Alliances, Perceptions, and International Politics*

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Abstract
Much of international behavior can be understood as attempts by asymmetrically informed states or other actors to influence the perceptions of partners or competitors. It follows that the value in seeking to alter perceptions varies with actors’ initial beliefs. Rational expectations and intangibility make it difficult to distinguish the impact of perceptions from interests or material variables. Here, I examine a context where perceptions appear to matter empirically. I offer two versions of a formal model of alliance formation, one in which potential attackers are ignorant about attributes of individual defenders, but possess information about the distribution of defender preferences, and a second model in which potential attackers possess “noisy” information about individual defenders. Noisy information reflects a middle ground between full information and asymmetric information models in which actors often lack a history of play. Consistent with the noisy information hypothesis, Logit and GAM estimates report a non-linear relationship between state interests and alliance formation. Results also appear to support the broader informational approach.

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1
1 Introduction

Developments in the study of international relations emphasize the role of informational asymmetries in generating strategic behavior. Perceptions guide bargaining and decision making in an uncertain world, providing states and other actors with incentives to manipulate the perceptions of partners or competitors. This informational approach provides powerful insights about international affairs, but current formulations are also essentially ahistorical. States are treated as if they have yet to interact in precisely the manner described in informational models. Rather than simple uncertainty, it may be more appropriate to characterize perceptions as “noisy.” Prior interaction leaves actors with perceptions of particular counterparts that condition subsequent interaction, perceptions that contain information as well as ignorance. The degree to which actors benefit from altering the perceptions of partners or competitors then depends on the content of these ex ante beliefs.\(^1\)

Here, I offer an initial review of the conditions under which heterogeneous prior perceptions influence interstate interaction. I show that a modest elaboration of the conventional treatment of perceptions is capable of enriching empirical predictions drawn from formal models of international politics.\(^2\) The lack of attention to initial beliefs in informational arguments can be traced to the way that rational theory treats perceptions and to an implicit assumption that actors share homogenous, rather than actor-specific, perceptions. Rational expectations mean that perceptions simply mimic interests and material variables in large samples. Similarly, when states are assumed to share the same perceptions, then the incentives to signal are generally monotonic in the value of variables for which information is asymmetric. Broadly, assuming homogenous perceptions implies that history does not matter much in the conduct of international affairs. If instead, a heterogeneous history of play provides states with beliefs about particular counterparts, then the impact of interests or material variables may be non-monotonic while the role of history in international affairs is larger than existing arguments imply.

I use alliance theory as the basis for a discussion of the salience of different assumptions about ex ante beliefs. Realist accounts see states as choosing alliance partners to “balance” opposing coalitions by aggregating military

\(^1\)I use the terms “perceptions” and “beliefs” interchangeably.

\(^2\)Reputation implies that states share common conjecture perceptions about actors or events [28] [33]. Game theory requires that actors that share the same history of play possess the same equilibrium beliefs, but states are likely to differ in their interactions.
capabilities. Other research points to shortcomings in capability aggregation theories, and instead conceives of alliances as partnerships of states with common or complementary interests (c.f. [9] [10] [25]). Put succinctly, “friends” co-ally [43, page 416]. This rationale for alliance behavior is in turn incomplete unless alliances operate independently of ex ante perceptions. Fearon [13] notes that alliances address commitment and/or credibility problems by signaling resolve (“sunk costs”) or by augmenting incentives to intervene (“tying hands”). As signals, alliances inform observers about the likelihood that states will act in concert in a crisis. Yet, international actors with a history of interaction are bound to possess prior beliefs about the propensities of other actors. States perceived as having common interests are more likely to be expected to cooperate. “Friends” have less need to manipulate perceptions precisely because existing perceptions are relatively beneficial. If alliances signal intent, then it is not just affinity, but the disparity between perceived and actual interests that leads states to ally. Treating alliances as a response to perceptions, rather than as a consequence of preferences implies a non-linear relationship between affinity and the probability of alliance formation. Similar interests encourage states to act in concert while ex ante beliefs about similar interests reduce the need to signal.

The paper seeks to make three contributions. First, it refines and extends the logical claims of informational theories. Second, the argument as it is applied to alliance theory yields predictions that serve as tests of the specific claims of the study and further assess the validity of the informational approach. The hypothesis of a non-linear relationship between state affinity and the probability of alliance formation is counterintuitive and, I believe, novel. Third, the study may further integrate rationalist explanations with insights from political psychology. In the sections that follow, I review portions of the literature on signaling and alliances. I then discuss the role of perceptions in international politics and illustrate the effect of prior beliefs in the context of alliance decision making. Next, I present two asymmetric information alliance models with, and without, heterogeneous prior beliefs. I conduct tests of the main empirical prediction distinguishing the two models using a variety of data and methods. After reporting the results, I offer conclusions about implications of the study for alliance research, for informational theories, and for international relations in general.

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3Fearon also argues that states with similar interests co-ally [13, page ***].
4I discuss the relationship between rationality and psychology only briefly. See [18].
2 Literature

*How do perceptions influence the conduct of international affairs?* Answers to this question vary depending on context and theoretical perspective. The role of perceptions in international politics is a subject of diverse inquiry. A comprehensive review of the literature is beyond the scope of this study. Instead, I focus on summarizing major approaches to the topic and also review relevant aspects of the alliance literature.

2.1 Perceptions in International Politics

Perceptions are commonly treated in one of three ways in the study of international relations. First, researchers can essentially ignore perceptions. Realists and others point out that there are strong incentives for key actors to respond objectively to preferences (realists assume undifferentiated interests) or to environmental conditions, such as power.\(^5\) If perceptions are largely correct, then trying to characterize perceptions constitutes an extraneous step in a logic of state behavior [47] [48]. A second approach is to treat perceptions as pathological. Psychological explanations for the behavior of international leaders emphasize leader misperception, often as the result of motivated bias, etc. (c.f. [17] [20]). Most of the evidence provided in support of misperception arguments is in the form of case studies, evidence that fails to demonstrate whether errors in perception are modal or largely random noise.\(^6\) A third option used in informational game theory is to allow for stochastic misperception. Leaders and other international observers err in their perceptions, but beliefs are assumed to be unbiased. In this conception, discrepancies between perceptions and reality are non-systematic.

As assumptions, each approach has advantages and disadvantages. Obviously, assuming that actors invariably correctly perceive is highly suspect empirically, but it is a convenient simplification and has been defended on parsimony grounds. The assumption of equilibrium bias is perhaps more

\(^5\)The assumption of undifferentiated interests simplifies the characterization of preferences and their role in international affairs. If states all want power or security, then dividing preferences is simple, but also relatively uninformative (A lack of variation makes a constant, and constants do not explain behavior.). Also, misperception should be relatively rare since inferences about motives are as easy for statesmen as for scholars.

\(^6\)Lebow notes of misperception that, "...nobody has been able to provide a clear, empirically useful and generally accepted definition of the concept" [20, page 90].
defensible empirically, but it too seems to be an exaggerated representation of reality. After all, why should researchers believe in their own perceptions if they judge those of others with such disdain? In practice, the division of loyalties between approaches seems to come down to subject matter and personal taste, with each side treating alternative assumptions as caricatures. Clearly, leaders misperceive, but just as clearly, they seek not to. Whether misperception occurs in equilibrium (whether it is behavior that will appear as systematic in quantitative studies) is largely unanswerable (one cannot observe perceptions, only the products of their use). On balance, the appeal of the third approach is that it allows for both possibilities, while facilitating positivist objectives of prediction and empirical evaluation.

2.2 Models of Alliance Formation

A logic of alliance formation is a key dynamic of theories of international politics.\(^7\) According to Waltz, alliances are attempts to form “balances of power” [48, page 125]. States seek to affect structural stability by switching alliances to balance one coalition or another [48, page 163] and to permit states to pool military resources to counter other states or alliances [48, page 170]. Walt [46] sees states as focusing on threats rather than on capabilities. States ally to “balance” against threats or they “bandwagon,” allying with states that constitute threats in the absence of an alliance. Bandwagoning joins states with different interests. Christensen and Snyder [8] extend Walt’s theory, asserting that alliances are intended to counter threats. In an analysis of the pre-World War I and pre-World War II periods, they find that a perceived offensive advantage led to balancing, while a perceived defensive advantage lead to attempts to pass burdens to others.

Other research broadens the study of alliance choice beyond capability aggregation. Altfeld [2] and Morrow [25] offer models of alliance formation that explain alliances as tradeoffs between security and autonomy. Altfeld describes alliances as imposing opportunity costs in the form of wealth or autonomy. He also notes the limited value of alliances as mechanisms of security aggregation for capable states. Morrow claims that asymmetric alliances (those between security-seeking and autonomy-seeking states) are easier to form and are more durable than symmetric alliances. Morrow shows that most alliances form between militarily weak and strong states and that such

\(^7\)This review is abbreviated. See, Holsti, Hopmann, and Sullivan [16].
alliances last longer than alliances involving symmetric capabilities.

Smith [43] takes issue with previous research that claims that alliances are unreliable (c.f. [32]). He argues that potential aggressors probably access the reliability of states’ allies when considering an attack. Reliable allies discourage aggression while unreliable partners do not. Tests of alliance reliability using data on disputes or wars involving alliances probably over represent alliance failures. Smith [43], following Bueno de Mesquita [6], claims that alliances form between states with similar preferences. He and others (c.f. [26], argue that alliances are costly so that states ally only when they possess mutual interests. Yet, states considering aggression are likely to evaluate the odds that a victim will receive assistance from any quarter, allied or not.

Sorokin [44] offers a constrained-optimization model of the decisions that states make in mixing arms and alliances. He emphasizes tradeoffs in terms of capabilities and autonomy [44, page 424]. Sorokin tests his model on four monadic cases (pre-World War I France and Austria-Hungary, and 1963-1988 Syria and Israel) and concludes that states consider alliance tightness when making decisions about arms versus allies [44, page 444]. Sorokin documents the need to link alliance formation with other military decisions. Conybeare [9] hypothesizes that states choose alliance “portfolios” to optimize risk and return. Drawing on portfolio diversification theory, Conybeare analyzes the alliance system from 1879 to 1914 and finds support for his hypothesis. “the three most risk averse countries preferred the low-risk, low-return Triple Alliance and the three most risk-acceptant countries chose the Triple Entente with its higher risks and higher returns” [9, page 82]. Conybeare [10] extends this analysis to NATO and the Warsaw Pact and finds that portfolio benefits partially offset the burden of free riding.

3 Discussion

3.1 Goldie Locks and the Three Rationalist Approaches to Perceptions in International Politics

The treatment of information in formal (rational) models of international politics is analogous to the problem of Goldie Locks and the Three Bears. Early game theoretic models assumed that actors were fully informed about all relevant aspects of their interaction. In addition to being unrealistic, full information models precluded use of uncertainty is a causal factor in interna-
tional behavior (too hot). Asymmetric information models allow actors to be uncertain about salient characteristics of partners or competitors. This is a significant advantage in conceptualizing international behavior, particularly since researchers are becoming increasingly aware that information itself is a determinant of interstate conflict [12]. Yet, in many asymmetric information models in international politics, states are assumed to treat partners and competitors as largely unknown entities. Actors in asymmetric information models have beliefs represented as probability distributions over unknown values of strategic variables. Actors are treated as if they are largely ignorant about key features of particular counterparts. This assumption is in turn unrealistic to the degree that it represents excessive uncertainty (too cold). In actuality, states are bound to accumulate perceptions from previous interactions with specific partners or competitors. Asymmetric information models themselves imply that this must be so, as states must become better informed through repeated interactions of the type characterized in informational arguments. Through a history of play states are likely to create heterogeneous perceptions tailored to specific counterparts (just right?).

Dealing with perceptions is not easy, and in many contexts, it may not even be particularly useful. Assuming away past interactions vastly simplifies one’s theoretical model. It may also be defended on theoretical grounds. An obvious simplifying step is to treat the beliefs of actors as a summary of previous interactions. Rationality requires that perceptions be correct in equilibrium. Beliefs must generally be consistent with past behavior, though they can err in particular instances. Yet, if perceptions faithfully (if somewhat noisily) represent reality, why should perceptions be analytically interesting? In equilibrium, the stochastic component of beliefs must be randomly distributed about the “true” value while the non-stochastic component simply mirrors actual situational variables. Given these circumstances, it is natural for researchers to concentrate on the dynamic process of informational change (through signaling, etc.) and to ignore ex ante beliefs.

The treatment of uncertainty in rational theory means that the net effect of stochastic beliefs will themselves be stochastic, at least in many contexts. A standard way to treat ex ante perceptions in informational models is to have one actor be ignorant about a strategic attribute of another actor in the game. The sequence of play then affords the asymmetrically informed actor an opportunity to reduce the uncertainty of its counterpart through separating behavior (making a “cheap talk” statement, or taking some costly action such as committing troops in a deterrence model or forming an alliance).
Yet, the value for the asymmetrically informed actor in seeking to manipulate the beliefs of an uninformed counterpart depends on the nature of the ex ante beliefs of the uninformed player. If players all have uniform ex ante perceptions, regardless of context and competitor, or if the asymmetrically informed player is uninformed about the perceptions of the uninformed counterpart, then there is no need to explore further. If instead, it is reasonable to assume that players possess heterogeneous perceptions due to dyadic variation in the history of play, and if the asymmetrically informed player can be said to have some knowledge of the uninformed player’s ex ante beliefs, then whether the informed player benefits from signaling or not depends at least in part on the content of the uninformed player’s ex ante perceptions.

I next turn to alliance formation to discuss the effect of noisy informational environments in a more concrete context. I should emphasize that the effects of noisy information are likely to matter in any situation where behavior is primarily intended to influence beliefs, not just relative to alliances. Whether a state engages in costly signaling behavior depends on what it knows of other actors’ beliefs, and on the cost and likely impact of the signal. If observers already possess perceptions that benefit the objectives of a given state, then the value in acting to influence beliefs must be less than if the target possesses beliefs harmful to the sender’s interests.

### 3.2 Perceptions in the Context of Alliances

An important function of military alliances is communication. They reassure partners and warn adversaries. Two aspects of the alliance mechanism facilitate communication.\(^8\) Alliances can “tie hands” or “sink costs” [13]. “Tying hands” addresses the commitment problem states face in seeking to deter aggression when allies have \textit{ex post} incentives to abandon their partners. Alliances bind states \textit{ex ante} to costly behaviors \textit{ex post} by linking a failure to intervene to censure by domestic or international audiences. Alliances can also “sink costs.” The added cost of formal institutions signals the willingness of states to protect partners. Sinking costs addresses the credibility problem posed when states seek to communicate information about common interests [13]. Fearon shows that sinking costs is the less effective of the two methods. Sunk costs signal credibility but do not alter the subsequent incentives of alliance members. Fearon argues that states typically prefer tying

\(^8\)These two aspects may coincide, occurring in the same alliance.
hands, since ex post consequences serve both as a signal and as an inducement to cooperate. However, the relative merits of the two approaches may not be uniform. The value of “tying hands” or “sinking costs” depends in part on the nature of the problem for which alliance is the remedy. “Friends”—states with similar worldviews—with limited capabilities may find that tying hands provides additional incentives to overcome the commitment problem. States perceived to be lacking “friendship” may be more willing to sink costs.

This logic can be extended to a general explanation of alliance behavior. States believed to possess both common interests and abundant capabilities should be less willing to sink costs or tie hands. It is not enough that states are “friends” or that they have motives to cooperate. States can cooperate informally. Alliances are needed when informal alignments prove inadequate, where doubt exists about the credibility of an alignment or the commitment of states to intervene. Alliances prove useful where states need additional institutional assistance to warn or reassure. If friends and foes alike acknowledge the intentions of states to protect one another—in other words, if an alignment is common conjecture—then an alliance is redundant.9 The United States and Israel—often referred to as “allies”—have no such formal commitment. One reason that the two countries have no alliance is that the international community widely perceives that the United States has incentives to protect Israel in the event of direct military challenge.

3.3 Reputation

Reputation costs are commonly used to motivate alliances [26]. States use alliances to link themselves and their reputations to one another. Failure to come to a partner’s aid leaves a defecting state with a reputation as an unreliable partner. A state branded as unreliable in turn has greater difficulty securing future international objectives through verbal commitments alone. Some states may thus come to the assistance of partners in spite of unilateral incentives not to intervene because they fear a damaged reputation. The argument is persuasive, but it is not clear why an alliance is assumed to be the only means by which states link reputation to certain actions. States often appear to find that their reputations are tied to intervention, even without a formal commitment. States frequently make informal promises

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9Nuclear deterrence seems to require formal commitment. Protecting partners in the face of mutual assured destruction involves substantial credibility problems [34] [35].
that appear to be believed by other states [33]. Additional measures are needed when a simple verbal commitment is unlikely to be believed.

Parallel incidents surrounding US participation in Korea and the Persian Gulf illustrate the argument. In both cases, the United States had no formal obligation to intervene on behalf of the states subject to attack. In each case there was initially debate, both within the government and among the larger public, about whether intervention was advisable [1] [27]. In both instances, US officials possessed the knowledge that the world community would perceive a failure to intervene as an important marker delimiting US resolve. Two US presidents in different domestic political contexts found it necessary to protect states that were not allies. The world community perceived that the United States perceived that intervention was in its interest. Failure to intervene would not only yield undesirable material consequences, but would also damage the country’s reputation for acting in its own interests.

It may be argued that the United States, South Korea and Kuwait could have benefited from formal alliance commitments. It is also possible that North Korea and Iraq would have attacked anyway. Discerning the true nature of relationships through counterfactuals is not at issue here. In both cases informal security agreements were judged sufficient precisely because all actors concerned—including the eventual attackers—believed that the United States had unilateral incentives to intervene. It was not until North Korea and Iraq were given new information suggesting that the United States was not willing to protect South Korea and Kuwait that attacks occurred. If alliances serve to reassure friends and warn adversaries, then alliances are most desirable when friends or adversaries are most in doubt.

Smith [43] and others argue that alliances occur between “friends,” states with similar preferences. If alliances involve some non-zero cost, then only states with similar security interests will pay to ally. Yet, this contention is in some tension with the logic of signaling through alliances. Potential aggressors should have beliefs about whether certain states will assist one another, whether or not these states ally. States with similar interests may be more likely to protect one another, but if this proposition can be deduced by social scientists, it should also be available to states. The tendency for states

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10Statements from US officials may have triggered each attack [24, pages 69,247–250].

11Smith describes alliances as contracts between “friends” [43, pages 416–418] with “common preferences” [43, page 416] or with “a commonality of international preferences” [43, page 419]. “If C’s policy preferences are closer to nation A’s than to nation B’s then nation C is friends with nation A” [43, page 411].
with similar worldviews to protect one another is then common conjecture. Since alliances are more expensive than alignments, alliances will be more valuable when intervention is in doubt. It is with states that would not normally be expected to protect each other that alliances prove their greatest worth. I explore this argument and its implications formally in the next section to better and more fully demonstrate these deductions.

4 The Model

This section formalizes aspects of the argument presented above. The models are approximations of reality intended only to reinforce the plausibility of earlier claims and to illustrate some of the less intuitive implications. I present two models—one with asymmetric information and a second model with “noisy” information. Potential attackers do not always realize the portent of alignments.\(^{12}\) By formalizing a commitment to intervene, states supply international observers with information about their willingness to fight. While the argument implies uncertainty about states’ utility functions, the question is really how much uncertainty exists. The standard way of representing uncertainty in game theory is to model actors as being unable to identify opponent “types.” This is almost as implausible as assuming that states are fully informed. States in the empirical world obviously possess some (more or less imprecise) information about their opponent’s preferences.

Most elements are common to both models. There are four actors. Player \(A\) is the protector. \(A\) makes the alliance decision (\(a\) “alliance” or \(\sim a\) “no alliance”). \(A\) also decides whether to intervene (\(i\)) or not (\(\sim i\)) if player \(B\) is attacked. Player \(B\) is the potential ally. \(B\) can also make an alliance decision, but \(B\)’s decision is redundant. There is no equilibrium where \(A\) seeks to ally and \(B\) does not. Further, if \(A\) does not seek to ally, \(B\)’s choice is mute. I simplify the game by making \(B\) a non-strategic actor. Player \(C\) is the potential attacker. \(C\) uses force (\(f\)) or not (\(\sim f\)). The fourth actor, Nature (\(N\)), determines \(A\)’s ideal point. Actors differ over a bundle of excludable issues represented on a single dimension of unit domain (\(x\), where \(0 \leq x \leq 1\)). For tractability and with no loss of generality, I normalize actors’ ideal points so that player \(B\) prefers an outcome of zero (0), \(C\)’s ideal point is one

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\(^{12}\)An informational theory for war argues that states fight when they are asymmetrically informed about strategic variables and possess incentives to bluff [11] [12]. Alliances affect the probability of war if they alter a state’s uncertainty.
(1) and \( \mathbf{A} \)’s ideal point (\( x_A \)) is between zero (0) and one half (\( \frac{1}{2} \)) inclusive (\( x_A \sim U[0, \frac{1}{2}] \)). \( \mathbf{A} \)’s ideal point varies relative to the other two actors, but \( \mathbf{A} \) at least weakly prefers \( \mathbf{B} \)’s ideal point to \( \mathbf{C} \)’s.\(^{13}\) The status quo ante, \( x_{SQ} \), can be located anywhere in the issue space, but to simplify the game, and without loss of generality, I often assume a value of zero (0).

Figure 1 represents the game. First, Nature (\( N \)) assigns player \( \mathbf{A} \) an ideal point at random (\( x_A \sim U[0, \frac{1}{2}] \)). Second, \( \mathbf{A} \) decides whether to ally with \( \mathbf{B} \) (\( a \)) or not (\( \sim a \)). Third, \( \mathbf{C} \) decides to fight \( \mathbf{B} \) (\( f \)) or not (\( \sim f \)). Finally, \( \mathbf{A} \) intervenes (\( i \)) or leaves \( \mathbf{B} \) to fend for itself (\( \sim i \)). I assume that \( \mathbf{C} \) beats \( \mathbf{B} \) if they fight alone but that \( \mathbf{A} \) and \( \mathbf{B} \) together beat \( \mathbf{C} \). Thus, if \( \mathbf{A} \) intervenes after \( \mathbf{C} \) has chosen to fight \( \mathbf{B} \), \( \mathbf{B} \) receives its preferred outcome (0). Otherwise, \( \mathbf{C} \) receives its preferred outcome.\(^{14}\)

If \( \mathbf{A} \) chooses to ally, then both \( \mathbf{A} \) and \( \mathbf{B} \) pay some fee \( c \) (where \( c > 0 \)). Alliance costs reflect the price of start-up and maintenance of alliance activities. The cost of fighting, \( w \) (where \( w > 0 \)), can be different for each actor. Fighting is costly, as is reneging on commitments. \( \mathbf{A} \) pays a price \( r \) (where \( r \geq 0 \)) for abandoning its ally. The price equals the present value of \( \mathbf{A} \)’s loss in reputation if \( \mathbf{A} \) allies but fails to intervene. States must suffer some consequence for reneging on an alliance.

Figure 1 lists players’ payoffs at each terminal node. Payoffs result from placement of an outcome on the issue space and associated costs. Linear loss utility functions appear below:\(^{15}\)

\[
U_A = \left[ \left( -|x - x_A| \right) - iw_A - a \left( c + (1 - i) r \right) \right]
\]

\( (1) \)

\[
U_B = \left[ \left( -x \right) - ac - fw_B \right]
\]

\( (2) \)

\[
U_C = \left[ \left( x - 1 \right) - fw_C \right]
\]

\( (3) \)

Payoffs are obtained by substituting one (1) for affirmative decisions and zero (0) for negative decisions. For example, if player \( \mathbf{A} \) allies (\( a \)) but does

\(^{13}\)For any \( x^* \), (\( \frac{1}{2} \leq x^* < 0 \)), there exists (\( \frac{1}{2} \geq x^{**} > 0 \)) s.t. \( \mathbf{B} \) is indifferent between \( x^* \) and \( x^{**} \) and \( \mathbf{C} \) prefers \( x^{**} \).

\(^{14}\)The contest could be probabilistic, so that intervention by \( \mathbf{A} \) simply improves \( \mathbf{B} \)’s prospects for victory. Results are the same. Also, \( \mathbf{A} \) need not be stronger than either \( \mathbf{B} \) or \( \mathbf{C} \). \( \mathbf{A} \) and \( \mathbf{B} \) need merely exceed \( \mathbf{B} \) alone.

\(^{15}\)O’Neill [30] points out that non-linear utilities in international relations are seldom amenable to empirical evaluation because data is typically ordinal rather than interval.
Figure 1: The Alliance Game.
not intervene (\(\sim i\)) while player \(C\) does not fight, (\(\sim f\)), then (\(a = 1, \ i = 0, \ f = 0\)) or \(U_A = \left[-\left|x - x_A\right| - c\right], \ U_B = \left[-(x - e)\right], \ U_C = \left[(x - 1)\right].\)

4.1 The Alliance Game with Asymmetric Information

Nature (\(N\)) first assigns \(A\) an ideal point (\(0 \leq x_A \leq \frac{1}{2}\)), known only to player \(A\). \(C\) is said to possess beliefs (\(b\)) about \(A\)'s “type.” Beliefs are “common knowledge,” in that \(A\) can decipher \(C\)'s beliefs, \(C\) knows that \(A\) knows, and so on. \(C\) chooses unaware of \(A\)'s ideal point. A perfect Bayesian equilibrium solution requires that players’ strategies be sequentially rational and that players update beliefs using Bayes’ rule where possible.

Players’ strategies and the equilibria for the game are identified through backward induction. Player \(A\) intervenes if the benefit of intervention exceeds war costs (\(w_A\)), (\(x_A < \frac{1}{2}(1 - w_A + r)\), if allied, and \(x_A < \frac{1}{2}(1 - w_A)\), if not). \(C\) knows the rule \(A\) uses to decide whether to intervene (\(i\)), but \(C\) does not know \(A\)'s type (\(x_A\)). Player \(C\) calculates its best response to each potential type of player \(A\) and weighs its actions by the probability of encountering a particular type. The uniform distribution of types means that all types are equally likely. The probably of any behavior is thus just the proportion of types that will choose a given action in a given context. \(C\) fights if its expected utility for fighting exceeds its utility for the status quo, \(U_C^{\text{ff}} < EU_C^{\text{ff}} = U_C^{\text{ff}} \cdot p^i + U_C^{\text{ff}}(1 - p^i)\), where \(p^i\) is the proportion of players’ \(A\) that intercede. \(C\)'s decision rule thus equates to (\(w_C < (1 - x_{SQ}) - p^i\)).

In the no alliance subgame, no type of player \(A\) intervenes if war costs are high (\(w_A \geq 1 \rightarrow i = 0 \forall x_A\)), and all types \(A\) prefer to intervene (\(i = 1\)) if war costs equal zero. The probability that \(C\) encounters a state \(A\) that intervenes if \(0 < w_A < 1\) equals the portion of types \(A\) willing to intervene. In the no alliance subgame, \(C\) expects \(A\) to intervene with probability \(p^i = (1 - w_A), (0 \leq w_A \leq 1)\). \(C\) fights if \(w_C < w_A - x_{SQ}\). However, some types of \(A\) may choose to ally, removing themselves from the sample that confronts \(C\) in the no alliance subgame. \(C\)'s rule appears as Equation (4), where (\(t, 0 \leq t \leq \frac{1}{2}\)) is the type of \(A\) that is just indifferent between allying and not allying. If all types of \(A\) ally, \(C\) fights if \(w_C < w_A - x_{SQ} - r\). Equation (5) describes \(C\)'s decision rule for the alliance subgame.
\[ w_C < (1 - x SQ) - p_{A}^{\alpha,i}, \quad p_{A}^{\alpha,i} = 1 - \left( \frac{w_A}{1 - 2t} \right), \]

s.t. \[ 0 \leq p_{A}^{\alpha,i} \leq 1, \quad 0 \leq t < \frac{1}{2} \]  \hspace{1cm} (4)

\[ w_C < (1 - x SQ) - p_{A}^{\alpha,i}, \quad p_{A}^{\alpha,i} = \left( \frac{1 - w_A + r}{2t} \right), \]

s.t. \[ 0 \leq p_{A}^{\alpha,i} \leq 1, \quad 0 \leq t < \frac{1}{2} \]  \hspace{1cm} (5)

\( A \)'s alliance decision can communicate information to player \( C \). \( A \) allies with \( B \) if \( EU_{A}^{a} > EU_{A}^{a,c} \). Equation (6) describes \( A \)'s alliance calculation where \( A \) prefers allying and where \( p \) is the probability \( C \) does not fight, \( q \) is the probability that \( C \) fights and \( A \) intervenes and \((1-p-q)\) is the probability that \( C \) fights and \( A \) does not intervene \((p \text{ and } q \text{ equal zero or one})\):

\[
\begin{align*}
U_{A}^{a,i} \cdot p^{a} + U_{A}^{a,j,i} \cdot q^{a} + U_{A}^{a,f,i} \cdot (1 - p^{a} - q^{a}) > \\
U_{A}^{\alpha,a,i} \cdot p^{\alpha} + U_{A}^{\alpha,a,j,i} \cdot q^{\alpha} + U_{A}^{\alpha,a,f,i} \cdot (1 - p^{\alpha} - q^{\alpha})
\end{align*}
\]  \hspace{1cm} (6)

Alliance costs mean that \( A \) only allies when there is a positive expected payoff with an alliance. If \( A \) intervenes in both subgames, then \( A \) prefers no alliance, since \( c > 0 \Rightarrow U_{A}^{a,i} < U_{A}^{\alpha,a,i} \forall x_{A}, c, w_{A} \). Three sets of conditions exist in which Equation (6) holds and an alliance is formed:

\[
\begin{align*}
U_{A}^{a,i} > U_{A}^{a,j,i} \Rightarrow (|x_{SQ} - x_{A}| - c) > -x_{A} - w_{A}; \\
\text{if } x_{SQ} \leq x_{A} \Rightarrow c < (x_{SQ} + w_{A}), \\
\text{or if } x_{SQ} > x_{A} \Rightarrow x_{A} > \frac{1}{2} (x_{SQ} - w_{A} + c)
\end{align*}
\]  \hspace{1cm} (7)

\[
\begin{align*}
U_{A}^{a,j,i} > U_{A}^{\alpha,a,j,i} \Rightarrow (-x_{A} - w_{A} - c) > (x_{A} - 1) \Rightarrow x_{A} < \frac{1}{2} (1 - w_{A} - c)
\end{align*}
\]  \hspace{1cm} (8)
\[ U_A^{a_{i}} > U_A^{a_{i}, \sim i} \Rightarrow (- |x_{SQ} - x_A| - c) > (x_A - 1); \]

if \( x_{SQ} \leq x_A \Rightarrow x_A < \frac{1}{2}(1 + x_{SQ} - c), \)

or if \( x_{SQ} > x_A \Rightarrow c < (1 - x_{SQ}) \) \hspace{1cm} (9)

If Equation (7) holds, then \( x_A < \frac{1}{2}(1 - w_A) \) (because of \( U_A^{a_{i}} \)). If \( x_{SQ} \leq x_A \), then \( c < (x_{SQ} + w_A) \). This means that, \( c - x_{SQ} < (1 - w_A) \Rightarrow c - x_{SQ} < (1 - 2x_A) \Rightarrow x_A < \frac{1}{2}(1 + x_{SQ} - c) \). Thus, it is true for all types \( A \) for which \( x_{SQ} \leq x_A \) and \( x_A < \frac{1}{2}(1 - w_A) \), and \( c < (x_{SQ} + w_A) \), that Equation (7) is just a special case of Equation (9). Similarly, Equation (9) is a special case of Equation (7) if \( x_{SQ} > x_A \). \( U_A^{a_{i}, \sim i} \)

implies \( x_A \geq \frac{1}{2}(1 - w_A) \) and \( x_{SQ} > x_A \) and \( U_A^{a_{i}} > U_A^{a_{i}, \sim i} \), implies \( c < (1 - x_{SQ}) \). So, \( c < (1 - x_{SQ}) \Rightarrow 1 > x_{SQ} + c \Rightarrow 1 - w_A > x_{SQ} - w_A + c \), and \( x_A \geq \frac{1}{2}(1 - w_A) \Rightarrow x_A \geq \frac{1}{2}(1 - w_A) \Rightarrow x_A > \frac{1}{2}(x_{SQ} - w_A + c) \). Finally, \( U_A^{a_{i}} > U_A^{a_{i}, \sim i} \) and \( U_A^{a_{i}, \sim i} \) implies \( x_A < \frac{1}{2}(1 - w_A - c) \) but \( U_A^{a_{i}, \sim i} \) implies \( x_A < \frac{1}{2}(1 - w_A) \). Since, by definition, \( (1 - w_A - c) < (1 - w_A) \) \forall c \geq 0 \), there are no values of \( x_A \) such that Equation (8) holds true. For every combination of \( x_{SQ} \) and \( x_A \), there is a unique value of \( x_A (t) \) such that \( A \) is just indifferent between alternative subgames if \( t = \frac{1}{2}(1 + x_{SQ} - c) \) and \( x_{SQ} \leq x_A \) or \( t = \frac{1}{2}(x_{SQ} - w_A + c) \) and \( x_{SQ} > x_A \).\(^{17}\)

### 4.1.1 Players’ Optimal Strategies for Asymmetric Information Variant (B omitted):

\[
\text{Where } t = \frac{1}{2}(1 + x_{SQ} - c) \text{ if } x_{SQ} \leq x_A, \\
\text{and } t = \frac{1}{2}(x_{SQ} - w_A + c) \text{ if } x_{SQ} > x_A, \text{ s.t. } (0 \leq t \leq \frac{1}{2}).
\]

\(^{17}\)The model predicts no equilibrium where \( C \) fights an alliance [Nodes 1 and 2]. This is due to the one-sided asymmetric information (\( A \) knows what \( C \) knows). Two-sided uncertainty adds realism without altering basic insights and vastly increasing complexity.
A: \( a = 1 \) if \((1 - x_{SQ}) - p^a_i \leq w_C < (1 - x_{SQ}) - p^{\sim a}_A,\)
and \( x_A \geq \frac{1}{2} (1 - w_A), \) and \( x_A < (1 - |x_{SQ} - x_A| - c)\)
or if \((1 - x_{SQ}) - p^a_i \leq w_C < (1 - x_{SQ}) - p^{\sim a}_A,\)
and \( x_A < \frac{1}{2} (1 - w_A), \) and \((1 - |x_{SQ} - x_A| - c) > (1 - x_A - w_A)\)
= 0 if else.

\( i = 1 \) if \( a = 1, f = 1, \) and \( w_A < (1 - 2x_A) + r\)
or if \( a = 0, f = 1, \) and \( w_A < (1 - 2x_A)\)
= 0 if else.

C: \( f = 1 \) if \( a = 1, \) and \( w_C < (1 - x_{SQ}) - p^a_i,\)
and where \( p^a_i = \frac{1 - w_A + r}{2t}, \) s.t. \( 0 \leq p^a_i \leq 1\)
or if \( a = 0, \) and \( w_C < (1 - x_{SQ}) - p^{\sim a}_A,\)
and where \( p^{\sim a}_A = 1 - \frac{w_A}{1 - 2t}, \) s.t. \( 0 \leq p^{\sim a}_A \leq 1\)
= 0 if else.

\( b = (x_A | a = 1, x_A \in x \sim U[0, t]) \)
if \((1 - x_{SQ}) - p^a_i \leq w_C < (1 - x_{SQ}) - p^{\sim a}_A\)
= \((x_A | a = 0, x_A \in x \sim U[t, \frac{1}{2}]) \)
if \((1 - x_{SQ}) - p^a_i \leq w_C < (1 - x_{SQ}) - p^{\sim a}_A\)
= \((x_A | a = 0, x_A \in x \sim U[0, \frac{1}{2}]) \) if else.
4.1.2 Equilibria for Asymmetric Information Variant:

[Node 3] if \( x_A \geq \frac{1}{2} (1 - w_A) \), and \( x_A < (1 - |x_{SQ} - x_A| - c) \),
and \( (1 - x_{SQ}) - p_{A}^{a_i} \leq w_C < (1 - x_{SQ}) - p_{A}^{a_i} \)

or if \( x_A < \frac{1}{2} (1 - w_A) \), and \( (- |x_{SQ} - x_A| - c) > (x_A - w_A) \),
and \( (1 - x_{SQ}) - p_{A}^{a_i} \leq w_C < (1 - x_{SQ}) - p_{A}^{a_i} \)

[Node 5] if \( x_A < \frac{1}{2} (1 - w_A) \), and \( w_C < (1 - x_{SQ}) - p_{A}^{a_i} \)

or if \( x_A < \frac{1}{2} (1 - w_A) \), and \( (- |x_{SQ} - x_A| - c) \leq (x_A - w_A) \),
and \( (1 - x_{SQ}) - p_{A}^{a_i} \leq w_C < (1 - x_{SQ}) - p_{A}^{a_i} \)

[Node 6] if \( \frac{1}{2} (1 - w_A) \leq x_A < \frac{1}{2} (1 - w_A + r) \),
and \( w_C < (1 - x_{SQ}) - p_{A}^{a_i} \), and \( x_A \geq (1 - |x_{SQ} - x_A| - c) \)

or if \( x_A \geq \frac{1}{2} (1 - w_A + r) \), and \( w_C < (1 - x_{SQ}) - p_{A}^{a_i} \)

or if \( x_A \geq \frac{1}{2} (1 - w_A) \), and \( x_A \geq (1 - |x_{SQ} - x_A| - c) \),
and \( (1 - x_{SQ}) - p_{A}^{a_i} \leq w_C < (1 - x_{SQ}) - p_{A}^{a_i} \)


Equilibria in the asymmetric information variant support the conventional wisdom that “friends” co-ally.

4.2 The Alliance Game with “Noisy” Information

With one exception, assumptions of the third game are the same as in the standard asymmetric information game. The results, however, are notably distinguishable. The major change is that Nature—in addition to assigning player A an ideal point \((0 \leq x_A \leq \frac{1}{2})\)—supplies noisy information about A’s ideal point to the other players. Nature publicly reveals A’s ideal point as \(x_N\), but this value is subject to error \((N, x_N \text{ s.t. } (x_N - \epsilon) \leq x_A \leq (x_N + \epsilon))\), where \(\epsilon \sim U[0, \tau]\), \(0 \leq \tau \leq \frac{1}{2}\). States have imprecise information about what
other states want, but they probably have a better idea about international preferences than is assumed in the asymmetric information model.

Once again, players evaluate strategies in terms of payoffs and the sequence of play. A’s decision to intervene is the same. Given an alliance, A intervenes if \( x_A < \frac{1}{2} (1 - w_A + r) \) and A intervenes with no alliance if \( x_A < \frac{1}{2} (1 - w_A) \). C’s fight decision rule is nominally, \((w_C < (1 - x_{SQ}) - p^i)\), but this is modified by Nature’s revelation \((x_N)\). Since \( \frac{1}{2} (1 - w_A + r) \geq \frac{1}{2} (1 - w_A) \) and \((x_N + \epsilon) \geq (x_N - \epsilon)\), six sets of conditions relate Nature’s revelation \((x_N)\), the error term \((\epsilon)\), and other parameters to players’ actions. The first condition set describes circumstances in which all types of player A permitted by the revelation of \((x_N)\) intervene, regardless of alliance status (since \((x_N - \epsilon) \leq (x_N + \epsilon) < \frac{1}{2} (1 - w_A) \leq \frac{1}{2} (1 - w_A + r)\)). Given these conditions, C prefers not to fight. The second condition set represents circumstances where no player A prefers to intervene, regardless of alliance status. If all types of player A possible prefer not to intervene, then C prefers to fight if the cost of fighting is less than the difference between C’s ideal point and the status quo, \(w_C < (1 - x_{SQ})\) (because \(p^i = 0\)).

In the four remaining condition sets, player A makes different decisions contingent on type. The third condition set represents the simplest remaining. No types of A will intervene without an alliance, but all types intervene if an alliance exists. Therefore, if \( \frac{1}{2} (1 - w_A) \leq (x_N - \epsilon) \leq (x_N + \epsilon) < \frac{1}{2} (1 - w_A + r)\), C fights if there is no alliance and \(w_C < (1 - x_{SQ})\). The last three condition sets require C to rely on probability to formulate its strategy. In each case, C’s decision problem is analogous to C’s problem in the asymmetric information game, the major exception being that common knowledge exists about A’s more tightly bounded type space. Because the logic of the decision is similar, I keep my comments brief.

In the fourth condition set, some types of A permitted by Nature’s revelation will intervene if there is an alliance while others will not. Again, no types intervene without the alliance. C knows A’s type space and the alliance decision. Without an alliance, C fights if \(w_C < (1 - x_{SQ})\) (since the probability that A intervenes is zero). If A allies, C knows that \(x_A < t = (1 - |x_{SQ} - x_A| - c)\). C uses its decision rule, \(w_C < (1 - x_{SQ}) - p^i\), where \(p^i\) equals the probability that A will intervene calculated as the portion of types allowed by Nature’s revelation that will ally and intervene \(\frac{1}{2} (1 - w_A + r) - (x_N - \epsilon)\), divided by the portion of types that ally \(t - (x_N - \epsilon)\). Given an alliance, C fights if Equation (11) holds. In condition set 5, A will sometimes intervene without an alliance and A always intervenes given
an alliance. Therefore, \( C \) never fights if \( A \) and \( B \) ally. Without an alliance, \( C \) determines the probability that \( A \) will intervene by determining the portion of types allowed by Nature’s revelation that intervene without an alliance \( \frac{1}{2} (1 - w_A) - t \), divided by the portion of types that choose not to ally \( (x_{N+} - t) \). \( C \) thus decides to fight if Equation (10) holds and chooses not to fight otherwise. The last set of conditions simply combines the rules described in condition sets 4 and 5. Without an alliance, \( C \) fights if Equation (10) holds. Given an alliance, \( C \) fights if Equation (11) is correct.

\[
w_C < (1 - x_{SQ}) - p_A^{a, i}, p_A^{a, i} = 1 - \left( \frac{(x_{N+}) - \frac{1}{2}(1 - w_A)}{(x_{N+}) - t} \right),
\]

\[s.t. 0 \leq p_A^{a, i} \leq 1, (x_{N-}) \leq t < (x_{N+}) \quad (10)\]

\[
w_C < (1 - x_{SQ}) - p_A^{a, i}, p_A^{a, i} = \left( \frac{1}{2}(1 - w_A + r) - (x_{N-})}{t - (x_{N-})} \right),
\]

\[s.t. 0 \leq p_A^{a, i} \leq 1, (x_{N-}) \leq t < (x_{N+}) \quad (11)\]

\( A \)'s alliance decision largely parallels its alliance decision in the asymmetric information game. However, because \( C \) can infer different things than in the asymmetric information game, \( A \) does not always ally under the same conditions as before. \( A \) allies with \( B \) if \( EU_A^a > EU_A^{a'} \). Given the discussion in the asymmetric information game, we know that \( EU_A^a > EU_A^{a'} \) if \( x_A < t \) (where \( t = \frac{1}{2}(1 + x_{SQ} - c) \) if \( x_{SQ} \leq x_A \) and \( t = \frac{1}{2}(x_{SQ} - w_A + c) \) if \( x_{SQ} > x_A \) ) and only if \( C \) fights without an alliance but not with an alliance.

4.2.1 Players’ Optimal Strategies for “Noisy” Information Variant (\( B \) omitted):

Where \( t = \frac{1}{2}(1 + x_{SQ} - c) \) if \( x_{SQ} \leq x_A \),

and \( t = \frac{1}{2}(x_{SQ} - w_A + c) \) if \( x_{SQ} > x_A \), s.t. \( (x_{N-}) \leq t \leq (x_{N+}) \).
A: \( a = 1 \) if \( (1 - x_{SQ}) - p_A^{a,i} \leq w_C < (1 - x_{SQ}) - p_A^{\sim a,i} \),
and \( (x_N+) > \frac{1}{2}(1 - w_A) \), and \( x_A \geq \frac{1}{2}(1 - w_A) \)
and \( x_A < (1 - |x_{SQ} - x_A| - c) \)
or if \( (1 - x_{SQ}) - p_A^{a,i} \leq w_C < (1 - x_{SQ}) - p_A^{\sim a,i} \),
and \( (x_N+) > \frac{1}{2}(1 - w_A) \),
and \( x_A < \frac{1}{2}(1 - w_A) \) and \(( -|x_{SQ} - x_A| - c) > (-x_A - w_A)\)
= 0 if else.

\( i = 1 \) if \( a = 1, f = 1, \) and \( w_A < (1 - 2x_A) + r \)
or if \( a = 0, f = 1, \) and \( w_A < (1 - 2x_A) \)
= 0 if else.

C: \( f = 1 \) if \( a = 1, \) and \( w_C < (1 - x_{SQ}) - p_A^{a,i} \),
and \( (x_N+) > \frac{1}{2}(1 - w_A + r) \),
and where \( p_A^{a,i} = \left( \frac{\frac{1}{2}(1 - w_A + r) - (x_N-)}{t - (x_N-)} \right), \) s.t. \( 0 \leq p_A^{a,i} \leq 1 \)
or if \( a = 0, \) and \( w_C < (1 - x_{SQ}) - p_A^{\sim a,i}, \) and \( (x_N+) > \frac{1}{2}(1 - w_A) \),
and where \( p_A^{\sim a,i} = 1 - \left( \frac{(x_N+) - \frac{1}{2}(1 - w_A)}{(x_N+) - t} \right), \) s.t. \( 0 \leq p_A^{\sim a,i} \leq 1 \)
= 0 if else.

\( b = (x_A | a = 1, x_A \in x \sim U[(x_N-), t]) \)
if \( (1 - x_{SQ}) - p_A^{a,i} \leq w_C < (1 - x_{SQ}) - p_A^{\sim a,i} \)
= \( (x_A | a = 0, x_A \in x \sim U[t, (x_N+)]) \),
if \( (1 - x_{SQ}) - p_A^{a,i} \leq w_C < (1 - x_{SQ}) - p_A^{\sim a,i} \)
= \( (x_A | a = 0, x_A \in x \sim U[(x_N-), (x_N+)]) \) if else.
4.2.2 Equilibria for “Noisy” Information Variant:

[Node 3] if \( x_A \geq \frac{1}{2} (1 - w_A) \), and \( x_A < (1 - |x_{SQ} - x_A| - c) \),
and \((1 - x_{SQ}) - p_A^{a,i} \leq w_C < (1 - x_{SQ}) - p_A^{a,i} \),
and \((x_N+) > \frac{1}{2} (1 - w_A) \)
or if \( x_A < \frac{1}{2} (1 - w_A) \) and, \((1 - x_{SQ}) - p_A^{a,i} \leq w_C < (1 - x_{SQ}) - p_A^{a,i} \),
and \((x_N+) > \frac{1}{2} (1 - w_A) \), and \((- |x_{SQ} - x_A| - c) > (-x_A - w_A) \)

[Node 5] if \( x_A < \frac{1}{2} (1 - w_A) \), and \( w_C < (1 - x_{SQ}) - p_A^{a,i} \),
and \((x_N+) > \frac{1}{2} (1 - w_A) \)
or if \((1 - x_{SQ}) - p_A^{a,i} \leq w_C < (1 - x_{SQ}) - p_A^{a,i} \),
and \((x_N+) > \frac{1}{2} (1 - w_A) \), and \((- |x_{SQ} - x_A| - c) \leq (-x_A - w_A) \)

[Node 6] if \( \frac{1}{2} (1 - w_A) \leq x_A < \frac{1}{2} (1 - w_A + r) \), and \( w_C < (1 - x_{SQ}) - p_A^{a,i} \),
and \((x_N+) > \frac{1}{2} (1 - w_A) \), and \( x_A \geq (1 - |x_{SQ} - x_A| - c) \)
or if \( x_A \geq \frac{1}{2} (1 - w_A + r) \), and \( w_C < (1 - x_{SQ}) - p_A^{a,i} \),
and \((x_N+) > \frac{1}{2} (1 - w_A) \)
or if \((1 - x_{SQ}) - p_A^{a,i} \leq w_C < (1 - x_{SQ}) - p_A^{a,i} \),
and \((x_N+) > \frac{1}{2} (1 - w_A) \), and \( x_A \geq (1 - |x_{SQ} - x_A| - c) \)
and \( x_A \geq \frac{1}{2} (1 - w_A) \)


Examination of the two models allows us to see that the introduction of noisy information has one important effect. Part of the alliance equilibrium is replaced by the status quo equilibrium [Node 4] because player C is
sometimes able to ascertain that all types of $A$ are resolved enough to intervene. While the precise relationship cannot always be obtained, $C$ is able to identify states that must be “friendly” enough for $A$ to intervene. I emphasize two results. First, it is not necessarily the states with the most similar preferences that co-ally. As long as war costs are expected to be moderate, pairs of states $A$ and $B$ at either extreme of the issue space do not ally. Alliance contracts between “friends” occur less often than alliances between states with some differences in their interests. Second, the effect declines in the cost of war. An intuitive way to think about this is that at some point the costs of a contest are so high that even friends may question intervening. The effect of noisy signaling should diminish for states anticipating major threats (e.g. nuclear deterrence requires formal ties).

The noisy signaling model shows that states have conflicting incentives to ally. On one hand, similar preferences provide the basis for alignments. On the other hand, opponents recognize that states with similar preferences are more likely to cooperate. “Friends” may be more willing to act as allies, but precisely for this reason they have less need to ally. If alliances are costly signals, then there is no point in signaling to a world that has already gotten the message. Alliances are needed when the audience may infer incorrectly.

5 Tests of Perceptions and Alliance Formation

This section assesses the external validity of the perceptions argument posed above. I first describe the hypotheses and data before moving on to the research design and a report of the results.

5.1 Hypotheses

Figure 2 describes two conceptions of the relationship between the similarity of states’ preferences and the probability that states ally. The horizontal axis measures dyadic preference similarity while the vertical axis indicates the probability of an alliance. The preferences argument from the first game theoretic model anticipates a positive monotonic relationship between preference similarity and the probability of alliance formation in the dyad. “Friends” are most likely to ally. In the models, only two players are available to co-ally. Extrapolating to a multi-state system where states select among partners,
pairings are expected to occur among states with the most similar interests. Allowing for multiple alliances simply relaxes this tendency by degrees. The perceptions hypothesis claims that the likelihood of alliance formation is a function of both preferences and perceptions. Similar interests encourage states to act in concert, but global perceptions of similar interest obviate the need for formal commitments to threaten or reassure. Results of the second model thus predict a non-linear relationship between preference similarity and the probability of alliance formation.

![Figure 2: Two Hypothesized Relationships Between Preference Similarity and Alliance Formation.](image_url)

**Hypothesis 1**  
*PREFERENCES or “FRIENDS” HYPOTHESIS.* The probability of alliance formation increases in the similarity of state interests.

**Hypothesis 2**  
*PERCEPTIONS HYPOTHESIS.* The probability of alliance formation first increases and then declines in the similarity of state interests.

Note that linear approximations of the two hypotheses are bound to look very similar. Estimating a line through each relationship allows the arguments to differ only in the magnitude of the slope. The preferences hypothesis anticipates a positive monotonic relationship while ex ante perceptions
implies a second or third-order function where the highest term is negative. While the overall relationship is positive, the function is initially positive and increasing and later positive and decreasing. Assessing the two hypotheses thus requires tests that allow for non-linear relationships between the key independent and dependent variables. I use two estimators, logit with multiple preference terms and the General Additive Model (GAM). Before proceeding, however, I first review the data and research design.

5.2 Data

With the exception of the dependent variable, the Correlates of War (COW) alliance data, and the index of state interest affinity, most data in the analyses are generated using EUGene [4]. These data are widely used and available, so I keep the description here brief. The unit of analysis is the dyad year (some variables code on state- or system-level attributes). The spatial-temporal domain is a sample of pairwise combinations of states (dyads) listed as members of the international community by the COW Inter-state System Membership Dataset for 1946–1996 (1992 in some cases).

The dependent variable in the analyses comes from two versions of the COW Alliance Data [38]. Officially distributed data from the COW project code alliances for the period 1815 to 1984. I rely on two “ unofficial” sources for alliance data, though I also verify my findings using the official dataset. First, Bennett and Lebrun offer a revised version of the COW data, updated to 1992. I refer to these as the “old” alliance data, though they are newer than the official dataset from COW. Second, the COW project is conducting a revision of the alliance data. I use a “beta” version of these data (henceforth referred to as the “new” alliance data) with alliances coded to 1996 and including a substantial number of changes and extensions of the earlier data. I analyze these data to extend and validate results of the study. COW data code alliance membership by state for three types of alliance commitment (defense pacts, ententes, and non-aggression pacts). I report results using

\footnote{Leeds et al. [22], provide an alliance dataset that represents several major improvements in coding. Unfortunately, there is currently no temporal overlap between these data and the United Nations-based measure of state interest similarity used in this study.}

\footnote{Use of the beta version of the “new” alliance data has not been authorized by the COW project. Since this beta version of the new alliance data has been circulating for about 5 years, I believe that further delay in the hopes of an official release is unwarranted.}
both all alliance types and for defense pacts.21

Initial alliance years are coded “1.” Subsequent years of alliance and dyad years without alliances are coded “0.” I lead the dependent variable (alliance onset) on the independent variables by placing alliance values at time $t - 1$ in the subsequent year (time $t$). Thus, all of the independent variables are lagged on the dependent variable, limiting endogeneity and providing more stringent tests of the hypotheses. Alliances involve four phases: formation, maintenance, termination, and non-alliance. The hypotheses refer to formation and non-alliance. Factors leading states to ally may differ from those encouraging states to maintain existing commitments [5]. The distinction between subsequent alliance dyad years and no-alliance dyad years poses problems in estimation. I adopt the approach used in previous research of analyzing a sample of the population of all dyad years composed of all initial alliance years and randomly selected cases of non-alliance years [42]. This approach offers several advantages over alternatives. First, sampling reduces temporal dependence associated with time-series [3]. Observations are not linked temporally. Second, sampling reduces the inflation of significance tests that occurs in very large samples (I use Huber/White robust estimates of variance and correct for dyadic clustering). One concern when sampling is that it can bias coefficient estimates [19]. While not crucial for hypothesis testing, I sample alliance onset and a small portion of non-alliance years equal to the percentage of total alliance years in the population (8.31% for the old alliance data, 5.46% in the new data) so that the probability of a dyad containing an alliance in the samples is comparable to the probability of an alliance in the population.22 Finally, GAM is computationally intensive. I need to analyze a smaller number of cases than the large population of post-World War II dyad years. I use identical samples for each estimator to facilitate comparison and to corroborate results.

The analysis requires a measure of state preference similarity. Preferences are a theoretical construct related to “utility” in rational theory. Preferences are not observable, but proxies exist that arguably capture some of the qualities of the theoretical construct. I examined two different measures in preliminary research, though I report results only from the affinity index. Bueno de Mesquita’s alliance portfolio index ($\tau_B$), incorrectly believed to

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21As in other instances, there is no substantive change in the results.
22I over-sample non-alliance cases to compensate for more frequent listwise deletion of non-alliance dyad years. Results using all dyad years and coding the dependent variable for the presence or absence of alliance are essentially the same.
measure “utility”) is available for the entire period covered by the alliance data [6, pages 109–118], [7, pages 286-294]. The alliance portfolio measure is widely used and referenced in the literature. Nevertheless, alliance ties may constitute a biased indicator of the similarity of state preferences. First, the cost of outcomes distorts observers’ perceptions of actors’ preference orderings. I may prefer Ferrari’s to Ford’s, but the differential cost of exercising this preference means that observers will not know whether observing me at the Ford dealership is indicative of my ranking or of my budget constraint. *Ceteris paribus*, a preference index based on costly behavior will bias in favor of less expensive acts. Second, if the perceptions argument posed here is correct, then a preference indicator based on alliance patterns bias tests of the hypotheses. Alliances indicate preferences but also highlight shortcomings in international perceptions of preferences. Allies are not necessarily states with the most similar preferences so that a measure based on which states ally may not accurately attribute states’ interests. A third concern is that using alliance ties to predict alliance formation is empirically incestuous.24

For these reasons, I adopt a measure of preference similarity based on roll-call voting in the United Nations General Assembly. Affinity uses Signorino and Ritter’s “S” indicator to calculate the association between states’ annual voting records in the UN [36].25 Use of UN voting constrains analysis to the period 1946-1996, respectively the inaugural year of meetings at the United Nations and the most recent year for which data has been coded. UN voting data codes a state’s vote as positive (voting “yes” on a resolution), negative (“no”), absent, abstain, or present and non-voting. One version of the index codes only “yes” or “no” votes (the vast majority of votes). Another version codes absences, abstentions and non-votes as a category between positive and negative votes. I examined both versions of the index, but report results for only the three category data, since results were equivalent using both versions of these data. Values of Affinity range

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23The τB measure has been incorrectly described as a utility index. Utility functions map a particular actor’s valuation of different outcomes. τB and Affinity relate two actors’ choice of outcomes to the outcomes arrived at by other pairings of actors, an interpersonal comparison that cannot recover individual utilities. Note also that the construction of Affinity differs from the τB measure [6].

24The construction of τB removes much of the correlation between individual alliances and the index. Both preference indices (τB and Affinity) produce similar results, though the latter indicator exhibits greater variance for the post-World War II period.

25S = 1 – 2*|d/dmax|, where d = Σ(the metric distance between votes) and dmax = the largest possible value of d.
from -1 (least similar interests) to 1 (most similar interests). To simplify the scale, I add 1 and divide by 2, to produce a scale of 0 to 1.

Other independent variables seek to address competing influences on state alliance decisions. States may be less involved in the affairs of other states that are far from their own borders. EUGene offers two indicators of proximity. Distance reports the metric distance between state capitals, or between major cities for large countries. I log the variable, replacing negative values with “0.” POL_REL codes for dyadic contiguity. States that border one another or that are closer than 150 miles by sea are coded as “1”, otherwise “0.” Power is an important potential determinant of alliance formation. Capable states can better manage some of the hurdles of distance while unequal capabilities in a dyad encourage patronage. EUGene codes COW Composite Index of National Capability scores (CINC) for all states for which there exists data. I recode CINC scores into two dyadic variables representing higher (CINCHI) and lower (CINCLO) values. COW also provides a list of major power states. Some argue that major powers behave differently from other states. I construct dummy variables for the presence of one (MAJPOWR1) or two major powers (MAJPOWR2) in the dyad. Systems arguments also suggest that alliance ties are more likely to change when structural shifts occur in the international system. MAJCHANG is a dummy variable equal to “1” for a five year period (two year lead and two year lag) surrounding any change in the number of major powers in the system, and “0” otherwise. The coding of MAJCHANG is admittedly rather arbitrary, but the variable seems to capture the effects of systemic change.26

There is considerable interest in regime effects in the literature. Regime type may influence states’ alliance decisions [14] [15] [21] [31] [37] [39]. Using Polity data, I construct variables for higher and lower regime scores in the dyad, where REGIME = (DEMOC + AUTOC + 10) / 2.27

Finally, I include variables to control for the effects of war on alliance formation. Wars can influence states’ alliance decisions in at least three ways. First, contests within the dyad arguably affect alliance ties. I use a dummy variable (WAR) constructed by Zeev Maoz in the DYMID1.1 dataset to code the presence or absence of war in a dyad year [23]. I lag values five years to capture any follow-on effects. Second, contests involving one, but not

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26 Other measures of structural change yielded no noticeable alteration in key results.
27 This construction differs from that of Oneal and Russett [29], in that values range between 0 and 10, as do values for the constituent Polity variables.
both, states in a dyad could induce or deter alliances before or after contests. I construct one leading and one lagging dummy variable using Militarized Interstate Dispute data (MIDs) to attempt to capture any confounding third-party effects. MIDS are coded as 2 (threats), 3 (demonstrations), 4 (uses of force) or 5 (wars). I remove disputes involving both states in a dyad. The resulting third-party variables equal “0” if neither state in a dyad is involved in a MID, “1” if one state experiences an outside MID, and “2” if both states participate in (separate) disputes. Finally, conflict external to a dyad might spread. Contagion effects could lead states to be more aggressive in seeking out alliance partners [40] [41]. Alliance formation may be affected by expectations about future conflict with other states. I therefore include a variable for the presence of wars in the system. A dummy variable for the current year and a lagged year identifies whether the presence of MID level 5 events (“wars”) in the system appear to precipitate alliance formation. While certainly not exhaustive, this list of variables seeks to address major influences on alliance behavior beyond interests.

5.3 Analysis

Tests of theories in social science are seldom irrefutable. Assessing signaling theories is doubly difficult because signaling is unobservable (Schultz 2001). Researchers cannot see communication. At best, one can identify apparently unique implications of signaling. The relationships I examine are bound to be muted by the indirect nature of the tests. Nevertheless, key findings appear to be unanticipated by alternative explanations even as the results appear robust. I offer a number of analyses to reduce the possibility that the results are due to a particular method or approach.

Table 1 lists multivariate logit estimates of six models of dyadic alliance formation.\footnote{Results are a representative sample of those examined in preparing this study.} Models 1 through 3 include all initial alliance years (alliance formation dyad years) and a random sample of dyad years in which there is no alliance. The dependent variable in models 4 through 6 includes only defense pacts. Models 1, 4, and 6 use the “old” alliance data while models 2, 3, and 5 report results using the “new” alliance data. The size of each sample is determined by first calculating the proportion of alliance dyad years in the population of dyad years. Second, I randomly select cases from the population of dyad years that are not alliance dyad years. For example,
model 1 uses the old alliance data. There are 38,773 alliance dyad years out of 466,770 dyad years (or 8.31% of the sample) between 1946 to 1992. After dropping cases of subsequent alliance dyad years, I randomly select 8.31% of the non-alliance dyad years or 30,039 cases and add the 995 initial alliance formation events. This process is repeated with the new alliance data.\textsuperscript{29}

I use robust Huber/White estimates of variance to compensate for panel effects in cross-sectional data. I also control for clustering in dyads. Temporal dependence is less of a problem here and less easily remedied than in typical cross-sectional time-series analyses [3]. Sampling interrupts the periodicity of the time-series. Consecutive cases within dyads are separated by an average of 12 and 18.3 years, for the old and new samples respectively.

The construction of several variables representing state preference similarity is central to the analysis. I use variables for linear, square and cube functions of affinity. Again, the baseline “friends” hypothesis (Hypothesis 1) suggests that preference similarity is positively and monotonically related to the likelihood of alliance formation. Second and third power exponents of affinity should be positive or insignificant. The perceptions hypothesis (Hypothesis 2) implies a non-monotonic function—one that is first positive-increasing, then positive-decreasing. In both two term and three term models, the highest-power coefficient is expected to be negative.

Models 1 through 6 in Table 1 estimate the probability of alliance (or of defense pact) formation. In Model 1, the coefficient for the linear term measuring preference similarity is positive and significant while the squared term is significant and negative. This is also the case in Model 2 which uses the “new” alliance data. Model 3 estimates three coefficients representing preference similarity. The 3 term model “over-fits” the data, with the linear term reporting a negative coefficient. Still, the coefficient for the highest power term is negative. Models 4 through 6 demonstrate equivalent findings for defense pacts. Preference similarity seems to have a specific non-linear effect on the probability of alliance formation.

Most of the other independent variables perform as expected. Distance is significant and negative; the more proximate two states, the more likely they are to ally. The more democratic the dyad, the more likely the states are to ally. The greater the difference in regime types, the less likely is

\textsuperscript{29}The approach slightly over samples non-alliance dyad years (0’s). Over sampling compensates for the higher proportion of non-alliance dyad years that are deleted during regression analysis due to missing values. I replicated model 1, Table 1 using a true representative sample and found comparable results (results are available from the author).
an alliance. Lower dyadic capabilities is negative but is at times only marginally significant. The more powerful the less powerful state in the dyad, the less likely an alliance. Higher dyadic capabilities shows that larger disparities in capabilities are associated with a significant increase in the probability of alliance formation. The presence of a major power in the dyad significantly increases the likelihood of an alliance. Two major powers in a dyad further increase the chances of alliance formation. Dyadic war reduces the probability of an alliance, but this is only significant in the old alliance data. Third party effects are generally insignificant, though third party lag is significant and negative when predicting defense pacts. States appear less likely to form defense pacts if they suspect a looming conflict. System war does not appear significant. Political relevancy alone offers a surprise. Pol. rel. dyad is negative and significant.  

A more readily interpretable look at the results comes from predicted probabilities. Figure 3 offers six graphs, one each for the six models in Table 1. Predicted values are generated using the method of recycled predictions [45]. I replace all values of the preference variables in the data with a given value (say 0). Values for all independent variables are then run back through the coefficients to generate predicted probabilities of alliance formation. Results are stored as a new variable and the process is repeated with another substitute value of the preference variables (say 0.05). Mean predicted probabilities of the stored variables are plotted in Figure 3. All alliance types appear in the left column while defense pacts are plotted on the right. The top two rows of plots use a linear and a squared term. The bottom row lists predicted probabilities for models with three terms (linear, square, and cube). All plots appear to support the perceptions hypothesis.

A second test draws on a related implication of the perceptions argument. So far, the tests depend on the inference that “friends” are recognized as having common interests. Another way to examine the argument is to note that states are most likely to err in their perception of the similarity of other states’ interests when interests are in flux. The perceptions argument emphasizes the discrepancy between state interests and perceptions of interest. Observers may seek to extrapolate from current preference relations in an attempt to predict which states are destined to become “friends.” Extrapolations are bound to err in proportion to the dynamism of preference

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30 Collinearity between pol. rel. dyad and maj. power appears responsible. Pol. rel. dyad also embeds causes of conflict, such as hostility and culture.
Figure 3: Predicted Probabilities of Alliance Formation for Dyads.
relations. States that recognize that observers are likely to underestimate their true preference similarity should be more likely to ally.

Measuring international perceptions is tricky. One cannot observe leaders' perceptions. However, one can use Affinity to characterize a rational guess by states. Contemporary indicators of state preferences give observers a crude reference with which to extrapolate future trends. This information is "noisy," but it is bound to be more informative than no information at all. States use current behavior to predict where other states are headed.

Discrepancies between the similarity of state interests and international perceptions of interest increase state incentives to signal through alliances. To measure discrepancies between state preferences and perceptions of preference similarity, I construct a variable that calculates the difference between the similarity of interests as measured by Affinity and an estimate of the similarity of state interests based on a linear extrapolation of prior Affinity scores. I calculate a baseline estimate of the similarity of state interests using a three-year running average. This measure is then lead two time periods into the future and subtracted from actual 'future' values of Affinity. The final step is to lag the discrepancy between the 'future' Affinity score and the estimate by three periods (back to the past) to represent any discrepancy between expected and actual future Affinity scores. I assume that states correctly anticipate their own alignments. Dyad members anticipate future values of their own Affinity index (in the near-term) and can calculate the leading estimate based on past Affinity values. The dyad knows whether it is being underestimated. Positive values of the constructed discrepancy variable thus indicate an increased likelihood of alliance formation.

This measure of the discrepancy between perceptions and preferences is certainly far from ideal. The period over which states are said to anticipate is arbitrary. I use an indirect indicator of preference to construct an even more indirect measure of perceptions. However, the variable does capture a key feature of the perceptions argument. If alliances warn and/or reassure, then Discrepancy measures a situation where warning or reassuring is valuable. The measure is bound to miss much of what it is intended to capture but it is unlikely to capture unintended effects. Discrepancy appears much more likely to commit errors of omission than of commission.

I append the discrepancy variable to Model 1 from Table 1. Since the regression already includes Affinity, Discrepancy captures only the effect of perceptions. Discrepancy is positive and significant at the 0.001 level. Even controlling for interests and other factors, underestimating changes in
preferences increases the likelihood of an alliance. Results for other variables are similar to Model 1. I omit reporting the results in favor of a descriptive presentation. Figure 4 lists predicted probabilities of alliance formation for values of the combined affinity variables (linear and squared) as well as for discrepancy. Examining marginal effects in this way allows for a direct comparison of the magnitude of changes in the probability of alliance formation associated with standard changes in discrepancy.

Figure 4: The Effect of Discrepancies Between International Expectations and Future Level of State Preference Affinity (Logit Regression Model 1 + Discrepancy).

Two effects are apparent. First, changes in discrepancy alter the probability of alliance. For example, for a state with an affinity score of 0.75, increasing discrepancy from its mean value by two standard deviations increases the odds of an alliance by roughly 50%. States with interests that are closer than observers realize are more likely to ally than states that are not underestimated by international observers, regardless of actual preference similarity. Second, the effect is non-monotonic. The largest effect occurs among states whose preferences are similar but not identical.

The results of Table 1 and Figures 3 and 4 are informative, but logit re-
gressions with multiple terms are an inelegant way to model what is thought to be a non-linear process. Table 2 reports four representative examples of regressions using the General Additive Model (GAM). GAM allows for a non-linear relationship between the dependent variable and key independent variables. I use loess (locally smoothed regression) to estimate the relationship between the affinity variable (this time there is no need for multiple terms) and state alliance decisions. Models 1 and 2 use the old alliance data, while models 3 and 4 report the new alliance data. Models 1 and 3 use just the single preference term, while models 2 and 4 include a measure of the difference between affinity and expectations of the similarity of interests. Results for other variables are as expected.

Perhaps the best way to assess the GAM results is to examine plots of the loess smoothed functions linking affinity with alliance formation. Figure 5 provides six such plots, one for each affinity variable in Table 2 and two plots of the (linear) relationship between the discrepancy variable and alliance formation. Plots are laid out in the same fashion as in Figure 3. Once again, the effect of affinity on alliance behavior is first positive and then negative, while the probability of alliance increases in the discrepancy between actual and expected values of affinity. Thus, GAM results also appear to support the perceptions hypothesis.

6 Conclusion

Applications of game theory to international politics has tended to treat states and other actors as initially being either fully informed or totally ignorant about the interests or capabilities of partners or competitors. While this may be a reasonable simplification of reality in some contexts, a more plausible assumption is that states possess both knowledge and uncertainty about the variables of strategic interest in cooperation, competition, and conquest. A history of interaction between international actors should lead to beliefs that are noisy, that are founded on fact but also subject to error. The task in this study has been to begin to examine where this refinement in the treatment of perceptions matters, where different claims about initial beliefs lead to different empirical predictions. Tests of the perceptions argument in the context of alliances seem to show that noisy information can be a significant determinant of international behavior, at least in the context of behavior that is primarily directed at the manipulation of actors’ beliefs. As
Figure 5: Plots of affinity and discrepancy using GAM statistical model (from Table 2).
suggested by informational theories, it appears that alliances are as much about perceptions as about power or preferences. States are most likely to seek to formalize their security partnerships when common interests are insufficiently recognized or acknowledged by the international community.

More generally, the results presented here lend support to the informational approach to international relations. Signaling theories are persuasive and deductively powerful, but their attention to the communication of information makes them difficult to evaluate empirically. The challenge to researchers is to identify circumstances where signaling theories make empirical predictions that are novel enough to distinguish them from alternative accounts. There does not appear to be a well-articulated alternative to noisy signaling as an explanation for the relationship identified here.

Finally, this study suggests that powerful insights about international behavior can be obtained by linking the insights of political psychology and rational theory. A better understanding of international relations involves relaxing assumptions that privilege material variables, such as power. At the same time, it is important to find areas where one may safely prescribe the influence of perceptions. Science requires validity checks that typically involve statistical analysis of social hypotheses. While actors may misperceive in particular instances, there is not typically a way to rigorously evaluate claims about individual events. If international actors correctly perceive in equilibrium, then general propositional claims about international behavior will tend to cancel out perceptual errors, leading rational theory to discount misperception as an explanation and leading proponents of psychological explanations to discount rational theory. Modal behavior in rational theory is often bound to reflect interests and material variables. In some situations, however, as in the case of alliance formation, variation in perception, even if stochastic in aggregate, produces novel and counterintuitive empirical consequences. It is these unanticipated characteristics of the interaction of power, preferences, and perceptions that will hopefully receive additional attention in the future and which will help in validating and extending informational theories of international relations.
References


### TABLE 1: Logit Estimates of Alliance Formation, Onset + Sample (Robust S.E., Adj. for Clustering in Dyads)

<table>
<thead>
<tr>
<th>Dep. Variable</th>
<th>Model 1 - 1 Alliances</th>
<th>Model 1 - 2</th>
<th>Model 1 - 3</th>
<th>Model 1 - 4 Defense Pacts</th>
<th>Model 1 - 5</th>
<th>Model 1 - 6</th>
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<tbody>
<tr>
<td></td>
<td>&quot;Old&quot; data</td>
<td>&quot;New&quot; data</td>
<td>&quot;New&quot; data</td>
<td>&quot;Old&quot; data</td>
<td>&quot;New&quot; data</td>
<td>&quot;Old&quot; data</td>
</tr>
</tbody>
</table>

#### AFFINITY

**Linear**
- Coefficient: 45.499
- S.E.: 8.977
- Z: 5.068

**Square**
- Coefficient: -30.694
- S.E.: 5.160
- Z: -5.471

**Cubed**
- Coefficient: -32.749
- S.E.: 6.242
- Z: -5.246

#### DISTANCE (logged)
- Coefficient: -0.663
- S.E.: 0.106
- Z: -6.236

#### POL. REL. DYAD (dummy)
- Lower Dyadic: 0.111
- Higher Dyadic: -0.156

#### DEMOCRACY (Dem-Aut+10)/2
- Lower Dyadic: 0.111
- Higher Dyadic: -0.156

#### CAPABILITIES (CINC/total)
- Lower Dyadic: -40.921
- Higher Dyadic: 9.357

#### MAJ. POWER (dummy, 2 lags)
- One: 1.966
- Both: 5.079

#### WAR (dummy, 5 lags)
- 3rd Party Lag: 0.025
- 3rd Party Lead: -0.235

#### CONSTANT (dummy, 2 lags)
- -15.618

### Additional Statistics
- N: 20407
- Wald Chi²: 565.45
- Prob > Chi²: 0.0000
- Pseudo R²: 0.2108
- Log Likelihood: -2120.7396
### TABLE 2: GAM Estimates of Alliance Formation, Onset + Sample

<table>
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<th>Dep. Variable:</th>
<th>Model 2 - 1</th>
<th>Model 2 - 2</th>
<th>Model 2 - 3</th>
<th>Model 2 - 4</th>
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<td>&quot;Old&quot; data</td>
<td>&quot;New&quot; data</td>
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<td>AFFINITY</td>
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<td>Similarity of Preferences coeff -40.890</td>
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<td>12.633</td>
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<tr>
<td>z</td>
<td>-2.541</td>
<td>1.803</td>
<td>1.424</td>
<td>2.279</td>
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<tr>
<td>Difference btw coeff 1.653</td>
<td>.949</td>
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<td>Affinity &amp; Exp.S. E.</td>
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<td>(0.349)</td>
<td>(0.394)</td>
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<td>z</td>
<td>5.219</td>
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<td>DISTANCE</td>
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<td>(logged)</td>
<td>S. E.</td>
<td>(0.050)</td>
<td>(0.041)</td>
<td>(0.054)</td>
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<td></td>
<td></td>
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<tr>
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<td>0.155</td>
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<td>(Dem-Aut+10)/2</td>
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<td>(0.018)</td>
<td>(0.020)</td>
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<td>7.773</td>
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<td>(Dem-Aut+10)/2</td>
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<td>Lower Dyadic</td>
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<td>(CINC/total)</td>
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<td>z</td>
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<tr>
<td>One</td>
<td>coeff 1.572</td>
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<td>(0.128)</td>
<td>(0.091)</td>
<td>(0.092)</td>
</tr>
<tr>
<td>z</td>
<td>-0.946</td>
<td>-3.192</td>
<td>0.609</td>
<td>0.587</td>
</tr>
<tr>
<td>System</td>
<td>coeff 1.048</td>
<td>1.306</td>
<td>-0.062</td>
<td>-0.045</td>
</tr>
<tr>
<td>(dummy, 2 lags)</td>
<td>S. E.</td>
<td>(1.004)</td>
<td>(0.584)</td>
<td>(0.402)</td>
</tr>
<tr>
<td>z</td>
<td>1.044</td>
<td>2.238</td>
<td>-0.154</td>
<td>-0.111</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>coeff -0.142</td>
<td>0.867</td>
<td>3.449</td>
<td>3.410</td>
</tr>
<tr>
<td>S. E.</td>
<td>(1.070)</td>
<td>(0.667)</td>
<td>(0.588)</td>
<td>(0.587)</td>
</tr>
<tr>
<td>z</td>
<td>-0.133</td>
<td>1.300</td>
<td>5.869</td>
<td>5.810</td>
</tr>
</tbody>
</table>

| N             | 20407 | 20234 | 14176 | 14040 |
| Chi²          | 144.3702 | 326.757 | 83.26506 | 79.10271 |
| Prob > Chi²   | 0.0000 | 0.0000 | 0.0000 | 0.0000 |