Relational similarity: an introduction and an application to military alliances

Peter M. Li

At first glance, the answer to how one might measure the strength of a relationship between two actors seems self-evident. First, look at the actors in question and see whether or not there is a relationship. Second, if so, assess the depth or intensity of that relationship. However, this article argues that in many, if not most situations of interest to social scientists and policymakers, one needs to go beyond single, individual relationships. Instead, one needs to take a broader relational view whereby actors (e.g., countries, firms, people) are defined as much, if not more, by their external relationships (e.g., who their allies, business partners, and friends are) as by their internal attributes (e.g., what their military, industrial, or intelligence capabilities are). In this view, an individual is not a distinct entity per se but a collection of roles: friend, student, daughter, spouse, co-worker, etc. Extending this line of thought, the strength of any particular relationship (e.g., alliance, business, or friendship) might be the degree to which the actors involved have common or overlapping partners (i.e., allies, business partners, or friends). For example, one would argue that two people who have more friends in common are "closer" to one another than two people who have fewer.[1]

While the article applies a relational perspective to the question of why some military alliances succeed while others fail, the concepts, methods, and insights discussed here are applicable to a wide range of issues and topics of interest to social scientists and policymakers. Examples include patterns of international and domestic trade between countries and firms, of links between companies via their corporate boards, of the success or failure of social movements, of the ideological alignments of judges and legislators, of social networks, and of any phenomenon which has a relational structure. That said, the article first discusses the importance of employing a relational perspective when studying military alliances. Second, using military alliances for the period between 1816 and 2003, a new measure of the strength of alliance relationships, called relational similarity, is constructed.[2] Third, it is found that in comparison to existing measures of alliance credibility, relational similarity produces results that are more consistent with the hypothesized effect of alliance credibility and which are also better able to explain observed patterns of conflict.

This article first discusses the importance of employing a relational perspective when studying military alliances. Second, using military alliances for the period between 1816 and 2003, the article constructs a new measure of alliance strength called relational similarity. Third, it is found that in comparison to existing measures of alliance credibility, relational similarity produces results that are more consistent with the hypothesized effect of alliance credibility and which are also better able to explain observed patterns of conflict.

Structure and the strength of alliance relations

A standard answer to the question of why alliances succeed or fail is that their ability to deter depends on their credibility: the degree to which others believe that allies will fulfill their commitments.[3] To assess credibility, one might use the work of those who have analyzed the texts of alliance treaties in order to assess the level of commitment.[4] While such work has made valuable contributions to the understanding of alliances, their focus on the strength of individual alliance relationships can undermine the assessment of alliance credibility. First, the reliability of the information derived from individual alliance relations may be in question as observed levels of commitment may be idiosyncratic to a given time, place, or opponent. Moreover, because that information is derived from the text of alliance treaties it suffers from being nominal in nature. In either case, one may end up with a poor estimate of the actual or underlying level of commitment between countries and, consequently, of the credibility of alliances. Second, the focus on individual relationships unnecessarily limits one to using less evidence even when more is available. Such a view overlooks that there are often multiple alliance relationships between and among countries and consequently is unable to incorporate that information.

The single-relation perspective also overlooks information about how countries are linked or wired together by their alliances. This is important because the emergent structure of the network of alliance relationships can affect the strength, and hence the credibility, of individual alliance relationships. Consider the following. In the first scenario, there are three countries, A, B and C. A and B are allies. C is not allied with either A or B. In the second scenario, B forms an alliance with C. Now A and B are allies, and B and C are allies. If one were to focus on the individual relationship between A and B, one might think that either nothing has changed since the two are still allies, or that any observed change is due solely to dynamics within that relationship. This overlooks the contribution that B's alliance with C can have. The adoption of a relational perspective allows one to consider all three possible effects: no change, internal change or external (structural) change.

From a structural perspective, this example is simple and stylized. With actual data, the situation can be much more complex. The graph in Figure 1 for example maps relationships in 1816.[5] It is a typical but modest example of the complex

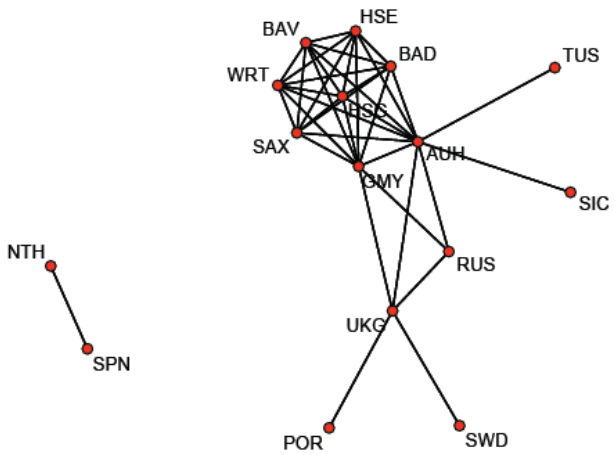

Figure 1: Defense alliances, 1816.
Source: see text.

structure of relational data in general and of alliance data in particular. The circles with the adjacent three-letter abbreviations represent sixteen countries. The lines represent the existence of an alliance relationship. For example, one can see that Spain (SPN) is allied with the Netherlands (NTH). This graph is constructed in the following way. The basic raw data is stored in matrices that record alliances and their allies. In Table 1, one sees that there are seven alliances listed as vertical columns, identified by a four-digit alliance code, and sixteen countries as horizontal rows, identified by a three-letter country code. If a country (i.e., a row) was a member of particular alliance, a 1 appears in the respective column of that row. If not, then a 0 appears. For example, Austria-Hungary (AUH) was part of four alliances (i.e., 2005, 2006, 2007, and 2008). If an alliance (i.e., a column) included a particular country as a member, a 1 appears in the respective row of that column. If not, then a 0 appears. For example, alliance number 2000 had two members, Portugal (POR) and the United Kingdom (UKG).

To see how individual countries are related to one another (i.e., to find all bilateral alliance relations), one transforms the matrix in Table 1 such that individual countries serve as rows and as columns (i.e., as observations and as variables). This is done by multiplying the matrix in Table 1 by its transpose.[6] The result is the matrix in Table 2. The elements along the main diagonal from the upper-left to the lower-right are the number of alliances of which that country is a member. For example, Austria-Hungary (AUH) is a member of four alliances (the element for AUH-AUH is 4). The off-diagonal elements of the matrix are the number of alliances to which a given pair of row and column countries are both members. For example, Austria-Hungary (AUH) and Prussia (GMY) had two alliances with one another. Even for this relatively simple example, it is difficult to see the aggregate structure of relationships in matrix form. Thus, one benefit of Figure 1 is that it provides a way of visualizing the information in Table 2.[7] Another, and perhaps more important benefit, is that by mapping all alliance relationships, one can look beyond pair-wise relations and see the entire,

Table 1: Alliances and country members, 1816

	2000	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
AUH	0	1	1	1	1	0	0
BAD	0	1	0	0	0	0	0
BAV	0	1	0	0	0	0	0
GMY	0	1	0	0	1	0	0
HSE	0	1	0	0	0	0	0
HSG	0	1	0	0	0	0	0
NTH	0	0	0	0	0	0	1
POR	1	0	0	0	0	0	0
RUS	0	0	0	0	1	0	0
SAX	0	1	0	0	0	0	0
SIC	0	0	1	0	0	0	0
SPN	0	0	0	0	0	0	1
SWD	0	0	0	0	0	1	0
TUS	0	0	0	1	0	0	0
UKG	1	0	0	0	1	1	0
WRT	0	1	0	0	0	0	0

Source: see text.

Table 2: Countries' list of allies, 1816

	AUH	BAD	BAV	GMY	HSE	HSG	NTH	POR	RUS	SAX	SIC	SPN	SWD	TUS	UKG	WRT
AUH	4	1	1	2	1	1	0	0	1	1	1	0	0	1	1	1
BAD	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	1
BAV	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	1
GMY	2	1	1	2	1	1	0	0	1	1	0	0	0	0	1	1
HSE	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	1
HSG	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	1
NTH	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
POR	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
RUS	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0
SAX	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	1
SIC	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SPN	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
SWD	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
TUS	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
UKG	1	0	0	1	0	0	0	1	1	0	0	0	1	0	3	0
WRT	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	1

Source: see text.

aggregate structure or network of relationships. As mentioned, this is important because the overall structure of relationships can have an impact on the strength of individual ones. It does so via three basic types of relational properties: multiplexity, transitivity, and clustering.

Multiplexity

Actors are often, if not typically, involved in relationships with more than one partner. People frequently have more than one friend. Firms usually do business with more than one other firm. States often trade with more than one other state. Similarly, countries can have multiple allies. Moreover, the number of partners can vary greatly. Some will have none. Others will have many. This property is called multiplexity. Graphically, this is represented by hub-and-spoke structures. For example, in 1816 the United Kingdom (UKG) had five alliance relationships: with Sweden (SWD), Portugal (POR), Russia (RUS), Austria-Hungary (AUH), and Germany (GMY).

Multiplexity is important for two reason. First, its presence indicates that not all alliance relationships are independent and autonomous. This is because many relationships include the same partners (e.g., the five alliance relations involving the United Kingdom). However, measures of the strength of a relation (e.g., alliance credibility) that focus solely on pair-wise relations can neither see nor incorporate such information. Second, as the number of countries with multiple allies increases, the chance of observing countries with common or overlapping partners also increases. When this occurs, the structural component of relational strength plays a greater role. This is because one might argue that, all else being equal, countries with more allies in common will have stronger and more credible alliance relationships than those with fewer or none. This is the basic notion behind the measure of relational similarity discussed in greater detail later on.

Transitivity

Even in the absence of a direct relationship, actors can be indirectly linked to one another through the presence of a third, fourth, or an *n*-th party (i.e., a higher order relationship). Friends, business and trading partners, as well as allies can themselves have their own sets of friends, partners, and allies. Called transitivity, this is captured graphically by daisy-chain structures.[8] These structures exist whenever two countries are connected by at least two alliances (i.e., lines) and at least one intermediary country. For example, while Sweden (SWD) does not have an alliance (i.e., a direct alliance relationship) with Tuscany (TUS), the two are indirectly linked via the United Kingdom (UKG) and Austria-Hungary (AUH).

Transitivity is important because while the ally of an ally is not literally an ally, a distant relation, regardless of how distant, is not equivalent to the absence of a relation. It may be less relevant and thus should be given less credit. However, it is clearly not irrelevant and should not be treated as such. That said, there are two ways of looking at transitive relationships. On the one hand, distant transitively related countries represent potential opportunities for the formation of new alliances. On the other hand, indirect relationships represent lost opportunities because tensions and animosities may have prevented them from becoming direct relationships. Regardless, all else being equal and based solely on information about alliance formation behavior, the potential for transitively related countries will be greater than for nations which have no relationship whatsoever. For this reason, a measure of relational strength which overlooks transitivity can underestimate the strength of relationships.

Clustering

Actors can end up as members of mutually exclusive sets or families of directly and indirectly related countries. This is called clustering.[9] In Figure 1, there are two clusters: the smaller one consists of Spain (SPN) and the Netherlands (NTH); the larger one consists of the other fourteen countries. The existence of clusters is important because they determine which countries are related and which are not. All countries within the same cluster will be directly or indirectly related to one another. Only countries residing in different clusters will be completely unrelated. For example, while Sweden (SWD) and Sicily (SIC) are three links or degrees of separation apart in Figure 1, since they reside in the same cluster they will have more in common than will Sweden (SWD) and Spain (SPN) who reside in different clusters and are completely unrelated. To accurately identify clusters, one needs to map out the entire network of relations, as illustrated in Figure 1, and identify all directly and indirectly related countries. This means identifying clusters endogenously, based on evidence and data rather than in an a priori fashion (e.g., limiting one's analysis only to shared third-parties). Anything less will be needlessly myopic and will negatively affect one's measure of relational strength (e.g., alliance credibility).

Relational similarity

To deal with the limitations and problems associated with a focus on individual relationships and with the oversight of the effects of the network structure of alliance relations, a measure of alliance credibility called relational similarity is constructed. Its conceptualization begins with the insight behind the measure known as alliance portfolio similarity: the more similar are countries' lists of allies, the more similar are their security interests.[10] Applying this idea to the issue of alliance credibility, the expectation is that alliances formed by countries with similar security interests will be more credible than those formed by countries with less similar interests. All else being equal, this should enhance deterrence and reduce the amount of militarized conflict experienced by those countries. The empirical benefits of such conceptualization are two-fold. First, by comparing lists of allies, it measures

credibility using information from multiple observations rather than from single observations. Second, it allows one to capture the effect that aggregate structure can have on individual relationships. In this way, relational similarity better exploits the information contained in the data on military alliances than do existing measures.

Implementing this conceptualization is a two-step process. The first step is to compute the first-order similarities of countries' lists of alliance partners. In terms of Table 2, this entails comparing each pair of rows (or equivalently, each pair of columns). This raises the question of what the definition of similarity should be. There are two basic notions of similarity: symmetric and asymmetric. Symmetric similarity gives credit to both a common presence (i.e., positive match) and a common absence (i.e., negative match) of an ally or partner. Asymmetric similarity gives credit only to a common presence. In terms of Table 2, when comparing rows (i.e., two countries' lists of allies), a common presence is indicated by the presence of two non-zero elements for a given column (i.e., would-be ally). For example, comparing the first two rows (i.e., alliance lists), one sees that both Austria-Hungary (AUH) and Baden (BAD) were in an alliance relationship with Württemberg (WRT). In contrast, a common absence is indicated by the presence of two zeroes for a given column (i.e., would-be ally). For example, one sees that neither Austria-Hungary (AUH) nor Baden (BAD) were in an alliance relationship with the Netherlands (NTH).

In this article an asymmetric definition of similarity is used in the construction of relational similarity. Looking again at Table 2 one can see why. If one compares the last two rows, one can see that the while the United Kingdom (UKG) and Württemberg (WRT) are not directly allied with one another, they do share two alliance partners: Austria-Hungary (AUH) and Prussia (GMY). Thus, there are two positive matches. There are also four negative matches, namely with the Netherlands (NTH), Sicily (SIC), Spain (SPN), and Tuscany (TUS). Thus, whether or not to use symmetric or asymmetric similarity depends on whether one should give credit to the fact that neither the United Kingdom nor Württemberg have an alliance with those four countries. While it is possible that the United Kingdom and Württemberg did indeed have a shared enmity toward those nations, it is not something one can infer from the alliance data. After all, there are many reasons in addition to antagonism that two countries are not allies (e.g., informal alliance, irrelevance). This is one reason why one may not want to give credit to negative matches.[11] Thus, an asymmetric measure of similarity known as the Jaccard coefficient is used here. To adjust for differences in the number of allies, this measure is constructed as a ratio of four basic counts: allies that are common to both countries (A), allies that are unique to the respective countries (B and C), and states that are not allied with either country (D). In the language of similarity, (A) represents the common presence of alliance members (i.e., positive matches) while (D) represents the common absence (i.e., negative matches). The formula for the Jaccard coefficient is (A) ÷ (A + B + C).[12]

The calculation of first-order similarity compares countries' lists of direct allies. But to assess the effect of aggregate structure, one needs to consider all possible

Figure 2: Network relational similarity, 1816.

higher order similarity (e.g., allies' allies). To do that, this article uses agglomerative hierarchical cluster analysis with a single-linkage or nearest-neighbor metric of inter-cluster similarity.[13] Cluster analysis allows one to calculate the degree of relational similarity between all pairs of states be they directly, indirectly, or completely unrelated to one another. In essence, cluster analysis maps out the entire network of relations and then imposes a metric of similarity. One can visualize the results in the form of a dendrogram, a kind of family tree (Figure 2). As indicated by the vertical scale, countries with the highest degree of relational similarity are at the bottom of the graph while those with the lowest are closer to the top. The height of a given horizontal branch represents the degree of relational similarity among all countries at that height. For example, the relational similarity between Tuscany (TUS) and Sicily (SIC) is 0.33. This is somewhat low and consistent with the image in Figure 1. Clusters which have a dissimilarity score of 0 have a have no common members. They are separate components with mutually exclusive sets of members. Thus in Figure 2, and consistent with what one observes in Figure 1, there are two components: a small one consisting of the pair of the Netherlands (NTH) and Spain (SPN), and a large one consisting of fourteen countries.

Analysis

Even if one were to accept that greater attention to network structure can better reflect the data of alliance relations and can better measure the commitment and credibility of alliance relations, the question remains as to whether relational similarity produces significantly different results than existing measures. To see whether this is the case, negative binomial models of count data are employed to compare the effects of relational similarity and the two basic bilateral measures of the strength and credibility of alliance relations—Nominal Alliance Commitment and an Alliance Dummy—on the number of interstate conflicts. Nominal Alliance Commitment[14] measures the nominal depth of commitment while Alliance Dummy simply records the presence or absence of an alliance relationship.

The unit of observation is the pair-combination, or undirected dyad. This means looking at all possible pairs of countries without regard to order (i.e., AB = BA). To measure conflict, one counts the number of militarized interstate disputes involving the pair.[15] This means counting all instances in which either country in the pair found itself in a militarized dispute, not just instances of conflict within the pair. To minimize confounding between the incidence and duration of a conflict, observations that occur after the onset of a militarized dispute are excluded.

The general expectation is that alliances reduce the number of observed instances of interstate conflict for countries in alliance. For measures of commitment, nominal or relational, the expectation is that the greater the commitment, the greater the credibility of the alliance. This, in turn, should increase the chance that deterrence will succeed and consequently decrease the number of observed conflicts. As additional controls the following variables were included. Lower Democracy and Higher Democracy record the "democraticness" of countries as measured by their regime-type score taken from the Polity IV data set.[16] The former is the lower polity score in the pair (i.e., the "weakest link") while the latter is the higher. They were included to address the claims of the democratic peace hypothesis which essentially argues that democracy reduces interstate conflict. A variable called Log Power Ratio is included to control for differences in power as measured by material capability.[17] To control for neighborhood effects—that wars and conflict often occurs among neighbors—Geographic Contiguity indicates whether the pair is geographically contiguous, be they physically contiguity or cross-water (i.e., less than or equal to 500 miles). Finally, to control for the size of the international system, the Number of Countries was also included.

Relational similarity itself is not a simple substitute for bilateral measures. Partly due to the costly signaling interpretation of alliances (in which existence alone is said to be significant) and partly due to transitivity (two countries can have some degree of relational similarity without being direct allies), one needs to examine the interaction between the existence of an alliance and countries' relational similarity. This means to simultaneously include a measure for the existence of an alliance relationship, Alliance Dummy, Relational Similarity, and the interaction of the two, as measured by the product of Alliance Dummy x Relational Similarity. When all three measures are included, the two meaningful things to look for are the coefficient for Relational Similarity and that of the interaction term.[18] The former measures the effect of relational similarity when states are not directly allied. The latter measures the effect of relational similarity when states are directly allied with one another.

There are three key empirical findings. First, the two bilateral measures, in models (1) and (2) have positive, significant coefficients. While contrary to expectations,

Table 3: Negative binominal regression: relational similarity and militarized disputes

	(1)	(2)	(3)
Intercept	-0.5942	-0.5959	-0.4267
	(0.017)	(0.017)	(0.018)
Lower democracy	-0.0032	-0.0042	-0.0043
	(0.001)	(0.001)	(0.001)
Higher democracy	0.0167	0.0163	0.0141
	(0.001)	(0.001)	(0.001)
Log power ratio	0.1634	0.1633	0.1346
	(0.003)	(0.003)	(0.003)
Geographic contiguity	0.4056	0.3886	0.4532
	(0.017)	(0.017)	(0.017)
Number of countries	-0.0021	-0.0022	-0.0019
	(0.000)	(0.000)	(0.000)
Nominal alliance commitment	0.1248		
	(0.003)		
Alliance dummy (AD)		0.4668	2.1842
		(0.011)	(0.033)
Relational similarity (RS)			-0.7284
			(0.037)
RSxAD			-1.5752
			(0.051)
Prediction error	3.202	3.199	3.165
Prediction error ratio	1	0.999	0.988
Number of observations	288,705	288,705	288,705

Note: All coefficients are statistically significant at the conventional levels; $p \leq 0.01$. Standard errors are given in parentheses.

other scholars have found this as well; perhaps nations at greater risk for conflict tend to seek allies in the first place. Second, the coefficients for both relational similarity alone and for the interaction between relational similarity and the existence of an alliance are negative and significant. This is consistent with the expectation of an alliance effect. Interestingly, the significance of relational similarity alone means that common interests or informal alignment can also reduce conflict even in the absence of a formal alliance. Third, not only are the results with relational similarity different from those of the standard bilateral measures, they also better explain the observed pattern of militarized interstate dispute. This can be seen in the lower prediction error for model (3) as compared to models (1) and (2). The prediction error is computed by comparing the ability of the different models to predict out-of-sample. This is done by dividing the data into subsets, using one subset to create estimates of the effect of alliance strength and credibility, and then comparing the resulting estimates' ability to explain the untouched subsets. A three-fold cross-validation method was used to compute the prediction error.

Conclusion

If alliance relations have a network structure then bilateral measures of alliance relations can lead to misleading inferences. To address this, a measure of relational similarity is constructed that incorporates network structures and properties. It is found that inclusion of such a measure leads to significantly and systematically different results than those obtained with standard bilateral measures and that better explains observed patterns of interstate conflict than do standard measures.

The value of mapping out the entire network of countries' alliance relations and then measuring the similarity of states' alliance relations is not just important in theory. From a practical and policy perspective, such an exercise is equally important. Knowing the identity of indirectly linked countries (i.e., distant relations) can help leaders to make new and more effective allies. Moreover, such countries will also be more likely to join an ongoing conflict on the same side. Neither is just some abstraction. There is something to be said about the idea that this is how diplomats, businessmen, and people often actually do, if not should, think. For alliances, diplomats and generals need to know the likelihood that their own allies or those of their opponents will actually come to their aid as promised. They also need to know how likely it is that those on the sidelines will possibly join the fray as well as on whose side.[19] For firms, knowing which partners have more or fewer options for partners, or finding potential new and more compatible partners, requires having information about existing business relations and can increase opportunities for greater profits or market share.

Notes

Peter M. Li is a Political Scientist (Ph.D., UCLA). He may be reached at lindbrook@gmail.com.

1. One observation and one point of clarification are in order. First, instead of just looking at single roles (e.g., friendships) one could just as easily assess the overall strength of the relations by looking at multiple roles. For example, people who have the same set of friends and who belong to the same clubs are closer than those who only have the same set of friends. Second, this notion of relational similarity is different from that of equivalence as used in social network analysis (e.g., Wasserman and Faust, 1994; Hanneman and Riddle, 2005). Equivalence measures the similarity of actors' relationships regardless of the identity of their partners. Equivalence looks for actors who have similar patterns in terms of the roles they play. As such, they may not necessarily have any direct contact or partners in common. For example, uncles are equivalent but they need not have nieces or nephews in common. With relational similarity the focus is more on the partners, while with equivalence the focus is on the roles.

2. The two major data sources are the Correlates of War Alliance Data Set (COW) (Gibler and Sarkees, 2004) and the Alliance Treaty Obligations and Provisions (ATOP) project (Leeds, *et al.* 2002; http://atop.rice.edu/). Except as noted, the article uses the ATOP data because it provides a more complete census of alliances.

3. The importance of credibility in explaining how alliances work comes from the theory of costly signaling (e.g., Schelling, 1960; Spence, 1973; Smith and Harper, 2003). According to this theory, the existence of common interest between would-be allies alone may not be enough to deter opponents. First, despite their common interests, they may not actually come to one another's aid. Second, despite their statements or promises to the contrary, countries may actually be bluffing. For this reason, to convince opponents, countries formalize a commonality of interests as an alliance. This formalization imposes costs on the allies: it cuts off their options vis-à-vis other potential partners, puts their reputations on the line, and imposes sunk costs (e.g., coordination of military strategies). The benefit of paying such additional costs, even for "honest" countries, is that those costs make the alliance credible. The expectation is that only those willing to honor their commitments will be the ones that will be willing to pay the costs associated with alliance formation. In essence, the costs of alliance formation separate the committed from the uncommitted. In this way, an alliance becomes a credible signal that reliably indicates the commitment of its members and which, consequently, deters opponents and reassures partners.

4. For instance, Leeds, *et al*. (2002); Gibler and Sarkees (2004).

5. The data is only for defensive alliances and come from the Correlates of War Alliance Data Set. The country codes and countries are as follows: AUH Austria-Hungary; BAD Baden; BAV Bavaria; GMY Germany/Prussia; HSE Hesse Electoral; HSG Hesse Grand Ducal; NTH Netherlands; POR Portugal; RUS Russia; SAX Saxony; SIC Sicily; SPN Spain; SWD Sweden; TUS Tuscany; UKG United Kingdom; and WRT Württemberg.

6. In the language of social network analysis, one transforms two-mode data about the relationships between alliances and countries into one-mode data about the relationships among countries. The transpose is a transformation that exchanges rows with columns.

7. For the sake of illustration, only information about the existence of an alliance relationship (i.e., values greater than zero) rather than the number of relationships (i.e., the actual values) is used. However, if one wanted, one could graph separate lines for each number of alliance relations. Also, one could use lines of different widths to indicate differences in nominal commitment. The layout is determined by Fruchterman and Reingold's force-directed placement algorithm as implemented in Carter T. Butts's "sna" library, Version 2.0-1, for R.

8. The article defines multiplexity as being mutually exclusive of transitivity. The former includes only direct relations. For the case of military alliances, multiplexity includes only the set of nations with which a state has an alliance. Such nations are one degree of separation apart (i.e., a hub and its spokes). Transitivity includes only indirect relations. Transitive relations are the set of nations with which one's allies, but not oneself, has a formal alliance. Such nations are two or more degrees of separation apart (i.e., links in daisy chain). While transitively related states are not literally allies, they are still "related." Thus, they have some similar security interests. Thus, the notion of transitivity is one of indirect transitivity (e.g. if A is related to B and B is related to C then A is related to C). The situation of direct transitivity (e.g., if A is allied with B and B allied with C, then A is allied with C) applies if and only if all three nations have direct alliance relations with one another. However, such closed transitive relations are, in the terminology of this article, captured by the notion of multiplexity.

9. In social network analysis and graph theory, such clusters are called components.

10. Wallace (1973); Bueno de Mesquita (1975); Signorino and Ritter (1989).

11. Another reason concerns the relative balance between positive and negative matches. When negative matches significantly outnumber positive ones, one's measure is dominated and potentially inflated by the weight of zeros or the absence of relationships.

12. The basic measure of symmetric similarity is the matching coefficient: $(A + D) \div (A + B + C + D)$.

13. Kaufman and Rousseeuw, 1990; Everitt and Rabe-Hesketh, 1997. The single-linkage metric is sometimes called the "friends of friends" clustering strategy.

14. In the ATOP alliance data set, five categories of commitment are recorded: offense, defense, neutrality, non-aggression, and consultation. To test the hypothesized deterrent effect of alliance, information about offensive commitments are excluded. The remaining four categories were weighted in order of the depth of commitment from a high of "4" for defensive commitments to a low of "1" for consultation. Then, the highest observed commitment is recorded as the nominal commitment.

15. See Jones, Bremer, and Singer (1996).

16. Marshall and Jaggers (2002).

17. Measures of material capability are based on the Composite Index of National Capability (CINC) scores from the Correlates of War data set (v3.02) (Singer, Bremer, and Stuckey, 1972). The CINC score is the average of each state's share of material power across six separate categories: total population, urban population, iron and steel production, energy consumption, military personnel, and military expenditure. For a given pair of countries, the Ratio of Power is the natural logarithm of the quotient of the higher CINC score divided by the lower CINC score.

18. Braumoller (2004).

19. Of course, indirect relationships may not be missed opportunities but dead ends. The absence of a direct alliance may be the result of irresolvable tension, if not animosity. Generally speaking, however, being indirectly connected (i.e., being in the same cluster), means that there is will be greater potential for a strong and credible alliance than there will be if there were no relationship whatsoever (i.e., being in different clusters).

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