A Division of Defense Labor Across Nations*

How Alliances Promote the Shared Production of Security

J Andrés Gannon

July 7, 2024

There is substantial variation in how military alliances aggregate defense capabilities, but scholars lack a good understanding of how collective defense varies and why. This article argues that military alliances engage in an efficient division of labor over the production of defense under certain conditions. Alliances that have high strategic compatibility and are hierarchical incentivize complementarity in national military capabilities while alliances without those two factors are composed of redundant national militaries with overlapping capabilities. This occurs because strategic compatibility and hierarchy allow states to minimize the risk of opportunism and cost of coordination in a manner conducive to the efficient distribution of defense capabilities across actors. Applying a novel network-level measure of division of labor to data on disaggregated national military capabilities across defense alliances from 1970 − 2014 provides evidence consistent with the theory. These findings provide new evidence of mutually interdependent security cooperation under anarchy and the institutional conditions that make it possible.

*The author is thankful to many who provided feedback on earlier and related drafts, especially Steven Brooks, Rosella Cappella Zielinski, Jonathan Caverley, Ben Fordham, Erik Gartzke, Nadiya Kostyuk, Kendrick Kuo, David Lake, Sara Plana, Abigail Post, Philip Roeder, Erik Sand, Kaija Schilde, Ryan Shandler, Branislav Slantchev, Brad Smith, Jennifer Spindel, and Sanne Verschuren. This project could not have happened without help from the many research assistants helped construct the rDMC dataset on which this article relies. This project benefited from financial support from the UC San Diego Center for Peace and Security Studies (cPASS), the Smith Richardson Foundation, the Department of Defense Minerva Initiative, the Stand Together Trust, and the APSA Centennial Center.

1 Introduction

The collective action problem is one of the most enduring dilemmas in political science (Olson 1965; Hardin 1982). How can a group of actors who would benefit from working together toward a common goal minimize the risk of opportunism and the cost of coordination that can otherwise make cooperation untenable? This problem is particularly pronounced in international security, where the stakes concern coercive military threats and cooperation requires trusting that others will come to your defense despite the absence of any externally enforceable mandate to do so (Axelrod and Keohane 1985).

Across space and time, alliances vary in *how* they aggregate defense capabilities to improve collective and individual security. The goal of this study is to identify the characteristics of military alliances that are most conducive to its members engaging in a division of labor over the production of defense. Some alliances consist of member states whose military capabilities complement each other, while others include states with overlapping force structures. This variation across security alliances cannot be solely attributed to economic factors or geography. Political considerations influence the degree to which alliance members can overcome the risks inherent in collective security decisions with actors who can defect (Niou and Ordeshook 1994).

I argue that alliances with higher strategic compatibility and a higher level of hierarchy are more successful at efficiently allocating defense capabilities across actors in a way that maximizes complementarity and minimizes redundancy. Drawing from sociological research on inter-firm collaboration, I develop a theory of security cooperation that explains how these two factors help allied states reduce the risk of opportunism and the cost of coordination sufficient to make the benefits of a division of defense labor worthwhile. Strategic compatibility – the degree to which states agree about the nature of the international threat environment

– creates compatible payoff structures by increasing the gains to an efficient joint warfighting force. Alliances that are more hierarchic – meaning they have a more asymmetric distribution of influence over security decisions – are better able to resolve information asymmetries and establish interoperability standards.

To test this theory, I analyze the distribution of military capabilities across defensive alliances from 1970 - 2014 (Leeds et al. 2002; Gannon 2023). Using these data, I create a new index adapted from statistical ecology measuring the division of labor as the complementarity of military capabilities across alliance members. I also build upon existing measures of strategic compatibility (Leeds, Mattes, and Vogel 2009; Poast 2019a) and hierarchy (Beardsley et al. 2020) by developing a composite index of threat compatibility and a novel entropy-based estimate from network topology, respectively. Consistent with my theory, I find evidence across a variety of statistical models suggesting alliances have a higher division of labor when they have high strategic compatibility and when they are more hierarchic. This suggests that these two conditions allow states to minimize the risk of opportunism and the cost of coordination sufficient for the gains to mutually interdependent security cooperation to be realized.

This study advances our understanding of several key issues in international politics. First, contrary to the foundational view that the ability to use force and the absence of central authority motivate states to behave as like-units (Stein 1982; Posen 1984), divisions of defense labor provides evidence of functional differentiation by states adopting different roles and responsibilities through negotiated bargains (Bukovansky et al. 2012, 6–7). Second, disagreement about the efficacy of alliances at improving security and stability often stem from disparate empirical findings about their role in the guns versus butter trade-off and the cost of burden-sharing (Kimball 2010; Blankenship 2023). Complementarity is a novel mechanism explaining how allies efficiently pooling distinct capabilities can reduce internal defense spending through individual specialization (Gannon 2024). Third, allies and armaments have long been debated as strategies for augmenting defense that either substitute or complement each other (Morrow 1993; Diehl 1994). Instead of focusing on alliances and the amount of military spending (Alley and Fuhrmann 2021; Cooley et al. 2022), scholars should considers ways in which alliances alter the *composition* of armaments. Differences in alliances regarding the compatibility of member security interests and the centrality of decision-making control helps explain variation in how alliances produce collective security. In short, the nature of international cooperation matters for *how* states arm.

This paper is organized into four sections. Section 2 outlines existing explanations for how states seek to improve their security by arming and allying. Section 3 then details a theory of a shared production model of security, outlining how strategic compatibility and hierarchy can overcome the collective action problem sufficient to allow a division of labor over defense capabilities. Section 4 provides an quantitative empirical test of that theory using cross-national data on disaggregated military capabilities from 1970 − 2014. Section 4.4 concludes by discussing the implications of these findings for theories about international cooperation and conflict providing suggestions for future research.

2 Existing explanations for cooperative security

A well-established literature has theorized that the two ways a state can develop a military response to foreign threats are internal balancing (arming) and external balancing (allying).[1] Both strategies share the same primary motivation: security. States develop arms as a military response to foreign threats (Conybeare 1994b; Goldman 2007; Nordhaus, Oneal, and Russett 2012) and at their core, military alliances are fundamentally an agreement about when and how

[1] See, for example, Altfeld (1984); Barnett and Levy (1991); Morrow (1991); Conybeare (1992); Morrow (1993); Diehl (1994); Sorokin (1994); Conybeare (1994b); Kimball (2010); DiGiuseppe and Poast (2016); Yarhi-Milo, Lanoszka, and Cooper (2016); Horowitz, Poast, and Stam (2017).

to fight (Niou and Zeigler 2019; Poast 2019a) by states conveying that the security of the whole is an vital component of the security of the homeland (Conybeare and Sandler 1990).. Other positive externalities can motivate both arming and allying, and these incentives may in some cases be more salient, but an expectation of improved security is a necessary condition.[2]

Neither arming nor allying is a strictly dominant strategy for improving security across all circumstances and contingencies. Investing in arms (internal balancing) provides more certain access to defense capabilities, but it is slower and more costly since resources devoted to guns are resources a state is not devoting to butter (Powell 1993; Clark 2001; Poast 2019b). On the other hand, allying with like-minded states (external balancing) accesses defense capabilities more quickly and allows more resources to be devoted to domestic issues, but security decisions may now be at a whim of others on whom you now rely and may have to defend when you otherwise would not (Snyder 1984; Walt 1987). Whether arming and allying are substitutes or complements has long been debated, with a mixed empirical record (Thies 1987; Morrow 1991, 928–29; Conybeare, Murdoch, and Sandler 1994, 526).

To take Europe as an example, while "one might expect a continent with both a long-established military alliance and highly integrated economies and policymaking machineries to also have a highly integrated defense economy" (Mawdsley 2018), some have found that Europe's defense market is actually quite fragmented and protectionist (Bitzinger 2009). The 27 states in the EU have a combined 25 armies, 21 air forces, and 18 navies most of which possess different weapons systems and that rarely coordinate force planning (Howorth 2007). This is not a new problem either; not long after the end of the Cold War (De Vestel 1995) noted that the redundancy of Europe's defense platforms was becoming increasingly costly. Similarly, research on extended nuclear deterrence continues to debate the relationship between the perceived reliability of a nuclear state's promise of protection and a protege's demand for nuclear

[2]Non-security reasons for alliance formation include, for example, trade and economic cooperation (Poast 2012; Haim 2016; Kinne and Bunte 2020), domestic policy concessions (Barnett and Levy 1991; T. Kim 2016), and influence over another state's foreign and domestic policy (Morrow 1991; Lake 1999).

and conventional arms (Bleek and Lorber 2014; Fuhrmann and Sechser 2014; Monteiro and Debs 2014; Reiter 2014; Lanoszka 2018; Narang and Mehta 2019).

These conflicting findings are due to inattention to the *composition* of arms aggregated across an alliance (Olson and Zeckhauser 1966). Efforts to examine the composition of alliance military capabilities have still largely black boxed alliances to compare them to non-alliances (Becker et al. 2024; Gannon 2024) or black-boxed arming by just looking at defense spending (Alley 2021), military recruitment (Margulies 2021), or specific military institutions (Kostyuk 2024). As a result, the state of the art insufficiently explains why states facing a common threat vary in how they aggregate defense against that threat. How does variation in alliance reliability – and the factors that shape it – change the strategic composition of arms across allied states?[3] Understanding this phenomenon is a worthwhile endeavor, as how each state contributes to collective security has long been (Olson and Zeckhauser 1966; Christensen and Snyder 1990; Palmer 1990; Snyder 1997), and remains, a central question in international politics (Fuhrmann 2020; Blankenship 2023; Kinne and Kang 2023). Differences in how alliances bring military resources together has important implications for the outcome of conflict (Conybeare, Murdoch, and Sandler 1994; Bensahel 2007; Cappella Zielinski and Poast 2021; Lanoszka 2022, 118–23) as well as the political and economic costs of defense production (Hartley 1987; De Vestel 1995; Gannon 2024).

3 Theory: Bringing balance to each other's force

Alliances are a promise to cooperate with another actor under a given set of contingencies (Papayoanou 1997; Morrow 2000). What are the conditions under which allies are able to

[3] On alliance reliability more generally, see Morrow (1994); A. Smith (1995); Fearon (1997); Leeds, Long, and Mitchell (2000); Leeds (2003a); Leeds (2003b); Leeds and Savun (2007); B. V. Benson (2012); Crescenzi et al. (2012); Mattes (2012a); Mattes (2012b); B. V. Benson, Meirowitz, and Ramsay (2014); Blankenship (2020); Henry (2020); B. C. Smith (2021); B. V. Benson and Smith (2023).

ensure that a promise to cooperate with each other in the development and deployment of military capabilities happens successfully? Much research on bargaining within alliances starts with the Ricardo (1817) model of comparative advantage in trading goods based on differences in production costs (Snyder and Diesing 1977; Snyder 1984, 1997; Palmer 1990; Morrow 1993). A complementary division of labor over these capabilities can be an efficient way to undertake defense cooperation, but it requires intra-alliance bargaining over the terms of that cooperation. Who produces what matters because these capabilities differ in their private benefits (economies of scale), public benefits (contribution to aggregated defense), and asset specificity.

The central argument I set out is as follows: intra-alliance bargaining can more easily reduce the risk of opportunism and costs of coordination costs when (1) there is high strategic compatibility, meaning members have similar security interests (Papayoanou 1997; Poast 2019a) and (2) the alliance is hierarchic, allowing a small number of participants to dictate the terms of the bargain (Krasner 1991; Lake 2001). Under these conditions, states are able to produce complementary militaries in ways that garner the efficiency gains of specialized production while maintaining the security gains of a diversified defense portfolio. If intra-alliance bargaining does not succeed because a gap in strategic compatibility has narrowed the bargaining range and/or because one actor cannot dictate the terms of the bargain sufficient to reach a mutually agreeable solution, then there will not be a shared division of labor over the production of security.[4] In this way, a division of labor serves as evidence of confidence in the durability of an alliance since "[s]pecialization of forces may leave both allies exposed to other threats" (Morrow 1994, 272). States will thus design defense portfolios that rely less on the capabilities of others and are thus more redundant and self-reliant. After outlining the broader

[4] I make a common knowledge assumption in the intra-alliance bargaining process whereby alliance partners have a reasonable amount of certainty about each other's threat environment and the military capabilities of their ally. While not strictly true in all cases, allies do generally have an incentive both to believe their partner and be honest with them since lying to your partner about those things creates costs from false compatibility or unnecessary duplication.

problem of cooperation in Section 3.1, Section 3.2 and Section 3.3 detail the solution.

3.1 Barriers to cooperation under anarchy

A state's decision about whether to cooperate with other states over the ownership and use of security assets is a function of three factors - the gains from cooperation, the expected cost of opportunism, and the expected cost of coordination (Axelrod and Keohane 1985; Oye 1985; Lake 1997).[5] While these features are a hallmark of the collective action problem more generally, they are particularly pronounced in the context of international security cooperation since that requires resolving integrated command and control, intelligence sharing, and interoperability of complex and constantly evolving systems (Bensahel 2007). The gains from cooperation include economic benefits from economies of scale, political benefits from the efficiency gains of focusing on core competencies, and security benefits from improved performance at particular security needs (Gannon 2024). After all, one of the expected payoffs from developing relationships with strategically compatible states is the expectation that some aspect of your ally's military resources are available during war (Olson and Zeckhauser 1966; Conybeare 1992).

The expected cost of opportunism is a function of the severity and likelihood of abandonment, entrapment, and exploitation (Snyder 1984; Christensen and Snyder 1990). Relying on another state that may renege when asked to contribute to your defense could seriously jeopardize a state's security (Dekker 2004). If this risk is seen as high, states should instead opt to produce security on their own. Opportunism via abandonment (shirking or buck-passing), entrapment

[5] While I here focus on defense pacts as the primary institution through which states coordinate strategies to jointly produce security (Sandler and Forbes 1980; Murdoch and Sandler 1982), there is an extensive body of research concerning different forms of defense cooperation and security alignments (Lake 1996; Weber 1997, 2000; Adler and Barnett 1998; Haftendorn, Keohane, and Wallender 1999; Leeds et al. 2002; B. V. Benson 2012; Wilkins 2012; Kinne 2018; Edgerton 2024). While the theory may generalize to these other less formal forms of defense cooperation, I here take the easiest case of defense pacts as the clearest case of an arrangement where states may have agreement about the use and division of force.

(chain ganging), or exploitation can prove fatal to a state that depends on another for defense, especially if that dependence took the form of a specialization via omitting necessary defense assets. Avoiding this requires avenues for communication and routines for interaction that mitigate concerns about opportunism and the cost of war sufficient to encourage coordinated military strategies (Ikenberry 2001, 65–69; Wolford 2014). Because relying on your partner to provide assets risks losing autonomy over the conduct of those assets during combat, there can be ambiguity about the effects of cooperation on a state's security goals (Morrow 1991). As Auerswald and Saideman (2014, 232) put it, "in alliance warfare, allies sometimes do not always show up when needed or they show up but are not able to do what is needed."

The expected cost of coordination are distinct and concern how much work is required to ensure the relationship achieves the expected benefits (Gulati and Singh 1998; White 2005, 1385). Collaboration requires communication, making adjustment in response to your partners actions. While opportunism costs focus on uncertainty regarding your partner, coordination costs are about uncertainty regarding the task (Oxley 1997). An actor can have full confidence their partner will not act opportunistically if they have identical interests, but there still has to be a designation of roles coordination who is contributing what. This is fundamentally an issue of information asymmetry (Bearce, Flanagan, and Floros 2006), so creating a "common knowledge assumption" can induce and stabilize cooperation by reducing uncertainty about the other actor's payoffs structure and conveying one's own payoff structure to your partner (Gulati and Nohria 1992, 19). Theories of international cooperation inspired by Williamson (1985) and the accompanying transaction cost framework have been less concerned with coordination costs, instead arguing opportunism costs drive most of the variation in security relationships (Lake 1996). Coordination costs may not be particularly salient in contexts where resources are simply pooled, but that is not the case in the security context (Overhage 2013). It is quite difficult to fight a war with another state's tools. In defense, "duplication of facilities, differences in requirements, coordination problems, lack of clear control and delays due to different budgetary systems all tend to increase the costs of collaborative projects" (R. Smith 1996, 69–70).

3.2 Cooperative benefits of strategic compatibility

I define strategic compatibility as the consistency of states' security interests and degree to which they agree on the nature of the possible international threat environment (Poast 2019a, 5). When security interests among states are consistent, an adversary that poses a threat to one state's security interests also poses a threat to the other states' security interests (Yarhi-Milo, Lanoszka, and Cooper 2016; Markowitz and Fariss 2018). In this situation, states are more likely to have compatible payoff structures regarding behavior conducive to the creation or maintenance of the optimal international environment (Axelrod and Keohane 1985; A. Smith 1995; Johnson, Leeds, and Wu 2015).[6] Some degree of strategic compatibility is necessary for security-motivated defense cooperation, but it is not a sufficient condition for cooperation (Gibler and Rider 2004).

Strategic compatibility is conducive to a division of defense labor because it increases the gains of cooperation and reduce opportunism and coordination costs. Strategically compatible alliances share the same desired outcome in the event of a military contest with an adversary. They consequently have an incentive to make more effective coalition contributions (Snyder 1984; Stueck 1997; Kreps 2011; McInnis 2019; Cappella Zielinski and Grauer 2020). This reduces the risk of opportunism because the presence of a common objective that both actors seek produces higher payoffs to conscious policy coordination (Oye 1985; Thies 2003; Wolford 2014). Importantly, this creates incentives for coordination, rather than like-minded actors facing a common threat in isolation. Strategic compatibility positively shapes that coalition's

[6] I assume homogeneity in what alliance members are willing to fight for. But whether alliance partners agree that the expected costs of war are preferable to the demands they would otherwise concede could create different reservation points across allies (Wolford 2015).

collective strategy to ensure that each actors' participation is augmenting the efforts of the others (Wolford 2015). Snyder (1997, 166) writes that "among the most prominent issues in intra-alliance bargaining are the coordination of military plans, the stance to be adopted toward the opponent in a diplomatic crisis, and the sharing of preparedness burdens in peacetime."

The gains from a division of labor can now be realized if the accompanying costs have been sufficiently reduced. By increasing the expected gains of cooperation and overcoming the expected costs of opportunism and coordination, high strategic compatibility can increase states' willingness to embrace a shared production model of military capabilities. Under complementarity, the gains from economies of scale mean that each state is better off than if they simply added their redundant military capabilities together. Each state can specialize in capabilities that take advantage of its relative economic and geographic advantages in a way that allows them to develop focus resources and innovations efficiently (Gannon 2024).

Hypothesis 1: Defense alliances with high strategic compatibility should have a higher division of labor than alliances without high strategic compatibility.

3.3 Cooperative benefits of hierarchy

I define hierarchy as a community with an asymmetric distribution of influence where a small number of dominant actors authoritatively control the behavior and characteristics of a larger number of subordinate actors when it comes to international security (Zaheer and Venkatraman 1995; Donnelly 2006).[7] In contrast to its early conceptualizations, hierarchy here is a structural attribute of a community defined by its relations; a network of actors has some

[7] I scope my analysis to security hierarchies and think about them narrowly as a contract-functionalist arrangement deliberately constructed by purposive agents to advance their interests. See Zarakol (2017, 4–10) for an overview of different ways to conceptualize hierarchies. Similar theories have been developed on hierarchies concerning, for example, economics (Manger, Pickup, and Snijders 2012) and social status (Hobson and Sharman 2005; Larson and Shevchenko 2014; Musgrave and Nexon 2018).

observable degree of hierarchy defined by the nature of their relationships (MacDonald 2018; Beardsley et al. 2020).[8] Influence within the network is asymmetric in that decisions about self-enforcement are controlled by one or a few dominant actors which contrasts with non-hierarchical communities where arrangements about defense efforts are largely self-enforcing (Jung and Lake 2011). Authoritative control means that the dominant state(s) exerts influence over the decisions of other states with varying degrees of consent and/or coercion, although the means used do not determine if a community is hierarchical (Beardsley 2024).[9]

While hierarchy involves power imbalances and structures of control and decision-making, it is not strictly synonymous with either of these concepts (Lake 1997).[10] Although some hierarchical relationships have an unequal distribution of material military power such that "a more powerful state has the material capability to intervene in and provide security for the weaker one" the presence of such a capability is not synonymous with hierarchy nor is its absence indicative of a more symmetrical relationship (Wendt and Friedheim 1995, 696). Such a perspective does not give appropriate agency to the actors whose decisions create these relationships, which is especially important when thinking about hierarchy as complex networks involving multiple overlapping ties between actors (Onuf 1989, 2013). Similarly, hierarchy can create formal institutions of cooperation, but does not need to (Keohane 1984). Centralizing decision-making is distinct from formalizing it, and in fact dominant states may avoid formalizing cooperation within institutions if doing so reduces flexibility of response in cases of unreliable alliance partners (Morrow 2000; Mattes 2012b).

[8] Especially concerning empirical identification and measurement, only recently has work on hierarchies in international politics shifted its level of analysis from dyads (Lake 2009; Jung and Lake 2011; Nieman 2016) to networks (Beardsley et al. 2020; Kinne and Kang 2023).

[9] For contrasting views on the role of consent and coercion in hierarchy, see Holsti, Hopmann, and Sullivan (1985), Lake (1996), Hobson and Sharman (2005), Lake (2007), Lanoszka (2013), Mattern and Zarakol (2016, 632), MacDonald (2018), Mcconaughey, Musgrave, and Nexon (2018), and Nicholls (2020).

[10] This also explains why hierarchy is not equally present in every alliance with a militarily capable state. Hierarchy requires the subordinate state to give up some autonomy, which they do not always want to do (Bukovansky et al. 2012, 16; Lanoszka 2013; Hynd and Connolly 2023) and it also requires the dominant state to be willing to absorb governance costs (Lake 1996) and transaction costs (Weber 2000) that rise with hierarchy and can outweigh its benefits.

Hierarchy reduces the risk of opportunism because a leading "alliance manager" can solve information asymmetries and creating mutual interdependence (Gulati, Wohlgezogen, and Zhelyazkov 2012, 533). Hierarchy resolves information asymmetries by centralizing the flow of authoritative communication (Galbraith 1977; Beek et al. 2024), reducing uncertainty about future tasks (Pondy 1977), and providing rules of thumb concerning the role each state plays in the relationship (Oye 1985). Institutionalization allows actors to figure out the "anticipated organizational complexity of decomposing tasks among partners along with ongoing coordination of activities to be completed jointly or individually across organizational boundaries and the related extent of communication and decisions that would be necessary" (Gulati and Singh 1998, 304). The dominant state delegates nodes of responsibility to the subordinate state either because those tasks are less important niche capabilities or because the subordinate state can perform those tasks at a lower cost given comparative advantage offered by geography or industrial capacity (Sugiyama and Sugawara 2017). By transferring a purely exchange relationship into a power relationship, hierarchy ensures unified command and standard operating procedures that create the type of task coordination needed for a division of responsibility (March and Simon 1958; Galbraith 1977; Gulati and Singh 1998).

While some of these mechanisms assume a division of labor in hierarchies is dictated by the dominant state through delegation, that is not the only way this can occur.[11] Because it is easier to catch flies with honey than vinegar, states in hierarchical alliances can collectively agreed upon differentiated obligations to manage collective problems given the inequality of their material capabilities (Ikenberry 2001, 35–77; Beardsley 2024). Even in hierarchical alliances where the strong state is determining the terms of the agreement, both states are able to leverage the power of their allies to achieve international outcomes that are in their favor (Davidson 2011). Smaller states may desire institutionalizing their relationship with more dominant states precisely because that increases their bargaining leverage and creates mutual

[11] I here will not attempt to empirically identify which mechanism is at play, but that presents an important avenue for future research.

interdependence (Bosse and Alvarez 2010; Schneider 2011). The dominant state benefits from such an arrangement, as it resolves credible commitment problems at a lower cost since – like mutual hostage-taking – a division of labor can reduces incentives to free ride by making some degree of dependence mutual (Williamson 1983). This provides a way for both actors in an alliance to value the alliance independent of the degree of control they exercise in determining the structure and terms of that alliance (Schroeder 2004; Weitsman 2004; Bearce, Flanagan, and Floros 2006). By reducing the costs of coordination, institutionalization makes that interdependence of tasks easier which, in turn, facilitates a division of labor (Ikenberry 2001, 75–77).

Hypothesis 2: More hierarchical defense alliances should have a higher division of labor than less hierarchical defense alliances.

In sum, I predict a high division of labor in alliances that have high strategic compatibility and that are hierarchical because the expected gains of cooperation exceed the expected costs of opportunism and coordination. In this situation, purposeful functionally differentiation across militaries is possible and desirable despite a division of labor creating potentially costly dependence on other states (Lake 1997). Otherwise, allies will be composed of redundant militaries with overlapping capabilities that rarely coordinate with one another.

4 Empirics

4.1 Dependent Variable

I conceptualize security as an output that requires a number of distinct *tasks* (observed as military capabilities) that can, in theory, be distributed among some number of members of an alliance (Gorelick et al. 2004).[12] The division of labor over the production of this security output can be quantified as the degree to which members of the alliance specialize in one task versus performing all tasks and whether a task is performed by one alliance member or many of them (Gorelick and Bertram 2007). When multiple allies possess the same military capabilities and omit the same military capabilities, their division of labor is low and can be described as redundant – neither is making a substantial unique contribution to their "pooled" defense capabilities. By comparison, when multiple allies possess different military capabilities from one another, they each fill in the gaps such that the combination of their capabilities is distinct from that of any individual state.

The unit of analysis is an alliance-year defined as a network of states that share a defensive alliance pact. Alliance membership is measured annually using the Alliance Treaty and Provisions (ATOP) data set version 5 (Leeds et al. 2002). The division of labor among states in an alliance is calculated as their 'niche overlap' which measures the weighted mean similarity of members' military portfolios in a given year (Araújo et al. 2008; Dormann et al. 2009). This is measured using the Distribution of Military Capabilities (rDMC) dataset providing country-year counts of military capabilities across roughly 70 categories (Gannon 2023).

For each alliance-year t, consider a bipartite network as an $n \times m$ matrix with a row for each alliance member N and column for each technology M. $\theta_{ij} = \sum_m min(p_{im} p_{jm})$ describes the mean similarity measure for state i and every state $j \neq i$ where p_{im} and p_{jm} represent the relative proportions of technology m within each state i and j, respectively, as well as the relative proportion of technology m across all states (Hurlbert 1978; Zaccarelli, Bolnick, and Mancinelli 2013). A division of labor can thus be observed as the complementarity associated with high dissimilarity since it means your partners possesses capabilities you do not and

[12] I assume that these technologies could at least in theory be allocated to the defense of other allied states. Some states are members of multiple alliances (Gibler and Wolford 2006, 137–38; Adler and Greve 2009; Kinne 2013a; Li et al. 2017), complicating inferences about whether a state's possession of a particular military capability is associated with one alliance as opposed to another. This will be discussed in the empirical model.

visa versa. The distribution of this index across the universe of alliance-years is shown in Figure 1.

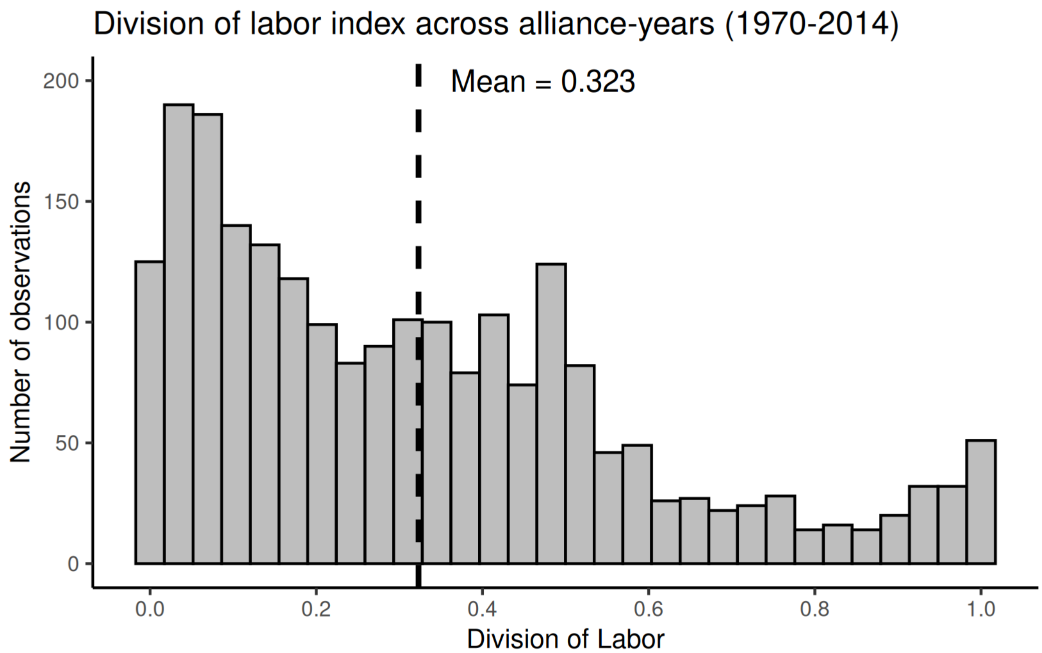


Figure 1: Distribution of alliance-year division of labor. The measure is bounded between 0 and 1, with 1 representing the highest level of division of labor.

This measure has a few unique properties that make it well-suited to the task at hand. Unlike other measures of portfolio similarity, this measure can account for actors with very sparse military portfolios, was developed to account for wide differences in the availability of technologies across a sample, and is scale-invariant which allows for comparisons of relative complementarity across alliances of different sizes and years with different technologies (Hurlbert 1978; Manthey and Fridley 2009). Additionally, the measure includes the simultaneous weighting of capability distribution within and across actors, as it quantifies the interdependence between state nodes and technology nodes as mutual entropy (Bolnick et al. 2002; Gorelick and Bertram 2007). The index consequently measures the redundancy of military portfolios across countries relative to a baseline prior expectation informed by the distribution of capabilities within each state and the distribution of each capability across states. For example, in a bilateral alliance in 2000 where each partner possesses 150 main battle tanks, that capability similarity does not contribute very much to their overall similarity because main battle tanks are generally quite common and each state possesses the modal value in that year. By contrast, a bilateral alliance where each partner possessed 150 ICBMs would, as a result, have more similarity given the rarity of that capability globally makes two states possessing that capability in similar and unusual quantities unlikely.

4.2 Independent Variables

I differentiate alliances over time and space by operationalizing the two variables described earlier – strategic compatibility and hierarchy. Despite the well-recognized challenges of empirically measuring these concepts (MacDonald and Lake 2008; Häge 2011), recent methodological innovations concerning similar concepts provide means to improve existing measures (Poast 2019a; Beardsley et al. 2020).

4.2.1 Measuring strategic compatibility

Strategic compatibility describes the consistency of states' security interests and agreement on the nature of the international threat environment. I create a new index of strategic compatibility across alliance members in a given year. I first create an annual measure of each state's geopolitical threat environment, defined as the actors within a state's geopolitical environment with whom competition could involve coercive bargaining intended to degrade that state's perceived security (Maoz 1996; Powell 1999; Markowitz and Fariss 2018; Beardsley 2024). Scholars have long moved past the view that anarchy means every state is a threat to every other state (Powell 1993); instead, whether a state constitutes a geopolitical threat is a function of foreign policy orientation and power (Leeds and Savun 2007; Poast 2019a). This is coded as any state B that meets at least one of the following criteria:[13] (1) strategic rivals, meaning both states perceive each other as enemies and resource competitors (Bremer 1992; Thompson 2001; Colaresi, Rasler, and Thompson 2008) using data from Thompson, Sakuwa, and Suhas (2021, 34–46); (2) peace scale rivals, coded as a "severe rivalry" or a non-allied "lesser rivalry", meaning both states have war plans, unresolved issues, and "see the use of military force as a legitimate means for resolving disputes" (Goertz, Diehl, and Balas 2016, 34; Diehl, Goertz, and Gallegos 2021); or (3) politically relevant threat environment, meaning state B is contiguous or a great power (Maoz 1996, 168; Lemke and Reed 2001; M. A. Benson 2005; Bennett 2006) *and* it is non-allied with a kappa chance-corrected alliance similarity score below the population median (Cohen 1960; Häge 2011; Chiba, Johnson, and Leeds 2015). This consequently only includes political relevant dyads with an inconsistent foreign policy orientation (Leeds and Savun 2007; Leeds, Mattes, and Vogel 2009).

These criteria produce a list of threatening states with whom an actor could reasonably expect to engage in coercive bargaining as a function of willingness (foreign policy orientation) and capability (power); its strategic rivals, its negative peace rivals, and its politically relevant threat environment.[14] Following Poast (2019a, 55), I then identify the threats that all states in an alliance have in common each year and sum their CINC scores.[15] So if State A and State B had a bilateral alliance and State A's threat environment was composed of State X and State Y while State B's threat environment was composed of State Y and State Z, that

[13]The appendix contains a more thorough description of the three criteria – including definitions from the primary sources – as well as a comparison of their coverage. This measure relies heavily on the extensive efforts of all of the scholars mentioned, but particularly Leeds and Savun (2007) and Poast (2019a), as I largely combine and slightly modify their measures.

[14]Dangerous dyads have been used to identify threats based on dispute density and conflict history (Bremer 1992; Klein, Goertz, and Diehl 2006), but they are inapplicable here as they are endogenous with alliance military capabilities (Leeds 2003b). Dangerous dyads also assumes that states one has fought constitute threats and that those one hasn't fought aren't, despite much historical evidence to the contrary (Thompson 2001, 574; Poast 2019a, 53–55).

[15]This differs from Poast (2019a, 55–56) in that his measure of strategic compatibility is binary, not continuous, and is a ratio of the count of shared versus non-shared threats, rather than shared threats weighted by CINC score.

bilateral alliance's shared threat environment would be the CINC score of State Y, since it is the only state in both alliance members' threat environment. The measure is continuous and scaled between 0 and 1 where higher values represent an alliance where all members share a highly salient common threat environment. While formal alliance membership itself may not change rapidly or substantially, this measure allows more variation within and across alliances as threats to alliance members change. Figure 3 shows the evolution of US-Japan strategic compatibility as existing shared threats like the Soviet Union became less powerful (Wallander 2000) and as changes in states' foreign policy orientation altered when China and North Korea were considered shared adversaries by the US and Japan (Lind 2004).

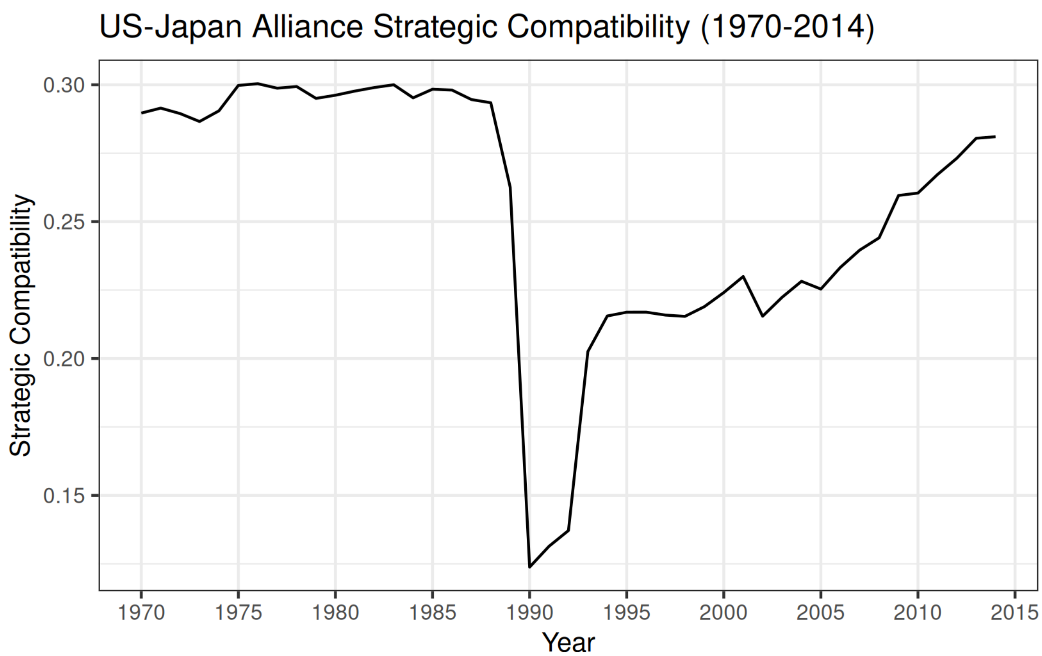


Figure 2: Strategic compatibility index for the US-Japan alliance. Higher y-axis values indicate higher aggregated CINC scores for countries in the shared US and Japan threat environment.

4.2.2 Measuring hierarchy

Alliances are joint-production security communities. As it is defined as the distribution of authoritative control of security decisions across actors in a community, hierarchy is a community-level measure based on the relative influence of actors within that community.[16] An alliance is more hierarchical if it its members have differing levels of influence on security-production decisions. Arms sales dependence has been used by many recent works to measure asymmetry in the relative influence of each state on its security community (Kinne 2012; Beardsley et al. 2020; Chou, Teng, and Tung 2023). This appropriately measures my conception of hierarchy because a dominant state is not simply one that possesses a high concentration of defense capabilities, but because it "reside[s] in central positions in networks of exchange" (MacDonald 2018, 131). Armaments are vital war input materials (Cappella Zielinski and Poast 2021), and the ability to determine what arms allies possess constitutes an important degree of authority over decisions about the joint-production of security in a community (Thurner et al. 2019; Beardsley et al. 2020, 735–36). An alliance network where all states are equally central in the exchange of war input materials is relatively non-hierarchic. But if one or a few states produce and distribute many of the capabilities that its partners possess, the alliance is relatively hierarchic because that network has a structural power imbalance that comes from a few states influencing the production of security (Morrow 1991; Kahler 2009).

To measure this, I create an annual global network with weighted directed edges accounting for arms sales between each pair of states using the "SIPRI Arms Transfers Database" (2024) Trend Indicator Values (TIV). Within each alliance, I identify the importance of each state to the overall structure of the network by measuring the consequence on that alliance's stock and flow of arms of that actor being removed. This is quantified as the network's ability to

[16] Measurements of hierarchy have evolved beyond dyadic measures due to methodological advancements in network analysis (Hoff and Ward 2004; Maoz 2010, 2012; Poast 2010, 2016; Warren 2010; Dorff and Ward 2013; Kinne 2013b; Cranmer, Menninga, and Mucha 2015; Cranmer and Desmarais 2016; Fordham and Poast 2016; Galambos 2024).

respond to the loss of that node; the more change that is required to stabilize the network after a given node has been removed, the more important that node was to the structure of the network (Qi et al. 2012). Computationally, this is a measure of each state's Laplacian entropy $C_L(v_i, G) = \frac{(\Delta E)_i}{E_L(G)} = \frac{E_L(G) - E_L(G_i)}{E_L(G)}$ where G is a weighted network with vertices $V(G) = (v_1, v_2, \dots, v_n)$ and directed edges w_{ij} with non-negative integer weights (Gutman and Zhou 2006; Guerrero 2022).[17] G and G_i refer to the original network and the network with node i removed, respectively, such that $E_L(G)$ is the Laplacian entropy of the entire network. $C_L(v_i, G)$ thus measures the amount of "effort" required to create a most-similar distribution of arms exchange across an alliance network if each actor i were removed.

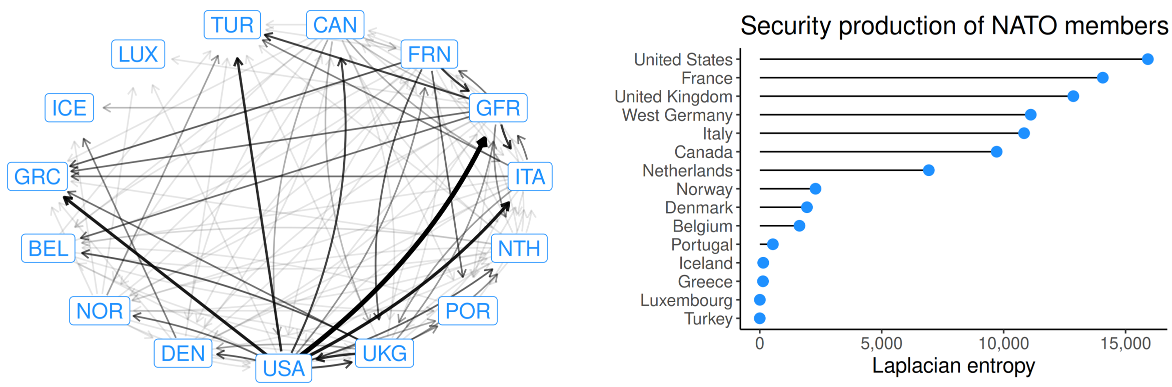
For each alliance year, I then calculate $E_L(G) = \frac{\sum_i^n max(C_L) - C_{Li}}{n}$ as the mean of the difference between the highest state's value and every other value. This represents the network-level measure of hierarchy with measurable distinctions between networks with a single dominant state, those with multiple dominant states, and those where all states occupy equally central positions as security-producers in the network (Savage 2021). Figure 3 demonstrates the construction of this measure for NATO in 1975. In Figure 3a, the alliance's joint-production of security is measured as the flow of arms throughout the network from each member to the others. Figure 3b quantifies the consequence of each member of the alliance being theoretically removed from the alliance with higher values indicating a larger "shock" to the network if that node were removed. The results are consistent with the historical record in identifying the most central security-producing NATO members as the United States followed by France and the United Kingdom.

This measure is similar to, and positively correlated with, other measures of network centrality.[18] It differs in accounting for weighted and directed edges and being invariant to network

[17] As states are represented in the network as vertices, this is quantified as the sum of squares of the eigenvalues in the matrix of arms sales (Boley, Buendia, and Golnari 2018; Cordeiro et al. 2018). The notation provided is taken from the formal proofs in Qi et al. (2012).

[18] This measure has been previously used to identify the relative importance of central actors in terrorist networks (Qi et al. 2013) and cyber operations (Aksoy, Purvine, and Young 2021).

size which allows across-alliance comparisons. Additionally, because this measure accounts for the overall flow of armaments in the whole network, the dependence of each state on others accounts for the relative amount of arms they receive from that actor as well as the other states who in turn depend on that state. In other words, if State A is the sole arms provider to State B who then provides a majority of the arms for States C, D, E, and F, that downstream dependence makes State A important despite being a degree removed from the majority of arms recipients.



(a) Directed edges represent arms sales among NATO members. Darker and thicker edges corresponding to higher arms sales.

(b) Laplacian entropy of each node in the network. Higher values indicate the node is more important in the network.

Figure 3: Hierarchy measure of security production, NATO (1975).

4.3 Models and Results

With these new measures, I can now quantitatively identify the association between an alliance's ability to overcome collective action problems and that alliance's division of defense labor. The dependent variable is the division of labor of military capabilities measured for each alliance-year where higher index values represent a higher division of labor from more complementarity with fewer redundant capabilities.[19] As the dependent variable is continuous,

[19]Since the theory is about variation in the institutional characteristics of alliances, limiting the scope to observed alliances is not selecting on the dependent variable since there is no comparison being drawn

the models are estimated using a series of simplified and fully specified ordinary least squares (OLS) regressions, as the best unbiased linear estimator should be optimal under common assumptions (Portnoy 2022). I account for the panel nature of the data with various time trend and standard errors clustering specifications given the non-independence of repeated alliance observations and since the evolution of technologies over time may impact the observed division of labor and the error structure of the model. The first pair of models account for time trends using cubic year polynomials (Carter and Signorino 2010), the second pair instead include year fixed effects (Bell and Jones 2015; Plümper and Troeger 2019), and the final pair are hierarchical multilevel models nesting observations within year (Hazlett and Wainstein 2022).[20]

For each model specification, I first include only the theorized explanatory variables as a first cut descriptive correlation given the risk of post-treatment bias and over-adjustment posed by the inclusion of control variables, especially with panel data where the predicted relationships have unspecified temporal dynamics (Montgomery, Nyhan, and Torres 2018; Clarke, Kenkel, and Rueda 2018; Dworschak 2023). I then add a battery of control variables that existing research suggests could also influence the degree to which a group of states have similar military portfolios or that could influence the degree to which those states cooperate on security issues.[21] The models control for the proportion of states in an alliance that are a democracy, measured as a Polity score greater or equal to 6, since democratic allies may differ in trust and expectations of cooperation (Chiba, Johnson, and Leeds 2015; DiGiuseppe and Poast 2016; Warren 2016; Fjelstul and Reiter 2019). Because geographic proximity may better enable allied states to cooperate militarily (Bak 2018) and also increases the chance two states

between alliances and non-alliances (Vance and Ritter 2014). This is consistent with prior research on the design of security institutions (Leeds and Anac 2005; Leeds and Savun 2007; Chiba, Johnson, and Leeds 2015).

[20] Unit fixed effects are omitted because they assume exogeneity between past treatment and current outcome as well as past outcome and current treatment which is not true for these data and is hard to measure given the unknown and heterogeneous temporal lag in anticipated treatment effect (Imai and Kim 2019).

[21] Many of these variables were compiled using the peacesciencer R package (Miller 2022), with some modifications. All code is provided in the replication material.

fight alongside each other (Gartzke and Gleditsch 2022), the model controls for the proportion of alliances members that are contiguous and the maximum capital to capital distance in an alliance network (Fordham and Poast 2016). Larger alliances may inherently have a lower division of labor since more partners increases the potential for overlap and redundancy in capabilities (Chiba, Johnson, and Leeds 2015) and because the benefits of hierarchy decline with group size (Beek et al. 2024), so the model includes a control for the logged number of states in each alliance-year. Established alliances are more likely to have deeper roots for cooperation and thus have an easier time cooperating, so the model controls for the average number of years each member has been in the alliance (Palmer 1990; B. V. Benson and Clinton 2016).

These primary results are presented in Table 1. Across all model specifications, strategic compatibility and hierarchy both have a positive and statistically significant association with the division of labor in a military alliance. This provides suggestive evidence that alliances with high strategic compatibility and hierarchy are more likely to have a high division of labor in the military capabilities that their members possess, even factoring in other explanations for why states might have redundant or complementary armaments. I do not interpret the model coefficients for any of the control variables due to the absence of confounders for those variables (Keele, Stevenson, and Elwert 2020; Dworschak 2023) and also do not compare the coefficients of the fixed effects models with the cross-sectional models because they only explain across-unit variation (Mummolo and Peterson 2018; Hill et al. 2020).

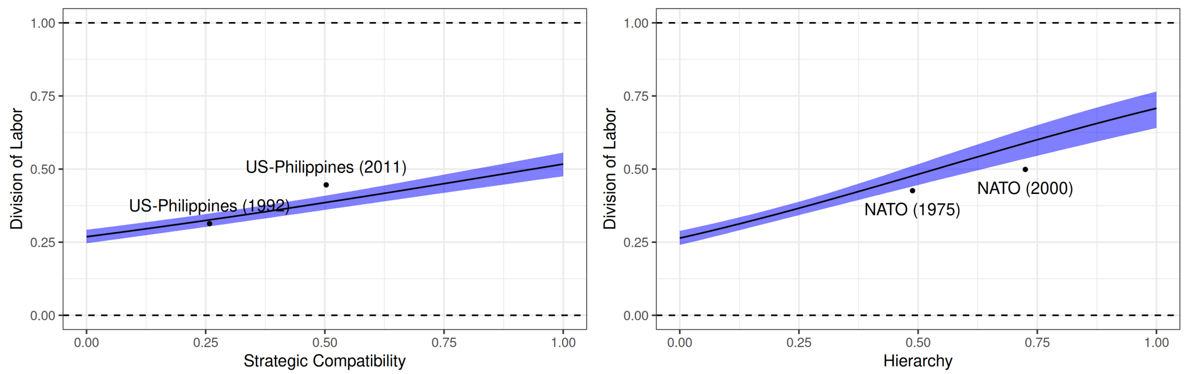
The results are also substantively significant. Figure 4 illustrates the conditional effects of the two explanatory variables using an ordered beta regression, which appropriately accounts for the bounded nature of the dependent variable (Kubinec 2022).[22] For strategic compatibility (Figure 4a), a one standard deviation increase centered around the mean value is associated

[22]A table of the full ordered beta regression results is provided in the appendix rather than Table 1 as the coefficients are on a log odds scale and not comparable to the coefficients from the other models.

Table 1: Coefficient estimates for regression models.

	Year Polynomials		Year FE		Multilevel Model	
	(1)	(2)	(3)	(4)	(5)	(6)
Strategic Compatibility	0.185***	0.232***	0.192***	0.241***	0.197***	0.252***
	(0.047)	(0.054)	(0.049)	(0.057)	(0.020)	(0.022)
Hierarchy	0.408***	0.401***	0.401***	0.383**	0.400***	0.408***
	(0.074)	(0.115)	(0.074)	(0.117)	(0.022)	(0.039)
Democracy Ratio		0.069		0.068		0.065***
		(0.049)		(0.051)		(0.018)
Contiguity Ratio		0.092		0.064		0.064
		(0.106)		(0.105)		(0.045)
Maximum Distance (log)		0.008		0.004		0.004
		(0.014)		(0.014)		(0.005)
Number of Members (log)		-0.049*		-0.047*		-0.051***
		(0.023)		(0.023)		(0.009)
Alliance Age (avg)		0.001		0.001		0.000
		(0.002)		(0.002)		(0.000)
Num.Obs.	2225	2206	2225	2206	2225	2206
R2	0.200	0.224	0.229	0.254		
R2 Adj.	0.198	0.220	0.213	0.236		
R2 Marg.					0.124	0.148
R2 Cond.					0.212	0.236
AIC	-108.2	-172.1	-108.7	-176.7	-45.6	-68.6
BIC	-73.9	-109.4	159.6	119.7	-17.1	-11.6
RMSE	0.24	0.23	0.23	0.23	0.23	0.23

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$



(a) Strategic Compatibility

(b) Hierarchy

Figure 4: Predicted values of division of labor for each explanatory variable. Predictions based on an ordered beta regression with year fixed effects and all control variables described above held at their mean value. Highlight points represent the observed values on each dimensions for those observations. The difference between the points on the x-axis is one standard deviation and the difference between the points on the y-axis is the estimated conditional expectation.

with a 0.062 unit increase in the division of labor. Put concretely, this was how much strategic compatibility in the US-Philippine alliance increased from 1992 to 2008. The end of the Cold War reduced the salience of many of the threats that the US and Philippines jointly faced, and by 1992 the US withdrew all troops because of failure to negotiate terms justifying a continued US presence. But soon after, Chinese aggression in the South China Sea caught the Philippines' attention when they occupied Mischief Reef in 1995, prompting tension between the two states (de Castro 2009). This marked the beginning of a revival in US-Philippine defense cooperation, including the creation of a Joint Defence Assessment (JDA) mechanism in 1999 as a precursor to being designated a major non-NATO ally for the War on Terror in 2003 (Medeiros et al. 2008, 114–15). As a part of this, the US helped the Philippines specialize in counter-terrorism naval capabilities it did not itself possess while also trying to ensure it remained an effective hedge against China (Green, Hicks, and Cancian 2016, 73–78). By 2011, the US-Philippine division of labor had increased one average expected contrast given the average conditional expectations of the other covariates in the model.

For hierarchy (Figure 4b), a one standard deviation increase centered around the mean value is associated with a 0.097 unit increase in the division of labor. This is what we observe in NATO from 1975 to 2000. A decade after the end of the Cold War, NATO was more hierarchical than it had been when facing the Soviet Union. Part of this can be attributed to the increasingly dominant role of the United States in the provision of alliance security (Burton 2018) and part of it can also be attributed to NATO expansion, as the Czech Republic, Hungary, and Poland had smaller than average militaries that developed capabilities for search and rescue and air defense in an explicit attempt demonstrate their value to the alliance through the provision of niche capabilities (Herspring 1994; Danov 2001).

A series of additional models in the appendix provide further evidence of a robust positive association consistent with theoretical expectations. To ensure the results are not just an artifact of new explanatory variable measurements, I estimate strategic compatibility and hierarchy using well established indices of most-similar concepts like alliance portfolio similarity and military power asymmetry. I find no statistically significant results for an interaction term for strategic compatibility and hierarchy, despite research suggesting they may serve as substitutes if lower strategic compatibility requires more hierarchy or a more coercive form of hierarchy (Beardsley 2024). I also find consistent results using alternate control variables for democracy and geography as well as with the addition of control variables for NATO (Gibler and Sewell 2006), alliances with US participation (DiGiuseppe and Poast 2016), and the Cold War (Leeds and Mattes 2007; Fuhrmann 2020). Consistent results are also found with different corrections for the panel structure of the data like two-way clustered standard errors (alliance and year) (Chiang and Sasaki 2023). The results of a Bayesian multilevel model also produces posterior means for the expected division of labor conditional on strategic compatibility and hierarchy that is consistent with theoretical expectations (Shor et al. 2007; Bürkner 2017) and a double/de-biased machine learning model produces similar predictions that are robust to omitted variable bias and overfitting by using a cross-fitting split for out of sample validation

(Chernozhukov et al. 2018; Bach et al. 2024).

Despite the robustness of the results across a wide variety of model specifications, the limitations of causal inference from quantitative models using observational panel data warrant caution in interpreting this as evidence of a causal relationship. Although many recent methodological advances have improved causal inference with observational panel data, many of these methods are not applicable here due to staggered treatment timing, continuous treatment variables, and the treatment and outcome variables being temporally non-monotonic within-unit (Kropko and Kubinec 2020; Imai and Kim 2021; Sun and Shapiro 2022; Chiu et al. 2023; Roth et al. 2023; Arkhangelsky and Imbens 2024; Liu, Wang, and Xu 2024). Most notably, while one would ideally be able to estimate the long term effects for alliances and military spending given the temporal nature of the theorized relationship (DiGiuseppe and Poast 2016; Williams 2016), existing methods are designed for a dichotomous dependent and/or explanatory variable (Gandrud and Williams 2017) or require a theoretically informed duration specification which is not possible here given the time lag for the development of a military capabilities (and asymmetric time lag for de-development) varies based on country, year, and capability in an immeasurable manner. Furthermore, there is a plausibly endogenous relationship that the models cannot account for – a state's relationship with other states influences the capabilities each state produces but the capabilities each state has at their disposal also impacts the decision to ally with another state (DiGiuseppe and Poast 2016). Absent qualitative evidence about the timing of these decisions, an anticipatory effect cannot be assessed. The hope is that the theory and results presented here provide a justification for such research in the future, including the use of other empirical strategies with distinct strengths and weaknesses.

4.4 Discussion and Conclusion

The theory and empirical results presented here have important implications for our understanding of three foundational debates in international politics; cooperation under anarchy, burden-sharing, and allies versus armaments. First, pessimism about cooperation under anarchy is challenged not, as others have argued, by the existence of alliances, but rather by evidence that those alliances produce functional differentiation. When it comes to defense, states are not like-units (Sørensen 1998). States strategically choose to functionally differentiate when interstate security cooperation can sufficiently resolve the collective action problem that otherwise makes a division of labor too risky. This runs counter to foundational claim that while there is “functional specialization - an intense division of labor” within states and other organizations, “the same is obviously not true of international politics. There, power is distributed more equally than in organizations. Moreover, it is distributed to protect no group purpose. There is no functional specialization among states.” (Posen 1984, 36–37).

Second, the public goods theory of alliances concludes that although it would be ideal if every alliance participant contributed to collective defense, the incentive to free ride renders such a situation unlikely, even for actors behaving in their own self-interest. One conclusion from this is pessimism and distrust of alliances as a security mechanism. But competing strategies for augmenting security – internally arming or externally allying – have been treated as fungible assets compared based on their relative size. But by looking at *what* states are contributing to the common defense, rather than how much they are spending, new perspectives on burden-sharing and the value of the alliance may emerge (Thies 1987; Blankenship 2023). What is commonly observed as free riding may actually be efficient specialization by actors participating in a division of labor (Conybeare and Sandler 1990). Actors with common security interests recognize that, if coordinated, their defense capabilities can focus on “special responsibilities” in ways that are more than the sum of their parts (Bukovansky et al. 2012, 5–17).

Third, traditional debates concerning the efficacy of alliances and armaments as competing strategies for improving security assume resources devoted toward each of these means are zero-sum. But since the military capabilities a state needs is a function of the military capabilities their ally possesses, external balancing influences how a state internally balances. States differ in the military capabilities they choose for their security because the composition of their force structure is conditioned by those of their allies and the nature of their relationship with those allies. This suggests a novel mechanism by which the rewards of shared production can be reaped internally. States can save resources in a constrained optimization environment by sharing the production of international security with other states in a way that allows each state to allocate relatively more resources toward non-security functions (Conybeare 1994a; DiGiuseppe and Poast 2016). The efficiency gains observed in alliances are the product of strategic compatibility and hierarchy enabling a division of labor (Pamp, Dendorfer, and Thurner 2018; Alley and Fuhrmann 2021; Kinne and Kang 2023).

This paper also makes an important empirical contribution in being the first quantitative measure of the distribution of military capabilities across states. Similarities and differences across states has been of significant interest in the domains of economics (Hidalgo et al. 2007; I. S. Kim, Liao, and Imai 2020) and institutions (Lai and Reiter 2000; Edgerton 2024). But there has been no prior effort to identify the degree to which two states arm in similar ways. The measurement produced here can be used to advance the study important topics like arms racing, military innovation, and scientific R&D cultures. The improvement in existing measures of strategic compatibility and hierarchy is also of note, given the centrality of those concepts to the contemporary study of international politics is matched only by its difficulty.

Far from being the final word, this study advances our understanding of the relationship between alliances and how states arming in a way that motivates multiple avenues for future research. For example, this study assumes homogeneity in what alliance members are willing to fight for. But whether alliance partners agree that the expected costs of war are preferable to the demands they would otherwise concede could create different reservation points across allies (Wolford 2015). Additionally, I here take the alliance as the unit of analysis. While the network-based nature of this measure is an advancement beyond traditionally dyadic theories, it does not theoretically or empirically identify who within the alliance specializes and what they specialize in. Future researchers could examine this descriptively based on the new measure produced, and in doing so develop a novel theory about how one's degree and type of specialization is impacted by where a state is located in the alliance hierarchy.

Alliances are supposed to help a state be more secure than it would be otherwise. But there are downsides to relying on others for defense. Coordinating joint efforts is costly, and even when that occurs other states could defect in a way that presents a risk to your national security and defense. Alliances must contain ways to guard against these risks (Yarbrough and Yarbrough 2016). Divisions of responsibility over defense capabilities are evidence that strategically compatible security interests and hierarchical security networks can accomplish this. While the US possesses only 2 Arctic-capable icebreakers (as opposed to Russia's 40), 7 of the 8 Arctic nations are US allies via NATO or NATO-partners (Markowitz 2020, 76–78). This is not simply a case of the US delegating a low-priority security task to untrustworthy partners, as the Thule Air Base housing the US Ballistic Missile Early Warning System (BMEWS) can only be accessed by sea in the winter because of Canada's icebreaking fleet (Cross 2019). This US omission is render less costly because of its allies' strengths. By having a division of labor whereby US allies operate icebreakers in the Arctic, "allies and partners can free up U.S. time and resources to focus elsewhere. They can also help improve situational awareness and manage tensions more broadly to minimize dangers and create opportunities in and near the North American and European Arctic" (Avey 2019). The composition of military assets, not just the amount spent, is what is truly of tremendous consequence for how states deal with future threats. And consequently what potential or actual partners can bring to the table matters for international conflict and cooperation.

References

Adler, Emanuel, and Michael Barnett. 1998. *Security Communities*. Cambridge University Press.

Adler, Emanuel, and Patricia Greve. 2009. "When Security Community Meets Balance of Power: Overlapping Regional Mechanisms of Security Governance." *Review of International Studies* 35 (S1): 59–84. https://doi.org/10.1017/S0260210509008432.

Aksoy, Sinan G., Emilie Purvine, and Stephen J. Young. 2021. "Directional Laplacian Centrality for Cyber Situational Awareness." *Digital Threats: Research and Practice* 2 (4): 1–28. https://doi.org/gtzpvf.

Alley, Joshua. 2021. "Alliance Participation, Treaty Depth, and Military Spending." *International Studies Quarterly* 65 (4): 929–43. https://doi.org/10.1093/isq/sqab077.

Alley, Joshua, and Matthew Fuhrmann. 2021. "Budget Breaker? The Financial Cost of US Military Alliances." *Security Studies* 30 (5): 661–90. https://doi.org/10.1080/09636412.2021.2021280.

Altfeld, Michael. 1984. "The Decision To Ally: A Theory and Test." *Western Political Quarterly* 37 (4): 523–44. https://doi.org/10.1177/106591298403700402.

Araújo, Márcio S., Paulo R. Guimarães, Richard Svanbäck, Aluisio Pinheiro, Paulo Guimarães, Sérgio F. dos Reis, and Daniel I. Bolnick. 2008. "Network Analysis Reveals Contrasting Effects of Intraspecific Competition on Individual Vs. Population Diets." *Ecology* 89 (7): 1981–93. https://doi.org/10.1890/07-0630.1.

Arkhangelsky, Dmitry, and Guido Imbens. 2024. "Causal Models for Longitudinal and Panel Data: A Survey." arXiv. https://doi.org/10.48550/arXiv.2311.15458.

Auerswald, David, and Stephen Saideman. 2014. *NATO in Afghanistan: Fighting Together, Fighting Alone*. Princeton, NJ: Princeton University Press.

Avey, Paul. 2019. "The Icebreaker Gap Doesn't Mean America Is Losing in the Arctic."

War on the Rocks. https://warontherocks.com/2019/11/the-icebreaker-gap-doesnt-mean-america-is-losing-in-the-arctic/.

Axelrod, Robert, and Robert O. Keohane. 1985. "Achieving Cooperation Under Anarchy: Strategies and Institutions." *World Politics* 38 (1): 226–54. https://doi.org/10.2307/2010357.

Bach, Philipp, Malte S. Kurz, Victor Chernozhukov, Martin Spindler, and Sven Klaassen. 2024. "DoubleML: An Object-Oriented Implementation of Double Machine Learning in R." *Journal of Statistical Software* 108 (3): 1–56. https://doi.org/gt3cht.

Bak, Daehee. 2018. "Alliance Proximity and Effectiveness of Extended Deterrence." *International Interactions* 44 (1): 107–31. https://doi.org/10.1080/03050629.2017.1320995.

Barnett, Michael, and Jack Levy. 1991. "Domestic Sources of Alliances and Alignments: The Case of Egypt, 1962–73." *International Organization* 45 (3): 369–95. https://doi.org/10.1017/S0020818300033142.

Bearce, David H., Kristen M. Flanagan, and Katharine M. Floros. 2006. "Alliances, Internal Information, and Military Conflict Among Member-States." *International Organization* 60 (3): 595–625. https://doi.org/10.1017/S0020818306060188.

Beardsley, Kyle. 2024. "The Coevolution of Networks of Interstate Support, Interstate Threat, and Civil War." *The Journal of Politics*, February, 000–000. https://doi.org/gt2xvn.

Beardsley, Kyle, Howard Liu, Peter J. Mucha, David A. Siegel, and Juan F. Tellez. 2020. "Hierarchy and the Provision of Order in International Politics." *The Journal of Politics* 82 (2): 731–46. https://doi.org/10.1086/707096.

Becker, Jordan, Seth Benson, J Paul Dunne, and Edmund Malesky. 2024. "Disaggregated Defense Spending: Introduction to Data." *Journal of Peace Research*, March, 00223433231215785. https://doi.org/10.1177/00223433231215785.

Beek, Maël van, Michael Z. Lopate, Andrew Goodhart, David A. Peterson, Jared Edgerton, Haoming Xiong, Maryum Alam, Leyla Tiglay, Daniel Kent, and Bear F. Braumoeller.

2024. "Hierarchy and War." *American Journal of Political Science* 0 (0): 1–15. https://doi.org/10.1111/ajps.12855.

Bell, Andrew, and Kelvyn Jones. 2015. "Explaining Fixed Effects: Random Effects Modeling of Time-Series Cross-Sectional and Panel Data." *Political Science Research and Methods* 3 (1): 133–53. https://doi.org/gcx9g2.

Bennett, D. Scott. 2006. "Exploring Operationalizations of Political Relevance." *Conflict Management and Peace Science* 23 (3): 245–61. https://doi.org/10.1080/07388940600837748.

Bensahel, Nora. 2007. "International Alliances and Military Effectiveness: Fighting Alongside Allies and Partners." In *Creating Military Power: The Sources of Military Effectiveness*, edited by Risa A. Brooks and Elizabeth Stanley, 186–206. Stanford University Press.

Benson, Brett V. 2012. *Constructing International Security: Alliances, Deterrence, and Moral Hazard*. Cambridge University Press.

Benson, Brett V., and Joshua D. Clinton. 2016. "Assessing the Variation of Formal Military Alliances." *Journal of Conflict Resolution* 60 (5): 866–98. https://doi.org/10.1177/0022002714560348.

Benson, Brett V., Adam Meirowitz, and Kristopher W. Ramsay. 2014. "Inducing Deterrence Through Moral Hazard in Alliance Contracts." *Journal of Conflict Resolution* 58 (2): 307–35. https://doi.org/10.1177/0022002712467936.

Benson, Brett V., and Bradley C. Smith. 2023. "Commitment Problems in Alliance Formation." *American Journal of Political Science* 67 (4): 1012–25. https://doi.org/10.1111/ajps.12693.

Benson, Michelle A. 2005. "The Relevance of Politically Relevant Dyads in the Study of Interdependence and Dyadic Disputes." *Conflict Management and Peace Science* 22 (2): 113–33. https://doi.org/10.1080/07388940590948556.

Bitzinger, Richard A. 2009. "The European Defense Industry in the 21st Century: Challenges and Responses." In *The Modern Defense Industry: Political, Economic, and Technological Issues: Political, Economic, and Technological Issues*, edited by Richard Bitzinger, 175–95. ABC-CLIO.

Blankenship, Brian. 2020. "Promises Under Pressure: Statements of Reassurance in US Alliances." *International Studies Quarterly* 64 (4): 1017–30. https://doi.org/10.1093/isq/sqaa071.

———. 2023. *The Burden-Sharing Dilemma: Coercive Diplomacy in US Alliance Politics*. Cornell Studies in Security Affairs. Ithaca: Cornell University Press.

Bleek, Philipp, and Eric Lorber. 2014. "Security Guarantees and Allied Nuclear Proliferation." *Journal of Conflict Resolution* 58 (3): 429–54. https://doi.org/10.1177/0022002713509050.

Boley, Daniel, Alejandro Buendia, and Golshan Golnari. 2018. "Random Walk Laplacian and Network Centrality Measures." arXiv. https://arxiv.org/abs/1808.02912.

Bolnick, Daniel I., Louie H. Yang, James A. Fordyce, Jeremy M. Davis, and Richard Svanbäck. 2002. "Measuring Individual-Level Resource Specialization." *Ecology* 83 (10): 2936–41. https://doi.org/10.1890/0012-9658(2002)083%5B2936:MILRS%5D2.0.CO;2.

Bosse, Douglas A., and Sharon A. Alvarez. 2010. "Bargaining Power in Alliance Governance Negotiations: Evidence from the Biotechnology Industry." *Technovation* 30 (5): 367–75. https://doi.org/10.1016/j.technovation.2010.01.003.

Bremer, Stuart A. 1992. "Dangerous Dyads: Conditions Affecting the Likelihood of Interstate War, 1816-1965." *Journal of Conflict Resolution* 36 (2): 309–41. https://www.jstor.org/stable/174478.

Bukovansky, Mlada, Ian Clark, Robyn Eckersley, Richard Price, Christian Reus-Smit, and Nicholas J. Wheeler. 2012. *Special Responsibilities: Global Problems and American Power*. New York, NY: Cambridge University Press.

Bürkner, Paul-Christian. 2017. "Brms: An R Package for Bayesian Multilevel Models Using Stan." *Journal of Statistical Software* 80 (1): 1–28. https://doi.org/gddxwp.

Burton, Joe. 2018. *NATO's Durability in a Post-Cold War World*. SUNY Press.

Cappella Zielinski, Rosella, and Ryan Grauer. 2020. "Organizing for Performance: Coalition Effectiveness on the Battlefield." *European Journal of International Relations* 26 (4): 953–78. https://doi.org/10.1177/1354066120903369.

Cappella Zielinski, Rosella, and Paul Poast. 2021. "Supplying Allies: Political Economy of Coalition Warfare." *Journal of Global Security Studies* 6 (1): 1–7. https://doi.org/10.1093/jogss/ogaa006.

Carter, David B., and Curtis S. Signorino. 2010. "Back to the Future: Modeling Time Dependence in Binary Data." *Political Analysis* 18 (3): 271–92. https://doi.org/10.1093/pan/mpq013.

Chernozhukov, Victor, Denis Chetverikov, Mert Demirer, Esther Duflo, Christian Hansen, Whitney Newey, and James Robins. 2018. "Double/Debiased Machine Learning for Treatment and Structural Parameters." *The Econometrics Journal* 21 (1): 1–68. https://doi.org/gc2snx.

Chiang, Harold D., and Yuya Sasaki. 2023. "On Using The Two-Way Cluster-Robust Standard Errors." arXiv. https://doi.org/10.48550/arXiv.2301.13775.

Chiba, Daina, Jesse C. Johnson, and Brett Ashley Leeds. 2015. "Careful Commitments: Democratic States and Alliance Design." *The Journal of Politics* 77 (4): 968–82. https://doi.org/10.1086/682074.

Chiu, Albert, Xingchen Lan, Ziyi Liu, and Yiqing Xu. 2023. "What To Do (and Not to Do) with Causal Panel Analysis Under Parallel Trends: Lessons from A Large Reanalysis Study." {{SSRN Scholarly Paper}}. Rochester, NY. https://doi.org/10.2139/ssrn.4490035.

Chou, Chelsea C., Chih-Sung Teng, and Hans H. Tung. 2023. "How Do Alliances Trade Arms? Political Alliance Networks and Global Arms Transfers." *PLOS ONE* 18 (3): 1–14. https://doi.org/10.1371/journal.pone.0282456.

Christensen, Thomas, and Jack Snyder. 1990. "Chain Gangs and Passed Bucks: Predicting

Alliance Patterns in Multipolarity." *International Organization* 44 (2): 137–68. https://doi.org/10.1017/S0020818300035232.

Clark, David H. 2001. "Trading Butter for Guns: Domestic Imperatives for Foreign Policy Substitution." *Journal of Conflict Resolution* 45 (5): 636–60. https://doi.org/10.1177/0022002701045005005.

Clarke, Kevin A., Brenton Kenkel, and Miguel R. Rueda. 2018. "Omitted Variables, Countervailing Effects, and the Possibility of Overadjustment." *Political Science Research and Methods* 6 (2): 343–54. https://doi.org/gf5hbn.

Cohen, Jacob. 1960. "A Coefficient of Agreement for Nominal Scales." *Educational and Psychological Measurement* 20 (1): 37–46. https://doi.org/dghsrr.

Colaresi, Michael P., Karen Rasler, and William R. Thompson. 2008. *Strategic Rivalries in World Politics: Position, Space and Conflict Escalation.* Cambridge: Cambridge University Press.

Conybeare, John A. C. 1992. "A Portfolio Diversification Model of Alliances: The Triple Alliance and Triple Entente, 1879-1914." *Journal of Conflict Resolution* 36 (1): 53–85. https://doi.org/10.1177/0022002792036001003.

———. 1994a. "The Portfolio Benefits of Free Riding in Military Alliances." *International Studies Quarterly* 38 (3): 405–19. https://doi.org/10.2307/2600739.

———. 1994b. "Arms Versus Alliances: The Capital Structure of Military Enterprise." *Journal of Conflict Resolution* 38 (2): 215–35. https://doi.org/10.1177/0022002794038002003.

Conybeare, John A. C., James C. Murdoch, and Todd Sandler. 1994. "Alternative Collective-Goods Models of Military Alliances: Theory and Empirics." *Economic Inquiry* 32 (4): 525–42. https://doi.org/10.1111/j.1465-7295.1994.tb01349.x.

Conybeare, John A. C., and Todd Sandler. 1990. "The Triple Entente and the Triple Alliance 1880-1914: A Collective Goods Approach." *American Political Science Review* 84 (4): 1197–1206. https://doi.org/10.2307/1963259.

Cooley, Alexander, Daniel H. Nexon, Paul Poast, Joshua Alley, and Matthew Fuhrmann. 2022. "Estimating Alliance Costs: An Exchange." *Security Studies* 31 (3): 510–32. https://doi.org/10.1080/09636412.2022.2101324.

Cordeiro, Mário, Rui Portocarrero Sarmento, Pavel Brazdil, and João Gama. 2018. "Dynamic Laplace: Efficient Centrality Measure for Weighted or Unweighted Evolving Networks." arXiv. https://arxiv.org/abs/1808.02960.

Cranmer, Skyler J., and Bruce A. Desmarais. 2016. "A Critique of Dyadic Design." *International Studies Quarterly* 60 (2): 355–62. https://doi.org/10.1093/isq/sqw007.

Cranmer, Skyler J., Elizabeth J. Menninga, and Peter J. Mucha. 2015. "Kantian Fractionalization Predicts the Conflict Propensity of the International System." *Proceedings of the National Academy of Sciences* 112 (38): 11812–16. https://doi.org/10.1073/pnas.1509423112.

Crescenzi, Mark J. C., Jacob D. Kathman, Katja B. Kleinberg, and Reed M. Wood. 2012. "Reliability, Reputation, and Alliance Formation." *International Studies Quarterly* 56 (2): 259–74. https://doi.org/10.1111/j.1468-2478.2011.00711.x.

Cross, Tyler. 2019. "The NATO Alliance's Role in Arctic Security." *The Maritime Executive*. https://www.maritime-executive.com/editorials/the-nato-alliance-s-role-in-arctic-security.

Danov, Vassil. 2001. "Comparative Analysis of the Reforms in the Armies of the Czech Republic, Hungary, Poland and Bulgaria During the 1990-1998 Period." North Atlantic Treaty Organization.

Davidson, Jason. 2011. *America's Allies and War: Kosovo, Afghanistan, and Iraq*. New York, NY: Springer.

de Castro, Renato Cruz. 2009. "The US-Philippine Alliance: An Evolving Hedge Against an Emerging China Challenge." *Contemporary Southeast Asia: A Journal of International and Strategic Affairs* 31 (3): 399–423.

De Vestel, Pierre. 1995. "Defence Markets and Industries in Europe: Time for Political Decisions?" Chaillot {{Paper}} 21. Institute for Security Studies.

Dekker, Henri C. 2004. "Control of Inter-Organizational Relationships: Evidence on Appropriation Concerns and Coordination Requirements." *Accounting, Organizations and Society* 29 (1): 27–49. https://doi.org/10.1016/S0361-3682(02)00056-9.

Diehl, Paul F. 1994. "Substitutes or Complements?: The Effects of Alliances on Military Spending in Major Power Rivalries." *International Interactions* 19 (3): 159–76. https://doi.org/10.1080/03050629408434825.

Diehl, Paul F., Gary Goertz, and Yahve Gallegos. 2021. "Peace Data: Concept, Measurement, Patterns, and Research Agenda." *Conflict Management and Peace Science* 38 (5): 605–24. https://doi.org/10.1177/0738894219870288.

DiGiuseppe, Matthew, and Paul Poast. 2016. "Arms Versus Democratic Allies." *British Journal of Political Science* 48 (4): 981–1003. https://doi.org/10.1017/S0007123416000247.

Donnelly, Jack. 2006. "Sovereign Inequalities and Hierarchy in Anarchy: American Power and International Society." *European Journal of International Relations* 12 (2): 139–70. https://doi.org/10.1177/1354066106064505.

Dorff, Cassy, and Michael D. Ward. 2013. "Networks, Dyads, and the Social Relations Model." *Political Science Research and Methods* 1 (2): 159–78. https://doi.org/10.1017/psrm.2013.21.

Dormann, Carsten F., Jochen Fründ, Nico Blüthgen, and Bernd Gruber. 2009. "Indices, Graphs and Null Models: Analyzing Bipartite Ecological Networks." *The Open Ecology Journal* 2 (1): 7–24.

Dworschak, Christoph. 2023. "Bias Mitigation in Empirical Peace and Conflict Studies: A Short Primer on Posttreatment Variables." *Journal of Peace Research* 61 (3): 462–76. https://doi.org/10.1177/00223433221145531.

Edgerton, Jared F. 2024. "Cooperative Communities in the International System: Networked Cooperation of Similar States." *The Journal of Politics*, February, 000–000. https://doi.org/gt225f.

Fearon, James D. 1997. "Signaling Foreign Policy Interests Tying Hands Versus Sinking Costs." *Journal of Conflict Resolution* 41 (1): 68–90. https://doi.org/10.1177/0022002797041001004.

Fjelstul, Joshua C., and Dan Reiter. 2019. "Explaining Incompleteness and Conditionality in Alliance Agreements." *International Interactions* 45 (6): 976–1002. https://doi.org/10.1080/03050629.2019.1647838.

Fordham, Benjamin O., and Paul Poast. 2016. "All Alliances Are Multilateral: Rethinking Alliance Formation." *Journal of Conflict Resolution* 60 (5): 840–65. https://doi.org/10.1177/0022002714553108.

Fuhrmann, Matthew. 2020. "When Do Leaders Free-Ride? Business Experience and Contributions to Collective Defense." *American Journal of Political Science* 64 (2): 416–31. https://doi.org/10.1111/ajps.12502.

Fuhrmann, Matthew, and Todd S. Sechser. 2014. "Signaling Alliance Commitments: Hand-Tying and Sunk Costs in Extended Nuclear Deterrence." *American Journal of Political Science* 58 (4): 919–35. https://doi.org/10.1111/ajps.12082.

Galambos, Kevin. 2024. "Military Exercises and Network Effects." *International Studies Quarterly* 68 (1): sqae004. https://doi.org/10.1093/isq/sqae004.

Galbraith, Jay R. 1977. *Organization Design.* Boston, MA: Addison-Wesley Pub. Co.

Gandrud, Christopher, and Laron Williams K. 2017. "Simulating Probabilistic Long-Term Effects in Models with Temporal Dependence." *The R Journal* 9 (2): 401–8. https://doi.org/gtthsm.

Gannon, J Andrés. 2023. "Planes, Trains, and Armored Mobiles: Introducing a Dataset of the Global Distribution of Military Capabilities." *International Studies Quarterly* 67 (4): 1–12. https://doi.org/10.1093/isq/sqad081.

———. 2024. "Allies as Armaments: Explaining the Specialization of State Military Capabilities." *Security Studies* 0 (0).

Gartzke, Erik A., and Kristian Skrede Gleditsch. 2022. "Ties That Bias in International Conflict: A Spatial Approach to Dyadic Dependence from Alliance Ties and Inbetweenness." *International Studies Quarterly* 66 (1): 1–13. https://doi.org/gtvhjc.

Gibler, Douglas M., and Toby J. Rider. 2004. "Prior Commitments: Compatible Interests Versus Capabilities in Alliance Behavior." *International Interactions* 30 (4): 309–29. https://doi.org/10.1080/03050620490883985.

Gibler, Douglas M., and Jamil A. Sewell. 2006. "External Threat and Democracy: The Role of NATO Revisited." Edited by Christopher Sprecher and Volker Krause. *Journal of Peace Research* 43 (4): 413–31. https://doi.org/10.1177/0022343306065115.

Gibler, Douglas M., and Scott Wolford. 2006. "Alliances, Then Democracy: An Examination of the Relationship Between Regime Type and Alliance Formation." *Journal of Conflict Resolution* 50 (1): 129–53. https://doi.org/10.1177/0022002705281360.

Goertz, Gary, Paul Francis Diehl, and Alexandru Balas. 2016. *The Puzzle of Peace: The Evolution of Peace in the International System*. Oxford University Press.

Goldman, Emily O. 2007. "International Competition and Military Effectiveness: Naval Air Power, 1919-1945." In *Creating Military Power: The Sources of Military Effectiveness*, edited by Risa A. Brooks and Elizabeth Stanley, 158–85. Stanford University Press.

Gorelick, Root, and Susan M. Bertram. 2007. "Quantifying Division of Labor: Borrowing Tools from Sociology, Sociobiology, Information Theory, Landscape Ecology, and Biogeography." *Insectes Sociaux* 54 (2): 105–12. https://doi.org/10.1007/s00040-007-0923-z.

Gorelick, Root, Susan M. Bertram, Peter R. Killeen, and Jennifer H. Fewell. 2004. "Normalized Mutual Entropy in Biology: Quantifying Division of Labor." *The American Naturalist* 164 (5): 677–82. https://doi.org/10.1086/424968.

Green, Michael, Kathleen Hicks, and Mark F. Cancian. 2016. "Asia-Pacific Rebalance 2025: Capabilities, Presence, and Partnerships."

Guerrero, José. 2022. "Laplacian Energies of Vertices." arXiv. https://arxiv.org/abs/2201.

01252.

Gulati, Ranjay, and Nitin Nohria. 1992. "Mutually Assured Alliances." *Academy of Management Proceedings* 1992 (1): 17–21. https://doi.org/10.5465/ambpp.1992.4976638.

Gulati, Ranjay, and Harbir Singh. 1998. "The Architecture of Cooperation: Managing Coordination Costs and Appropriation Concerns in Strategic Alliances." *Administrative Science Quarterly* 43 (4): 781–814. https://doi.org/10.2307/2393616.

Gulati, Ranjay, Franz Wohlgezogen, and Pavel Zhelyazkov. 2012. "The Two Facets of Collaboration: Cooperation and Coordination in Strategic Alliances." *The Academy of Management Annals* 6 (1): 531–83. https://doi.org/10.1080/19416520.2012.691646.

Gutman, Ivan, and Bo Zhou. 2006. "Laplacian Energy of a Graph." *Linear Algebra and Its Applications* 414 (1): 29–37. https://doi.org/bzz4wp.

Haftendorn, Helga, Robert Keohane, and Celeste Wallender, eds. 1999. *Imperfect Unions: Security Institutions Over Time and Space.* Oxford: Oxford University Press.

Häge, Frank M. 2011. "Choice or Circumstance? Adjusting Measures of Foreign Policy Similarity for Chance Agreement." *Political Analysis* 19 (3): 287–305. https://www.jstor.org/stable/23011439.

Haim, Dotan A. 2016. "Alliance Networks and Trade The Effect of Indirect Political Alliances on Bilateral Trade Flows." *Journal of Peace Research* 53 (3): 472–90. https://doi.org/10.1177/0022343316630938.

Hardin, Russell. 1982. *Collective Action.* Resources for the Future.

Hartley, Keith. 1987. "Public Procurement and Competitiveness: A Community Market for Military Hardware and Technology?" *JCMS: Journal of Common Market Studies* 25 (3): 237–47. https://doi.org/10.1111/j.1468-5965.1987.tb00293.x.

Hazlett, Chad, and Leonard Wainstein. 2022. "Understanding, Choosing, and Unifying Multilevel and Fixed Effect Approaches." *Political Analysis* 30 (1): 46–65. https://doi.org/gpbxrr.

Henry, Iain D. 2020. "What Allies Want: Reconsidering Loyalty, Reliability, and Alliance Interdependence." *International Security* 44 (4): 45–83. https://doi.org/10.1162/isec_a_00375.

Herspring, Dale R. 1994. "'Refolution' in Eastern Europe: The Polish, Czech, Slovak and Hungarian Militaries." *European Security* 3 (4): 664–90. https://doi.org/10.1080/09662839408407196.

Hidalgo, C. A., B. Klinger, A.-L. Barabasi, and R. Hausmann. 2007. "The Product Space Conditions the Development of Nations." *Science* 317 (5837): 482–87. https://doi.org/10.1126/science.1144581.

Hill, Terrence D., Andrew P. Davis, J. Micah Roos, and Michael T. French. 2020. "Limitations of Fixed-Effects Models for Panel Data." *Sociological Perspectives* 63 (3): 357–69. https://doi.org/gjrgr5.

Hobson, John M., and J. C. Sharman. 2005. "The Enduring Place of Hierarchy in World Politics: Tracing the Social Logics of Hierarchy and Political Change." *European Journal of International Relations* 11 (1): 63–98. https://doi.org/10.1177/1354066105050137.

Hoff, Peter D., and Michael D. Ward. 2004. "Modeling Dependencies in International Relations Networks." *Political Analysis* 12 (2): 160–75. https://doi.org/bfrv3c.

Holsti, Ole R., P. Terrence Hopmann, and John D. Sullivan. 1985. *Unity and Disintegration in International Alliances*. New York: John Wiley & Sons.

Horowitz, Michael C., Paul Poast, and Allan C. Stam. 2017. "Domestic Signaling of Commitment Credibility: Military Recruitment and Alliance Formation." *Journal of Conflict Resolution* 61 (8): 1682–1710. https://doi.org/10.1177/0022002715612576.

Howorth, Jolyon. 2007. *The Security and Defence Policy in the European Union*. London: Palgrave Macmillan.

Hurlbert, Stuart H. 1978. "The Measurement of Niche Overlap and Some Relatives." *Ecology* 59 (1): 67–77. https://doi.org/c2f9p9.

Hynd, Alexander M, and Daniel Connolly. 2023. "Domination for the Rest? Creating and Contesting Secondary State-Led International Hierarchies." *International Studies Quarterly* 67 (4): 1–13. https://doi.org/10.1093/isq/sqad098.

Ikenberry, G. John. 2001. *After Victory: Institutions, Strategic Restraint, and the Rebuilding of Order After Major Wars*. Princeton: Princeton University Press.

Imai, Kosuke, and In Song Kim. 2019. "When Should We Use Unit Fixed Effects Regression Models for Causal Inference with Longitudinal Data?" *American Journal of Political Science* 63 (2): 467–90. https://doi.org/gfwnpf.

———. 2021. "On the Use of Two-Way Fixed Effects Regression Models for Causal Inference with Panel Data." *Political Analysis* 29 (3): 405–15. https://doi.org/gjgvvd.

Johnson, Jesse C., Brett Ashley Leeds, and Ahra Wu. 2015. "Capability, Credibility, and Extended General Deterrence." *International Interactions* 41 (2): 309–36. https://doi.org/10.1080/03050629.2015.982115.

Jung, Danielle F., and David A. Lake. 2011. "Markets, Hierarchies, and Networks: An Agent-Based Organizational Ecology." *American Journal of Political Science* 55 (4): 972–90. https://doi.org/10.1111/j.1540-5907.2011.00536.x.

Kahler, Miles, ed. 2009. *Networked Politics: Agency, Power, and Governance*. Ithaca: Cornell University Press.

Keele, Luke, Randolph T. Stevenson, and Felix Elwert. 2020. "The Causal Interpretation of Estimated Associations in Regression Models." *Political Science Research and Methods* 8 (1): 1–13. https://doi.org/10.1017/psrm.2019.31.

Keohane, Robert O. 1984. *After Hegemony: Cooperation and Discord in the World Political Economy*. Princeton, N.J.: Princeton University Press.

Kim, In Song, Steven Liao, and Kosuke Imai. 2020. "Measuring Trade Profile with Granular Product-Level Data." *American Journal of Political Science* 64 (1): 102–17. https://doi.org/10.1111/ajps.12473.

Kim, Tongfi. 2016. *The Supply Side of Security: A Market Theory of Military Alliances.* Stanford University Press.

Kimball, Anessa L. 2010. "Political Survival, Policy Distribution, and Alliance Formation." *Journal of Peace Research* 47 (4): 407–19. https://doi.org/10.1177/0022343310368346.

Kinne, Brandon J. 2012. "Multilateral Trade and Militarized Conflict: Centrality, Openness, and Asymmetry in the Global Trade Network." *The Journal of Politics* 74 (1): 308–22. https://doi.org/10.1017/S002238161100137X.

———. 2013a. "IGO Membership, Network Convergence, and Credible Signaling in Militarized Disputes." *Journal of Peace Research* 50 (6): 659–76. https://doi.org/10.1177/0022343313498615.

———. 2013b. "Network Dynamics and the Evolution of International Cooperation." *American Political Science Review* 107 (4): 766–85. https://doi.org/10.1017/S0003055413000440.

———. 2018. "Defense Cooperation Agreements and the Emergence of a Global Security Network." *International Organization* 72 (4): 36.

Kinne, Brandon J., and Jonas B. Bunte. 2020. "Guns or Money? Defense Co-operation and Bilateral Lending as Coevolving Networks." *British Journal of Political Science* 50 (3): 1067–88. https://doi.org/10.1017/S0007123418000030.

Kinne, Brandon J., and Stephanie N. Kang. 2023. "Free Riding, Network Effects, and Burden Sharing in Defense Cooperation Networks." *International Organization* 77 (2): 405–39. https://doi.org/10.1017/S0020818322000315.

Klein, James P., Gary Goertz, and Paul F. Diehl. 2006. "The New Rivalry Dataset: Procedures and Patterns." *Journal of Peace Research* 43 (3): 331–48. https://doi.org/10.1177/0022343306063935.

Kostyuk, Nadiya. 2024. "Allies and Diffusion of State Military Cybercapacity." *Journal of Peace Research* 61 (1): 44–58. https://doi.org/10.1177/00223433241226559.

Krasner, Stephen D. 1991. "Global Communications and National Power: Life on the Pareto

Frontier." *World Politics* 43 (3): 336–66. https://doi.org/10.2307/2010398.

Kreps, Sarah. 2011. *Coalitions of Convenience: United States Military Interventions After the Cold War*. New York: Oxford University Press.

Kropko, Jonathan, and Robert Kubinec. 2020. "Interpretation and Identification of Within-Unit and Cross-Sectional Variation in Panel Data Models." *PLOS ONE* 15 (4): 1–22. https://doi.org/gg337v.

Kubinec, Robert. 2022. "Ordered Beta Regression: A Parsimonious, Well-Fitting Model for Continuous Data with Lower and Upper Bounds." *Political Analysis*, July, 1–18. https://doi.org/10.1017/pan.2022.20.

Lai, Brian, and Dan Reiter. 2000. "Democracy, Political Similarity, and International Alliances, 1816-1992." *Journal of Conflict Resolution* 44 (2): 203–27. https://doi.org/10.1177/0022002700044002003.

Lake, David A. 1996. "Anarchy, Hierarchy, and the Variety of International Relations." *International Organization* 50 (1): 1–33. https://www.jstor.org/stable/2706997.

———. 1997. "The Rise, Fall, and Future of the Russian Empire." In *The End of Empire? The Transformation of the USSR in Comparative Perspective*, edited by Karen Dawisha and Bruce Parrott, 30–62. New York: M.E. Sharpe.

———. 1999. *Entangling Relations: American Foreign Policy in Its Century*. Princeton University Press.

———. 2001. "Beyond Anarchy: The Importance of Security Institutions." *International Security* 26 (1): 129–60. https://doi.org/10.1162/016228801753212877.

———. 2007. "Escape from the State of Nature: Authority and Hierarchy in World Politics." *International Security* 32 (1): 47–79. https://doi.org/10.1162/isec.2007.32.1.47.

———. 2009. *Hierarchy in International Relations*. Cornell University Press.

Lanoszka, Alexander. 2013. "Beyond Consent and Coercion: Using Republican Political Theory to Understand International Hierarchies." *International Theory* 5 (3): 382–413.

https://doi.org/10.1017/S1752971913000249.

———. 2018. *Atomic Assurance: The Alliance Politics of Nuclear Proliferation.* Cornell Studies in Security Affairs. Ithaca, NY: Cornell University Press.

———. 2022. *Military Alliances in the Twenty-First Century.* Hoboken, NJ: John Wiley & Sons.

Larson, Deborah Welch, and Alexei Shevchenko. 2014. "Managing Rising Powers: The Role of Status Concerns." In *Status in World Politics*, 33–57. Cambridge: Cambridge University Press.

Leeds, Brett Ashley. 2003a. "Alliance Reliability in Times of War: Explaining State Decisions to Violate Treaties." *International Organization* 57 (4): 801–27. https://doi.org/10.1017/S0020818303574057.

———. 2003b. "Do Alliances Deter Aggression? The Influence of Military Alliances on the Initiation of Militarized Interstate Disputes." *American Journal of Political Science* 47 (3): 427–39. https://doi.org/10.1111/1540-5907.00031.

Leeds, Brett Ashley, and Sezi Anac. 2005. "Alliance Institutionalization and Alliance Performance." *International Interactions* 31 (3): 183–202. https://doi.org/10.1080/03050620500294135.

Leeds, Brett Ashley, Andrew G. Long, and Sara McLaughlin Mitchell. 2000. "Reevaluating Alliance Reliability: Specific Threats, Specific Promises." *Journal of Conflict Resolution* 44 (5): 686–99. https://doi.org/10.1177/0022002700044005006.

Leeds, Brett Ashley, and Michaela Mattes. 2007. "Alliance Politics During the Cold War: Aberration, New World Order, or Continuation of History?" *Conflict Management and Peace Science* 24 (3): 183–99. https://doi.org/10.1080/07388940701473054.

Leeds, Brett Ashley, Michaela Mattes, and Jeremy S. Vogel. 2009. "Interests, Institutions, and the Reliability of International Commitments." *American Journal of Political Science* 53 (2): 461–76. https://www.jstor.org/stable/25548129.

Leeds, Brett Ashley, Jeffrey Ritter, Sara Mitchell, and Andrew Long. 2002. "Alliance Treaty Obligations and Provisions, 1815-1944." *International Interactions* 28 (3): 237–60. https://doi.org/10.1080/03050620213653.

Leeds, Brett Ashley, and Burcu Savun. 2007. "Terminating Alliances: Why Do States Abrogate Agreements?" *The Journal of Politics* 69 (4): 1118–32. https://doi.org/10.1111/j.1468-2508.2007.00612.x.

Lemke, Douglas, and William Reed. 2001. "The Relevance of Politically Relevant Dyads." *Journal of Conflict Resolution* 45 (1): 126–44. https://doi.org/10.1177/0022002701045001006.

Li, Weihua, Aisha E. Bradshaw, Caitlin B. Clary, and Skyler J. Cranmer. 2017. "A Three-Degree Horizon of Peace in the Military Alliance Network." *Science Advances* 3 (3): 1–10. https://doi.org/10.1126/sciadv.1601895.

Lind, Jennifer M. 2004. "Pacifism or Passing the Buck? Testing Theories of Japanese Security Policy." *International Security* 29 (1): 92–121. https://www.jstor.org/stable/4137548.

Liu, Licheng, Ye Wang, and Yiqing Xu. 2024. "A Practical Guide to Counterfactual Estimators for Causal Inference with Time-Series Cross-Sectional Data." *American Journal of Political Science* 68 (1): 160–76. https://doi.org/gqmpxv.

MacDonald, Paul K. 2018. "Embedded Authority: A Relational Network Approach to Hierarchy in World Politics." *Review of International Studies* 44 (1): 128–50. https://doi.org/10.1017/S0260210517000213.

MacDonald, Paul K., and David A. Lake. 2008. "The Role of Hierarchy in International Politics." *International Security* 32 (4): 171–80. https://www.jstor.org/stable/30129795.

Manger, Mark S., Mark A. Pickup, and Tom A. B. Snijders. 2012. "A Hierarchy of Preferences: A Longitudinal Network Analysis Approach to PTA Formation." *Journal of Conflict Resolution* 56 (5): 853–78. https://www.jstor.org/stable/23414713.

Manthey, Michael, and Jason D. Fridley. 2009. "Beta Diversity Metrics and the Estimation of Niche Width via Species Co-Occurrence Data: Reply to Zeleny." *Journal of Ecology* 97 (1): 18–22. https://doi.org/10.1111/j.1365-2745.2008.01450.x.

Maoz, Zeev. 1996. *Domestic Sources of Global Change.* Ann Arbor, MI: University of Michigan Press. https://doi.org/10.3998/mpub.14663.

———. 2010. *Networks of Nations: The Evolution, Structure, and Impact of International Networks, 1816–2001.* Cambridge University Press.

———. 2012. "How Network Analysis Can Inform the Study of International Relations." *Conflict Management and Peace Science* 29 (3): 247–56. https://doi.org/10.1177/0738894212443341.

March, James G., and Herbert Alexander Simon. 1958. *Organizations.* Hoboken: John Wiley & Sons.

Margulies, Max Z. 2021. "Patrons and Personnel: The Foreign Determinants of Military Recruitment Policies." *Security Studies* 30 (3): 354–84. https://doi.org/gm4748.

Markowitz, Jonathan N. 2020. *Perils of Plenty: Arctic Resource Competition and the Return of the Great Game.* New York: Oxford University Press.

Markowitz, Jonathan N., and Christopher J. Fariss. 2018. "Power, Proximity, and Democracy: Geopolitical Competition in the International System." *Journal of Peace Research* 55 (1): 78–93. https://doi.org/10.1177/0022343317727328.

Mattern, Janice Bially, and Ayşe Zarakol. 2016. "Hierarchies in World Politics." *International Organization* 70 (3): 623–54. https://doi.org/10.1017/S0020818316000126.

Mattes, Michaela. 2012a. "Democratic Reliability, Precommitment of Successor Governments, and the Choice of Alliance Commitment." *International Organization* 66 (1): 153–72. https://doi.org/fxxr9p.

———. 2012b. "Reputation, Symmetry, and Alliance Design." *International Organization* 66 (4): 679–707. https://doi.org/10.1017/S002081831200029X.

Mawdsley, Jocelyn. 2018. "Armaments Decision-Making: Are European States Really Different?" *Comparative Strategy* 37 (4): 260–71. https://doi.org/10.1080/01495933.2018.1497319.

Mcconaughey, Meghan, Paul Musgrave, and Daniel H. Nexon. 2018. "Beyond Anarchy: Logics of Political Organization, Hierarchy, and International Structure." *International Theory* 10 (2): 181–218. https://doi.org/10.1017/S1752971918000040.

McInnis, Kathleen. 2019. "Varieties of Defection Strategies from Multinational Military Coalitions: Insights from Operation Iraqi Freedom." *Contemporary Security Policy* 40 (1): 116–33. https://doi.org/10.1080/13523260.2018.1506964.

Medeiros, Evan, Keith Crane, Eric Heginbotham, Norman Levin, Julia Lowell, Angel Rabasa, and Somi Seong. 2008. "Pacific Currents: The Responses of U.S. Allies and Security Partners in East Asia to China's Rise." RAND Corporation. https://doi.org/10.7249/MG736.

Miller, Steven V. 2022. "{Peacesciencer}: An R Package for Quantitative Peace Science Research." *Conflict Management and Peace Science* 39 (6): 755–79. https://doi.org/10.1177/07388942221077926.

Monteiro, Nuno P., and Alexandre Debs. 2014. "The Strategic Logic of Nuclear Proliferation." *International Security* 39 (2): 7–51. https://doi.org/gghsn3.

Montgomery, Jacob M., Brendan Nyhan, and Michelle Torres. 2018. "How Conditioning on Posttreatment Variables Can Ruin Your Experiment and What to Do about It." *American Journal of Political Science* 62 (3): 760–75. https://www.jstor.org/stable/26598780.

Morrow, James D. 1991. "Alliances and Asymmetry: An Alternative to the Capability Aggregation Model of Alliances." *American Journal of Political Science* 35 (4): 904–33. https://doi.org/10.2307/2111499.

———. 1993. "Arms Versus Allies: Trade-Offs in the Search for Security." *International Organization* 47 (2): 207–33. https://doi.org/10.1017/S0020818300027922.

———. 1994. "Alliances, Credibility, and Peacetime Costs." *Journal of Conflict Resolution*

38 (2): 270–97. https://doi.org/10.1177/0022002794038002005.

———. 2000. "Alliances: Why Write Them Down?" *Annual Review of Political Science* 3 (1): 63–83. https://doi.org/10.1146/annurev.polisci.3.1.63.

Mummolo, Jonathan, and Erik Peterson. 2018. "Improving the Interpretation of Fixed Effects Regression Results." *Political Science Research and Methods* 6 (4): 829–35. https://doi.org/gdj8q2.

Murdoch, James C., and Todd Sandler. 1982. "A Theoretical and Empirical Analysis of NATO." *Journal of Conflict Resolution* 26 (2): 237–63. https://doi.org/10.1177/0022002782026002003.

Musgrave, Paul, and Daniel H. Nexon. 2018. "Defending Hierarchy from the Moon to the Indian Ocean: Symbolic Capital and Political Dominance in Early Modern China and the Cold War." *International Organization* 72 (3): 591–626. https://doi.org/10.1017/S0020818318000139.

Narang, Neil, and Rupal N. Mehta. 2019. "The Unforeseen Consequences of Extended Deterrence: Moral Hazard in a Nuclear Client State." *Journal of Conflict Resolution* 63 (1): 218–50. https://doi.org/10.1177/0022002717729025.

Nicholls, Daniel Hywel. 2020. "All Hegemons Are Not the Same: The Role(s) of Relational Structures and Modes of Control." *International Studies Review* 22 (3): 600–625. https://doi.org/gt2mm7.

Nieman, Mark David. 2016. "The Return on Social Bonds: Social Hierarchy and International Conflict." *Journal of Peace Research* 53 (5): 665–79. https://doi.org/10.1177/0022343316642509.

Niou, Emerson M. S., and Peter C. Ordeshook. 1994. "Alliances in Anarchic International Systems." *International Studies Quarterly* 38 (2): 167–91. https://doi.org/10.2307/2600974.

Niou, Emerson M. S., and Sean M. Zeigler. 2019. "External Threat, Internal Rivalry, and Alliance Formation." *The Journal of Politics* 81 (2): 571–84. https://doi.org/10.1086/

701724.

Nordhaus, William, John R. Oneal, and Bruce Russett. 2012. "The Effects of the International Security Environment on National Military Expenditures: A Multicountry Study." *International Organization* 66 (3): 491–513. https://doi.org/10.1017/S0020818312000173.

Olson, Mancur. 1965. *The Logic of Collective Action*. Harvard Economic Studies 124. Cambridge, Mass.: Harvard Univ. Press.

Olson, Mancur, and Richard Zeckhauser. 1966. "An Economic Theory of Alliances." *The Review of Economics and Statistics* 48 (3): 266–79. https://doi.org/10.2307/1927082.

Onuf, Nicholas G. 1989. *World of Our Making: Rules and Rule in Social Theory and International Relations*. Columbia, SC: University of South Carolina Press.

———. 2013. *Making Sense, Making Worlds: Constructivism in Social Theory and International Relations*. New York: Routledge.

Overhage, Thomas. 2013. "Pool It, Share It, or Lose It: An Economical View on Pooling and Sharing of European Military Capabilities." *Defense & Security Analysis* 29 (4): 323–41. https://doi.org/10.1080/14751798.2013.842712.

Oxley, Joanne E. 1997. "Appropriability Hazards and Governance in Strategic Alliances: A Transaction Cost Approach." *The Journal of Law, Economics, and Organization* 13 (2): 387–409. https://doi.org/10.1093/oxfordjournals.jleo.a023389.

Oye, Kenneth A. 1985. "Explaining Cooperation Under Anarchy: Hypotheses and Strategies." *World Politics* 38 (1): 1–24. https://doi.org/10.2307/2010349.

Palmer, Glenn. 1990. "Corralling the Free Rider: Deterrence and the Western Alliance." *International Studies Quarterly* 34 (2): 147–64. https://doi.org/10.2307/2600706.

Pamp, Oliver, Florian Dendorfer, and Paul W. Thurner. 2018. "Arm Your Friends and Save on Defense? The Impact of Arms Exports on Military Expenditures." *Public Choice* 177 (1): 165–87. https://doi.org/10.1007/s11127-018-0598-1.

Papayoanou, Paul. 1997. "Intra-Alliance Bargaining and U.S. Bosnia Policy." *Journal of*

Conflict Resolution 41 (1): 91–116. https://doi.org/10.1177/0022002797041001005.

Plümper, Thomas, and Vera E. Troeger. 2019. "Not so Harmless After All: The Fixed-Effects Model." *Political Analysis* 27 (1): 21–45. https://doi.org/gfs8k3.

Poast, Paul. 2010. "(Mis)Using Dyadic Data to Analyze Multilateral Events." *Political Analysis* 18 (4): 403–25. https://doi.org/10.1093/pan/mpq024.

———. 2012. "Does Issue Linkage Work? Evidence from European Alliance Negotiations, 1860 to 1945." *International Organization* 66 (2): 277–310. https://doi.org/10.1017/S0020818312000069.

———. 2016. "Dyads Are Dead, Long Live Dyads! The Limits of Dyadic Designs in International Relations Research." *International Studies Quarterly* 60 (2): 369–74. https://doi.org/10.1093/isq/sqw004.

———. 2019a. *Arguing about Alliances: The Art of Agreement in Military-Pact Negotiations.* Ithaca: Cornell University Press.

———. 2019b. "Beyond the 'Sinew of War': The Political Economy of Security as a Subfield." *Annual Review of Political Science* 22 (1): 223–39. https://doi.org/10.1146/annurev-polisci-050317-070912.

Pondy, Louis R. 1977. *The Other Hand Clapping: An Information-Processing Approach to Organizational Power.* Ithaca, NY: Cornell University, School of Industrial and Labor Relations.

Portnoy, Stephen. 2022. "Linearity of Unbiased Linear Model Estimators." *The American Statistician* 76 (4): 372–75. https://doi.org/gp64c4.

Posen, Barry R. 1984. *The Source of Military Doctrine: France, Britain, and Germany Between the World Wars.* Ithaca: Cornell University Press.

Powell, Robert. 1993. "Guns, Butter, and Anarchy." *American Political Science Review* 87 (1): 115–32. https://doi.org/10.2307/2938960.

———. 1999. *In the Shadow of Power: States and Strategies in International Politics.*

Princeton, N.J: Princeton University Press.

Qi, Xingqin, Robert D. Duval, Kyle Christensen, Edgar Fuller, Arian Spahiu, Qin Wu, Yezhou Wu, Wenliang Tang, and Cunquan Zhang. 2013. “Terrorist Networks, Network Energy and Node Removal: A New Measure of Centrality Based on Laplacian Energy.” *Social Networking* 2 (1): 19–31. https://doi.org/10.4236/sn.2013.21003.

Qi, Xingqin, Eddie Fuller, Qin Wu, Yezhou Wu, and Cun-Quan Zhang. 2012. “Laplacian Centrality: A New Centrality Measure for Weighted Networks.” *Information Sciences*, Intelligent Knowledge-Based Models and Methodologies for Complex Information Systems, 194 (1): 240–53. https://doi.org/10.1016/j.ins.2011.12.027.

Reiter, Dan. 2014. “Security Commitments and Nuclear Proliferation.” *Foreign Policy Analysis* 10 (1): 61–80. https://doi.org/10.1111/fpa.12004.

Ricardo, David. 1817. *On the Principles of Political Economy, and Taxation*. London: John Murray.

Roth, Jonathan, Pedro H. C. Sant’Anna, Alyssa Bilinski, and John Poe. 2023. “What’s Trending in Difference-in-Differences? A Synthesis of the Recent Econometrics Literature.” *Journal of Econometrics* 235 (2): 2218–44. https://doi.org/gr8d4n.

Sandler, Todd, and John F. Forbes. 1980. “Burden Sharing, Strategy, and the Design of NATO.” *Economic Inquiry* 18 (3): 425–44. https://doi.org/10.1111/j.1465-7295.1980.tb00588.x.

Savage, Jesse Dillon. 2021. “Common-Pool Hierarchy: Explaining the Emergence of Cooperative Hierarchies.” *International Studies Quarterly* 65 (3): 712–23. https://doi.org/gt2mm8.

Schneider, Christina J. 2011. “Weak States and Institutionalized Bargaining Power in International Organizations.” *International Studies Quarterly* 55 (2): 331–55. https://doi.org/10.1111/j.1468-2478.2011.00651.x.

Schroeder, Paul W. 2004. “Alliances, 1815–1945: Weapons of Power and Tools of Management.” In *Systems, Stability, and Statecraft: Essays on the International History of*

Modern Europe, 195–222. New York: Palgrave Macmillan. https://doi.org/10.1007/978-1-137-06138-6_10.

Shor, Boris, Joseph Bafumi, Luke Keele, and David Park. 2007. "A Bayesian Multilevel Modeling Approach to Time-Series Cross-Sectional Data." *Political Analysis* 15 (2): 165–81. https://doi.org/bq4db5.

"SIPRI Arms Transfers Database." 2024. Stockholm International Peace Research Institute.

Smith, Alastair. 1995. "Alliance Formation and War." *International Studies Quarterly* 39 (4): 405–25. https://doi.org/10.2307/2600800.

Smith, Bradley C. 2021. "Military Coalitions and the Politics of Information." *The Journal of Politics* 83 (4): 1369–82. https://doi.org/10.1086/711625.

Smith, Ron. 1996. "Weapons Procurement and the Defence Industry." In *About Turn, Forward March With Europe: New Directions for Defence and Security Policy*, edited by Jane M. O. Sharp, 63–75. London: Rivers Oram Press.

Snyder, Glenn H. 1984. "The Security Dilemma in Alliance Politics." *World Politics* 36 (4): 461–95. https://doi.org/10.2307/2010183.

———. 1997. *Alliance Politics*. Ithaca: Cornell University Press.

Snyder, Glenn H., and Paul Diesing. 1977. *Conflict Among Nations: Bargaining, Decision Making, and System Structure in International Crises*. Princeton: Princeton University Press.

Sørensen, George. 1998. "States Are Not 'Like Units': Types of State and Forms of Anarchy in the Present International System." *Journal of Political Philosophy* 6 (1): 79–98. https://doi.org/c2txwt.

Sorokin, Gerald L. 1994. "Arms, Alliances, and Security Tradeoffs in Enduring Rivalries." *International Studies Quarterly* 38 (3): 421–46. https://doi.org/10.2307/2600740.

Stein, Arthur A. 1982. "Coordination and Collaboration: Regimes in an Anarchic World." *International Organization* 36 (2): 299–324. https://doi.org/10.1017/S0020818300018968.

Stueck, William Whitney. 1997. *The Korean War: An International History.* Princeton: Princeton University Press.

Sugiyama, Ayumi, and Toshiharu Sugawara. 2017. "Improvement of Robustness to Environmental Changes by Autonomous Divisional Cooperation in Multi-agent Cooperative Patrol Problem." In *Advances in Practical Applications of Cyber-Physical Multi-Agent Systems: The PAAMS Collection*, edited by Yves Demazeau, Paul Davidsson, Javier Bajo, and Zita Vale, 259–71. Lecture Notes in Computer Science. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-59930-4_21.

Sun, Liyang, and Jesse M. Shapiro. 2022. "A Linear Panel Model with Heterogeneous Coefficients and Variation in Exposure." *Journal of Economic Perspectives* 36 (4): 193–204. https://doi.org/gtw9d7.

Thies, Wallace J. 1987. "Alliances and Collective Goods: A Reappraisal." *Journal of Conflict Resolution* 31 (2): 298–332.

———. 2003. *Friendly Rivals: Bargaining and Burden-shifting in NATO.* Armonke: M.E. Sharpe.

Thompson, William R. 2001. "Identifying Rivals and Rivalries in World Politics." *International Studies Quarterly* 45 (4): 557–86. https://www.jstor.org/stable/3096060.

Thompson, William R., Kentaro Sakuwa, and Prashant Hosur Suhas. 2021. *Analyzing Strategic Rivalries in World Politics: Types of Rivalry, Regional Variation, and Escalation/De-escalation.* Springer Nature.

Thurner, Paul W., Christian S. Schmid, Skyler J. Cranmer, and Göran Kauermann. 2019. "Network Interdependencies and the Evolution of the International Arms Trade." *Journal of Conflict Resolution* 63 (7): 1736–64. https://doi.org/10.1177/0022002718801965.

Vance, Colin, and Nolan Ritter. 2014. "Is Peace a Missing Value or a Zero? On Selection Models in Political Science." *Journal of Peace Research* 51 (4): 528–40. https://doi.org/f6cx7n.

Wallander, Celeste A. 2000. "Institutional Assets and Adaptability: NATO After the Cold War." *International Organization* 54 (4): 705–35. https://doi.org/10.1162/002081800551343.

Walt, Stephen M. 1987. *The Origins of Alliances*. Cornell University Press.

Warren, T. Camber. 2010. "The Geometry of Security: Modeling Interstate Alliances as Evolving Networks." *Journal of Peace Research* 47 (6): 697–709. https://doi.org/10.1177/0022343310386270.

———. 2016. "Modeling the Coevolution of International and Domestic Institutions: Alliances, Democracy, and the Complex Path to Peace." *Journal of Peace Research* 53 (3): 424–41. https://doi.org/10.1177/0022343316633375.

Weber, Katja. 1997. "Hierarchy Amidst Anarchy: A Transaction Costs Approach to International Security Cooperation." *International Studies Quarterly* 41 (2): 321–40. https://doi.org/10.1111/1468-2478.00044.

———. 2000. *Hierarchy Amidst Anarchy: Transaction Costs and Institutional Choice*. Albany: SUNY Press.

Weitsman, Patricia A. 2004. *Dangerous Alliances: Proponents of Peace, Weapons of War*. Stanford University Press.

Wendt, Alexander, and Daniel Friedheim. 1995. "Hierarchy Under Anarchy: Informal Empire and the East German State." *International Organization* 49 (4): 689–721. https://doi.org/10.1017/S0020818300028484.

White, Steven. 2005. "Cooperation Costs, Governance Choice and Alliance Evolution." *Journal of Management Studies* 42 (7): 1383–1412. https://doi.org/10.1111/j.1467-6486.2005.00548.x.

Wilkins, Thomas S. 2012. "'Alignment,' Not 'Alliance' – the Shifting Paradigm of International Security Cooperation: Toward a Conceptual Taxonomy of Alignment." *Review of International Studies* 38 (1): 53–76. https://doi.org/10.1017/S0260210511000209.

Williams, Laron K. 2016. "Long-Term Effects in Models with Temporal Dependence." *Political Analysis* 24 (2): 243–62. https://doi.org/f8nxsq.

Williamson, Oliver E. 1983. "Credible Commitments: Using Hostages to Support Exchange." *The American Economic Review* 73 (4): 519–40. https://www.jstor.org/stable/1816557.

———. 1985. "The Economic Institutions of Capitalism. Firms, Markets, Relational Contracting." In *Das Summa Summarum Des Management*, 61–75. Wiesbaden: Springer.

Wolford, Scott. 2014. "Showing Restraint, Signaling Resolve: Coalitions, Cooperation, and Crisis Bargaining." *American Journal of Political Science* 58 (1): 144–56. https://doi.org/10.1111/ajps.12049.

———. 2015. *The Politics of Military Coalitions*. Cambridge: Cambridge University Press.

Yarbrough, Beth V., and Robert M. Yarbrough. 2016. *Cooperation and Governance in International Trade: The Strategic Organizational Approach*. Princeton: Princeton University Press.

Yarhi-Milo, Keren, Alexander Lanoszka, and Zack Cooper. 2016. "To Arm or to Ally? The Patron's Dilemma and the Strategic Logic of Arms Transfers and Alliances." *International Security* 41 (2): 90–139. https://doi.org/10.1162/ISEC_a_00250.

Zaccarelli, Nicola, Daniel I. Bolnick, and Giorgio Mancinelli. 2013. "RInSp: An r Package for the Analysis of Individual Specialization in Resource Use." *Methods in Ecology and Evolution* 4 (11): 1018–23. https://doi.org/10.1111/2041-210X.12079.

Zaheer, Akbar, and N. Venkatraman. 1995. "Relational Governance as an Interorganizational Strategy: An Empirical Test of the Role of Trust in Economic Exchange." *Strategic Management Journal* 16 (5): 373–92. https://www.jstor.org/stable/2486708.

Zarakol, Ayşe, ed. 2017. *Hierarchies in World Politics*. Cambridge: Cambridge University Press. https://doi.org/10.1017/9781108241588.