HIERARCHY AND THE PROVISION OF ORDER IN INTERNATIONAL POLITICS

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Abstract. The anarchic international system is actually heavily structured: communities of states join together for common benefit; strong states form hierarchical relationships with weak states to enforce order and achieve preferred outcomes. Breaking from prior research, we conceptualize structures such as community and hierarchy as properties of networks of states' interactions that can capture unobserved constraints in state behavior, constraints that may reduce conflict. We offer two claims. One, common membership in trade communities pacifies to the extent that breaking trade ties would entail high switching costs: thus, we expect heavy arms trade, more than most types of commercial trade, to reduce intra-community conflict. Two, this is driven by hierarchical communities in which strong states can use high switching costs as leverage to constrain conflict between weaker states in the community. We find empirical support for these claims using a time-dependent multilayer network model and a new measure of hierarchy based on network centrality.

Keywords: International conflict, interdependence, network analysis, hierarchy, community

Anarchy may continue to be a useful starting point for explaining international politics, but a cursory examination will reveal that states have made much with it. Even in the absence of a legitimate sovereign over the set of nation-states in the current international system, interstate organization is heavily structured. Undergirding this structure is a web of unobserved interests and constraints that guides states' behavior. We record echoes of this web in *networks* of interstate interactions. These networks capture more than just dyadic behavior: they represent the complex, higher-order interdependencies necessary to understand the behavior of states (Dorff and Ward, 2013). For example, explanations of recent relatively stable Israeli-Egyptian relations and volatile Israeli-Syrian relations would be incomplete if they were to solely focus on the domestic politics of Israel, Egypt and Syria, or even on their pairwise affinities, to the exclusion of how these states fit within regional and global structures of power.

Different observed networks capture different aspects of the underlying web.[1] We confine our attention to interstate conflict behavior and two networks that we believe signal states' underlying interests and constraints in this regard—their networks of arms and commercial trade. We further focus on two properties of these networks: the *communities* present within them and the degree of *hierarchy* within each community.

Our concept of community captures implicit group membership that is maintained over time. Intuitively, a set of communities is a partition of the set of states in which the volume of trade within each community substantially exceeds the volume between communities. In contrast to explicit instances of group membership, such as formal alliance blocs, the communities that emerge endogenously from our model offer the promise of teasing out otherwise hidden patterns that might signal power relationships outside of formal blocs, such as those between the USA and Israel or Egypt, or between Russia and Syria, in addition to relationships between regional powers.

Using trade volume to represent ties also allows us to explore our second network measure, hierarchy, more cleanly than one could with dichotomous ties. Hierarchy, as we define it, is

[1] Using the heuristic provided by Kahler (2009), we focus on *networks-as-structures*.

a measure that captures the dispersion of trade volume within a community. Hierarchical communities contain states with substantially unequal contributions to the trade network, while flatter communities comprise more equal trading partners.

Our focus on community and hierarchy enables two main contributions. The first is theoretical: we offer a novel explanation of interstate conflict based on a logic of switching costs and the *interaction* between community and hierarchy. We argue that trade ties capture not just the volume of trade between states and thus magnitudes of gains from trade, but also an array of potential positive and negative inducements between the parties. Cutting a trade tie, even should a similar source for the good in question be found, entails switching costs for the states. The greater these switching costs, the more constrained a state will be in its conflict behavior toward other members of the trading community by the desire to maintain the existing trade network. We claim that conflict constraint within trading communities will be pronounced when communities are hierarchical—so that states which are less central to the trading network will find it especially costly to cut ties with one or a few central states which have incentives to maintain order in the community—and when the good being traded is less fungible—so that states cannot easily switch to another source of the good. This suggests that we should see a reduction in intra-community conflict in hierarchical arms trade communities over and above what we would expect merely from dyadic trade flows. We elaborate on this suggestion and the theory underlying it in section two, and find support for it in the empirical analysis in section four.

Second, we contribute new methods to the discipline for calculating community and hierarchy in the international system. With respect to community, we employ a time-dependent multilayer network model that allows us to use both recent and contemporary tie data in community detection. We take advantage of this in constructing joint-production security communities (JPSCs) out of arms-trade data, which betray sufficient temporal variation so as to have hindered prior analysis.[2] With respect to hierarchy, we introduce a measure that

[2]We use the "joint-production" modifier to be transparent about a focus on communities based on transactional flows rather than more normative or cultural ties. For work on security communities from more of a sociological perspective, see especially Deutsch et al. (1957); Adler and Barnett (1998).

builds on Kinne (2012) to capture a notoriously difficult concept in international relations. The hierarchy measure makes use of information on the weight and directionality of network ties to characterize how asymmetrically distributed the influence of states is within a given community.[3] Related to the link between network centrality and social power uncovered in earlier scholarship (Hafner-Burton and Montgomery, 2009; Lake and Wong, 2009), we argue that communities where few (or one) states are highly influential are structured more hierarchically than communities where states share equal influence. This approach can be applied to any weighted network, and we employ it in both arms trade and commercial trade communities. We describe the new model and measure in section three.

Community, Hierarchy, and Conflict

Networks in the International System. Our theory rests on the idea that underlying the international system is a web of interests and constraints that guide states' behavior. These incentives and constraints might be anything from the pull of shared democratic norms to the rational unwillingness to deviate from strategic optimality. Though the web is unobservable, aspects of it can be inferred from the *networks* of interstate relations it induces. Examples of such networks are arms or commercial trade, common UN voting behavior or INGO membership, or conflict and cooperation.

Our focus on networks builds on recent literature that has identified the insufficiency of purely dyadic interactions for understanding interstate behavior (Hoff and Ward, 2004; Dorff and Ward, 2013; Cranmer and Desmarais, 2016). The argument proffered by these and other scholars is that it is not just the existence of a third party that affects dyadic behavior, it is the larger network of interactions that multiple parties engender. There are many ways to

[3]See Kinne (2012) for a related approach to measuring centrality in the broader international system.

incorporate insights from network analysis;[4] we focus on two summary network properties that are closely tied to our theory: *community* and *hierarchy*.[5]

Community. Our focus on network characteristics begins with one that has been receiving increasing attention in the context of interstate conflict: community membership. Membership in IGO (Greenhill and Lupu, 2017), trade (Lupu and Traag, 2013), UN voting (Pauls and Cranmer, 2017), and Kantian (Cranmer, Menninga and Mucha, 2015) communities has been shown to reduce conflict between the states within these communities.[6] We propose that the same may be true under certain conditions for Joint-Production Security Communities (JPSCs), which are defined on a network comprising the volume of arms trade between states.

To determine community membership, one must first derive a set of communities present in a network. A common approach is to identify a network partition that assigns each node in the network—here, each state in the international system—to a single community.[7] There are many different methods in use to determine the set of communities for a given network, but they all share the same basic intent (Porter, Onnela and Mucha, 2009; Fortunato, 2010; Fortunato and Hric, 2016). Simply put, states that make up a particular community should have stronger ties to other states within that same community than they do to states outside that community. For our JPSCs, the key idea is that states within each JPSC engage in a much larger volume of arms trade within these communities than between them.

How might membership in a JPSC reduce intra-community conflict? Consider first a concrete example: the complex relationship between the USA, Egypt, and Israel. In 1979,

[4]For instance, Cranmer, Desmarais and Kirkland (2012) use exponential random graph models and Warren (2010, 2016) uses stochastic actor models to explore and explain the evolution of alliance networks over time to provide a better understanding of international conflict. Similarly, Kinne (2017) demonstrates that the network of defense cooperation agreements can explain the formation of new bilateral defense cooperation agreements.

[5]Summary statistics such as these are viable proxies for the effect of the larger network when they capture the posited theoretical mechanism. For instance, the degree of globalization in a trade network might be productively captured by the density of the network.

[6]Though see the erratum at `https://github.com/vtraag/trading-communities-replication/commit/e82b76879498d87c5c2de21c39b13bd7eb96f8a3` regarding trade communities.

[7]There are methods that assign membership probabilistically. We use an approach that captures probabilistic membership, but typically assigns a node to a single community as detailed below.

the USA helped broker a peace treaty between Egypt and Israel. This was the fruit of years of effort that commenced with disengagement after the 1973 October War, still the last war between Egypt and Israel. One of the key carrots that the Americans offered to seal the deal took the form of billions of dollars of annual military aid to both countries, which subsequently has been used to purchase American arms. Effectively, Egypt and Israel have since been participating in the joint production of security with the USA, which is exactly what the USA had hoped would bolster an Egyptian-Israeli détente. Assisted by the USA, Egypt and Israel have been investing in military forces to secure their lands from interstate and intrastate foes. Moreover, their military investments have improved the security of the USA, which has complex security ties in the region. Purely dyadic approaches to explain conflict behavior are ill-suited to capture these observed dynamics, as are approaches that focus on formal alliance ties because the USA does not have a formal alliance with Israel or Egypt.

In this example, sharing the same JPSC translated into less intra-community conflict, but what are the mechanisms by which common JPSC membership might do so in general? Prior work has posited that interdependence increases the opportunity costs for conflict (Hegre, Oneal and Russett, 2010; Mansfield and Pevehouse, 2000; Lupu and Traag, 2013), the ability for states to make costly signals (Gartzke, 2007; Kinne, 2013, 2014), and external vested interests in peace (Lupu and Traag, 2013). Certainly, JPSC membership might have all the same effects. Conflict could result in the loss of valuable arms trade, JPSCs might increase transparency due to common use of weapons systems and available costly signals, and third parties might desire to prevent armed conflict among common buyers and suppliers. More generally, arms transfers indicate the extent to which, at minimum, the supplier does not see the buyer as a threat, and at maximum, the supplier finds it mutually beneficial to invest in the buyer's security. In this way, we might infer that states that have strong ties to one another via arms transfers have the potential to develop (or are already undertaking) robust joint security production.

We can also draw on the alliance formation literature. Kinne (2017) shows that states form explicit defense cooperation agreements as a response to common threat, and Kinne (2016) shows that defense cooperation agreements well explain the flow of arms transfers. Arms trade is thus an element of the joint production economy of security (Lake, 1999), one that underlies informal alliances, such as those between the USA and Israel or between Russia and Syria. Regardless of whether the alliance is formal or informal, however, the goal of participating is the same: to pool resources and take advantage of comparative advantages in security production (Deutsch et al., 1957; Walt, 1990). This can lead to reductions in intra-community conflict: formal alliance commitments enable member states to coordinate behavior, overcome bargaining problems, and to reduce the potential for conflict among one another (Pressman, 2008; Mattes and Vonnahme, 2010; Bearce, Flanagan and Floros, 2006; Fang, Johnson and Leeds, 2014; Long, Nordstrom and Baek, 2007; Weitsman, 2004). JPSC membership, which overlaps with formal as well as informal alliances, can have a similar effect.[8]

While these arguments in favor of a pacifying within-community effect of common JPSC membership are compelling, we take a more nuanced view of the role of community membership for two reasons. First, there are potentially countervailing effects to some arguments. For example, frequent interactions within the community may themselves lead to more occasions for dispute (Starr, 2002) and relevance of relative gains (Barbieri, 2002, 1996). And the *ex ante* costs of conflict may already be built into the demands of challengers and the willingness of targets to concede and thus may not affect the efficiency of conflict bargaining (Morrow, 1999).

Second, if common membership in a community is to matter in explaining interstate conflict, it must capture a latent relationship among the states in a community *beyond that present in individual states' dyadic relationships*. With respect to the existing literature,

[8] It may be possible that strong JPSCs would lead to increases in inter-community conflict, as improved security production can threaten states outside the community, potentially leading to a security dilemma spiral (Snyder, 1984, 2007), though it is important to note that these processes are jointly endogenous and thus complex to analyze (Smith, 1995). We consider this question empirically below without offering strong theoretical expectations.

common community membership may proxy for common preferences (Pauls and Cranmer, 2017), mutual opportunities that could be lost if fighting were to arise (Lupu and Traag, 2013), or synergies arising from alliance obligations (Cranmer, Desmarais and Kirkland, 2012). We argue that under certain circumstances common JPSC membership can proxy for a latent network of constraints on states' conflict behavior.[9] Making this argument requires first specifying the incentives of states to form and maintain the observable network connections from which communities are created.

Why might states engage in the trade of heavy weapons?[10] The simplest answer is for suppliers' profit and buyers' security. This ignores, however, the degree to which the trade partners would experience switching costs were they to cut ties. Any state that would find it costly to search for a new trading partner potentially faces constraints on its behavior arising from the existence of the tie, in that its trading partner may decide to use maintenance of the tie as leverage to extract concessions. In contrast, the trade ties of states that can both easily and cheaply transfer ties to alternatives are far more difficult to use as leverage, suggesting lesser constraint on these states.

We argue that the trade of heavy arms entails substantial switching costs, particularly, though not exclusively, on the side of buyers. Buying into weapons systems can necessitate a further spate of supporting purchases, including services (Kinsella, 1998). Heavy arms are not interchangeable across manufacturers, and the transaction costs to shift suppliers are high—it would require major adjustments to personnel training, maintenance procedures, and acquisition of replacement parts, not to mention the replacement of expensive munitions for relevant weapons systems. For these reasons, and in part maintained by heavy offsets by the suppliers to the buyers, the arms trade marketplace remains oligopolistic, as five suppliers—the USA, Russia, UK, France and China—account for 80 percent of the trade (Stohl and Grillot, 2009; Markusen, 2004). In this vein, Thurner et al. (2018) use random-graph network models to show that the arms trade is dominated by a few sellers and that

[9] In probing the meaning of the network of ties in the arms trade, we are responding to the call of Kinsella and Montgomery (2016).

[10] Our theoretical and empirical focus is on the trade of heavy weapons; the argument is not likely to extend to the trade of light arms.

buyers typically only buy from one seller. Indeed, supplier states are often motivated to engage in arms transfers because of the leverage gained from the dependence that buyer states develop, and they worry that the growth of the number of suppliers in the international market in the post-Cold War era might threaten the political coin of arms transfers (Keller, 1995; Cornish, 1996). In other words, high switching costs on the part of buyers induce political leverage sellers can use to constrain buyers' behavior in ways favorable to sellers, which includes reduction of destabilizing intra-community conflict that would not enhance sellers' interests.

Sellers also face switching costs; buyers do occasionally switch suppliers or develop their own domestic production capacity, which can constrain suppliers (Brauer, 2003; Keller, 1995). While we view these costs as lower, all else equal, than those faced by buyers given the larger number of potential buyers, any level of asset specificity (viewing the trade tie as the asset) would also constrain the seller's actions. So, in total, we expect the arms trade network to capture underlying networks of mutual (though asymmetric) constraint.[11]

It is important to note that the latent network of constraint is present in JPSCs, but not to the same extent in communities formed from commercial trade networks. We expect, with some exceptions, commercial trade to be more fungible than trade in heavy arms, so

[11]We might consider defining our JPSCs using other ties as additional inputs into the community detection algorithm, as do Cranmer, Menninga and Mucha (2015) with different inputs. Foremost, explicit alliances and defense cooperation agreements clearly indicate an intention for states to jointly contribute to one another's security. Indeed, we demonstrate below that joint-membership in JPSCs based on explicit defense cooperation agreements results in similar conflict-reducing behavior as the JPSCs based on arms transfers, which is not surprising given that Kinne (2016) finds that weapons cooperation agreements are associated with greater flows in arms transfers. (For definitions of and data on defense cooperation agreements, see Kinne (2016, 2017).) We use the arms-transfer inputs in our core analyses for two reasons. First, one might more expect a conflict-reducing effect from alliances and defense cooperation agreements, in that they capture explicit pledges for security cooperation. This could leave relatively little independent role for community membership in predicting conflict reduction. In general, the advantage of using community detection on network data is to be able to uncover more embedded relationships that arise from the notion that community membership can be quite latent. *Because* arms transfers are shaped by market competition among large multinational arms manufacturers that might not well be explained by explicit attempts by states to enhance the security of their key allies, they provide an interesting venue to test the potential value added for considering community membership in addition to bilateral commitments. Second, arms transfers are directional and non-binary and thus provide a richer ability to consider the strength of ties and the direction of dependence, which are important components of our definition of hierarchy, described in more detail below.

that commercial trade network communities capture far less well the web of unobserved constraints between states that we posit leads to less conflict within communities. In contrast, both types of communities capture to some extent the loss of mutual economic opportunities cutting trade ties will bring. This brings us to our first hypothesis, which offers the counterintuitive expectation that arms sales can pacify potentially better than other forms of connection between states.

H1: All else equal, JPSCs will have a constraining effect on intra-community conflict.

Hierarchy. Our first hypothesis specifies an all-else-equal condition, but our specific mechanism of switching costs allows us to dig a bit deeper into variation across JPSCs in their ability to constrain conflict. We focus our attention on a network measure that we argue captures the presence of increased switching costs within a community: the community's level of hierarchy.

How does hierarchy relate to expectations of order within JPSCs? Some forms of joint security production are more hierarchical in the sense that one of the parties has more authority to make decisions concerning the joint production economy. Building on his earlier work, Lake (2009) develops a relational theory of hierarchy in which states will often confer some degree of legitimate authority on a dominant state in return for an expectation of security and order. This understanding of hierarchy has roots in social contract theory, in which actors grant another actor authority in return for a stream of public goods such as security.[12] A crucial feature of hierarchy is that the power imbalance of the dominant actors over the subordinate actors is legitimated by the common understanding that all actors stand to benefit from the relationship.

Our conceptualization of hierarchy matches Lake's in many substantive ways. However, we diverge from Jung and Lake (2011) in treating hierarchy, networks, and markets not as distinct actors, but rather as structural properties of a network of connected states (Kahler, 2009). Specifically, we conceptualize hierarchy as a community-level network property that captures the level of inequality of trade within each community. This enables us to explore

[12] See also Lake and Wong (2009). Mattern and Zarakol (2016) describe a number of logics by which hierarchy might shape international relations, and our approach focuses on a logic of trade-offs.

how hierarchy conditions the relationship between community and conflict. It also provides insight into how the implications of community membership might vary by market context, a topic largely overlooked in the growing literature on community.

For a concrete example of hierarchy within a community, consider again the example of Egypt and Israel. The pattern of behavior we identified above is indicative of more than just the joint production of security; it also represents a hierarchical relationship. Egypt and Israel are much more dependent on American contributions to their security production than the USA is on their efforts or than they are on one another. Moreover, the USA has asymmetric influence over the form of the joint security production, in terms of the types of weapons systems developed[13] and the ability to set other parameters of foreign policy.

We can generalize from this example to our argument using the logic of switching costs. Arms trade itself carries with it high switching costs due to practically expensive shifts in training, maintenance, and equipment, signaling the possibility for underlying constraint. As this example illustrates, hierarchical relationships can further raise these switching costs, particularly for subordinate states. A hierarchy in the trade of heavy arms implies the dominance of a key producer. Buyers from that producer may not have any alternative producers available for specific weapons systems to which they have already committed. A less hierarchical arms-trading relationship, in contrast, suggests multiple producers and thus relatively cheaper switching costs for the buyers. Switching arms suppliers in a hierarchical context also implies the potential loss of other benefits of being in a shared JPSC with a dominant power, including the provision of security, aid, advising, and the like. The desire to avoid the loss of these benefits increases switching costs, and so further increases constraints on states within hierarchical communities. This is consonant with the literature: when less-central states face substantial costs for exit from a community dominated by a central state, the central state has substantial leverage (Kahler, 2009; Lake, 2009). The central state, in turn, can use that leverage to enforce order among the community members. This leads to our second hypothesis:

[13]For example, Lin (2012) argues that the USA had used conventional arms transfers as a way to slow down the development of nuclear weapons by recipients, even Israel.

H2: All else equal, the more hierarchical is a JPSC, the more of a constraining effect on intra-community conflict it will have.

Two conditions increase the likelihood that our argument and hypothesis hold. One, subordinate states must be receiving the sorts of benefits described above from JPSC membership. Two, superordinate states must have incentive to provide these benefits so as to reduce collective action problems in security provision (Olson and Zeckhauser, 1966).

The assumption of concrete benefits for subordinate states in hierarchical relationships is consistent with a broad literature. Scholars such as Wohlforth (1999) have argued that a unipolar system such as that dominated by the USA after the collapse of the Soviet Union can have widespread security benefits for other states. Ikenberry (2009) argues that hegemonic states can lock in an international order through strategic restraint, whereby they set up international institutions that restrain the hegemon so as to get buy-in from other states, akin to Lake's relational theory of hierarchy built on social contract theory. Lake and Wong (2009) similarly point to three ways in which a central node in a network might make its exercise of power valuable—and thus reinforcing—to other network members: central nodes can reduce transaction costs for cooperation by setting and enforcing standards; they can provide dispute-resolution services to member states; and they can contribute to the growth of the network.

Undergirding this logic is a sense that the quality of the joint security production actually benefits from the concentration of authority and resources. Keohane (1985) builds on the logic of collective action to argue that in larger groups, a hegemon is often needed in an environment without sufficient institutions in place to sustain cooperation amongst the members of a group. Otherwise, the free-rider problem is too great. Trusting many other weaker states to come to one's own defense is more daunting than trusting a single strong state. Weaker states thus may find hierarchy an efficient means to enhance deterrence against outside threats. Further, less central states still have some limited ability to exit—the ties in a JPSC are less fungible relatively speaking, but are not unbreakable—which limits the ability of dominant states to threaten the security of other community members (Lake and Wong, 2009).[14]

In sum, then, subordinate states receive both concrete security benefits by operating within hierarchical JPSCs, as well as in some cases more material gains. What about superordinate states? Presumably, they are not asymmetrically helping community members in their security out of altruism, but rather in return for an asymmetric ability to control the form of community order. Such states also receive numerous benefits from the maintenance of order in their communities, including reduced uncertainty, greater gains from arms trade, more favorable policies in subordinate states, and coordination on systems and procedures. For example, superordinate states can provide security assistance in the form of joint exercises—such as those between the USA and the ROK—which can help lock in further arms purchases that benefit the relevant industries in the superordinate states.

Moreover, dominant states tend to have myriad vested economic interests and thus myriad potential threats to those interests. Contributing to the community's security helps reduce threats to those interests in two ways. First, it helps defend and deter against belligerents from outside of the community that may disrupt the joint production economy or otherwise pick off weaker allies until just the strong state is left.[15] Second, dominant states especially benefit from deterring hostility between members of their own community. NATO might have primarily been intended as a check on Soviet aggression, but it also was motivated to help prevent a repeat of war involving Germany. A dominant state's losses from conflict related to investment outputs and gains from trade are compounded when the disruptions involve multiple close partners who also have significant ties with other close partners. For

[14]For example, in the wake of Turkish frustrations with US stances on security issues including American support for Kurdish forces in Syria and accusations that the US was complicit in the 2016 attempted coup, Turkey has begun exploring a shift away from the US as its major arms seller, perhaps moving toward a post-Brexit UK. The point here is that threats to leave a security community can be credible even if quite costly, which provide some constraints against superordinate states overstepping their bounds. Moreover, the Trump administration's explicit support for Saudi Arabia after details emerged regarding the assassination of Jamal Khashoggi—a journalist residing in the USA—in the Saudi consulate in Turkey, demonstrates how superordinate states like the USA perceive constraints in severing their security partnerships with subordinate states because of the superordinate's own reliance on the relationship.

[15]Of course, the incentive to defend against outside aggression need not translate into less conflict incidence due to the reciprocal threat of hierarchical JPSCs to states outside the community.

these reasons, dominant states in more hierarchical communities may be more willing to contribute to joint security production.

Methods and Measures

To investigate these two hypotheses, we first operationally define both community and hierarchy. We then assess the level of conflict between co-members of the same community compared to non-co-members and whether the relationship between co-membership and conflict is conditioned by the level of hierarchy.

Community Detection. We apply a community detection algorithm using arms transfers to generate time-varying estimates of the JPSCs. The arms transfer data are reported by Stockholm International Peace Research Institute (SIPRI).[16]

As noted above, community detection seeks to partition a network into subgroups which interact more strongly within themselves than outside of themselves. Clustering and partitioning methods have long interested network scientists and are increasingly prominent in political science. Methods such as spectral clustering, hierarchical clustering, and block-modeling are some of most commonly used toolkits for researchers (Porter, Onnela and Mucha, 2009; Fortunato, 2010; Fortunato and Hric, 2016). One of the most widely used methods for community detection is based on the modularity measure introduced by Newman and Girvan (2004). The idea behind it is to compare the links within each of a proposed set of communities to those between these communities and find the best partitions by optimizing community distinctions according to the relative total weights of the edges within the communities. Since this method provides a principled way of discovering subgroup structure from rather complex networks and does not require researchers to predetermine the number of clusters, it has attracted many applications in recent political science studies including topics of roll-call voting in the Congress (Waugh et al., 2009), legislation cosponsorship networks in Congress (Zhang et al., 2008), European court citation networks on human rights

[16]The complete dataset that includes all dyadic arms transfers from the year 1960 to 1999 can be found and downloaded here: `https://www.sipri.org/databases`.

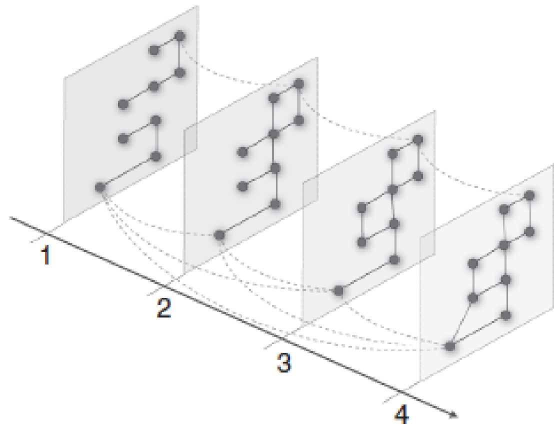
issues (Lupu and Voeten, 2012), and community effects on interstate conflict patterns (Lupu and Traag, 2013; Cranmer, Menninga and Mucha, 2015).

While applications of community detection have successfully contributed to the political science literature, some limitations of the original Newman-Girvan definition of modularity have been revealed by recent findings; e.g., its optimization may fail to identify smaller-scale communities (Fortunato and Barthelemy, 2007; Good, de Montjoye and Clauset, 2010).

Additionally, the Newman-Girvan definition of modularity is not capable of dealing directly with longitudinal data; all it can do is provide multiple snapshots of edge partitions in each time layer, which is often not enough for empirical research where temporal variation in data is both significant and meaningful. The use of arms-trade data requires the use of a new community detection method that can connect arms trade across time to account for the temporal "lumpiness" of the data. Arms transfers between close buyers and suppliers are not consistent, as spikes of activity are followed by troughs of inactivity after a procurement order has been met. The lull in activity should not be treated the same as an absence of arms transfers between pairs of states that have never traded, since the buyer typically is still dependent on the supplier for parts and maintenance of weapons systems, and the buyer is prone to return to the supplier as upgrades become available. Typical community-detection methods consider each year on its own and so would elide this important point. We view our method as superior for inter-temporal community detection, as it does not throw away data that arises from similarities across years that may be substantively meaningful.

Therefore, this study adopts a multilayer modularity method developed by Mucha et al. (2010). As an extension of modularity methods, this multilayer model addresses the issues of resolution limit and temporal variation of communities by incorporating two parameters, γ and ω, where γ represents a spatial parameter within layers (Reichardt and Bornholdt, 2006), and ω represents a temporal parameter across layers. Figure 1 visualizes the general concept of this method. Whereas Cranmer, Menninga and Mucha (2015) employed multilayer modularity to treat multiplex relationships at fixed times, we directly address temporal variation of communities.

Figure 1. Multilayer Community Detection



Source of The Figure: Community structure in time-dependent, multiscale, and multiplex networks (Mucha et al., 2010)

The determination of community structure is processed via quality functions to multilayer networks that are defined by (i) a spatial parameter weighting different penalties to community formation within temporal layers, and (ii) a temporal coupling parameter linking multiple adjacency matrices across time. The calculation of multilayer modularity $Q_{multilayer}$ is summarized by the following equation:

$$Q_{multilayer} = \frac{1}{2\mu} \sum_{ijsr} \left[\left(A_{ijs} - \gamma_s \frac{k_{is} k_{js}}{2m_s} \right) \delta_{sr} + \delta_{ij} C_{jsr} \right] \delta(g_{is}, g_{jr})$$

where A_{ijs} are the weighted adjacency matrices connecting state i and j in layer s, γ_s is a spatial resolution parameter, $\frac{k_{is}k_{js}}{2m_s}$ is the corresponding null model in layer s, C_{jsr} is a coupling parameter connecting state j with itself between layers s and r with weight ω, g is the community assignment of vertex i or j in layer s, and Kronecker δ indicators equal 1 when their two nodes are in the same community.

To calculate the modularity $Q_{multilayer}$, we started by setting $\gamma = \omega = 1$ and ran the generalized Louvain code through thousands of runs with pseudo-random vertex orders, and then selected the maximum observed value.[17] Instead of fixing an arbitrary parameter value and a set of particular community assignments, we scanned through a range of resolution parameters to explore partitions with high and low resolutions and tested our hypotheses against

[17]This Matlab code can be found here: `http://netwiki.amath.unc.edu/GenLouvain/GenLouvain`

each set of assignments to ensure robustness. Our core results discussed below are robust to each of these resolution specifications. Figure A.1 in the appendix shows six representative partitions using different parameter levels and the corresponding variation in community assignments across time.[18] Using this algorithm, the nodes (members of communities) are therefore allowed to transition between communities, or to create new communities based on the observed ties across years, thus incorporating the likelihood of temporal dependence of community membership. This property is particularly useful for the purpose of this study since arms transfers are relatively infrequent occurrences as compared to conventional trade and so have considerable seasonal variation. Without considering community stickiness across time and only partitioning groups based on yearly observations, it is very likely we would discover false partitions because states are not arms-trading with each other regularly in every year.

Figure 2 illustrates a sample of the output of community detection using this multilayer modularity. These are the communities produced for 1999, the last year for which we have data. Three representative partitions—corresponding to high (seven communities), medium (three communities), and low (two communities) resolution levels—are generated by using the γ value that yields the most stable partition across time and varying the ω value to reach different resolution levels.[19] The maps demonstrate the ability of the algorithm to detect

[18]An additional concern in utilizing community detection methods is the discovery of stable communities that are not sensitive to small variations in parameter values. With two parameters to adjust, we sought stable communities by first making ω large enough to produce nearly constant community assignments across time. Then we generated thousands of partitions by varying the γ parameter at that fixed ω to identify domains of modularity optimization that yielded the most stable communities. Figure A.2a in the Appendix illustrates that we were able to find a band of parameters over which community detection appears to be stable for our arms trade data, as a wider plateau represents a more stable partition under the parameter settings. This post-processing partition search led us to fix $\gamma = 0.5$ and 0.7. We then used these values to generate community assignments by varying ω (the temporal coupling parameter). More details on other available post-processing techniques can be found in Weir et al. (2017). We note that we were somewhat less able to find stable partitions (no apparent wider plateau) in our commercial trade data, as Figure A.2b shows. This is not inconsistent with our theoretical claims as to the relative fungibility of commercial trade ties, relative to arms trade ties. Based on the commercial trade data and the post-processing search, we settled on three different γ values ($\gamma = 0.7$, 0.9, 1.3) which yield four, six, and eight communities on average. ω values are set to 1 because commercial trade data do not have much temporal variation and changing the temporal coupling parameter does not yield sufficiently different community partitions.

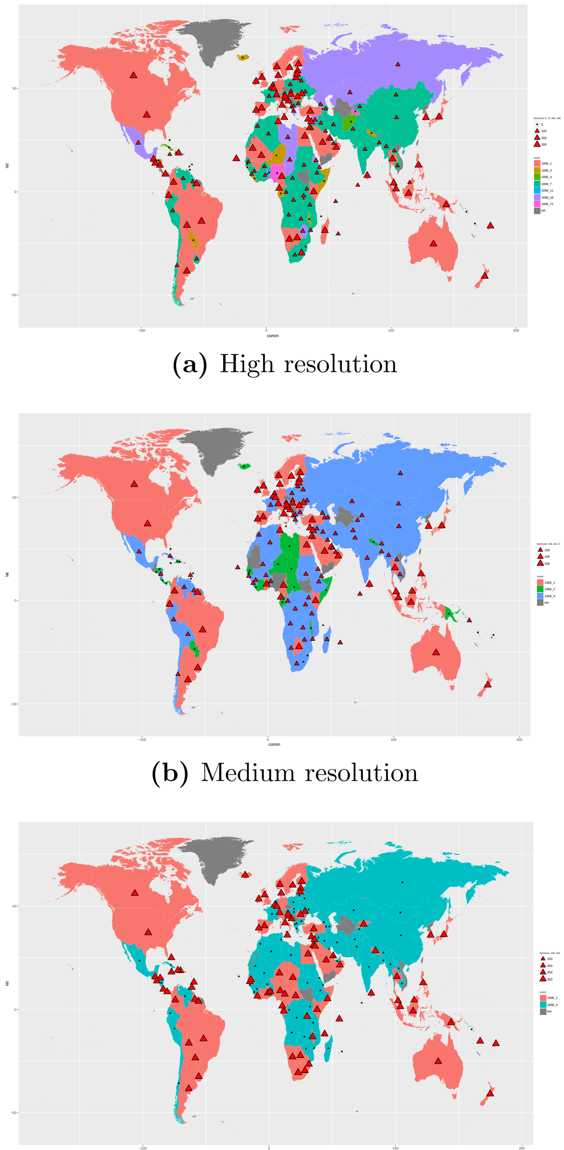
[19]For this figure, $\gamma = 0.5$ and $\omega = \{1, 5, 10\}$. We follow Lupu and Traag (2013) in their practice of showing low, medium, and high resolutions to demonstrate the effect of changing parameters on the number of communities detected.

communities different from ones based on simple definitions of regions or formal alliance blocs.

The maps reveal some consistencies across the defined communities—for example, the USA community always includes Egypt and Saudi Arabia, and the China community always includes Pakistan, Iran and Myanmar—but also some inconsistencies as well. Modular approaches to community detection typically will exhibit some variation from run to run as some communities are better defined than others. To account for this inherent uncertainty, we ran the algorithm 100 times at each parameter setting. From these runs, we calculated the empirical probability of each dyad's connecting two nodes in the same community. This probabilistic approach should be more robust than classifying co-memberships with a single iteration. For our reported regressions we consider a dyad to be in a shared community if more than half of these 100 iterations place them together.[20]

[20]As a robustness check, we replicated our results using the precise probability of being in the same community. All results are robust to using this probability instead of dichotomized community membership. We report these analyses in the Appendix.

Figure 2. Visualizations of JPSCs in 1999 at Different Resolutions and Hierarchy Scores



(a) High resolution

(b) Medium resolution

(c) Low resolution

Hierarchy Measure. In order to capture hierarchy within communities we rely on a measure of hierarchy used in the social networks literature that accounts for both the weight and directionality of ties in the network (Mones, Vicsek and Vicsek, 2012).[21] This approach takes

[21]While we use a measure of *relational* power derived from network ties, our conception of hierarchy overlaps with other conceptions of power based on disproportionate military capabilities. The states that are the dominant states in hierarchical JPSCs are also likely to be the states with the greatest amount of military capabilities. That being said, our regression models control for the bilateral ratio of latent military capabilities to distinguish the effect of hierarchy from the effects of other manifestations of power imbalance that could exist in the absence of joint community membership and in the absence of hierarchy.

as a starting point the notion that centrality is often used as a measure of nodal influence in network applications. Nodes (in our case, states) that are more central in a network are more influential than those found in the periphery, which is consistent with the concept of social power developed in previous work (Hafner-Burton and Montgomery, 2009; Kahler, 2009). A measure of hierarchy within a community should thus capture the degree of influence that each node has within that community. A community where one state is highly central (a 'star graph') is more hierarchical than a community where member states share equal centrality.

Towards this end, we follow Mones, Vicsek and Vicsek (2012) and adapt the *Global Reaching Centrality* (GRC) as a network characteristic that measures hierarchy. GRC takes the following form:

(1) $$GRC_R = \frac{\sum_i C_R^{Max} - C_R(i)}{N-1}.$$

Here, we define $C_R(i)$ as the closeness centrality[22] score of node i in community R. Since the full network of arms transfers is a disconnected graph (i.e., not all states in the network are connected via arms transfers), we measure closeness centrality using the method described in Opsahl, Agneessens and Skvoretz (2010) and used in Kinne (2012).[23] This measure of closeness centrality takes the inverse of the summed shortest paths from a country to all other countries to which it is connected, where the shortest path algorithm accounts for both weight of the ties (the amount of the transfers) and the number of intermediary nodes.

[22]There are various metrics for centrality that are appropriate in different contexts (Montgomery, 2015). We use closeness centrality in our hierarchy calculation because it assigns importance to indirect influence via intermediaries, an important component of our conceptualization of hierarchy. By comparison, degree centrality tends to emphasize only direct influence, while betweenness centrality assigns importance to nodes mediating relationships, rather than nodes who influence both directly and through mediators. As a test of robustness, we replicate the analysis using weighted out-degree in the hierarchy measure. The results are largely similar (Appendix Table A.10); further, we find the degree- and closeness-centrality based hierarchy measures are highly correlated.

[23]Closeness centrality in Opsahl, Agneessens and Skvoretz (2010) depends on a tuning parameter α, which weights the measure to reflect either the number of trading partners (α values closer to zero) or the depth of trading ties (α values closer to one). We present results from setting α equal to one, though we find results change little when we lower the parameter setting (e.g., setting α to 0.5).

The node with the largest closeness centrality score within R is defined by C_R^{Max}, and the total number of nodes within a community is defined by N.

Thus, GRC_R measures the average distance from each state's centrality score to the maximum centrality score within a given community R. Where many states within a community transfer arms, the resulting GRC will be low; in contrast, where one state provides all weapons transfers within a community (a star graph) the GRC will be high.[24] This captures well our theoretical definition of hierarchy in JPSCs, which focuses on inequality in arms trade across a community. It is also consistent with other approaches that have considered variation in power across network structures (Hafner-Burton and Montgomery, 2009; Kahler, 2009; Lake and Wong, 2009).

We see variation in hierarchy in the 1999 examples depicted in Figure 2. At each resolution, the community with the USA is the most hierarchical, which comports well with the perceptions of US hegemony in the post-war era.[25] Other communities, including rather large communities with China as a member, are flatter. We want to see if variation in hierarchy conditions the conflict-reducing potential of common community membership. Table A.1 in the appendix presents other descriptive statistics pertaining to community membership and levels of hierarchy across each of the parameter values.

Regression Models. Using data on militarized interstate disputes (MIDs), we use dyad-year data to assess if JPSC membership and the level of hierarchy within JPSCs can help explain the propensity for armed conflict between states. Following Lupu and Traag (2013), who examine the relationship between communities of commercial trade and conflict, we estimate the model using logistic regression with a set of control variables.[26] We generate standard errors that are robust to clustering on the level of the dyad. We run two models: a

[24]As we believe that outside options for sub(super)ordinate states will tend to decrease(increase) the ability of the superordinate state to exert constraint on subordinate states, throughout the paper we consider a state's arms transfers to every other state in the international system, not just transfers within its own community. However, results are similar if we consider only ties within the community when defining hierarchy (Appendix Table A.9).

[25]In a robustness check below, we find that the variation in hierarchy is still meaningful even when the communities with the USA are omitted. So, hierarchy is not just a proxy for connectedness to the USA.

[26]Results are substantively unchanged if we control for dyad commercial trade dependence.

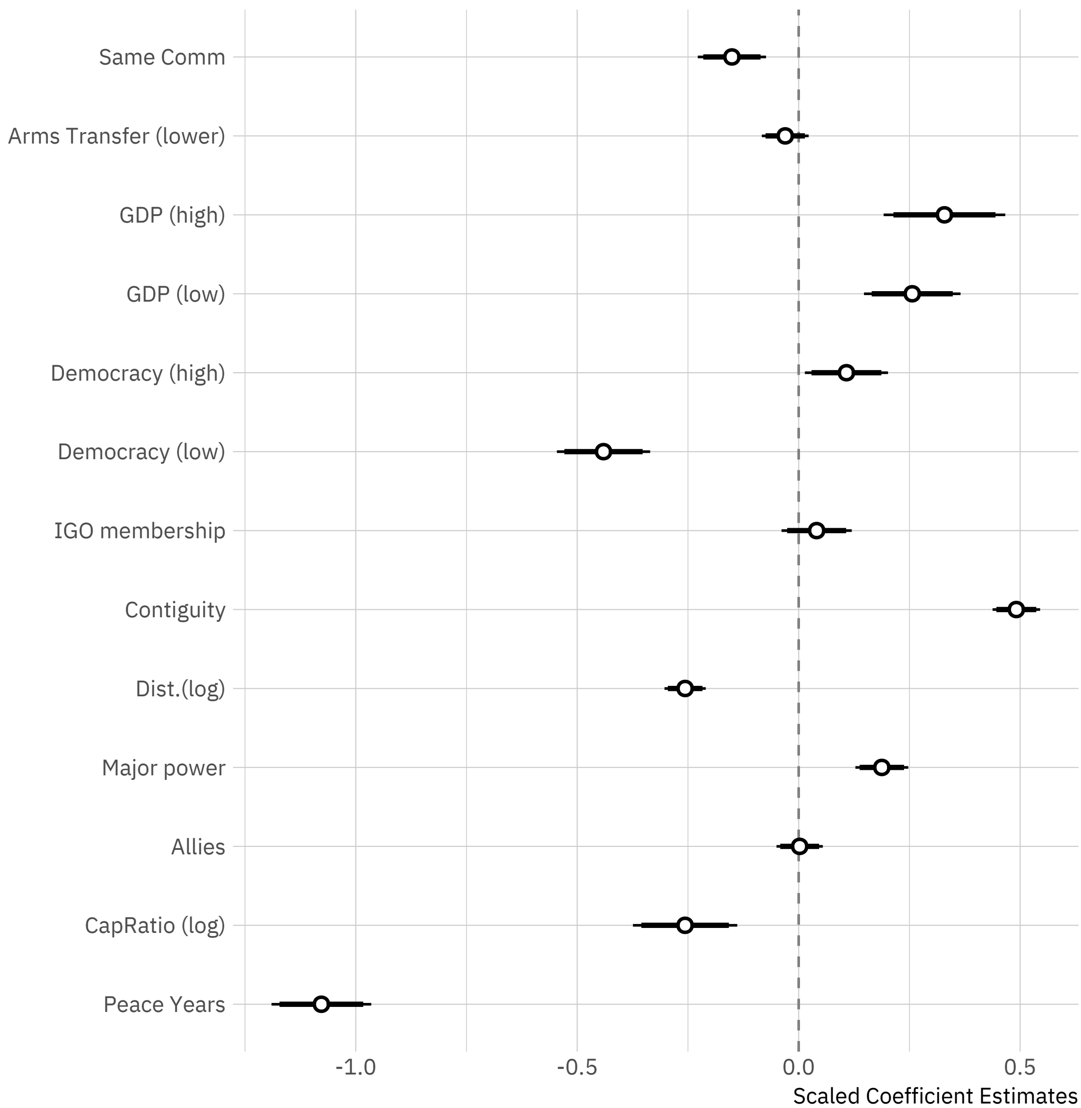
base model with JPSC membership but not hierarchy, and an interactive model with the low hierarchy score for the dyad interacted with common JPSC membership. We employ logistic regression to fit with prior literature, to enable easier uptake of our results, and because we have a clear argument for *how* network structure matters. However, we also demonstrate the robustness of our findings across a number of alternative community detection and regression model specifications, including specifications using TERGM and latent space approaches that more fully capture network interdependencies (Minhas, Hoff and Ward, 2016).

Results and Discussion

Hierarchy and Arms Trade. Figure 3 graphically depicts regression results from the base model, in which we consider only the role of community, absent considerations of hierarchy. It considers only one set of community detection parameter values we explored, but results are similar for others.[27]

[27]Table A.2 in the Appendix presents conventional regression output for six different sets of community detection parameter values. In addition, the results hold if we use the probability of two states being in the same community instead of a dichotomous indicator of community membership.

Figure 3. Base model regression results using parameter setting: $\omega = 1$, $\gamma = 0.5$.



The coefficient estimate for the indicator variable capturing whether a given dyad is within the same security community is negative, statistically significant, and, as seen through our standardized coefficients, substantively large. Consistent with our expectations, this suggests that being within the same JPSC decreases the likelihood of conflict between two states, over and above what variation the other variables in the model are able to capture. Importantly, joint community membership has a stronger pacifying effect than bilateral arms-transfers.

Moreover, the pacifying effect related to the presence of a formal alliance between the states is weaker than that for joint membership in the community—which includes informal alliances and only partially overlaps with formal alliance commitments. Accounting for community membership in the network of arms transfers better explains the potential for armed conflict than the simple level of bilateral arms sales between two states and the presence of a formal alliance, providing support for our first hypothesis.

As a robustness check, we also consider the potential for JPSCs to be defined by explicit defense cooperation agreements, as defined by Kinne (2017). Like the JPSCs defined by arms transfers, we similarly find that joint-membership in JPSCs defined by defense cooperation agreements is associated with less potential for a MID, even while controlling for the presence of a dyadic defense cooperation agreement. Table A.3 in the appendix presents the results.[28]

Next we turn to hierarchy and our second hypothesis. Table 1 contains full regression results for six different community detection parameter values.[29] This table contains several things of note. First, the coefficient on community, now representing community in the absence of hierarchy, is not consistently negative. This suggests community on its own may not be the driving force beyond the pacifying effects of arms trade, since states within "flatter" security communities are not necessarily less prone to conflict with each other than with states outside their community.[30] This also suggests that our "all else equal" condition in our first hypothesis was perhaps too strong: controlling for hierarchy might be *necessary* to understand the role of a JPSC in constraining conflict.

[28]Following the same post-processing procedure, we used three γ values ($\gamma = 0.7, 0.9, 1$) that yield four, three, and two communities. The value of ω was set high ($\omega = 100$) to capture the strong temporal dependence for defense agreements but varying ω (the temporal coupling parameter) does not yield appreciably different partition results.

[29]The results are robust to using probability of belonging to the same community instead of a dichotomous indicator.

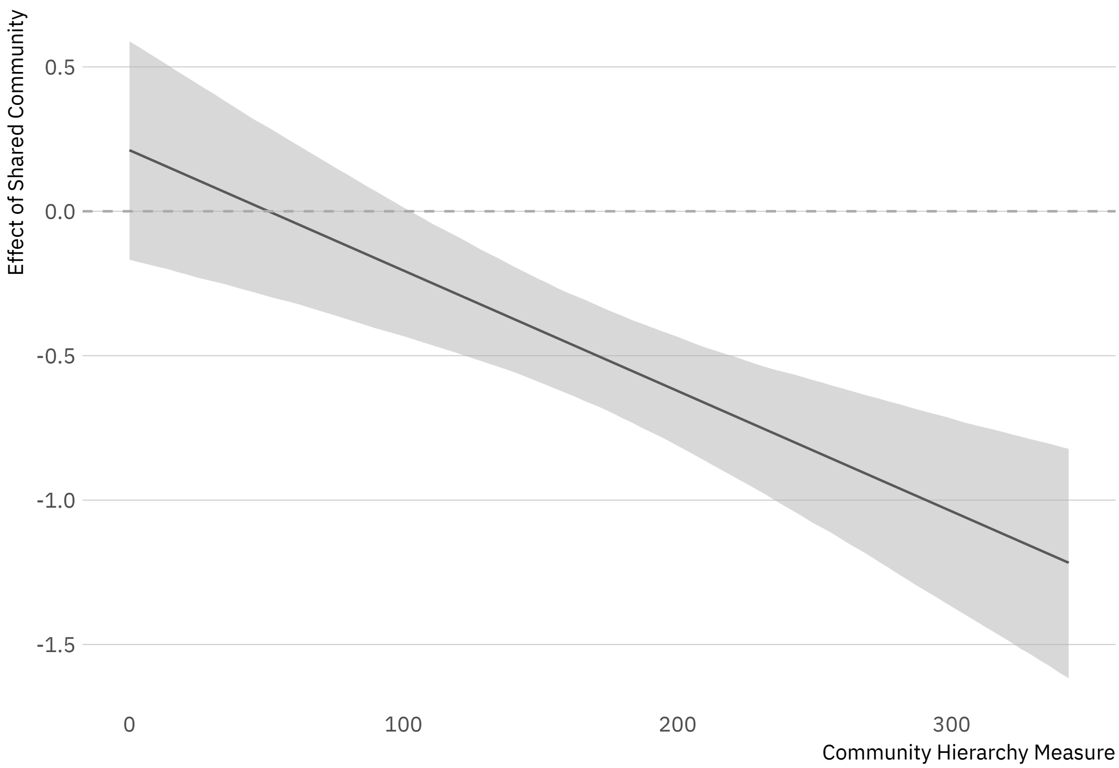
[30]We also ran additional analyses using some common network models. Tables A15-A22 in Appendix show that results are largely consistent when we use TERGM and AMEN models.

Table 1. Interstate arms trade: hierarchy models.

	Spatial Temp. (Low)			Spatial Temp. (High)		
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	-6.582^{***}	-6.778^{***}	-6.759^{***}	-6.488^{***}	-6.505^{***}	-6.267^{***}
	(0.425)	(0.441)	(0.450)	(0.401)	(0.420)	(0.385)
Same Comm	0.237	0.371	0.493^{*}	0.214	-0.203	-0.361^{*}
	(0.246)	(0.270)	(0.281)	(0.210)	(0.261)	(0.201)
Hierarchy(lower)	0.004^{***}	0.004^{***}	0.004^{***}	0.004^{***}	0.003^{***}	0.003^{***}
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Arms Transfer (lower)	-0.019	-0.019	-0.019	-0.019	-0.020	-0.021
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
GDP (high)	0.155^{***}	0.158^{***}	0.162^{***}	0.157^{***}	0.153^{***}	0.147^{***}
	(0.044)	(0.044)	(0.044)	(0.044)	(0.043)	(0.043)
GDP (low)	0.084^{**}	0.093^{**}	0.088^{**}	0.080^{*}	0.092^{**}	0.081^{**}
	(0.041)	(0.041)	(0.041)	(0.042)	(0.041)	(0.041)
Democracy (high)	0.024^{*}	0.025^{*}	0.024^{*}	0.025^{*}	0.024^{*}	0.022
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Democracy (low)	-0.126^{***}	-0.129^{***}	-0.124^{***}	-0.125^{***}	-0.126^{***}	-0.131^{***}
	(0.022)	(0.022)	(0.022)	(0.023)	(0.022)	(0.023)
IGO membership	0.006	0.006	0.006	0.006	0.005	0.006
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Contiguity	2.565^{***}	2.595^{***}	2.560^{***}	2.549^{***}	2.567^{***}	2.566^{***}
	(0.256)	(0.260)	(0.257)	(0.256)	(0.259)	(0.256)
Dist.(log)	-0.184^{***}	-0.180^{***}	-0.183^{***}	-0.185^{***}	-0.186^{***}	-0.184^{***}
	(0.025)	(0.026)	(0.025)	(0.025)	(0.026)	(0.025)
Major power	0.785^{***}	0.759^{***}	0.759^{***}	0.784^{***}	0.794^{***}	0.826^{***}
	(0.176)	(0.176)	(0.176)	(0.176)	(0.177)	(0.177)
Allies	0.049	0.043	0.065	0.046	0.047	0.010
	(0.150)	(0.150)	(0.149)	(0.148)	(0.151)	(0.148)
CapRatio (log)	-0.131^{***}	-0.126^{***}	-0.129^{***}	-0.133^{***}	-0.126^{***}	-0.132^{***}
	(0.043)	(0.043)	(0.043)	(0.043)	(0.042)	(0.042)
Peace Years	-0.334^{***}	-0.332^{***}	-0.334^{***}	-0.334^{***}	-0.331^{***}	-0.335^{***}
	(0.029)	(0.029)	(0.029)	(0.030)	(0.030)	(0.029)
Same Comm X Hierarchy	-0.004^{***}	-0.004^{***}	-0.005^{***}	-0.004^{***}	-0.002	-0.0004
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations:	390914	390914	390914	390914	390914	390914
Notes:	$^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$					

Second, consistent with our expectations, the pacifying effect of arms trade *is* present in communities that are characterized by high levels of hierarchy, and substantially so. With other control variables at their medians, contiguous states that are in the same community with maximum hierarchy have a more than 50 percent reduced risk of conflict compared to contiguous states that are not in the same community. Figure 4, a marginal-effects plot,

Figure 4. Same-community effect as community hierarchy increases. Parameters: $\omega = 1, \gamma = 0.5$.



visualizes the interactive effect of community status and community hierarchy in order to make this point. This supports our second hypothesis.[31]

Third, the conditioning effect of hierarchy appears consistent across community detection parameter values. This provides significant confidence in our inferences, in that this range of parameter values produces anywhere from 2 to 10 different communities in the world system. Regardless of how finely states are grouped, the same substantive effect holds: hierarchical arms trade communities pacify.[32]

[31]While our primary goal is not prediction, we also evaluate out-of-sample prediction using the network variables. We find that including the network variables marginally improves predictive performance.

[32]As a test of robustness, we also replicate the analysis by aggregating to the community-level and testing whether more hierarchical communities tend to have less conflict. The results are qualitatively similar, though some estimates do not reach conventional significance levels given the radically reduced sample size (Appendix Table A.11).

Finally, note that our argument, based on the degree to which stronger states can influence weaker ones to act in accordance with stronger states' desires, makes no claim on inter-community conflict. Dominant states in more hierarchical communities may be better able to defend community members, but such communities might be more threatening to other communities. The results indicate that the coefficient on hierarchy—the lower hierarchy score in each dyad—is significant and positive, showing greater conflict between more hierarchical communities. This inter-community finding corroborates in some ways existing understandings of international politics. Since more hierarchical communities better serve the dominant actor, they may induce a greater threat to strong external states, increasing the potential for conflict between central actors via a security dilemma logic. And if strong states are more likely to engage in conflict themselves, members of the hierarchical communities they lead will more easily be drawn into the conflict via a chain-ganging logic. Moreover, dominant states of different communities in dispute with one another have an incentive for the dispute to play out by proxy through confrontation between their subordinate states.

To further parse our results, we conducted a series of additional exploratory analyses. In the first, we find that the interactive effect of hierarchy and common-community membership only helps explain the reduction in conflict between subordinate states in the same community, and not as well the reduction between dominant and subordinate states. Tables A.4 and A.5 in the Appendix decompose the common-community variable into "flat" co-membership (when both states are not the most central state) and "imbalanced" co-membership (when one of the states is the most central). We see that the negative effect of co-membership in the presence of hierarchy is driven by the flat co-members. This is consistent with the finding from the main models that the relationship between dyadic arms-transfer volume and conflict is not statistically significant: it is not dyadic trade between flat co-members that reduces conflict, but rather the constraints on their behavior induced by trade with the dominant state. This provides further support for our argument regarding the conflict-reducing potential of hierarchy. It is not merely that dominant states limit conflict between themselves and weaker states; rather, dominant states in hierarchical communities reduce conflict between non-dominant members of their communities via the exertion of leverage enabled by high switching costs.[33]

In the second, we considered the potential for the effect of hierarchy to be solely driven by relationships with the USA. Existing scholarship has well explored the USA's efforts in the post-WWII era to promote peace in its spheres of influence.[34] In separate analyses, shown in Table A.6 in the appendix, we exclude the states that are in the same community as the USA and still find that hierarchy enhances the extent to which JPSC co-membership reduces the potential for conflict.

Overall, the results on arms trade networks confirm that JPSC membership and hierarchy within JPSCs help explain the occurrence of conflict in the international system. Joint-production security community membership and the level of hierarchy capture the underlying web of constraints. Arms trade, by enabling relatively strong influence of central states over non-central states due to high switching costs, is able to pacify within trading communities, past a sufficient level of hierarchy. Without this level of hierarchy, there is not the necessary source of constraint. This suggests again the importance of the concept of switching costs, which vary in hierarchy and enable constraint.

Hierarchy and interstate commercial trade. As further support for the centrality of a switching cost logic, we repeat the same core analyses on commercial, rather than arms, trade (Lupu and Traag, 2013). As noted in our second section, we expect that, on average, switching costs will be lower in commercial trade, leading to less constraint and so less of a role for commercial trade communities as pacifying agents. Further, as the role of hierarchy in security provision does not readily translate to commercial hierarchies, we do not expect hierarchy to play the same role in commercial trade networks.

[33]If hierarchy is based on legitimate authority, or more generally if JPSC structure is in equilibrium, the use of conflict by dominant states against subordinate states should be rare. That being said, failure of dominant states to keep subordinate states in line will erode the level of legitimacy and authority that the dominant state has, and so we should expect to observe some level of corrective measures by dominant states among members of their security communities, as observed in Soviet treatment of uprisings in Hungary (1956) and Czechoslovakia (1968).

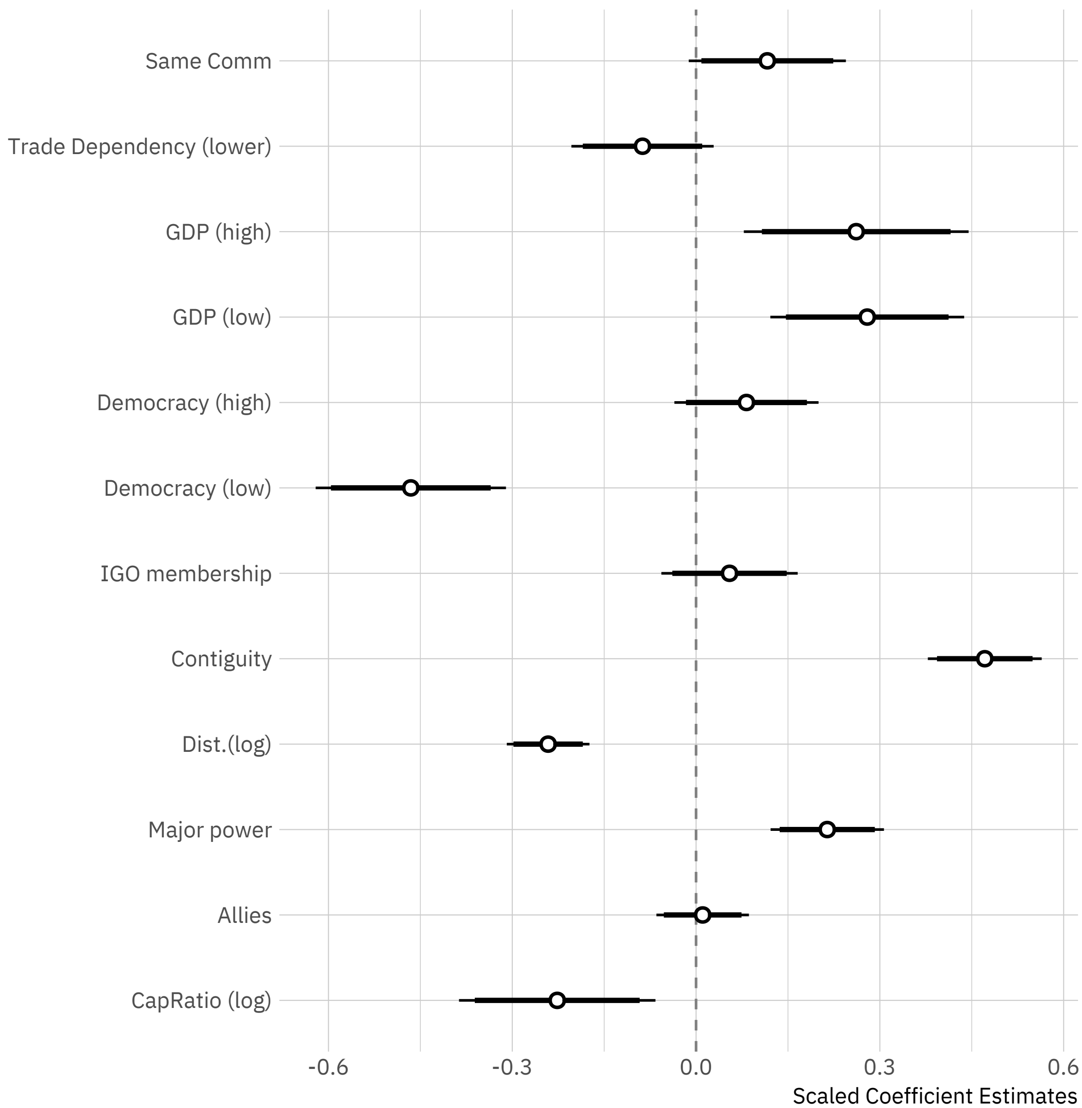
[34]See, for example, Lake (2009, 1999) and Ikenberry (2009).

Figure 5 presents results from the base model regressions, following the same procedure as above in determining interstate commercial trade community membership.[35] We note immediately the major difference between the effect of commercial and arms trade communities: whereas we found pacifying effects of arms trade community membership, we find *increased* propensity for conflict as a function of belonging to the same commercial trade community. This is true across a range of parameter values, as can be seen in Table A.7 in the appendix.[36]

[35]Figure 5 leaves out the coefficients on 'peace years' and the three splines for presentation purposes.

[36]This result is consistent with the erratum to Lupu and Traag (2013) posted at `https://github.com/vtraag/trading-communities-replication`.

Figure 5. Base model regression for commercial trade data.

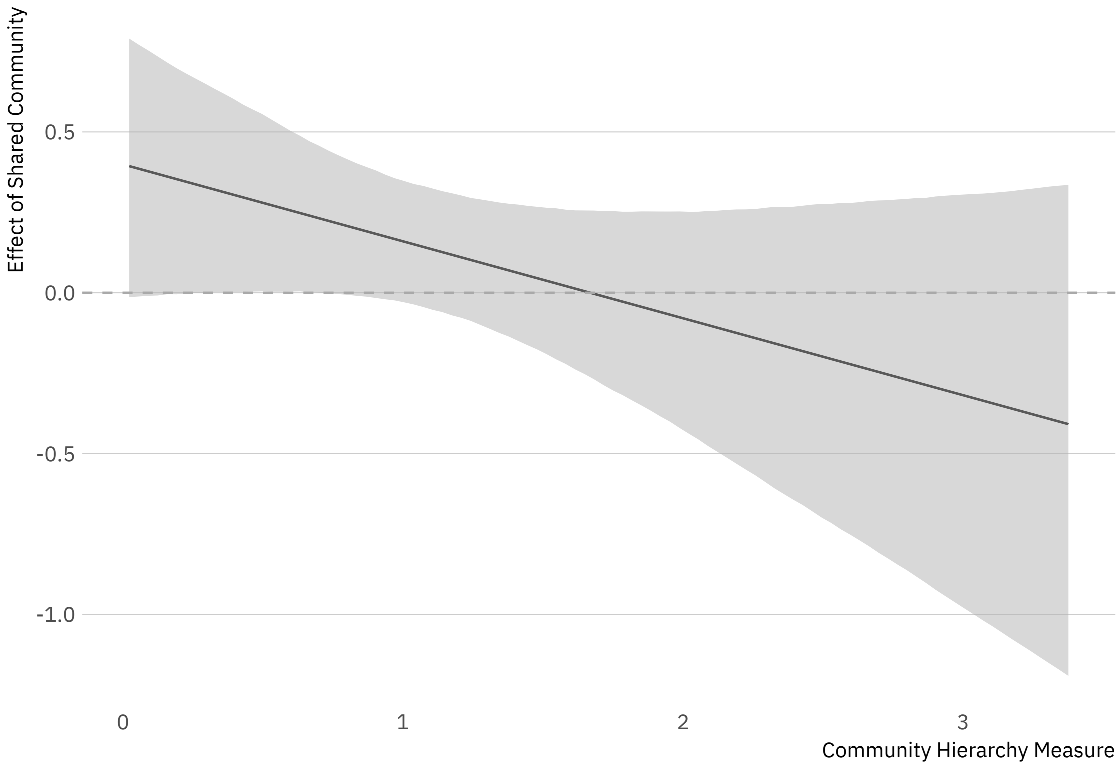


We calculate community hierarchy scores based on the dyadic trade dependence measure provided by Oneal and Russet (1997). Table A.8 in the appendix indicates that the interaction of hierarchy and same community membership is not statistically significant for any parameterization; the sign on the interaction is also inconsistent across parameterizations.

Further, even when we choose a parameterization that produces a negative sign on the interaction coefficient, as in the JPSC analysis, the marginal effect of community membership is never significantly different from zero at any level of hierarchy, as seen in Figure 6.

Thus, it appears that our expectation on the importance of switching costs is supported: not only do the more fungible commercial-trade communities fail to pacify, but we generally observe more conflict within commercial-trade communities. From existing theory we might expect that this is due to the more frequent interactions within commercial-trade communities, coupled with an inability of even central states to impose order. This inability comes not due to an absence of hierarchy as measured by asymmetry in commercial trade, but rather due to decreased switching costs, which diminish the power of leading states to constrain. If this conjecture were true, we would not expect to see a consistent pacifying role of hierarchy. This is what we find. Stronger states are simply less able to compel weaker states within their communities when weaker states are more free to break old ties and make new ones.

Figure 6. Same-community effect as community hierarchy increases for commercial trade.



Conclusion

We conceptualize hierarchy and community as two properties of network structure; together, they capture aspects of the underlying web of interests and constraints that drive interstate behavior. We bring to the discipline a new use of community detection for temporal data and a new measure of hierarchy within communities to show that common membership in joint-production security communities (JPSCs) leads to a reduction in conflict between states in the international system. In other words, arms trade, from which we constructed our JPSCs, can pacify. This is more true the more hierarchical are the JPSCs, and is not explained merely by dyadic trade ties. This result also does not arise solely from the presence of a common external threat: more hierarchical JPSCs exhibit more, not less, conflict between communities.

We argue that arms-trade communities have this intra-community pacifying effect, in part, due to the presence of switching costs. States suffer many kinds of costs from switching their suppliers of heavy arms, and suffer additional costs when these suppliers are strong states that are the only suppliers of specific weapons systems and that can provide other benefits to weaker states. The existence of these costs provides leverage to stronger states, which translates to constraints on weaker states' conflict behavior. We show that the same argument fails for communities constructed from commercial trade networks: commercial trade, on average, is more fungible than heavy arms trade, and so produces neither strong constraints nor pacification.

Future extensions of our approach might include multiple inputs into the detection of the JPSCs—not only arms transfers but also formal alliances, troop deployments, defense cooperation agreements, diplomatic ties, etc. That our JPSCs defined only with arms transfers do not cleanly overlap with regional orders or alliance blocs attests to the merit of considering arms transfers as an indicator of joint security production. Many other measures would miss important security cooperation among, say, the USA, Egypt, and Israel. That said, arms transfers are an imperfect measure alone, and it would be useful to consider additional information on joint security production.

We also plan to expand on our theory as to how communities affect conflict and cooperation. For example, a full causal mediation model that connects JPSC membership and hierarchy to foreign policy alignment would add to our understanding of the manner in which interdependent interactions between states condition state behavior. Even more ambitious would be the construction of a theoretical and empirical model that allows JPSCs at different levels of hierarchy to emerge endogenously from a network of conflict and cooperation and to allow the JPSCs to shape the network in turn.

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