\*\* See Table 1, page 26.

\*\*\* "NATO was created as, and is still today officially proclaimed to be, the shield that protects Western Europe from a Soviet attack on land. Yet it has never been clear how NATO could perform that function

quotas for UN contributions, with the result that the U.S. contribution rises. The meager level of total support for the UN and the haphazard state of its finances have also caused concern.

Some suppose that the disproportionate sharing of support for international undertakings such as NATO is due largely to an alleged American moral superiority, and that the poverty of international organizations is due to a want of responsibility on the part of some other nations. Before resorting to any such explanations, it would seem necessary to ask whether the different sizes of contributions by different countries could be explained in terms of their national interests. But why would it be in the interest of some countries and not others to contribute a larger proportion of their total resources to group undertakings? The European members of NATO are somewhat more accessible to enemy attack than the United States, and they are less able to defend themselves alone; thus it might be supposed that they would have an interest in devoting larger proportions of their resources to NATO than does the United States, rather than the smaller proportions that they actually contribute. And why do the NATO nations fail to provide the level of forces that they have themselves described as appropriate, that is, in their common interest? These questions cannot be answered without developing a logical explanation of how much a nation, acting in its national interest, will contribute to an international organization.

Any attempt to develop a theory of international organizations must begin with the purposes or functions of these organizations. One purpose that all such organizations must have is that of serving the common interests of member states. In the case of NATO, the proclaimed purpose of the alliance is to protect the member nations from aggression

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with the forces actually at its disposal or how it could have performed that function even with the much larger forces which its official spokesmen from time to time declared to be indispensable." Hans J. Morganthau, "Forward," in Robert Osgood, NATO: The Entangling Alliance, The University of Chicago Press, Chicago, Illinois, 1962, p. vii. John Pincus speaks of "the relative willingness of countries to accept NATO force goals," and the fact that "the trouble comes in meeting those goals." Economic Aid and International Cost Sharing, p. 58.



by a common enemy. Deterring aggression against any one of the members is supposed to be in the interest of all.\* The analogy with a nation-state is obvious. Those goods and services, such as defense, that the government provides in the common interest of the citizenry are usually called "public goods." An organization of states allied for defense similarly produces a public good, only in this case the "public" -- the members of the organization -- are states rather than individuals.

Indeed, almost all kinds of organizations provide public or collective goods. Individual interests normally can best be served by individual action, but when a group of individuals has some common objective, some collective goal, then an organization can be useful. Such a common objective is a collective good, since it has one or both of the following properties: (1) if the common goal is achieved, everyone who shares this goal automatically benefits, or in other words nonpurchasers cannot feasibly be kept from consuming the goods; (2) if the good is available to any one person in a group, it is or can be made available to the other members of the group at little or no marginal cost.\*\* Collective goods are thus the characteristic outputs not only of governments but of organizations in general.\*\*\*

Since the benefits of any action an individual takes to provide a public or organizational good also go to others, individuals acting independently do not have an incentive to provide optimal amounts of such goods. Indeed, when the group interested in a public good is very large, and the share of the total benefit that goes to any single individual is very small, usually no individual has an incentive

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\*"Peace is indivisible, and nuclear war even more so." Prime Minister Harold Wilson, as quoted in The New York Times, December 17, 1964, p. 2.

\*\* See John G. Head, "Public Goods and Public Policy," Public Finance, Vol. XVII, No. 31, 1962, pp. 197-219.

\*\*\* See Mancur Olson, Jr., The Logic of Collective Action: Public Goods and the Theory of Groups, Harvard University Press, Cambridge, Massachusetts, 1965, which treats organizations of individuals in something like the way this Memorandum treats organizations of nation-states.

voluntarily to purchase any of the good; thus states exact taxes and labor unions demand compulsory membership.\* When -- as in any organization representing a limited number of nation-states -- the membership of an organization is relatively small, the individual members may have an incentive to make significant sacrifices to obtain the collective good, but they will tend to provide only sub-optimal amounts of this good. There will also be a tendency for the "larger" members -- those that place a higher absolute value on the public good -- to bear a disproportionate share of the burden, as the model of alliances developed below will show.

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\*Ibid., pp. 5-52.

## II. THE MODEL

When a nation decides how large a military force to provide in an alliance, it must consider the value it places on collective defense and other, nondefense goods that must be sacrificed to obtain additional military forces. The value that each nation in an alliance places on the alliance collective good vis-à-vis other goods can be shown on a simple indifference map, such as that in Fig. 1. This is an ordinary indifference map cut off at the present income line and turned upside down. Defense capability is measured along the horizontal axis and valued positively; defense spending is measured along the vertical axis and valued negatively. The cost curves for the sake of simplicity are assumed to be linear. If the nation depicted in Fig. 1 were not a part of any alliance, the amount of defense it would obtain (OB) could be found by drawing a cost curve coming out of the origin and finding the point (Point A) where this cost curve is tangent to the "most favored" (most southeasterly) indifference curve.

In an alliance, the amount a nation spends on defense will be affected by the amount its allies provide.\* By moving the cost curve down along the vertical axis beneath the origin we can represent the defense expenditure of allied nations as the distance between the origin and the juncture of the cost curve and the vertical axis. If a nation's allies spend OD on defense, and their cost functions are the same as its own, then it receives OH of defense without cost. This is equivalent to an increase in income of OD.\*\* The more defense this nation's

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\*It may also be affected by the military expenditures of enemy nations, but since the problem of the interdependence of military expenditures among antagonistic nations exists whether there is any alliance or not, and has little analytical connection with the question of how allies interact, it would be a digression to deal with it here.

\*\*Free defense is not, however, the direct equivalent of an increase in income if the nation has already received so much defense that it would like to sell some if that were possible. This is what an ally would want to do if the CC curve had shifted so far to the right that it was no longer tangent to any indifference curve. In such a case there is a corner solution and the nation provides none of the collective good itself.

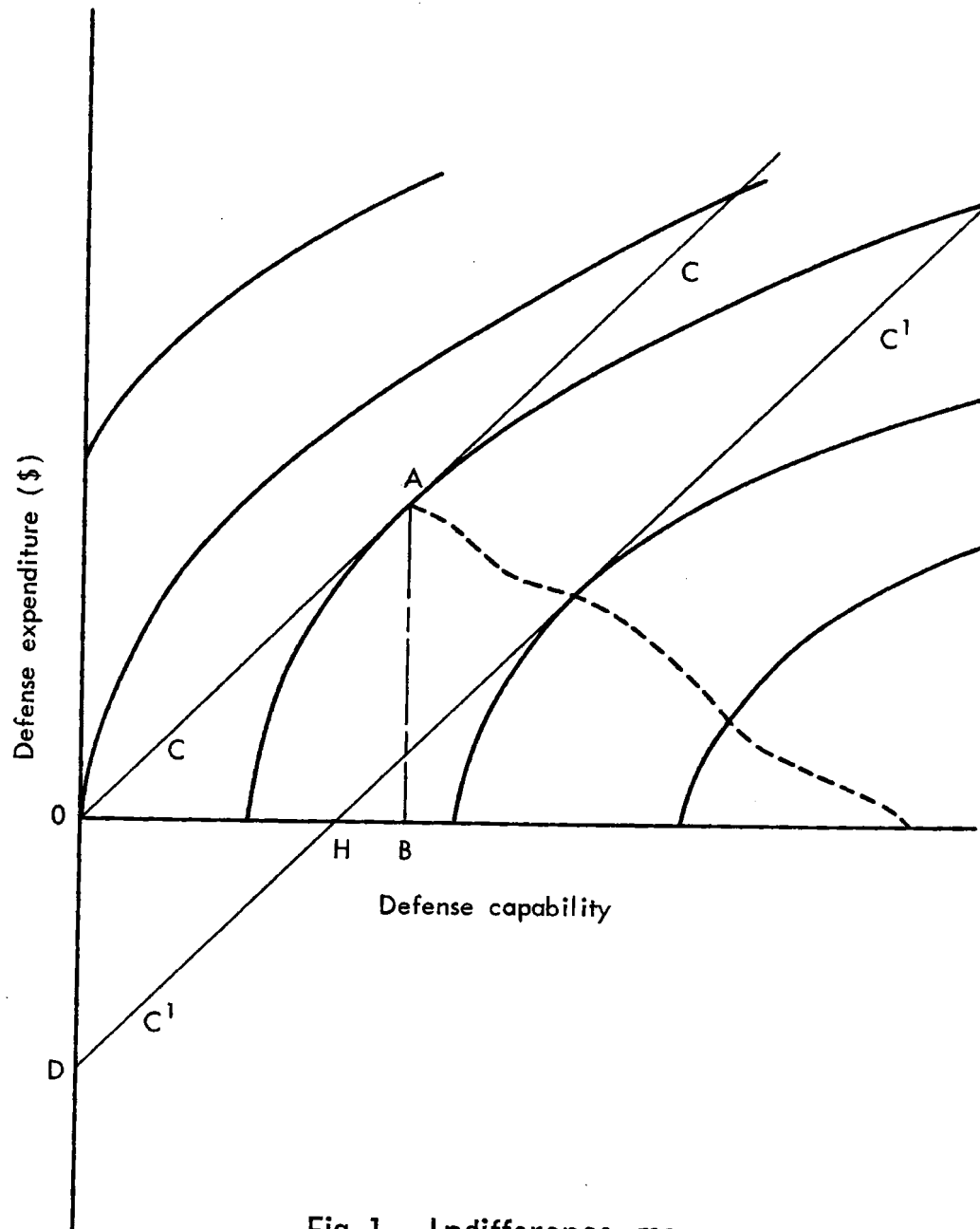


Fig.1—Indifference map

allies provide, the further the cost curve moves to the south-east, and the less it tends to spend on defense. By recording all the points of tangency of the total cost curve with the indifference curves, we can obtain this nation's reaction function. The reaction function indicates how much defense this nation will produce for all possible levels of defense expenditure by its allies. The amount of defense that this nation provides will in turn influence the defense output of its allies, whose reaction curves can be determined in the same way.

Figure 2 shows the reaction curves for a two-country model (which can easily be generalized to cover  $N$  countries).<sup>\*</sup> The intersection point of the two reaction curves indicates how much of the alliance good each ally will supply in equilibrium. The two reaction curves need not always intersect; if one nation has a very much larger demand for the alliance good than the other, its reaction curve may lie at every point outside that of the other, in which case it will provide all of the defense. The equilibrium output will then be the same as the isolation output of the country with the largest isolation output. Whether the reaction curves intersect or not, the equilibrium output is necessarily determinate and stable unless defense is an inferior good, in which case there may be a number of equilibria, one or more of which may be unstable. To see this, suppose that A and B in Fig. 2 trade reaction curves. Then the equilibrium point given by the intersection point will be unstable, and there will be a tendency for one of the nations to provide all the defense. If one nation's reaction curve lies wholly outside that of the other, there will be a unique and stable equilibrium, whether or not defense is an inferior good.

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<sup>\*</sup>The reaction curve is an  $n$ -dimensional surface in the  $n$ -nation alliance. This surface is symmetrical about all axes except the one for the reacting nation. The equilibrium is found at the point of joining intersection of these  $n$  surfaces. The symmetrical quality of these surfaces enables us to convert them into two-dimensional reaction curves relating the spending of one nation to the spending of all its allies.

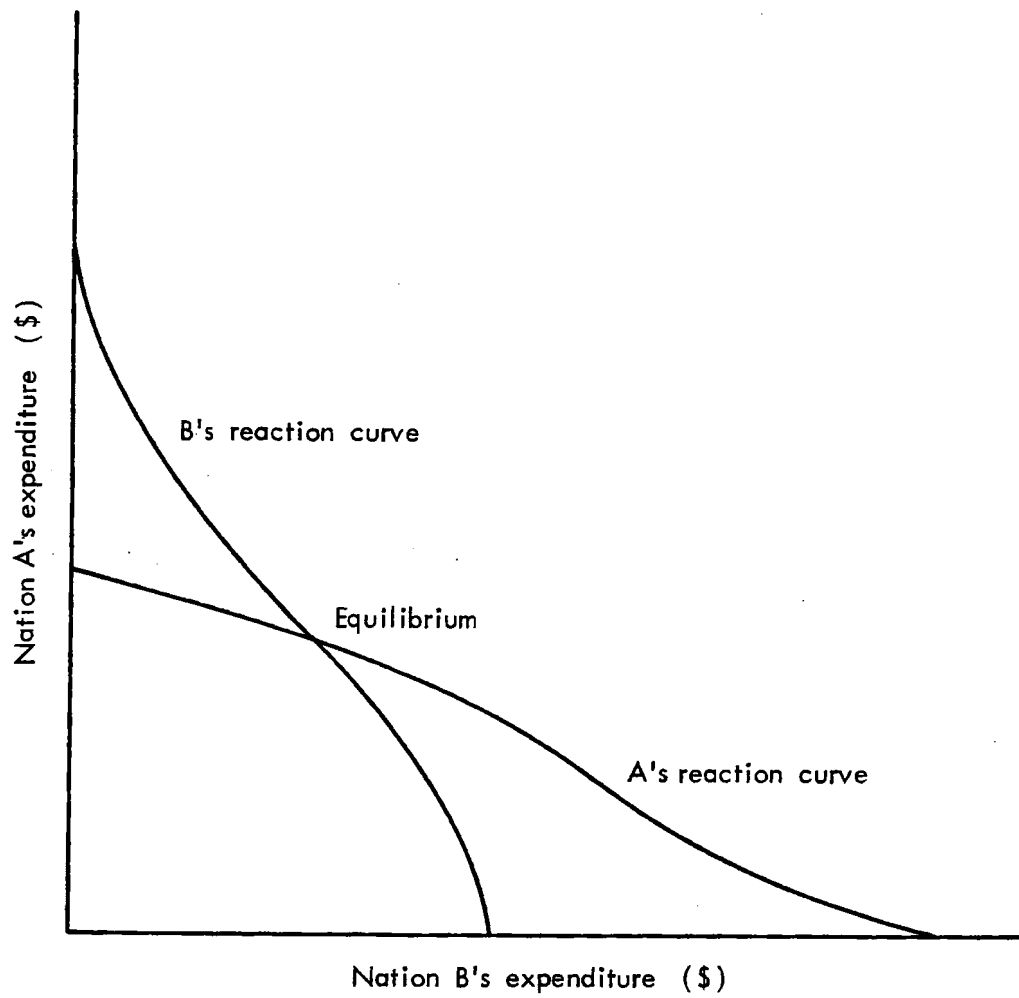


Fig.2—Reaction curves for a two-country model

In equilibrium the defense expenditures of the two nations are such that the "larger" nation -- the one that places the higher absolute value on the alliance good -- will bear a disproportionately large share of the common burden.\* It will pay a share of the costs that is larger than its share of the benefits, and thus the distribution of costs will be much different than a system of benefit taxation would bring about.\*\* This becomes obvious when income effects -- that is, the influence that the amount of nondefense goods a nation has already forgone has on its desire to provide additional units of defense -- are neglected.\*\*\* This is done in Fig. 3, which depicts the evaluation curves that each of two nations has for alliance forces. The larger nation, called Big Atlantis, has the higher, steeper valuation curve,  $V_B$ , because it places a higher absolute value on defense than Little Atlantis, which has evaluation curve  $V_L$ . The CC curve shows the costs of providing defense capability to each nation, since both by assumption have the same costs. In isolation Big Atlantis would buy  $B_1$  units of defense and Little Atlantis  $L_1$ , for at these

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\*We use the term "larger" here for illustrative purposes. In many cases, there may not be a one to one correspondence between the size of a nation's Gross National Product and its evaluation of the alliance good. For further discussion on this point see pages 17-19.

\*\*The authors do not advocate benefit taxation, but believe that proportionality of benefits and costs provides an obvious standard of comparison, particularly in alliances which nations join to further their national interests rather than to bring about any particular distribution of income among member nations. The equilibrium outputs are not consistent with any ordinary conceptions of ability to pay either. They would involve very regressive sharing if the larger nation in an alliance had the lower per capita income.

\*\*\*Income effects are probably very important in practice, partly because it is usually very difficult for a government to increase taxes enough to bring military or other government spending far above the customary levels. Moreover, large increases in defense spending may lead to serious reductions in capital formation: there appears to be a remarkable constancy of the percentage of GNP that is made up by the sum of defense spending and capital formation. See Richard Zeckhauser, "Defense Spending, Capital Formation, and Economic Growth" (forthcoming).

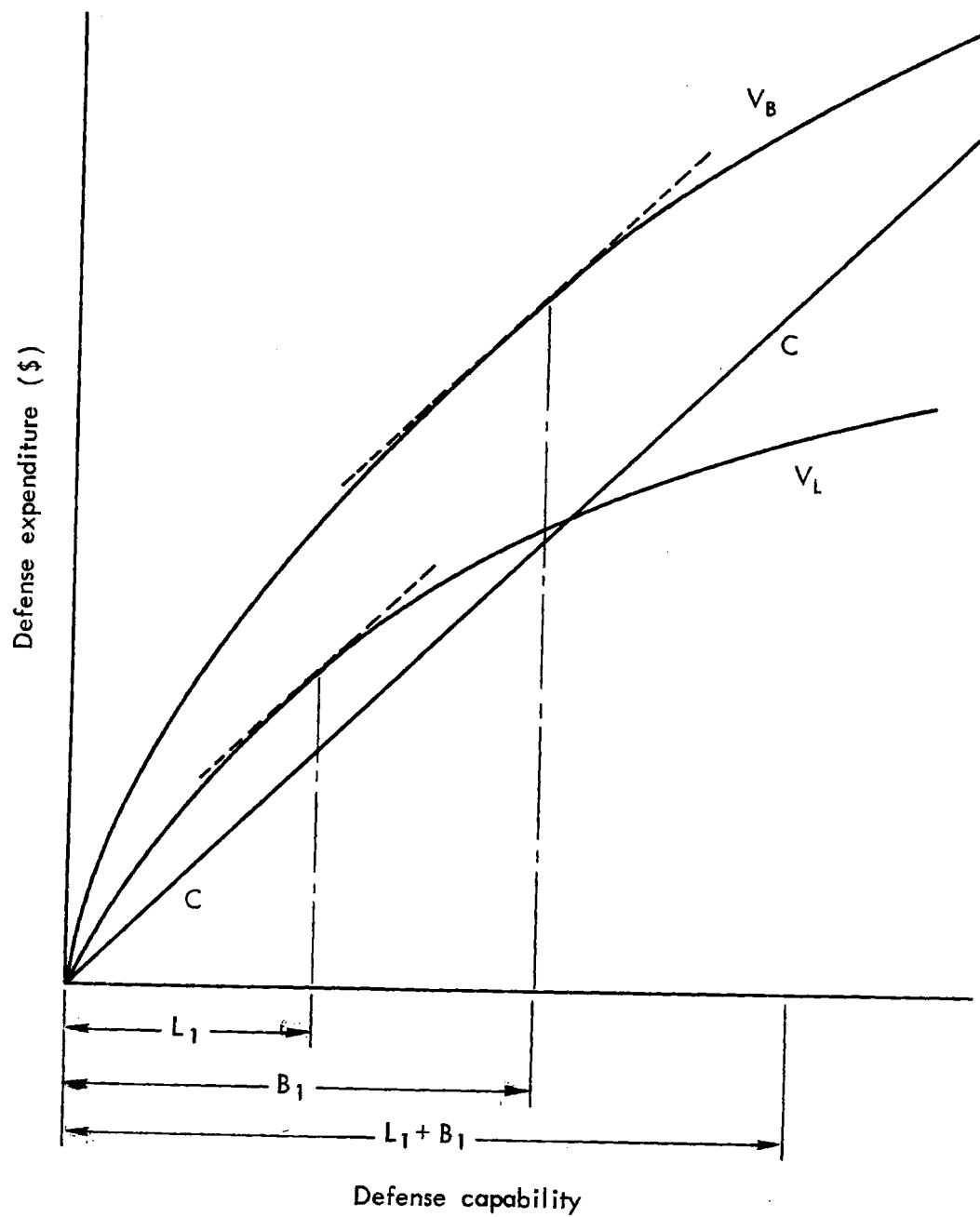


Fig.3—Evaluation curves for two countries



points their respective valuation curves are parallel to their cost functions. If the two nations continued to provide these outputs in alliance each would enjoy  $L_1 + B_1$  units of defense. But then each nation values a marginal unit at less than its marginal cost. Big Atlantis will stop reducing its output of deterrence when the sum supplied by the two nations together is  $B_1$ . When this amount (or any amount greater than  $L_1$ ) is available, it is not in Little Atlantis' interest to supply any defense whatever. The two nations are therefore simultaneously in equilibrium only when Big Atlantis provides  $B_1$  of defense and Little Atlantis provides no defense whatever.\*

The disproportionality in the sharing of burdens is less extreme when income effects are taken into account, but it is still important. This can be seen most easily by supposing that Big Atlantis and Little Atlantis are identical in every respect save that Big Atlantis is twice the size of Little Atlantis; per capita incomes and individual tastes are the same in both countries, but the population and GNP of Big Atlantis are twice that of Little Atlantis. Now imagine that at present Big Atlantis is providing twice as much alliance defense as Little Atlantis, as proportionality would require.\*\* In equilibrium the marginal rate substitution of money for the alliance good (MRS) must equal marginal cost for each of these countries, that is,  $MRS_{Big} = MRS_{Little} =$  marginal cost. But (since each country enjoys the same amount of the collective good) the MRS of Big Atlantis is double that of Little Atlantis, and (since the cost of an additional unit of defense is the same for each country) either Big Atlantis will want more defense or Little Atlantis will want less (or both will be true), and the common burden will come to be shared in a disproportional way.

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\* The country with the lower evaluation curve would supply all of the common defense if its evaluation curve were above the cost curve and at the same time had a steeper slope throughout the relevant range than the higher evaluation curve. This can be seen more easily by drawing the marginal curves that correspond to the total valuation and total cost curves in Fig. 3.

\*\* It could be the case that even in isolation Big Atlantis would buy proportionately more defense than Little Atlantis. This would be the case if a nation's income elasticity of demand for the good were greater than unity in the relevant range.

There is one important special case in which there will be no tendency toward disproportionality. That is when the indifference maps of the member nations are such that any perpendicular from the ordinate would intersect all indifference curves at points of equal slope. In this case, when the nation's cost constraint moves to the right as it gets more free defense, it would not reduce its own expenditure on defense. In other words, none of the increase in income that the nation receives in the form of defense is spent on goods other than defense. Defense in this situation is, strictly speaking, a "superior good," a good such that all of any increase in income is used to buy the good.

Apparently the literature has neglected goods of this kind, and not made clear that they are simply the logical converse of the much discussed inferior goods. And when the phrase "superior good" has been used, it has usually been given an unsymmetrical and unclear meaning. We therefore distinguish the following classes of goods, realizing that the category to which a good belongs may depend on the level of income.

<u>Class</u>	<u>Characteristic</u>	<u>Income Elasticity of Expenditure = E</u>
Inferior good	Expenditure on the good decreases or is unchanged as income increases.	$E \leq 0$
Inelastic good	Expenditure on the good increases, but by a smaller percentage than income increases.	$0 < E < 1$
Elastic good	Expenditure on the good increases by a percentage that is as great or greater than the percentage by which income increases, but by a smaller absolute amount.	$1 \leq E < Y_0/S_0$
Superior good	Expenditure on the good increases by as much or more than income increases.	$E \geq Y_0/S_0$

Note:

$S_0$  is the expenditure on the good when income is  $Y_0$ .

In terms of an ordinary indifference map (rather than the inverted form used in this Memorandum) an inferior good is a good that has an income-consumption line that (in the relevant range) approaches (or is parallel to) the axis along which income is measured, as the income constraint shifts outward. A superior good is a good with an income consumption line that (in the relevant range) approaches (or is parallel to) the axis along which the quantity of the good is measured, as the income constraint shifts outward. If there is an inferior good for an individual, there must be at least one superior good for that individual (saving is here considered a good) and all other goods in the aggregate must be superior. The converse is true for a superior good.

During periods of all-out war or exceptional insecurity, it is likely that defense is (or is nearly) an absolutely superior good, and in such circumstances alliances will not have any tendency toward disproportional burden sharing. The amount of allied military capability that Great Britain enjoyed during World War II increased from 1941 to 1944 as the United States mobilized, adding more and more strength to the allied side. But the British war effort was maintained if not increased during this period.\*

Although there is then one exception to the rule that alliance burdens are shared disproportionately, there is no equivalent exception to the rule that alliances provide suboptimal amounts of the collective good. The alliance output will always be suboptimal so long as the members of the alliance place a positive value on additional units of defense. This is because each of the alliance members contributes to the point where its MRS for the good equals the marginal cost of the good. In other words, the result of independent national maximization in an alliance, when the cost function is linear and the same for all members, is that  $MRS_1 = MRS_2 = MRS_N = MC$ . The individual nations in

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\* W. K. Hancock and M. M. Gowing, British War Economy, Her Majesty's Stationery Office, London, 1949, pp. 369-370; Mancur Olson, Jr., The Economics of the Wartime Shortage: A History of British Food Shortages in the Napoleonic War and World Wars I and II, Duke University Press, Durham, North Carolina, 1963, pp. 117-131.

an alliance would have an incentive to keep providing additional alliance forces until the Pareto-optimal level is reached only if there were an arrangement such that the alliance members shared marginal costs in the same proportions in which they shared additional benefits (that is, in the same ratio as their marginal rates of substitution of money for the good). And when there is such a marginal cost sharing arrangement, there need be no tendency toward disproportionality in the sharing of burdens.

The optimal level of provision of a collective good normally depends on the distribution of the costs of providing it. Though the costs of marginal units of the good must be shared in the same way as the benefits of additional units, if an optimal supply is to be obtained, the costs of intra-marginal units, and therefore total costs, can be shared in any number of ways. And when the distribution of the total cost changes, the distribution of income is changed, and this will normally change the marginal rates of substitution of money for the good for those involved. This, in turn, will typically imply a different optimal level of provision of the collective good. The fact that there are many optimal levels of provision of a collective good depending on the distribution of the costs of providing that good is roughly parallel to the well-known fact that the optimal supply of a private good depends on the distribution of income.

The model developed in this section thus shows that there are tendencies toward disproportional sharing of the burdens of providing collective goods and toward suboptimal levels of providing collective goods in alliances or other groups with small numbers of members. In the past, the behavior of small groups seeking collective goods has been explored mainly through the famous "theory of voluntary public exchange" developed by the Swedish economist Erik Lindahl.\* The model developed in this Memorandum has several advantages over

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\* See Erik Lindahl, "Just Taxation -- A Positive Solution," in Richard Musgrave and Alan Peacock (eds.), Classics in the Theory of Public Finance, The Macmillan Co., London, 1958, pp. 168-177 and 214-233, and also John Head, "Lindahl's Theory of the Budget," Finanzarchiv, Vol. XXIII, October 1964, pp. 421-454.

Lindahl's formal model and the uncommonly important improved versions of that model developed by Richard Musgrave and Leif Johansen.\* First, none of the Lindahl-type models reveals either the tendency toward disproportionality or the tendency toward suboptimality. This is mainly because these Lindahl-type models neglect the fact that a member of a group who places a relatively small value on a collective good has little or no incentive to provide any more of that good once the member who values it most highly has provided the amount he wants for himself. But it is also partly because the Lindahl-type models make the incorrect assumption that the members of groups seeking collective goods will necessarily share the costs of marginal units of these collective goods on a percentage basis. Second, the model developed here makes it clear, as Lindahl-type models do not, that the real income of a party seeking a collective good depends in part on how much of that good is being provided and on the distribution of the costs of providing it. Since the demand for a collective good is affected by such changes in real income, the "demand" curves in the Lindahl-type models shift with each change in the level of provision of the collective good and with each change in the distribution of the costs of providing the good. The result is that there is no determinate solution of the Lindahl-type models when income effects are taken into account. Finally, in neglecting income effects, the Lindahl-type models often also fail to make clear that there are always many Pareto-optimal levels of provision of a collective good, depending on the distribution of the burden of providing the good. Lindahl's seminal work, and the extremely interesting models it inspired, undoubtedly deserve a prominent place in the history of the theory of public finance. Nonetheless, in view of their aforementioned disadvantages, these models do not appear to us to be sufficient for a study of alliances or for any general analysis of collective goods.

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\* Richard Musgrave, "The Voluntary Exchange Theory of Public Economy," Quarterly Journal of Economics, Vol. LIII, February 1939, pp. 313-237 and The Theory of Public Finance, McGraw-Hill Book Company, Inc., New York, 1959, Chap. IV; Leif Johansen, "Some Notes on the Lindahl Theory of Determination of Public Expenditures," International Economic Review, Vol. IV, September 1963, pp. 346-358.

### III. QUALIFICATIONS AND ELABORATIONS

One simplification assumed in the foregoing model was that the costs of defense were constant to scale and the same for all alliance members. Although military forces are composed of diverse types of equipment and manpower, and thus probably vary less in cost and with scale of output from one country to another than many single products, it is still unlikely that costs are constant and uniform.\* For some special types of weapon systems there are undoubtedly striking economies of large-scale production, and for conventional ground forces there are probably rising costs as larger proportions of a nation's population are called to arms. Because of this latter tendency, a small country can perhaps get a considerable amount of conventional capability with the first few percentiles of its national income. This tends to keep the military expenditures of small nations in an alliance above the very low level implied by our constant cost assumption. In any event, cross-country variations in marginal costs should not normally alter the basic conclusions deduced from the model. The

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\*The diversity of the types of military capability makes it possible for each allied nation to specialize in that type of military capability in which it has a comparative advantage. Clearly, such military trade would tend to lower the costs of defense to the alliance as a whole. But NATO, like other alliances, has been organized in such a way that such trade in military capabilities is often not feasible politically. This is because each nation pays the full cost of any strength it provides for the alliance (except in the special case of "infrastructure" facilities) and therefore unilaterally determines the composition and character of the force it provides. If there were the sharing of marginal costs that a Pareto-optimal level of alliance forces would require, each nation could be influenced toward freer military trade through the fact that it received subsidies from its allies, and each ally could make its payment to other allies partly in the form of the military equipment which it produced most efficiently. In many political circumstances, of course, marginal cost sharing might also be politically infeasible; but it is by no means always out of the question, as the sharing of marginal costs in the NATO infrastructure indicates. On the principle of comparative advantage in alliances, see Malcolm Hoag, "Economic Problems of Alliance," Journal of Political Economy, LXV, December 1957, pp. 522-534; and Mancur Olson, Jr. and Richard Zeckhauser, "Collective Goods, Comparative Advantage, and Alliance Efficiency," in a forthcoming Universities-National Bureau of Economic Research volume on "The Economics of Defense."

differences in the amounts member nations would be willing to pay for marginal units of an alliance good are typically so great that the cost differentials could hardly negate their effect. Even if there were very large differences in marginal costs among nations, there is no reason to assume that national cost functions would vary systematically with the valuation a country places on alliance forces.\*

A nation's valuation of alliance forces obviously depends not only on its national income, but also on other factors. A highly exposed nation on the enemy's border may value defense more than one protected by distance or forbidding terrain. A nation that has a large area and long frontiers in relation to its resources may want a larger army than a compact country; on the other hand, if bomb and rocket attacks are the main danger, a crowded country may wish to invest more in defense against attack by air. Similarly, a nation's attitudes or ideologies may partly determine its evaluation of defense. Many observers think the uniformity and intensity of anti-communism is greater among the NATO countries with the highest per capita incomes, and these also happen to be the largest countries in the alliance. It also seems that many people in small and weak countries, both inside and outside of NATO, tend to be attracted to neutralist or pacifist ideologies.\*\* This pattern of attitudes may perhaps be partly

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\* There could be certain peculiar cost functions that would prevent any disproportionate burden sharing of the kind predicted by the model. If, for example, all of the nations had total cost curves with sharp kinks indicating abruptly rising costs after a certain point, they might all have an incentive to choose the defense outputs suggested by these kinks. These kinks would not, except by accident, be such as to lead the larger allies to bear a disproportionate share of the common burden.

\*\* One factor that might conceivably make small countries outside of an alliance spend little or nothing on defense is that they may think that the maximum force they could raise alone would not be sufficient to defeat any potential enemy, so there would be no point in having any military forces at all. In an alliance, on the other hand, a small nation might suppose that its forces could provide the margin of victory and therefore might increase its defense spending. The kink in the evaluation function that this argument implies is, however, made much less likely by the fact that even a small military force may be quite valuable to a small, unaligned country, for it might increase

explained by our model, for it suggests that small nations, who find that even large sacrifices on their part have little effect on the global balance, would often be attracted to neutral or passive foreign policies, and that large nations, who know that their efforts can decisively influence world events in their own interest, will continually need to emphasize the urgency of the struggle in which they are engaged. The popularity of pacific ideologies and the frequent adoption of neutralist policies in small and weak countries and the activist attitudes and policies of the United States and the Soviet Union are at least consistent with our model.

Whatever the reasons for the different evaluations that nations have for military capabilities in an alliance, the model here still applies. If two countries in an alliance had equal national incomes, but one was more concerned about the common enemy for geographic, ideological, historical, or other reasons, the more concerned nation would not only put a higher valuation on the alliance's military capacity, but would bear a share of the total alliance costs that was even greater than its share of the total benefits.\* The model deals with the general case of differences in the absolute valuation that nations put on additional units of an alliance good, whether these differences are due to differences in national income or to other reasons.

The value a nation puts on alliance forces may also vary with alliance policies. An alliance must sometimes choose which of two or more alternative public goods to provide: one public good may be more valuable to some alliance members and another more valuable to others. The NATO alliance, for example, provides conventional defense as well as nuclear protection, and there have been disagreements about the proper mix between these two goods. In such a case it is possible that some nations may supply additional forces in return for more

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the costs and risks to an aggressor enough to deter him from attacking a small (and therefore probably not very valuable) country. The argument that even a relatively small capability may sometimes be a useful deterrent is used to support the French nuclear force.

\* Benefits are, of course, defined in terms of the preferences of the two countries, which we here assume to have been revealed.



influence on alliance policy, whereas other nations may make policy concessions in order to get other members to assume a greater share of alliance costs. Such trade-offs need not change the qualitative conclusions about disproportional burden sharing; they might simply mean that a nation can bear part of its alliance burden by making policy concessions rather than by providing additional forces. When this happens, though, the allies who obtained the policy they wanted find they value the alliance good more than before. The opposite is true for those who have relinquished some of their control over alliance policy, and this, in turn, makes those nations who have gained influence provide still more defense, and those who have yielded influence still less.

Another assumption in the model developed in the foregoing section was that the military forces in an alliance provide only the collective benefit of alliance security, when in fact they also provide purely national, noncollective benefits to the nations that maintain them. When Portugal mobilizes additional forces to suppress the independence movement in Angola, a national goal unrelated to the purposes of NATO, she may at the same time be increasing the total strength of the alliance. Similarly, allied nations may be suspicious of one another, even as they cooperate in the achievement of common purposes, and may enlarge their military forces because of conceivable future conflicts with each other. In any situations in which the military forces of alliance members provide important noncollective benefits as well as alliance benefits, the degree of suboptimality and the importance of the disproportionality will decrease because the noncollective benefits give the member nations an incentive to maintain larger forces.

This fact leads to the paradoxical conclusion that a decline in the amity, unity, and commonality of interest among allies need not necessarily reduce the effectiveness of an alliance, because the decline in these alliance "virtues" produces a greater ratio of private to collective benefits. It suggests that up to a point alliances troubled by suspicions and disagreements may continue to work reasonably well. To be sure, the degree of coordination among the allies will decline, and this will reduce the efficiency of the alliance forces (in

a sense leaving them on a poorer production function). But the alliance forces will be larger.\*

At times individual alliance members may choose an independent, somewhat intractable relationship with the alliance body. They may feel that the increased costs of independence as well as the losses sustained because of the decline in alliance performance may be more than compensated by gains in national prestige and freedom of action. Extensive efforts toward independence by many alliance members may eventually result in a collapse of the organization, and a communal loss. This does not mean, however, that the strong national autonomy of its members is inimical to a strong alliance. To some extent it may even be beneficial.

However important the noncollective benefits of alliances may be, there can be little doubt that, above all, alliances produce collective goods. It is not easy to think of alliances that provide only private goods, though such alliances are perhaps conceivable. If nations simply trade sites for military bases, no common interests or public goods would necessarily be involved. An alliance might also be set up simply to provide insurance in the sense that two nations without any common purpose or common enemy would agree to defend each other in case of attack, but in which neither knew in advance which would suffer aggression. On the other hand, if these two nations thought (as they presumably would) that the fact of their alliance would make it less profitable for other nations to attack either of them, the alliance would provide a public good: a degree of deterrence that could deter an attack on either or both of these nations about as well as it could deter an attack on one alone. There is, moreover, no reason to describe a mere transaction in private goods as an alliance, and the word does not normally appear to be used in that way. A transaction in private goods would be quite as useful between enemies as between "allies," would normally be completed by a single pair of actions or a single

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\*Malcolm Hoag seems to have made this point, or at least a closely related one, earlier, but he did not relate this point to a general model of alliances. See his interesting review article "On NATO Pooling," World Politics, Vol. X, April 1958, pp. 475-483; especially p. 483.

agreement, and would not require the continuing consultation, cooperation, and organization characteristic of alliances.

Normally an additional member can be added to an alliance without substantially subtracting from the amount of defense available to those already in the alliance, and any good that satisfies this criterion is by definition a collective good.\* Suppose two nations of the same size face a common enemy with an army larger than either of them provides by itself. They then form an alliance and maintain a level of military forces larger than either of them had before, but smaller than the sum of their two pre-alliance armies. After alliance both nations enjoy (1) more military security and (2) lower defense costs than they had before. This result comes about, not only because a military force can often deter attack by a common enemy against an additional nation without a substantial increase in cost, but also because an alliance may make a greater level of security economically feasible and desirable, and the gains from obtaining this extra security can leave both nations better off. (This suggests that the conventional view, that a good is a pure public good if it can be offered to additional consumers for free without any less being available to those already consuming the good, is somewhat too simple. For a good might be such that, if extra consumers enjoyed it, there would be a little less for those who had already been consuming it. Yet it might pay to let new consumers enjoy the present supply of the good at a zero price, or even less, if they would agree to share the costs

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\*The number of people defended by a given military force can clearly increase without reducing the security per person. However, additional land area will normally require some additional military forces, if the area previously protected is to have the same degree of security as before, and if actual defensive conflict, rather than deterrence, is at issue. When the additional land area has no common border with the enemy, it can usually be defended without any significant extra cost. The extra cost to NATO of defending Belgium against a Soviet attack, once Germany and France are already defended, is negligible. And even when the extra land does have a common border with an enemy, it is not always true that it costs much more to defend it.

of providing the additional amount of the good that it would be optimal to purchase once the additional consumers were involved.)

Another defining characteristic that is sufficient (but not necessary) to distinguish a collective good is that the exclusion of those who do not share the cost of the good is impractical or impossible. Typically, once an alliance treaty has been signed, a member nation is legally bound to remain a member for the duration of the treaty. The decisions about how the common burden is to be shared are not, however, usually specified in the alliance treaty. This procedure works to the disadvantage of the larger countries. Often the smaller and weaker nations gain relatively more from the existence of an alliance than do the larger and stronger powers, and once an alliance treaty has been signed, the larger powers are therefore deprived of their strongest bargaining weapon -- the threat that they will not help to defend the recalcitrant smaller powers -- in any negotiations about the sharing of the common burden. Even at the time an alliance treaty is negotiated, exclusion may very well not be feasible, since most alliances are implicit in an already existing danger or goal common to some group of states. And that common danger or goal gives the nations that share it an incentive to treat each other tacitly as allies, whether or not they have all signed a formal agreement. A nation can only lose from having another nation with whom it shares a common interest succumb to an enemy, thus strengthening the enemy's side at the expense of its own. It may well be that most alliances are never embodied in any formal agreement.

This study also makes the simplifying assumption that no alliance member will take into account the reactions other members may have to the size of its alliance contribution. The mutual recognition of oligopolistic interdependence can be profoundly important in small groups of firms, but in the NATO alliance at least, it seems to have been somewhat less important (except with respect to the infrastructure, which will be considered later). There are at least two important reasons why strategic bargaining interaction is often less important in alliances than in oligopolistic industries. First, alliances are

often involved in situations that contain a strong element of irreversibility. Suppose that the United States were to threaten to cut its defense spending to nothing to get its allies to bear larger shares of the NATO burden. The Soviet Union, if it has the characteristics that American policy assumes, would then deprive the United States of its independence, in which case future defense savings would have little relevance. The U.S. threat would have only a limited credibility in view of the irreversibility of this process.

The second factor that limits strategic bargaining interaction among alliance members stems from an important difference between market and nonmarket groups. In an oligopolistic group of firms, any firm knows that its competitors would be better off if it were bankrupted or otherwise driven out of the industry. Large firms thus sometimes engage in price wars or cutthroat competition to drive out the smaller members of an oligopolistic group. By contrast, non-market groups and organizations, such as alliances, usually strive instead for a larger membership, since they provide collective goods which should increase as the membership increases. Since an ally would typically lose from driving another member out of an alliance, a bargaining threat to that effect may not be credible. This will be especially true if the excluded nation would then fall to the common enemy and (as we argued before) thereby strengthen the enemy at the expense of the alliance.

When strategic interaction is important in alliances, the advantage paradoxically still rests in most cases with the smaller nations.\* There are two reasons for this.\*\* First, the large country loses more

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\* Perhaps the bargaining advantage of the weaker nations should not be surprising. Schelling has found many other situations in which, for different reasons, weakness can be a source of bargaining strength. See Thomas C. Schelling, The Strategy of Conflict, Harvard University Press, Cambridge, Massachusetts, 1960, especially pp. 22, 23, 37, 52, and 158.

\*\* These two reasons came to our attention through Klaus Knorr, "Notes on a Theory of Alliances," unpublished rough draft, Center of International Studies, Princeton University, pp. 22-24, and 28.

from withholding an alliance contribution than a small country does, since it values a given amount of alliance force more highly. In other words, it may be deterred from carrying out any threat to end its alliance contribution by the very importance to itself of that contribution. Second, the large country has relatively less to gain than its small ally from driving a hard bargain. Even if the large nation were successful in the bargaining, it would expect only a relatively small addition to the alliance force from the small nation; but when the small nation wins the bargaining, it can expect a large addition to the alliance force from the large nation. There is accordingly no reason to expect that there is any disparity of bargaining in favor of the larger ally that would negate the tendency toward disproportionality revealed by our model.

#### IV. EMPIRICAL EVIDENCE

Other things being equal, the larger a nation is, the higher its valuation of the output of an alliance. Thus, if our model is correct, the larger members of an alliance should, on the average, devote larger percentages of their national incomes to the common defense than the smaller nations do.\* This prediction is tested against the recent data on the NATO nations in Table 1.

The following specific hypotheses are used to test the model's predictions:

$H_1$ : In an alliance there will be a significant positive correlation between the size of a member's Gross National Product and the percentage of its Gross National Product spent on defense.

$H_0$ : There will not be a significant positive correlation between the variables specified in  $H_1$ :

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\*The chief problem involved in testing this implication of our model is that it is difficult to tell exactly how much of a nation's defense expenditures are contributions toward the common defense. Though it will sometimes be true that virtually all of a nation's military forces represent an alliance contribution (this is probably true now of those NATO nations that have no apparent military needs independent of those of the alliance), there are, on the other hand, NATO members such as Greece, Turkey, and Portugal who obviously have military objectives that other members of the alliance do not share, and only part of their military forces should be considered a contribution to NATO. Unhappily, there is no objective way to determine exactly what part of such a nation's military expenditures should be considered an alliance contribution. Since variations in the proportions of different nations' defense expenditures that are devoted to NATO purposes should tend to cancel out in statistical tests, this assumption is less of a problem here than it would be if applied to only a single country. Moreover, it appears to be the case that several nations (such as Greece and Portugal) that spend more on defense than our hypothesis suggests have especially intense military interests that are easily distinguishable from those of NATO, and that several nations (such as Germany and Italy) that spend less than our hypothesis would suggest are among the NATO members with little or no military interests independent of the alliance. Thus it does not seem likely that the following tests of our model are rendered irrelevant by the fact that we must use a nation's total defense expenditures as a proxy for its alliance contribution.

Table 1

NATO STATISTICS: AN EMPIRICAL TEST

Country	Gross National Product 1964 (\$ billion)		Defense Budget as Percentage of GNP <sup>a</sup>		GNP Per Capita	
		Rank		Rank		Rank
United States	569.03	1	9.0	1	\$2,933	1
Germany	88.87	2	5.5	6	1,579	5
United Kingdom	79.46	3	7.0	3	1,471	8
France	73.40	4	6.7	4	1,506	6
Italy	43.63	5	4.1	10	855	11
Canada	38.14	6	4.4	8	1,981	2
Netherlands	15.00	7	4.9	7	1,235	10
Belgium	13.43	8	3.7	12	1,429	9
Denmark	7.73	9	3.3	13	1,636	3
Turkey	6.69	10	5.8	5	216	14
Norway	5.64	11	3.9	11	1,484	7
Greece	4.31	12	4.2	9	507	12
Portugal	2.88	13	7.7	2	316	13
Luxembourg	.53	14	1.7	14	1,636	4

Ranks:

GNP	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Defense Budget as % GNP	1	6	3	4	10	8	7	12	13	5	11	9	2	14
GNP Per Capita	1	5	8	6	11	2	10	9	3	14	7	12	13	4

Source:

All data taken from Institute for Strategic Studies, The Military Balance 1965-1966, London, November 1965.

Note:

<sup>a</sup>It must be recognized that not all of the member nations' defense expenditures goes to provide for the common defense. To the extent that primarily private benefits result from these expenditures, a "noise" element will be introduced into our data on alliance support. The verification of our predicted hypothesis even in the presence of this "noise" would indicate the strength of the tendencies towards disproportionality implied by the model. See also pages 19-20 above.



As there is no assurance that the data are parametrically distributed, nonparametrical statistical tests must be used. The Spearman rank correlation coefficient for Gross National Product and defense budget as a percentage of GNP is .490. On a one tailed test this value is significant at the .05 level.\* We therefore reject the null hypothesis and accept  $H_1$ ; there is a significant positive correlation indicating that the large nations in NATO bear a disproportionate share of the burden of the common defense.

This result holds even when the level of per capita GNP is held constant. There seemed to be the possibility that the positive correlation in  $H_1$  might be simply the result of a joint correlation of both GNP and the percentage of defense spending with per capita GNP, for it happens that the larger NATO nations often have the higher per capita incomes. Accordingly, the effects of differences in per capita GNP were "held constant" with the aid of the Kendall partial rank correlation coefficient, which measures the relationship between two variables after the effects of a third, possibly related, variable have been removed. The Kendall partial rank correlation coefficient of GNP and defense budget as a percentage of GNP, net of the effects of per capita GNP, is .445. To our knowledge there is no test for the significance of the Kendall partial rank correlation coefficient, but it is perhaps suggestive that this is somewhat greater than the Kendall rank correlation coefficient (.384) that results when the effects of differences in per capita GNP are not partialled out. Moreover, there is not a statistically significant positive relationship between per capita GNP and defense budget

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\* See Sidney Siegel, Nonparametric Statistics, McGraw-Hill Book Company, Inc., New York, 1956, p. 284. As a corroborative test, a different set of data for a different year (1960) was also used. With these data the Spearman rank correlation coefficient for Gross National Product and defense budget as a percentage of GNP was .635, a value significant at the .05 level on a one tailed test. Iceland was excluded; since she ranked fifteenth for both variables, her inclusion in either test would have improved the correlation.

as a percentage of GNP; in fact, the correlation is slightly negative. We conclude that the correlation between the size of an ally's GNP and the percentage of its GNP spent on defense cannot be explained in terms of any relationship of these two variables with per capita GNP.

Our model predicts that there are tendencies toward disproportional burden sharing, not only in military alliances, but also in other international organizations, such as the United Nations. The test of this prediction is complicated in the case of the UN by the fact that the organization is supported primarily through assessments levied against individual members. These assessments are determined by a formula constructed by a committee of experts. The model would suggest, however, that the degree to which a member fulfills or over-subscribes its quota would be positively correlated with its size, and thus gives the following hypotheses:

$H_2$ : In a voluntary organization with quota assessments that are not always satisfied, there will be a significant positive correlation between a member's GNP and the percentage fulfillment or overfulfillment of its quota.

$H_0$ : There will not be a significant positive correlation between the variables in  $H_2$ .

The Spearman rank correlation coefficient between 1961 GNP and percent of total UN contributions in 1961/normal assessment scale was .404. This result is significant at the .01 level.\* We thus accept  $H_2$  and reject  $H_0$ , for as the model predicted the larger nations in the UN did a better job of living up to their normal assessments.

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\*The data were taken from Norman J. Padelford, "Financial Crisis and the Future of the United Nations," World Politics, Vol. XV, July 1963, pp. 531-568. Our sample included 97 UN members cited, since separate GNP statistics were not given for the Ukraine or Byelorussia. We employed the Student's "t" distribution with conversion from the Spearman rank correlation coefficient to test the significance of the correlation. (See Siegel, p. 212.)

The fact that members may lose prestige and membership rights if they fail to meet their assessments (that is, that there are distinctly private benefits from contributions to the UN) makes this high correlation more striking.

The foreign aid that the industrialized democracies give to the underdeveloped countries is a collective good to these aid-giving nations, at least to the extent they all value the development of the less developed areas. On the other hand, individual aid-giving nations often concentrate all of their aid on particular underdeveloped areas, such as past or present colonies, in which they have a special interest, and to the extent that different nations are interested in different underdeveloped areas, their aid allocations constitute private rather than collective goods. This tends to limit any inclinations toward suboptimality and disproportionality in the provision of foreign aid. We can test for any disproportionalities with the aid of the following hypotheses:

$H_3$ : Among a group of developed nations there will be a significant positive correlation between foreign aid expenditures as a percentage of national income and the size of the national income.

$H_0$ : There will not be a significant correlation between the variables in  $H_3$ .

One set of data used to test these hypotheses revealed a correlation between real national income and total grants and loans to underdeveloped countries as a percentage of national income in 1960 of .770.\* This figure is significant at the .01 level. A different set of data

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\*The data were taken from Irving B. Kravis and Michael W. Davenport, "The Political Arithmetic of Burden Sharing," Journal of Political Economy, Vol. LXXI, August 1963, pp. 323 and 325. Though their articles does not explicitly rank the aid-giving nations by the percentage of their national incomes used for foreign aid, this ranking was nonetheless obtained by comparing the figures given for each nation's aid as a percentage of total aid with the figures given for each nation's national income as a percentage of the total income of the entire group of nations.

for a different year (1962) showed a correlation between GNP and total aid as a percentage of GNP of .439.\* With the small sample of only 12 nations, this value falls slightly short of the .05 level of significance (the borderline value is .506). Thus both sets of data yield correlation coefficients suggesting the expected positive relationship, but in one case the result is clearly statistically significant and in the other case it falls somewhat short of the .05 level of significance. We will take the most conservative course and await further research before finally accepting either  $H_3$  of the null hypothesis; but the most reasonable inference at the moment is that there is some tendency toward disproportional burden sharing, but that the private, or purely national, benefits from foreign aid are probably also very important. Moreover, this is about what might be expected from the fact that the industrialized Western nations express a common interest in the development of the poor nations generally, while at the same time many of these nations individually are interested above all in particular underdeveloped areas with which they have special relationships.

Our model indicates that when the members of an organization share the costs of marginal units of an alliance good, just as they share in the benefits of additional units of that good, there is no tendency toward disproportionality or suboptimality. In other words, if each ally pays an appropriate percentage of the cost of any additional units of the alliance good, the results are much different than when each ally pays the full cost of any amount of the alliance good that he provides. Unlike the costs of providing the main alliance forces, the costs of the NATO infrastructure (common supply depots, pipelines, and so forth), are shared according to percentages worked out in a negotiated agreement. Since each ally pays some percentage of the cost of any addition to the NATO infrastructure, we have here a marginal cost sharing arrangement.

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\*See Pincus, Tables 5-9 and 5-12, pp. 135 and 140, the most recent good source for this data. Pincus has usefully discounted the value of the loans given as foreign aid at the interest rate prevailing in the donor country in computing the value of each nation's foreign aid.

Thus our model suggests that the burdens of the NATO infrastructure should be borne much differently from the rest of the NATO burden. There are also other reasons for expecting that the infrastructure burden would be shared in a different way from the main NATO burdens. For one thing, the infrastructure facilities of NATO are all in continental European countries, and ultimately become the property of the host nation. Their construction also brings foreign exchange earnings to these countries, which for the most part are the smaller alliance members. In addition, infrastructure costs are very small in relation to the total burden of common defense, so a small nation may get prestige at a relatively low cost by offering to bear a larger percentage of the infrastructure cost. There are, in short, many private benefits for the smaller alliance members resulting from the infrastructure expenditures. Because of these private benefits, and more importantly because of the percentage sharing of marginal (and total) costs of the infrastructure, we would predict that the larger members of the alliance would bear a smaller share of the infrastructure burden than of the main alliance burdens.

This prediction suggests that the following hypotheses be tested:

- $H_4$ : In an alliance in which the marginal costs of certain activities are not shared (but fall instead on those members who individually have an incentive to provide additional units of the alliance good by themselves), and in which the marginal costs of other activities are shared (so that each member pays a specified percentage of the costs of these activities), the ratio of a member's share of the costs of the activities of the former type to his share of the costs of activities of the latter type will have a significant positive correlation with national income.
- $H_0$ : There will be no significant positive correlation between the variables in  $H_4$ .

To test these hypotheses we calculated the correlation coefficient between national income and variable T in Table 2. The Spearman rank correlation coefficient between these variables is .582, which on a one tailed test is significant at the .05 level. We therefore reject the null hypothesis and conclude that the larger numbers bear a larger proportion of the costs of the main NATO forces than they do of those NATO activities for which the costs of each unit are shared. The difference between the distribution of infrastructure costs and the distribution of alliance burdens generally is quite striking, as the tests of the following hypotheses indicate:

$H_5$ : In the NATO alliance there is a significant negative correlation between national income and the percentage of national income devoted to infrastructure expenses.

$H_0$ : There is no significant negative correlation between the variables in  $H_5$ .

The Spearman rank correlation coefficient between national income and variable R in Table 2 is -.538, which is significant at the .05 level. Thus not only is it the case that the larger nations pay a smaller share of the infrastructure costs than they do other alliance costs; in addition, there is a significant negative correlation between national income and the percentage of national income devoted to the NATO infrastructure, which is in vivid contrast to the positive correlation that prevails for other NATO burdens. This confirms the prediction that when there are marginal cost sharing arrangements, there no longer need be any tendency for the larger nations to bear disproportionately large shares of the costs of international organizations. If it happens at the same time that the smaller nations get greater than average private benefits from their contributions, they

Table 2

NATO INFRASTRUCTURE

Country	National Income 1960 (billion dollars) (1)	Infrastructure Percent Recon- sidered in 1960 (2)	R = (2)/(1) (3)	Military Budget 1960 (billion dollars) (4)	T = (4)/(2) (5)
United States	411.367	36.98	.0899	41.000	1.1087
United Kingdom	57.361	9.88	.1722	4.466	.4520
Germany	51.268	13.77	.2686	2.072	.1504
France	43.468	11.87	.2731	3.311	.2789
Canada	28.178	6.15	.2183	1.680	.2732
Italy	24.950	5.61	.2248	1.076	.1922
Netherlands	9.246	3.51	.3800	.450	.1282
Belgium	8.946	4.39	.4907	.395	.0900
Turkey	4.929	1.75	.3550	.244	.1394
Denmark	4.762	2.63	.5569	.153	.0582
Norway	3.455	2.19	.6339	.168	.0767
Greece	2.684	.87	.3241	.173	.1989
Portugal	2.083	.28	.1344	.093	.3321
Luxembourg	.386	.17	.4404	.007	.0412

Ranks:

(1)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
(3)	14	12	9	8	11	10	5	3	6	2	1	7	13	4
(5)	1	2	8	4	5	7	10	11	9	13	12	6	3	14

Sources:

Col. (1): Yearbook of National Accounts Statistics, United Nations 1963, New York, 1964.  
 Balance of Payments Yearbook, Vol. 15, International Monetary Fund,  
 Washington, D.C., 1964.

Col. (2): Charles Groot, "Coordination in the Sixties," reprinted from NATO Letter, August 1960.

may even contribute larger percentages of their national incomes than the larger members.\*

Recent trends in infrastructure sharing have not reversed this phenomenon. The most significant development has been a decrease in the United States percentage contribution. The largest share in the resulting slack has been taken up by Germany, but some smaller nations such as the Netherlands have also increased their contributions.

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\* Irving Kravis and Michael Davenport, in their previously cited article, appear at first sight to come to conclusions in direct opposition to our own, for they say, "All in all, there seems to be little basis for the feeling that the United States is bearing a disproportionate share of the costs of international cooperation." They examine the structure of contributions to the Universal Postal Union, the UN, the OECD, and the NATO infrastructure. Since each of these organizations usually shares marginal costs on a percentage basis, their results for these organizations are consistent with our predictions about the effects of marginal cost sharing and in accord with our findings about the NATO infrastructure. In the footnote on page 29 above, Kravis and Davenport also examined the foreign aid given by a number of industrialized countries, but we found their aid figures confirmed the hypothesis suggested by our model in situations where marginal costs are not shared. That the Kravis and Davenport article is not actually in conflict with our findings is evident not only because their data are generally consistent with our model, but also because they are concerned in large part with ethical or ability-to-pay considerations that are not relevant to it.



## V. CONCLUSIONS AND IMPLICATIONS

All of the empirical evidence seems to confirm the model. In the United Nations there appear to be systematic forces tending to make the small nations fail to meet their quotas and leading larger nations to assume larger shares of the costs. The larger industrialized nations, moreover, seem to bear disproportionate shares of the burden of aid to the less developed countries. And in NATO there is again a statistically significant positive correlation between the size of a member's national income and the percentage of its national income devoted to the common defense.

As our model indicates, this is in part because each ally gets only a fraction of the benefits of any collective good that is provided, but each pays the full cost of any additional amounts of the collective good. This means that individual members of an alliance or international organization have an incentive to stop providing the collective good long before the Pareto-optimal output for the group has been provided.\* This is particularly true of the smaller members, who get smaller shares of the total benefits accruing from the good, and who find that they have little or no incentive to provide additional amounts of the collective good once the larger members have provided the amounts they want for themselves, with the result that the burdens are shared in a disproportional way. The model indicates two special types of situations in which there need be no such tendency toward disproportionality. First, in cases of all-out war or extreme insecurity, defense may be what was strictly defined as a "superior good," in which case a nation's output of a collective good will not be reduced when it receives more of this good from an ally. Second,

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\*We do not argue that the output of every international institution ought to be increased; this is partly a question of personal values, and we feel that sometimes spending on some alliances and other international organizations might best be curtailed. The point here is rather that, given the values or preferences of the members of an international organization, they will tend to provide less of the collective good than would be Pareto-optimal in terms of those values.

institutional arrangements such that the members of an organization share marginal costs, just as they share the benefits of each unit of the good, tend to work against disproportionality in burden sharing, and it is a necessary condition of an efficient, Pareto-optimal output that the marginal costs be shared in the same proportions as the benefits of additional units. The NATO nations determine through negotiation what percentages of any infrastructure expenditure each member will pay, and this sharing of marginal costs has led the smaller members to bear a very much larger share of the infrastructure burden than they do of the other NATO burdens. The fact that the model predicts not only the distribution of the principal NATO burdens, but also the much different distribution of infrastructure costs, suggests that the results are in fact due to the processes described in the model, rather than to some other cause.

It does not follow from the model or from the empirical evidence supporting it that the small nations in an alliance should be told they "ought" to bear a larger share of the common burdens. No moral conclusions can follow solely from any purely logical model of the kind developed here.\* Indeed, our analysis suggests that moral suasion is inappropriate because the different levels of contribution are not due to different moral attitudes, and it would also be ineffective because the less than proportional contributions of the smaller nations are securely grounded in their national interests

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\* We must strongly emphasize that we are not questioning the fairness of the present distribution of the costs of any international undertaking. No statement about what distribution of costs ought to prevail can be made unless some (logically arbitrary) assumption is made about what income redistributions among participating nations would be desirable. Jacques van Ypersele de Strihou, in "Sharing the Burden of Defense Among Allies," an interesting Ph.D. thesis done at Yale University, has shown that, if the British rates of progression are used as a standard of fairness, it appears that the larger European members of NATO pay an unfairly large share of the common costs, that the United States (partly because of its high per capita income) pays about the right amount, and that the smaller NATO nations (because of the same general forces explained in this Memorandum) pay an unfairly small amount.

(just as the disproportionally large contributions of the larger countries are solidly grounded in their national interests). Thus American attempts to persuade other nations to bear "fair" shares of the burdens of common ventures are likely to be divisive and harmful even to American interests in the long run.

The model suggests that the problem of disproportionality and suboptimality in international organizations should be met instead through institutional changes that alter the pattern of incentives. Since suboptimal provision is typical of international organizations, it is possible to design policy changes that would leave everyone better off, and which accordingly may have some chance of adoption. Appropriate marginal cost sharing schemes, such as are now used to finance the NATO infrastructure, could solve the problem of suboptimality in international organizations,\* and might also reduce the degree of disproportionality. Substituting a union for an alliance or international organization would also tend to bring about optimality, for then the unified system as a whole has an incentive to behave in an optimal fashion, and the various parts of the union can be required to contribute the amounts their common interest requires. Even a union of the smaller members of NATO, for example, could be helpful, and be in the interest of the United States. Such a union would give the people involved an incentive to contribute more toward the goals they shared with their then more nearly equal partners.\*\* Whatever the disadvantages on other grounds

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\* A similar proposal has been suggested by Thomas Schelling. He suggests that each country's share of the alliance's expenditure be fixed and the overall total spending be left open. Thus a country whose share of the cost was 10 percent would find that in return for spending this money it gets not only the protection of the forces this money would buy, but also the forces created by those nations that paid the other 90 percent. See his International Cost Sharing Arrangements, Essays in International Finance, No. 24, Department of Economics and Sociology, International Finance Section, Princeton University, Princeton, New Jersey, September 1955, p. 19.

\*\* A union would also make it easier to produce each of the various types of military capability that was needed in the region or state of the unified sovereignty that could produce that type of military capability most efficiently. See Olson and Zeckhauser, "Collective Goods, Comparative Advantage, and Alliance Efficiency."

of these policy possibilities, they have at least the merit that they help to make the national interests of individual nations more nearly compatible with the efficient attainment of the goals that groups of nations hold in common.

A final implication of our model is that alliances and international organizations, as presently organized, will not work efficiently, or according to any common conception of fairness, however complete the agreement and commonality of interest among the members. Though there is obviously a point beyond which dissension and divergent purposes will ruin any organization, it is also true that some differences of purpose may improve the working of an alliance, because they increase the private, noncollective benefits from the national contributions to the alliance, and this alleviates the suboptimality and disproportionality.\* How much smaller would the military forces of the small members of NATO be if they did not have their private fears and quarrels? How much aid would the European nations give if they did not have private interests in the development of their past or present colonies? How much would the smaller nations contribute to the UN if it were not a forum for the expression of their purely national enmities and aspirations? The United States, at least, should perhaps not hope for too much unity in common ventures with other nations: it might prove extremely expensive.

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\*The hypothesis that increased noncollective benefits improve the functioning of an alliance, and other hypotheses suggested by our model, have been tested by James A. Robinson and Philip M. Burgess of the Merston Social Science Program at Ohio State University, through a most interesting gaming-simulation procedure. Though the analysis of the data has barely begun, one of the researchers has indicated that the data generally appear to support the hypothesis that private, noncollective benefits may strengthen an alliance, and probably also other hypotheses suggested by the model developed here. It is expected that the results of this research will be published by the Merston Social Science Program, probably in 1967.