Measuring Systemic Polarity

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Indicators of the tightness and discreteness of poles in the international system, as well as of the distribution of capabilities and interaction opportunities among poles, are developed. With alliance bonds as the focus, scores for each indicator are presented for each year of the past century and a half, and several prevalent theories linking polarity to war are tested. The amount of major power war begun during five-year periods is found to be unrelated to the tightness of the poles, although increases in tightness are substantially associated with large amounts of war. Bipolar systems are found to experience less war than multipolar systems, with increases in the number of clusters being especially strongly associated with the amount of major power war during subsequent five-year periods. Neither changes in the discreteness nor the distribution of capabilities among the poles has any appreciable effect on the amount of major power war.

Journalists, diplomatic historians, and political scientists alike agree that the polarization of the international system is closely associated with the amount of conflict present in that system. Despite the importance attributed to polarity, there have been very few efforts to develop rigorous, operational indicators of systemic polarization.[1] Yet, this is an essential task if we are to explore the large set of hypotheses linking polarity to war and other forms of international conflict. The principal purpose of this paper is to satisfy the need for indicators of polarity and to make the resultant data readily available to students of international politics.

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1. There have been three significant efforts to operationalize one or more aspects of polarity (Singer and Small, 1968; Haas, 1970; Wallace, 1973). Each of these is sufficiently limited in its usefulness to warrant the development of alternative

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The development of indicators must be guided, of course, by some prior set of theoretical concerns. In the case of the polarization of the international system and its effects on war, those concerns have been articulated by such researchers as Kaplan (1957), Deutsch and Singer (1964), Waltz (1964), Rosecrance (1964), and others. It seems prudent, therefore, to begin with an examination of the most important propositions in the literature on polarity and war. In doing so, I summarize the assumptions and hypotheses of various approaches, rather than the arguments of individual researchers. In this way it is possible to identify the elements of systemic polarity that have the greatest relevance for the study of international conflict.

THEORETICAL OVERVIEW

Three aspects of polarity appear to influence the amount of war that occurs between nations. The first concerns the number of poles—or clusters of nations—in the system.[2] The second concerns the degree to which the foreign policies of nations within a single cluster are similar to each other, and the degree to which the foreign policies of nations in different clusters are dissimilar. The third relevant attribute concerns the

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indicators. Singer and Small only measure whether the system is bipolar or multipolar; they do not measure any other attributes of the poles. Their measure of bipolarity is contaminated by the fact that targets of alliances are occasionally determined by examining the subsequent conflict behavior of the nations in the respective alliances. Consequently, their measure of bipolarity is partly defined by their dependent variable. Haas categorizes each international subsystem according to whether it is or is not tightly polarized. His intuitively derived dichotomization is too insensitive to shifts in system structure to be of much use in most research undertakings. What is more, the average duration of the observation of tightness for a spatiotemporal subsystem in Haas's study is 32 years. While this is useful for recording gross changes in a system's structure, it does not capture any of the smaller fluctuations that may trigger crises or wars. Wallace's indicator is rigorously derived and reproducible. Unfortunately, his indicator is only sensitive to similar alliance commitments; it is not sensitive to dissimilar commitments. Thus if nations A and B are aligned with the same ten states, and nation C is aligned with those ten states plus an additional set of ten states, Wallace's indicator would fail to distinguish between A's relationship with B and A's relationship with C. What is more, Wallace's measure does not provide clear boundaries for the clusters, nor does it provide an indication of the discreteness or dissimilarity of clusters. His measure basically is an indicator of the tightness of alliance bonds. The indicators developed in this paper, on the other hand, are rigorously derived, reproducible, and sensitive to the internal and external commitments of the nations in the system. The importance of these attributes is discussed at great length within the text.

2. I use pole, cluster, and bloc interchangeably throughout the text.

degree of inequality in the distribution of power—or the potential ability to wage war—among the clusters of nations.

Associated with the first set of attributes are studies concerned with the bipolarity or multipolarity of the international system (Deutsch and Singer, 1964; Waltz, 1964; Rosecrance, 1964; Masters, 1961). The second set of attributes comprises the focus of studies concerned with the tightness or looseness of the system's poles (Kaplan, 1957; Deutsch and Singer, 1964; Singer and Small, 1968; Haas, 1970; Brody, 1963). Finally, studies that focus on the third set of attributes are primarily concerned with such notions as the balance of power or the preponderance of power (Gulick, 1955; Morgenthau, 1961; Organski, 1968; Singer et al., 1972; Bueno de Mesquita and Singer, 1973; Lucier, 1974). In the case of each of these three sets of attributes, contradictory hypotheses have been promulgated as a consequence of alternative assumptions. Let us turn our attention to the investigation of those assumptions and their associated hypotheses.

It is generally agreed that when nations join military alliances, or in some other way link their foreign policy behavior to the behavior of other nations, they sacrifice some degree of decision-making autonomy. This follows from the observation that when nations make commitments to each other, they restrict the set of decision-making options available to their leaders when certain contingencies arise. The members of NATO, for instance, in principle have reduced their decision-making options in the event that any one of them is attacked by the Soviet Union. If they are to honor their commitments in NATO, they must all declare war on the Soviet Union. Thus, they have lost the options of remaining neutral or of siding with the Soviet Union.

The assumption of lost autonomy is essential to the pursuit of any investigation of polarity because the significance of a bloc of nations rests in the presumed unity of action of its members, at least in the face of some specified contingency. Because the notion of polarity is meaningless without assuming some degree of unified action by bloc-members, it follows that the number of *autonomous* actors in the international system equals the number of clusters of nations plus the number of nonaligned, and therefore unclustered, nations. The number of autonomous actors is assumed, in turn, to have important effects on the war-proneness of the international system. These effects, in fact, are at the heart of the distinction between bipolarity and multipolarity.

Those who subscribe to the notion that multipolar systems tend to lead to peace and bipolar systems tend to lead to war (Deutsch and Singer,

1964; Singer and Small, 1968) generally maintain that wars are initiated (a) when the initiator is fairly certain about the reaction by each autonomous actor to a potential war; and (b) when the expected outcome of the war favors the potential initiator. The level of certainty surrounding the outcome of any potential conflict is assumed to decrease as the number of autonomous actors in the system increases. This follows from the assumption that the ability to process information and to respond adequately to new patterns of interactions among states decreases as the amount of information and the number of potential interactor interactions increase. Since multipolar systems have more potential sources of information and more interactor interaction opportunities than bipolar systems, it follows that multipolar systems contain more uncertainty than bipolar systems and, therefore, that multipolar systems are less war-prone than bipolar systems.

Those who subscribe to bipolarity as a means of achieving peace (Waltz, 1964) agree with the assumption that multipolar systems produce more uncertainty than bipolar systems, but disagree with the assumption that uncertainty is conducive to peace. Instead, they assume that war is most probable when nations misperceive the intentions of their rivals or miscalculate their own prospects for victory. Advocates of bipolarity reason that such miscalculations and misperceptions are most likely to occur in multipolar systems because of the difficulties in processing incoming information in such systems.

Those who subscribe to bipolarity rest their case on two additional arguments. First, they maintain that the proliferation of autonomous actors (such as occurs in multipolar systems) is accompanied by a proliferation of demands among the actors.[3] Thus, the more poles there

3. This assumption follows from the notion that actors have no reason to remain autonomous if their preference ordering across all relevant potential outcomes is identical. Hence, the existence of separate groups is evidence of incompatibilities in their preference orderings. This argument is not really rejected by those who subscribe to multipolarity. Instead, they reason that the difficulties inherent in processing information make it difficult to ascertain the areas of shared preference. Thus, they imply that as information is processed, it becomes easier for nations in different clusters to establish relations with each other. This follows from the observation that as the number of blocs increases, the number of preference orderings among a set of important goals also increases. As this occurs, the probability that two clusters share similar, though not identical, preference orderings increases. As the similarity in preference orderings increases, especially with regard to the highest priority goals, the probability of cooperative behavior between clusters increases. Consequently, multipolar systems provide greater opportunities for cooperation between clusters than do bipolar systems, at least according to advocates of multipolarity.

are, the higher the probability is that interbloc interactions will uncover serious incompatibilities between the blocs, some of which may result in direct conflict and war. Second, advocates of bipolarity hypothesize that the division of all nations into two camps raises the costs of war to such a high level that all but the most fundamental conflicts are likely to be resolved without resort to violence (Rosecrance, 1964; Waltz, 1964).

Closely associated with the question of whether bipolar or multipolar systems are less war-prone is the question of the impact that the intrabloc and interbloc structure of the poles has on the war-proneness of the international system. In particular, attention is given to the degree to which the foreign policies of all nations within a bloc are similar, and the degree to which the foreign policies of nations in different blocs are dissimilar.

When nations in different blocs share at least some common goals, one can expect friendly links to develop between them, drawing their blocs closer together and, thereby, reducing the probability of war between those blocs. Since the probability of discovering shared goals outside one's own bloc increases as the number of alternative blocs increases, it follows that the larger the number of poles in the international system, the higher the probability that the interbloc structure will produce war-reducing friendly interactions across clusters (Deutsch and Singer, 1964; Singer and Small, 1968).

The likelihood that friendly interbloc interactions occur does not depend exclusively on the similarities in policy preferences of members of different blocs. It also depends on the nature of the intrabloc ties among allies. When all members of a bloc are highly committed to one another, it is difficult for any one member of the cluster to venture on an independent foreign policy course that involves developing relations with nations outside the bloc. Thus, the more tight-knit the commitments within a cluster, the lower the probability that friendly interbloc relations will develop. Hence, the more tight-knit a cluster is, the higher the probability that it will be engaged in war (Kaplan, 1957; Brody, 1963). This is, of course, opposite to the conclusion reached by Waltz (1964), and others, that interbloc interactions are likely to uncover hostility among members of different clusters of nations.

Finally, considerable attention is given to the distribution of power among the clusters in the international system. Some maintain that the more equally distributed the relevant capabilities, the lower the probability that any nation or set of nations will initiate a war. This argument rests on the assumption that an equal distribution of capabilities makes victory

at acceptable costs highly unlikely for the initiator (Riker, 1962; Lucier, 1974).[4] Since, by definition, the initiator can gain nothing without a victory, a potential war initiator in a balance of power system is disinclined to initiate the war (Singer et al., 1972; Bueno de Mesquita and Singer, 1973). Alternatively, it has been argued that a very unequal distribution of capabilities is likely to prevent war. This argument rests on two assumptions. The first is that the stronger states are satisfied with the status quo and so would not initiate a war unless they believed there was a serious threat to the status quo (Organski, 1968). The second assumption is that the weaker states, though dissatisfied, recognize the futility of initiating a war against their much stronger adversary, and so reluctantly accept their unhappy state of affairs. Only if the true capabilities of the rival clusters are misperceived is war likely to be initiated (Organski, 1968; Wallace, 1974).

By way of summary, the important concepts in the literature that require operationalization are (a) the number of poles in the international system; (b) the tightness of the links, or commitments, within the poles; (c) the degree of linkage, or commitment, between the poles; and (d) the degree of equality in the distribution of relevant capabilities among the poles. I now turn to the operationalization of these concepts.

NUMBER OF CLUSTERS

The foreign policies of nations can be clustered in a variety of ways. One might focus on (a) the similarities and dissimilarities in the UN voting records of each pair of nations (Alker, 1964; Alker and Russett, 1965); (b) the similarity or dissimilarity in each pair of nations' memberships in intergovernmental organizations (Wallace and Singer, 1970); (c) the degree to which pairs of nations trade with each other (Savage and Deutsch, 1960; Alker and Puchala, 1968); (d) the similarities in each pair of nations' alliance commitments (Singer and Small, 1968; Haas, 1970; Wallace, 1973); and so on.

The selection of an indicator that reflects foreign policy commitments will greatly influence, of course, the memberships and structures of the clusters that are identified. It is important, therefore, to be aware of the

4. This is simply an extension of the concept of blocking coalitions. Thus, a balance of power system is one in which no coalition is strong enough to defeat another. For interesting discussions of blocking coalitions in the context of international politics, see Riker (1962) and Zinnes (1970).

advantages and disadvantages of each potential dimension. Ideally, the dimension on which nations are clustered should be (a) sensitive to subtle changes in foreign policies; (b) closely related to decisions pertaining to the onset of war or the maintenance of peace; (c) comparable across nations and across time; (d) available for a lengthy period of time; and (e) available for a large number of nations.

Voting behavior is inadequate for two reasons. First, UN votes only occasionally pertain to the onset of war. And those votes that do pertain to war generally reflect national policies concerned with wars that have already begun, relating to the cessation of conflict and the restoration of peace. While these are, of course, very important concerns, they are not directly linked to the theoretical literature concerned with polarity and war. In any case, the United Nations has only existed since the end of the Second World War. This short time span makes it impossible to develop a historic perspective in devising tests of the hypotheses linking polarity to war. Thus such data must be rejected on the basis of criterion d above.

Data on intergovernmental organization memberships are available for a large number of nations for a rather long period of time (Wallace and Singer, 1970). Unfortunately, IGOs are not particularly sensitive to subtle shifts in foreign policies, particularly as those policies pertain to impending wars. Instead, many IGOs are concerned with highly specialized subjects, such as the protection of endangered species or the cooperative dissemination of scientific information, and so on. Only since the end of World War II has the bulk of IGOs been concerned with major international economic and military cleavages. Not surprisingly, the military cleavages are primarily represented by military alliances. Such alliances, of course, comprise one of the dimensions proposed above. Thus, IGOs do not constitute, by themselves, a fruitful dimension with which to investigate international polarization.

Trade is an important aspect of any nation's economic policies and, to a lesser extent, of its foreign policies. Trade is not, however, sufficiently sensitive to subtle changes in foreign policies (although it is sensitive to major changes in such policies; Holsti et al., 1968); it is not necessarily comparable across nations or across time periods (because of shifts in technology and changes in the substitutability of markets); nor is it readily available for a large number of nations across a lengthy time span. Even for many of the major powers, dyadic trade data are not available prior to World War I.

Military alliances satisfy the requirement that the dimension for clustering nations be sensitive to subtle policy changes, especially as they

pertain to potential conflicts and wars. Military alliances, after all, are formal commitments between nations to behave in prescribed ways during wartime. Alliance data are available for a very large set of nations for a rather lengthy period of time. With the application of suitable distinctions between types of alliances, they are generally comparable across nations and across time periods.

Alliance data do suffer from some potential disadvantages. First, agreeing to an alliance commitment does not guarantee honoring that commitment under the contingent condition. However, a surprisingly large percentage of allied nations have found that their allies do honor those commitments, even to the extent of declaring war when the contingent condition arises. Thus, between 1815 and 1960, 64% of the nations that belonged to an alliance and that were at war found that some of their allies fought alongside of them. Only 25% of the nonallied nations that were involved in wars were aided by the presence of other combatants on their side. The probability that this difference in percentages occurred by chance is less than one in a thousand. Looking only at those nations that were attacked, thereby excluding war initiators (Singer and Small, 1972) and duplicating the contingent condition of most military alliances, we find that 76% of the allied nations received fighting support from some of their allies, while only 17% of the nonallied states found anyone fighting alongside of them. This relationship would occur by chance less than one time in a thousand given the number of nations involved. (For the first set of percentages n equals 137, while n for the second set of percentages is 61.)

Second, alliances are allegedly insensitive to important informal links between nations—like those that arise out of a common history, common culture, and so forth. This inadequacy, however, may be more imagined than real. There is no assurance that common culture makes better allies, or that different cultures make alliances difficult. What is more, informal links among nations are often symbolically recognized by signing a formal agreement to ally. Thus, alliance commitments do reflect the special relationship between such nations as the United States and the United Kingdom, while also reflecting the less special relationship between the United States and France.

Because military alliances adequately satisfy all the requirements I have established for clustering nations along dyadic lines, I use them as the base for the discussion that follows. Following the coding scheme of the Correlates of War project, I distinguish between three types of military

alliances. These are (a) *defense pacts,* in which the signatories agree to come to each other's mutual defense in case any one signatory is attacked; (b) *neutrality or nonaggression pacts,* in which the signatories agree not to declare war against each other in the event that a third nation declares war against one of them; and (c) *ententes,* in which the signatories agree to consult each other in the event any one of them is attacked by a third party (Singer and Small, 1966; Small and Singer, 1969).

These three types of alliances, as well as a fourth category indicating no alliance between nations, can be ranked ordinally from the greatest sacrifice of decision-making autonomy to the least sacrifice of such autonomy. I assume that defense pacts represent the most serious loss of autonomy in that they require a declaration of war under the contingent conditions. Thus, they deprive their members of the option of remaining neutral or of choosing the other side. Neutrality pacts require the next greatest sacrifice of autonomy in that they require states to remain neutral when an alternative strategy might be preferred by the signatories' decision makers. Ententes require a smaller sacrifice of autonomy in that they only require leaders to consult with each other. Thus, ententes restrict the timing of a nation's foreign policy decisions to some extent, but they do not eliminate any specific policy options.[5] Of course, if two nations have not concluded an alliance with each other, then neither one loses any decision-making autonomy to the other.

In order to identify clusters of nations, one must determine the degree of similarity in alliance commitments across all possible pairs of nations. The computation of similarities in alliance commitments requires two additional assumptions. I assume that each nation has a defense pact with itself. In behavioral terms this means that each nation will defend itself against an external enemy. In measurement terms this assumption means that the internal tightness of a cluster can only be maximized when every member of the cluster has a defense pact with every other member of the cluster.[6] I return to this point when I discuss the measurement of the internal tightness of the clusters.

5. The ranking of the commitment involved in each type of alliance is somewhat problematic. Some would argue, for instance, that ententes represent a higher level of commitment than neutrality pacts since ententes establish a cooperative atmosphere between states, while neutrality pacts merely prevent hostile behavior between states. Whatever the merits of this argument, it is still the case that ententes require less sacrifice of decision-making options, in principal, than do neutrality pacts. Further support for the rankings I use can be found in Small and Singer (1969).

6. Of course, all members of a cluster need not be identically aligned in order for a single dyad to be identically committed to each other. A single dyad is

I also assume that the foreign policy commitments of two states can result in similar foreign policy responses to war-provoking situations, even though the two nations do not share an alliance with each other. For instance, because the Philippines and Australia were both allied with the United States during the Korean War, they were expected to fight alongside each other, although they did not have an alliance between them. Similarly, nations like South Korea and Taiwan, both of which belong to the same cluster without sharing an alliance between them, are expected to manifest very similar foreign policies during wartime because of the substantial similarity in their commitments to other nations. Thus, if hypothetical nations A and B each have a defense pact with C, while having no alliance between them, then A and B should always fight together, regardless of whom among the triad is attacked. If C is attacked, they are both committed to C's defense. If B is attacked, then C is committed to declare war on the attacker. Such action is likely to result in aggression against C. This, in turn, would require A to enter the war in defense of C. Thus, A enters a war on B's side when B is the initial victim because of A's commitment to C. In this way, nations that are not directly linked to each other may still share membership in the same cluster provided their commitments to other nations are similar. Of course, these nations are not as closely linked to each other as they would be if they added an alliance between them.

I construct a four-by-four contingency table for each dyad of nations. The columns represent the degree of military commitment between the column nation and every other active nation in the international system in some given year.[7] Thus, the first column includes all the nations with which the column nation has a defense pact, while the second column includes all the states with which the column nation has neutrality pacts. The third includes only the ententes, while the fourth column indicates the nations with which the column nation has no alliances. In the same fashion, the first row indicates all of the states with which the row nation

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identically committed if (a) each member of the dyad has the same class of alliance with every other nation in the system; and (b) the members of the dyad have a mutual defense agreement.

7. By active nation I mean one that belongs to at least one alliance during the year in question. Thus, my analyses exclude any nation in a given year if that nation did not have even one alliance. Including such nations would not appreciably change the results, except to decrease the overall polarity of the system. I exclude unaligned nations because of my focus on the relationships among states within and between poles. There are, of course, no within-cluster relationships for unaligned states.

(i.e., the other member of the dyad) has defense pacts, and so on. Tables 1 and 2 provide samples of contingency tables used in the analyses that follow. These tables, as well as all subsequent analyses, are based on the alliance data reported by Small and Singer (1969).

Table 1 is an example of two nations with identical military alliance commitments. As can be seen, all of the data fall on the principal diagonal of the contingency table. Table 2 is an example of a dyad with rather dissimilar alliance commitments.

TABLE 1
ALLIANCE PATTERNS OF HOLLAND AND CANADA FOR 1951

CANADA \ HOLLAND	Defense	Neutrality	Entente	No Alliance
Defense	CAN,HOL,BEL,DEN,ENG,FRN, ICE,ITA,LUX,NOR,POR,USA, GRE,TUR			
Neutrality				
Entente				
No Alliance				CUB,HAI,DOM,MEX,GUA, TAW,KON,HON,SAL,NIC, COS,PAN,KOS,JAP,COL, VEN,ECU,PER,BRA,IND, PAK,BUR,BOL,PAR,CHI, ARG,URU,IRE,SWZ,SPN, CME,CEY,NEP,THI,GMW, POL,AUS,HUN,ALB,PHI, INS,CZE,YUG,BUL,RUM, RUS,FIN,SWD,ETH,AUH, NGW,SAF,IRQ,UAR,SYR, LEB,JOR,ISR,SAU,YEM, AFG,CHN,MON

NOTE: Tau-b = 1.000; n = 77. Abbreviations follow those used by Singer and Small (1972).

TABLE 2
ALLIANCE PATTERNS FOR THE USA AND USSR, 1953

USSR \ USA	DEFENSE	NEUTRALITY	ENTENTE	NO ALLIANCE
DEFENSE				RUS,MON,CZE,POL,HUN, RUM,BUL,FIN,CHN,ALB
NEUTRALITY				AFG
ENTENTE				
NO ALLIANCE	USA,ARG,BOL,BRA,CHI, COL,COS,CUB,DOM,ECU, SAL,GUA,HAI,HON,MEX, NIC,PAN,PAR,PER,URU, VEN,BEL,CAN,DEN,ENG, FRN,ICE,ITA,LUX,HOL, NOR,POR,GRE,TUR		PHI,AUL, NEW,KOS	SPN,YUG,LBY,IRN,IRQ, EGY,SYR,LEB,JOR,SAU, YEM

NOTE: Tau-b = –.539; n = 60.

The degree of similarity in alliance commitments, as depicted in the contingency tables, can be summarized through the computation of an appropriate measure of association. In this case, I use tau-b. Once a suitable statistic of association is computed for each dyad each year, a square matrix representing all dyads is constructed for each year.[8] The cell

8. Other measures of association that could have been used include the Pearson product-moment correlation, the Spearman rank-order correlation, $\emptyset/\emptyset_{max}$, Yule's Q, and so forth.

entries, of course, are the dyadic tau-b scores. The square matrix is then used to identify the cluster membership of each nation. Several clustering techniques, such as factor analysis (Russett, 1968, 1971), typal analysis (McQuitty, 1957; Smoker, 1968; Newcombe et al., n.d.), smallest space analysis (Wallace, 1973), and others, might be adopted. I use typal analysis because (a) it keeps between-cluster discriminations as large as possible (i.e., it minimizes the links between clusters); and (b) it is easy and inexpensive to compute. As McQuitty (1957) and Smoker (1968) have shown, typal analysis yields results quite similar to factor analysis.

The actual computation of the typal analysis is quite simple. The highest tau-b score in each column of the square matrix is circled, with the highest circled score indicating the dyad which comprises the first two members of the first cluster. The tau-b scores in the rows for these two nations are then examined to see if any other circled tau-b scores occur with these states. If they do, then the nations represented by those tau-b scores are added to the cluster. If, in turn, any of these new members have circled tau-b scores within their rows, then the nations represented by those additional tau-b scores are added to the cluster. This procedure continues until all of the members of the cluster have been examined and no additional circled tau-b scores fall in any of their rows. Then, the highest unclustered circled tau-b score is located in the matrix, and the dyad that it represents forms the beginning of a new cluster. The earlier procedure is followed until this cluster is completed. The entire process is repeated until all the nations in the matrix (and hence all the circled tau-b scores) have been associated with a cluster. Using this method, one finds that each nation becomes part of the cluster in which its alliance commitments are more like a member of that cluster than they are like the alliance commitments of any other nation. This procedure results in a nation belonging to one and only one cluster. Joint membership in more than one cluster could occur only in the unlikely event that a nation has its highest score with two states, each of which has its highest score with a nation in a different cluster. This is so unlikely that, in my analysis of thousands of dyads from 1816 to 1960, it did not occur even once.

The appendix to this study provides a list of the number of clusters found each year from 1816 to 1960, as well as a list of the nations in each cluster each year.[9] It should be noted that the clustering procedure was

9. Although I have not done so, one can easily compute the amount of variance in alliance commitments that is explained by the clusters. For a discussion of the procedure, see Newcombe et al. (n.d.).

performed on all sovereign states active in alliances in the given year. Thus, I have tried to be as inclusive as possible, counting all clusters equally regardless of the role played by their members in the international system. Of course, the level of interdependency among nations differs quite dramatically from period to period and from region to region. Because of this, some may prefer to focus their attention on particular subsystems, such as the European subsystem or the Latin American subsystem. To facilitate such endeavors, the appendix also identifies the tightness—defined below—of each individual cluster. For my part, I prefer to focus on the entire international system while providing adequate information for those who prefer a more restricted focus.[10]

STRUCTURE OF THE CLUSTERS

The tau-b scores used in identifying cluster memberships are also useful in determining the similarity of alliance commitments among members of the same cluster, or among members of different clusters. Two nations with identical alliance commitments will have a tau-b score of +1.00 with each other. Since each nation is assumed to have a defense pact with itself, two nations cannot achieve a tau-b score of +1.00 with each other unless they have a mutual defense pact.[11] It follows from this that a cluster can achieve the maximum degree of similarity in commitments among its members only if they all have mutual defense pacts with each other, and if none of them have alliances with nations outside the cluster. That is, a cluster achieves the maximum possible amount of *tightness,* or similarity in commitments, if the sum of the tau-b scores within the cluster is equal to the number of dyads within the cluster. Insofar as any one of those tau-b scores is less than +1.00, the tightness of the cluster is loosened, either because some member has less than a defense pact commitment with another member or because some member has an alliance with a nation outside the cluster. Just as each cluster's tightness is represented by the sum of the tau-b scores within the triangular matrix that defines the cluster's membership, the system's tightness is characterized by the overall sum of within-cluster tau-b scores derived from the set of triangular matrices which define each dyad in each cluster. In order to standardize

10. Data on relationships between individual dyads, as well as on the intrabloc distribution of capabilities, are available on request from the author.

11. Of course, a mutual defense pact is not sufficient for a dyad to have a tau-b score of +1.00. The members of the dyad must also be identically linked to all other states.

this number so that it cannot exceed +1.00, one can use the following indicator of systemic tightness:

$$T = \frac{\sum_{i=1}^{x}\left(\sum_{a,b\epsilon i} W_{ab}\right)}{\sum_{i=1}^{x}\left(\frac{(n_i)(n_i-1)}{2}\right)}$$

with n_i equal to the number of nations in cluster i, x equal to the number of clusters in the system, and with W_{ab} being the tau-b score for each dyad ab where a,bεi. As T diminishes, the tightness of the system's clusters diminishes.

Following the same logic, one defines the *discreteness* of each cluster by the dissimilarity of the alliance commitments among members of different clusters: that is, the greater the dissimilarity in alliance commitments between clusters, the clearer the boundaries of the clusters. Maximum dissimilarity arises when members of the same cluster have defense pacts with each other, and members of different clusters have no alliances with each other. Under these circumstances, the tau-b score between two nations in different clusters is −1.00. By extension, two completely separate clusters would be characterized by having their between-cluster tau-b scores sum to −1.00 times the number of between-cluster dyads. Insofar as any of the between-cluster tau-b scores is greater than −1.00, nations in different clusters share some degree of similarity in their alliance memberships (or nonmemberships). It follows from this that the degree of systemic dissimilarity between clusters is measured by the sum of the between-cluster scores in the system, with that score summing to −1.00 times all of the interbloc tau-b scores in the triangular matrix representing all of the system's dyads. The scores are multiplied by −1.00 so that the dissimilarity, or discreteness, scores move in the same direction as the tightness scores. The discreteness of the system's clusters is defined algebraically as:

$$D = \frac{(-1)\sum_{i=1}^{x}\left(\sum_{a,c\notin i} B_{ac}\right)}{\left(\frac{\sum_{i=1}^{x} n_i\left(\sum_{i=1}^{x}(n_i)-1\right)}{2}\right) - \sum_{i=1}^{x}\left(\frac{(n_i)(n_i-1)}{2}\right)}$$

with B_{ac} equal to the between-cluster tau-b score for dyad ac where a,c$\notin$i, and with the denominator equal to the total number of dyads in the system minus the number of within-cluster dyads. When D equals +1.00, then the clusters are as discrete as possible.[12] The appendix contains the tightness and discreteness scores for the international system each year from 1816 to 1960.

DISTRIBUTION OF POWER

The distribution of power among actors in the international system is a complex problem that has attracted considerable attention (Organski, 1968; Organski et al., 1972; German, 1960; Fucks, 1965; Knorr, 1956; Singer et al., 1972). Rather than add to the already voluminous debate on the measurement of power, I adopt an indicator developed by the Correlates of War project, and used by Singer et al. (1972). First, their indicator has considerable face validity, as well as some demonstrated empirical utility (Singer et al., 1972; Kugler, 1973). Second, unlike most theoretically acceptable indicators of national power, their indicator is available for a large set of nations across a fairly long time span.[13]

12. More precisely, D varies between 0.00 and 1.00 for a bipolar system. Multipolar systems necessarily involve some degree of similarity in the bonding network of nations in different clusters. This is so because ideally each member of a cluster will have a defense pact with each other member of its cluster, and no nation will have an alliance with a nation outside its cluster. Consequently, members of cluster A and cluster B will share the fact of their nonalignment with members of clusters C, D, . . . , N. If this is considered undesirable, a correction term can be added to the computation of D. Such a correction term would simply involve determining the maximum possible discreteness score for a system with a given number of intercluster dyads.

13. The capabilities data are available for all aligned states from 1890 to 1965. Substantial capabilities data are available for many nations prior to 1890, but unfortunately, not for all aligned nations.

Unfortunately, the data are available only in the form of observations every fifth year. Although this is something of a limitation, it is one presently being corrected by the Correlates of War project.

The indicator of power is derived by combining the military capabilities–defined as military expenditures and military personnel, excluding reserves–the demographic capabilities–defined as the total population and the urban population in cities of 20,000 or more–and the industrial capabilities–defined as the iron or steel production and industrial energy consumption–of each nation each fifth year into a composite capability score. The national composite capability scores indicate each nation's share of these capabilities relative to all the other nations included in the international system (Singer and Small, 1972). The national capability scores are then summed for each cluster, resulting in a composite capability score for each cluster. These composite cluster capability scores are used as the basis for the computation of the degree of inequality in the distribution of military-industrial-demographic capabilities across poles.

There are many available measures of inequality–such as the Schutz index, the Gini index, and the Concentration index–which might be used in the computation of the inequality in the distribution of capabilities. The index I use must be relatively insensitive to changes in the number of clusters and must be reliable regardless of how few clusters there are. As has been carefully documented elsewhere (Ray and Singer, 1973), the Concentration index is less sensitive to these conditions than is either the Gini index or the Schutz index. Thus, with small n's, Concentration does the best job of indicating the degree of inequality that is directly attributable to the distribution of capabilities, rather than being attributable to changes in the number of clusters. Concentration is computed as follows:

$$\text{Con} = \sqrt{\frac{\sum_{i=1}^{x} (S_i)^2 - 1/x}{1 - 1/x}}$$

where S_i is cluster i's share of the system's composite capabilities, and x is the number of clusters in the system. Thus, the numerator is the observed standard deviation of composite cluster capability scores, while the denominator is the maximum possible standard deviation for a system with x clusters.

Con ranges from 1.00, when all the capabilities are in the hands of a single cluster, to 0.00 when the capabilities are equally distributed among all the clusters. Because the focus of attention in the polarity literature is more often on the balance of power than on the relative preponderance of power, I convert Con into a measure of equality rather than inequality by subtracting the Con score from 1.00. Thus, when Equality equals 1.00, capabilities are equally distributed, and when it equals 0.00, one cluster controls all of the system's war potential. The appendix contains the data generated by the Equality index for every fifth year (except that 1913 is substituted for 1915, 1938 for 1940, and 1946 for 1945) from 1890 through 1960.

CHARACTERISTICS OF THE SYSTEM

The data presented in the appendix can now be examined in terms of a few statistical properties of each indicator, including the bivariate correlations with each other indicator. The examination begins with the entire century and a half, and then proceeds to separate examinations of the nineteenth and twentieth centuries.

For the century and a half, the mean discreteness score was .411, with the nineteenth-century mean being .597 and the twentieth-century mean being .203. The probability that this difference in means between the centuries is due to chance is less than one in a thousand. The average level of tightness for the entire period was .713, with the mean in the earlier period equal to .725, and the mean for the present century equal to .693. The difference in tightness scores between the centuries is not significant. As with the discreteness indicator, there is a substantial difference in the number of poles in the two centuries, with the mean for the earlier period being 2.33, and the mean for the latter period being 5.88. This difference is primarily due to the rapid increase in the number of states participating in alliances after the First World War. Thus, while the average number of clusters increases with time, the size of the clusters remains about the same. The average cluster in the nineteenth century contained 4.58 members, while in the twentieth century the average cluster had 4.60 members. This difference is insignificant.

The distribution of capabilities among the system's clusters has varied considerably, with Equality ranging between .947 and .378. The mean equality score from 1890 through 1960 is .671.

The relative stability of the system is somewhat reflected in the autocorrelations among these variables. Here we find that tightness and the

number of poles are not autocorrelated for the century and a half, with their respective autocorrelations being −.01, and .18. Discreteness, on the other hand, reflects a substantial degree of stability, with the autocorrelation for the entire period being .91. The autocorrelations for the entire period mask substantial differences in the stability of the system on these indicators between the two centuries. Thus, all the indicators are substantially autocorrelated in the nineteenth century, while only systemic discreteness is autocorrelated in the twentieth century. The coefficients for tightness, discreteness, and the number of poles in the nineteenth century are .81, .82, and .67, respectively. In the twentieth century those coefficients are −.02, .78, and .09, respectively, with the autocorrelation for the quinquennial equality scores being a negligible −.09. Thus, the nineteenth century appears to have been substantially more stable than the present century, at least with respect to these indicators.

The intercorrelations among these indicators provide useful indications of the extent to which they measure distinct attributes of the international system. Tightness and discreteness are weakly correlated with each other for the entire period (.38, n = 104), with the correlation being higher in the nineteenth century (.38, n = 55) than in the twentieth century (.14, n = 49). The correlations between tightness and discreteness with the number of poles for the entire period are .11 and −.64, respectively. In the nineteenth century the comparable correlations are .21 and −.38, while in the twentieth century they are .60 and −.65. Turning to the quinquennial relationships with the equality indicator, we find the correlations between equality, on the one hand, and tightness, discreteness, and the number of poles, on the other hand, to be .06, .57, and −.54, respectively.

These correlations highlight the structural distinction between intracluster tightness and interbloc discreteness. Thus, these two variables are essentially uncorrelated, especially in the twentieth century. Of course, this is not surprising when one considers their definition, nor is it surprising in light of their respective autocorrelations. The correlations reported above also underscore the increasing propensity for nations to have links outside their cluster as the number of clusters, and therefore the number of interaction opportunities, increases. Thus, the discreteness indicator is substantially inversely correlated with the number of poles. None of the indicators are so highly correlated with each other, however, that one would conclude they measure the same attribute of systemic polarity.

POLARITY AND WAR: A TENTATIVE ANALYSIS

The theoretical significance of the correlations just reported resides in the separate effects of each indicator on the war-proneness of the international system. Although an examination of those effects is best left for a subsequent study (Bueno de Mesquita, 1975), I will provide some indication of the theoretical significance of each indicator here, at least with respect to the amount of war in the international system. The dependent variable for the analysis that follows is the amount of war involving at least one major power, for wars beginning anytime during the five-year periods t_0 to t_{+5} (such as 1900 to 1905; Singer and Small, 1972). The analysis is performed only on the twentieth century, and is based on quinquennial observations.[14] Quinquennial observations are used so that the equality indicator can be included, and the twentieth century is focused on because of its greater bearing on contemporary politics, as well as because of the reduced problem with autocorrelation.

Support for the notion that bipolarity generally leads to peace is found in the correlation between the dependent variable and the number of poles in the system. Before reporting this correlation, I should note that the number of poles has been transformed to reflect interaction opportunities by multiplying the number of poles times that number minus one and dividing by two. The correlation is .32 (n = 13 for all the correlations now being reported). That correlation increases substantially when our focus is on the change in the number of interaction opportunities over the five-year period ending immediately prior to the period of the dependent variable. Thus, the correlation with changes in interaction opportunities is .52. This correlation suggests that the greater the shift toward a multipolar system, the greater the amount of war that can be expected to begin during the subsequent five years.

The tightness of the system's clusters is found to be unrelated to subsequent amounts of war, but systems with tightening clusters have a substantial propensity to be followed by large amounts of war. Thus, the correlation between T (tightness) and the amount of major power war is only .11, while the correlation for tightening systems ($\Delta T_{t-5 \rightarrow t_0}$) is a very substantial .73. Systems with little discreteness have a modest

14. Several indicators of change are included in the analysis, such as $\Delta T_{t-5 \rightarrow t_0}$, and so forth. The observations of ΔT, ΔD, and ΔIO for 1913 and 1938 are based on the change in these variables from 1908 to 1913 and 1933 to 1938, respectively. The observations of these variables for 1946 are based on the change from 1938 to 1946. The capabilities data were not available for 1908 and 1933, so I used 1910 and 1935, respectively.

tendency to be followed by war, while changing discreteness is unrelated to war. The respective correlations with the amount of war are –.40 and .15. Finally, the distribution of capabilities among the clusters is only negligibly correlated with the amount of war ($r = -.20$), with changes in the distribution of capabilities being even less correlated with the amount of war ($r = .17$). Of course, this does not mean that capabilities have no effect on other aspects of war, such as who wins and who loses–they undoubtedly have an important bearing on the outcome of war, though not on the amount of war.

Note that the change in tightness and the change in interaction opportunities are the two most highly correlated variables with the amount of major power war begun within each five-year period. It will be recalled that the theoretical literature concerned with polarity focuses a great deal of attention on the notion of uncertainty. Uncertainty in the system almost certainly increases during periods of substantial change in alignments. (Of course, certainty may increase within individual poles. Such an increase in intrapolar certainty, on the other hand, may raise serious questions in the minds of potential rivals, especially regarding the motives underlying their opponents' shifting alignments.) The theoretical and empirical significance of the change variables is explored in much greater depth elsewhere, with the evidence indicating that the probability and the duration of twentieth-century wars are substantially affected by changes in the tightness of the system's poles (Bueno de Mesquita, 1975).

CONCLUSION

The set of indicators developed in this paper are useful predictors of the war-proneness of the international system. This and other studies have already demonstrated their utility in predicting the probability, duration, and amount of war in the international system. In particular, this study suggests that the bipolarization of the international system and the reduction of the system's tightness are likely to reduce the amount of war involving major powers. Future applications of the indicators to regional and other subsystems may provide useful clues about the propensity of those subsystems to fight wars. The tightness of individual clusters may provide future researchers with useful indications of poles that are likely to remain stable and poles that are likely to disintegrate. In the same way, the dyadic tau-b scores (which are available on request) may provide indications of which nations are likely to defect from their present pole, and to which pole they are likely to defect.

The discreteness indicator, and several of its components, including dyadic discreteness scores, may provide a basis for testing the effectiveness of detente as a strategy for building an international structure for peace. Thus, since detente represents the building of bonds between members of different, and generally rival, poles, it is certainly closely related to the notion of discreteness as used here.

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APPENDIX

SYSTEMIC TIGHTNESS (T), DISCRETENESS (D), AND EQUALITY (E) AND CLUSTER MEMBERSHIPS WITH CLUSTER TIGHTNESS

Year	No. of Poles	T	D	Cluster Memberships and Cluster Tightness
1816-1817	1	.570	NA	(ENG GMY BAV BAD SAX WRT HSE HSG AUH RUS:.570)
1818-1823	1	.454	NA	(ENG FRN GMY BAV BAD SAX WRT HSE HSG AUH RUS:.454)
1824-1826	1	1.000	NA	(GMY BAV BAD SAX WRT HSE HSG AUH:1.00)
1827-1830	2	.989	.961	(ENG FRN RUS:.885);(GMY BAV BAD SAX WRT HSE HSG AUH:1.00)
1831-1832	1	1.000	NA	(GMY BAV BAD SAX WRT HSE HSG AUH:1.00)
1833	2	.987	.914	(GMY BAV BAD SAX WRT HSE HSG AUH:.993); (RUS TUR:.834)
1834-1837	3	.984	.551	(ENG SPN POR:1.00);(GMY BAV BAD SAX WRT HSE HSG AUH:.988);(RUS TUR:.829)
1838-1839	3	.987	.561	(ENG SPN POR:1.00);(GMY HAN BAV BAD SAX WRT HSE HSG AUH:.991);(RUS TUR:.828)
1840	1	.464	NA	(ENG GMY HAN BAV BAD SAX WRT HSE HSG AUH RUS TUR:.464)
1841-1842	2	.793	.795	(ENG FRN SPN POR:1.00);(GMY HAN BAV BAD SAX WRT HSE HSG AUH RUS:.765)
1843	2	.806	.801	(ENG FRN SPN POR:1.00);(GMY HAN BAV BAD SAX WRT HSE HSG MEC AUH RUS:.784)
1844-1846	2	.923	.779	(ENG FRN SPN POR RUS:.612);(GMY HAN BAV BAD SAX WRT HSE HSG MEC AUH:.992)
1847-1848	2	.922	.407	(RUS MOD:.342);(GMY HAN BAV BAD SAX WRT HSE HSG MEC AUH:.935)
1849	1	1.000	NA	(MOD AUH:1.00)
1850	2	.913	.350	(RUS MOD:.208);(GMY HAN BAV BAD SAX WRT HSE HSG MEC AUH:.929)

NOTE: The Equality scores are reported from 1890 through 1960 on a quinquennial basis. NA indicates the indicator is Not Appropriate for the given year. The abbreviations are those suggested by Singer and Small (1972).

APPENDIX (Continued)

Year	No. of Poles	T	D	E	Cluster Memberships and Cluster Tightness
1851-1854	2	.859	.233		(RUS MOD PMA:.287);(GMY HAN BAV BAD SAX WRT HSE HSG MEC AUH:.897)
1855-1858	1	.610	NA		(GMY HAN BAV BAD SAX WRT HSE HSG MEC AUH MOD PMA:.610)
1859	3	.939	.521		(FRN ITA:1.00);(MOD PMA TUS:.886);(GMY HAN BAV BAD SAX WRT HSE HSG MEC AUH:.941)
1860	3	1.000	.598		(ECU PER:1.00);(MOD PMA TUS:1.00);(GMY HAN BAV BAD SAX WRT HSE HSG MEC AUH:1.00)
1861	3	.995	.587		(ECU PER:1.00);(ENG FRN SPN:.921);(GMY HAN BAV BAD SAX WRT HSE HSG MEC AUH:1.00)
1862	2	.994	.968		(ENG FRN SPN:.906);(GMY HAN BAV BAD SAX WRT HSE HSG MEC AUH:1.00)
1863	1	.726	NA		(GMY HAN BAV BAD SAX WRT HSE HSG MEC AUH RUS:.726)
1864	2	.745	.744		(COL ECU:1.00);(GMY HAN BAV BAD SAX WRT HSE HSG MEC AUH RUS:.741)
1865	2	1.000	1.000		(COL ECU:1.00);(GMY HAN BAV BAD SAX WRT HSE HSG MEC AUH:1.00)
1866	1	1.000	NA		(GMY HAN BAV BAD SAX WRT HSE HSG MEC AUH:1.00)
1867-1870	1	.500	NA		(GMY BAV BAD WRT:.500)
1871-1877	2	.719	.866		(PER BOL:1.00);(GMY AUH RUS:.625)
1878	3	.886	.480		(PER BOL:1.00);(ENG TUR:1.00);(GMY AUH RUS:.809)
1879-1880	3	1.000	.500		(PER BOL:1.00);(ENG TUR:1.00);(GMY AUH:1.00)
1881	2	.445	.642		(PER BOL:1.00),(GMY AUH RUS YUG:.353)
1882	2	.421	.576		(PER BOL:1.00);(GMY AUH ITA RUS YUG:.364)
1883	2	.400	.512		(PER BOL:1.00);(GMY AUH ITA RUS YUG RUM:.360)
1884-1886	1	.180	NA		(GMY AUH ITA RUS YUG RUM:.180)
1887	2	.337	.147		(ENG SPN:.668);(GMY AUH ITA RUS YUG RUM:.315)
1888	1	.088	NA		(ENG SPN GMY AUH ITA RUS YUG RUM:.088)
1889	2	.297	.223		(ENG SPN:.668);(GMY AUH ITA RUS YUG RUM:.272)
1890	2	.297	.223	.744	(ENG SPN:.668);(GMY AUH ITA RUS YUG RUM:.272)

APPENDIX (Continued)

Year	No. of Poles	T	D	E	Cluster Memberships and Cluster Tightness
1891-1893	3	.593	.284		(ENG SPN:.699);(FRN RUS:.867);(GMY AUH ITA YUG RUM:.555)
1894	3	.604	.294		(ENG SPN:.699);(FRN RUS:1.00);(GMY AUH ITA YUG RUM:.555)
1895	3	.604	.294	.943	(ENG SPN:.699);(FRN RUS:1.00);(GMY AUH ITA YUG RUM:.555)
1896	2	.705	.657		(GMY AUH ITA RUM:1.00);(FRN RUS CHN JAP:.409)
1897-1898	2	.672	.595		(GMY AUH ITA RUM:.959);(FRN RUS CHN JAP:.386)
1899	3	.717	.367		(ENG POR:1.00);(FRN RUS CHN JAP:.431); (GMY AUH ITA RUM:.955)
1900	3	.661	.340	.869	(ENG POR:1.00);(FRN RUS CHN JAP:.359); (GMY AUH ITA RUM:.906)
1901	3	.661	.340		(ENG POR:1.00);(FRN RUS CHN JAP:.359); (GMY AUH ITA RUM:.906)
1902	3	.696	.345		(ENG POR JAP:.539);(FRN RUS CHN:.434); (GMY ITA AUH RUM:.906)
1903	3	.757	.407		(ENG POR JAP:.525);(FRN RUS:.548);(GMY ITA AUH RUM:.907)
1904	3	.690	.330		(ENG POR JAP:.574);(FRN SPN RUS:.375); (GMY AUH ITA RUM:.906)
1905	3	.690	.330	.947	(ENG POR JAP:.574);(FRN SPN RUS:.375); (GMY AUH ITA RUM:.906)
1906	3	.690	.330		(ENG POR JAP:.574);(FRN SPN RUS:.375); (GMY AUH ITA RUM:.906) (
1907	3	.673	.328		(ENG POR JAP:.485);(FRN SPN RUS:.397); (GMY AUH ITA RUM:.906)
1908	3	.552	.272		(USA ENG POR JAP:.263);(FRN SPN RUS:.430); (GMY AUH ITA RUM:.904)
1909	3	.579	.273		(USA ENG POR JAP:.263);(FRN SPN RUS:.511); (GMY AUH ITA RUM:.929)
1910	3	.708	.333	.796	(ENG POR JAP:.485);(FRN SPN RUS:.481); (GMY AUH ITA RUM:.933)
1911	3	.708	.333		(ENG POR JAP:.485);(FRN SPN RUS:.481); (GMY AUH ITA RUM:.933)

APPENDIX (Continued)

Year	No. of Poles	T	D	E	Cluster Memberships and Cluster Tightness
1912	4	.714	.223		(ENG POR JAP:.514);(FRN SPN RUS:.553); (GMY AUH ITA RUM:.925);(YUG GRE BUL:.655)
1913	4	.783	.249	.694	(ENG POR JAP:.514);(FRN SPN RUS:.553); (GMY AUH ITA RUM:.925);(YUG GRE BUL:1.00)
1914-1918					
1919	5	.569	.179		(ENG POR:1.00);(BEL FRN POL:.482);(AUS CZE ITA YUG RUM:.466);(LAT EST:1.00); (AFG TUR:1.00)
1920	3	.752	.437	.536	(ENG POR JAP:.587);(BEL FRN:1.00);(CZE YUG:1.00)
1921	4	.594	.236		(ENG POR JAP:.650);(BEL FRN POL:.530); (CZE AUS YUG RUM:.531);(AFG TUR:1.00)
1922	4	.604	.251		(ENG POR:1.00);(BEL FRN POL:.518);(AUS CZE YUG RUM:.516);(AFG TUR:1.00)
1923	5	.657	.202		(ENG POR:1.00);(BEL FRN POL:.539);(AUS CZE YUG RUM:.544);(LAT EST:1.00);(AFG TUR:1.00)
1924	5	.569	.179		(ENG POR:1.00);(BEL FRN POL:.482);(AUS CZE YUG RUM ITA:.466);(LAT EST:1.00); (AFG TUR:1.00)
1925	4	.313	.206	.574	(ENG POR:1.00);(BEL FRN POL AUS CZE YUG ITA RUM:.225);(RUS TUR AFG:.630);(LAT EST:1.00)
1926	5	.422	.142		(ENG POR:1.00);(BEL FRN POL:.530);(GMY RUS LIT TUR AFG IRN:.355);(EST LAT:1.00); (AUS CZE ITA YUG RUM ALB:.391)
1927	5	.471	.154		(ENG POR:1.00);(BEL FRN AUS CZE POL YUG RUM:.390);(GMY RUS LIT IRN TUR AFG:.506); (LAT EST:1.00);(ITA HUN ALB:.511)
1928	5	.608	.145		(ENG POR:1.00);(BEL FRN POL CZE RUM YUG:.505); (GMY RUS LIT IRN TUR AFG:.478);(HUN ITA ALB GRE:.428);(LAT EST:1.00)
1929	4	.250	.145		(ENG POR:1.00);(BEL FRN POL CZE YUG RUM:.512); (GMY HUN ITA BUL GRE ALB RUS LIT IRN TUR AFG:.152);(LAT EST:.949)
1930	5	.435	.115	.651	(ENG POR:1.00);(BEL FRN POL CZE YUG RUM:.493); (GMY BUL RUS LIT IRN AFG TUR:.337);(LAT EST:.949);(HUN ITA ALB GRE:.449)

APPENDIX (Continued)

Year	No. of Poles	T	D	E	Cluster Memberships and Cluster Tightness
1931	5	.448	.126		(ENG POR:1.00);(BEL FRN POL CZE YUG RUM:.526); (GMY RUS LIT BUL IRN AFG TUR:.337);(ITA HUN GRE ALB:.469);(LAT EST:.949)
1932	6	.400	.058		(ENG POR IRQ:.682);(BEL FRN POL:.460); (GMY RUS LIT FIN BUL TUR IRN AFG:.279); (HUN ITA ALB GRE:.479);(CZE RUM YUG:.843); (LAT EST:.952)
1933	6	.409	.019		(ENG POR IRQ:.541);(BEL FRN POL CZE YUG RUM:.454);(GMY HUN ITA ALB:.366);(BUL GRE RUS TUR IRN AFG:.319);(LAT EST:.952); (FIN LIT:.395)
1934	6	.429	.048		(ENG POR IRQ:.542);(BEL FRN GMY POL:.421); (AUS HUN:.817);(CZE YUG GRE BUL RUM TUR:.437); (ALB ITA:.531);(RUS LIT EST LAT FIN IRN AFG:.387)
1935	6	.453	.032	.378	(ENG POR IRQ:.542);(BEL FRN GMY POL RUS FIN:.289);(AUS HUN:.817);(IRN AFG:.934); (CZE YUG RUM GRE TUR BUL:.437);(ALB ITA:.531); (LAT EST LIT:.952)
1936	7	.790	.182		(USA CUB HAI DOM MEX GUA HON SAL NIC COS PAN COL VEN ECU PER BRA BOL PAR CHI ARG URU-- Hereafter OAS--:.963);(ENG POR IRQ:.547); (BEL FRN GMY POL CZE RUS YUG RUM GRE BUL TUR JAP:.271);(HUN AUS ITA ALB:.511); (LAT EST LIT:.977);(FIN MON:.464);(AFG IRN:.969)
1937	10	.913	.142		(OAS:.967);(ENG POR EGY:.621);(GMY JAP:.844); (FRN POL CZE RUS:.500);(GRE BUL YUG RUM TUR:.501);(HUN AUS ITA ALB:.500);(IRN AFG IRQ:.821);(YEM SAU:1.00);(MON FIN CHN:.462); (LAT EST LIT:.972)
1938	11	.927	.143	.636	(OAS:.967);(ENG POR EGY:.621);(IRN AFG IRQ:.821); (CZE FRN POL RUS:.504);(RUM YUG:.856); (GMY JAP:.752);(AUS HUN ITA ALB:.501);(GRE BUL TUR:.733);(SAU YEM:1.00);(LAT EST LIT:.979); (MON FIN CHN:.462)
1939-1945					
1946	8	.847	.189	.495	(OAS.CAN:.954);(ENG EGY JOR IRQ:.676); (CHN MON FIN:.476);(POR SPN:.776);(NEW AUL:.976); (YUG ALB POL CZE RUS:.530);(TUR IRN AFG:.902); (LEB SYR SAU YEM:.974)
1947	11	.901	.166		(OAS CAN:.910);(ENG FRN:.625);(POR SPN:.780); (NEW AUL:.978);(RUS CZE POL YUG:.665); (RUM HUN:.478);(ALB BUL:1.00);(MON CHN:.478); (TUR IRN AFG:.905);(EGY IRQ JOR:.869); (LEB SYR SAU YEM:.976)

APPENDIX (Continued)

Year	No. of Poles	T	D	E	Cluster Memberships and Cluster Tightness
1948	9	.891	.185		(OAS CAN:.910);(ENG FRN HOL LUX BEL:.885); (POR SPN:.782);(RUS CZE POL YUG HUN RUM ALB BUL:.725);(EGY JOR IRQ:.871);(NEW AUL:.980); (MON FIN:.480);(TUR IRN AFG:.906);(LEB SYR SAU YEM:.978)
1949	8	.921	.197		(OAS:.970);(HOL BEL LUX FRN DEN ICE ITA CAN ENG POR SPN NOR--Hereafter NATO--:.815); (RUS POL HUN CZE RUM BUL ALB --Hereafter WTO--:.726);(YEM SYR LEB SAU:.979); (EGY JOR IRQ:.872);(NEW AUL:.981);(MON FIN:.480); (TUR IRN AFG:.907)
1950	8	.919	.186	.597	(OAS:.963);(NATO:.830);(WTO:.626);(TUR IRN AFG:.908);(FIN CHN MON:.481);(JOR IRQ EGY:.907);(SYR LEB YEM SAU:1.00);(NEW AUL:.981)
1951	8	.907	.175		(OAS:.964);(NATO+GRE TUR:.830);(WTO:.714); (AFG IRN:.873);(LEB SYR YEM SAU:1.00); (EGY JOR IRQ:.907);(NEW AUL PHI:.568); (FIN CHN MON:.481)
1952	7	.908	.165		(OAS:.964);(NATO+GRE TUR:.835);(WTO:.714); (IRN AFG:.873);(CHN MON FIN:.481);(AUL NEW PHI:.568);(IRQ JOR SAU YEM EGY SYR LEB:.927)
1953	9	.884	.153		(OAS:.965);(NATO+GRE TUR YUG:.739);(WTO:.716); (AFG IRN:.874);(SYR EGY LEB SAU YEM:1.00); (JOR LBY IRQ:.915);(CHN FIN MON:.482); (PHI KOS:.451);(NEW AUL:.982)
1954	9	.883	.133		(OAS:.964);(NATO+TUR GRE,-FRN ENG:.804); (FRN ENG:.877);(WTO:.717);(YUG LBY JOR SYR LEB EGY SAU YEM IRQ:.651);(NEW AUL PHI THI PAK--Hereafter SEATO--:.957); (AFG IRN:.875);(CHN FIN MON:.483);(TAW KOS:.463)
1955	8	.895	.154	.624	(OAS:.963);(NATO+GRE TUR GMW:.802);(WTO+GME:.949); (CHN FIN MON:.484);(YUG LBY JOR EGY SYR SAU YEM LEB IRQ:.739);(SEATO:.917);(AFG IRN:.702); (KOS TAW:.464)
1956	8	.895	.155		(OAS:.963);(NATO+GRE TUR GMW:.803);(WTO+GME:.949); (SUD EGY SYR LEB SAU YEM TUN JOR IRQ LBY YUG:.786);(AFG IRN:.703);(FIN CHN MON:.484); (KOS TAW:.465);(SEATO:.918)
1957	9	.901	.136		(OAS:.964);(NATO+GRE TUR GMW,-ENG FRN:.821); (ENG FRN MAL:.414);(WTO+GME:.949);(IRN [illegible] AFG:.703);(SUD EGY SYR LEB JOR SAU YEM LBY IRQ YUG TUN:.793);(CHN FIN MON:.485); (TAW KOS:.466);(SEATO:.919)

APPENDIX (Continued)

Year	No. of Poles	T	D	E	Cluster Memberships and Cluster Tightness
1958	9	.903	.137		(OAS:.964);(NATO+GRE TUR GMW,-ENG FRN:.821); (ENG FRN MAL:.422);(WTO+GME:.949);(IRN AFG:.703);(SUD EGY MOR LEB JOR SAU YEM LBY IRO YUG TUN:.801);(CHN FIN MON:.485); (TAW KOS:.466);(SEATO:.937)
1959	10	.904	.126		(OAS:.964);(NATO+GRE TUR GMW,-ENG FRN:.822); (ENG FRN MAL:.423);(WTO+GME:.949);(IRN AFG:.704);(TUN MOR SUD EGY SAU YEM LEB JOR LBY YUG IRO:.801);(SEATO:.938);(FIN CHN MON:.485);(GUI GHA:.985);(TAW KOS:.467)
1960	11	.900	.120	.603	(OAS-CUB:.962);(NATO+GRE TUR GMW,-ENG FRN:.822); (ENG FRN MAL:.423);(WTO+GME:.949);(TUN SUD EGY LEB SAU YEM MOR JOR LBY YUG IRO:.801); (FIN MON:.485);(CHN BUR:.610);(GUI GHA:.803); (IRN AFG:.634);(SEATO:.938);(TAW KOS:.467)