Kantian fractionalization predicts the conflict propensity of the international system

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Network science has spurred a reexamination of relational phenomena in political science, including the study of international conflict. We introduce a new direction to the study of conflict by showing that the multiplex fractionalization of the international system along three key dimensions is a powerful predictor of the propensity for violent interstate conflict. Even after controlling for well-established conflict indicators, our new measure contributes more to model fit for interstate conflict than all of the previously established measures combined. Moreover, joint democracy plays little, if any, role in predicting system stability, thus challenging perhaps the major empirical finding of the international relations literature. Lastly, the temporal variability of our measure with conflict is consistent with a causal relationship. Our results have real-world policy implications as changes in our fractionalization measure substantially aid the prediction of conflict up to 10 years into the future, allowing it to serve as an early warning sign of international instability.

networks | community detection | multiplex | international conflict

Immanuel Kant proposed a recipe for international peace in 1795 (1) that has proven remarkably insightful: the diffusion of democracy, economic interdependence, and the establishment of international institutions. Kant's fundamental idea is that the more interconnected the international system becomes, the less likely conflict is to occur. As democracy spreads, states become more economically interdependent, and international governmental organizations (IGOs) grow in scope and power, war becomes more costly, and alternatives to war become both more abundant and more appealing. Democracy checks executive power and promotes norms of compromise and negotiation. Trade increases the stakes of the conflict and provides incentives to resolve disputes without damaging mutually beneficial relationships. IGOs present forums, norms, and procedures for peaceful conflict resolution. Likewise, when these factors become less prevalent and the connectivity among states weakens, credible alternatives to war become harder to find and thus the potential for violent conflict increases. In many ways, Kant's logic is foundational for the idea that increasing contact between groups mitigates conflict (2, 3).

Many studies have explored the impacts of the components of the Kantian tripod individually (4, 5) as well as collectively (6, 7) on peaceful relations. However, these studies model the elements of the tripod as independent effects on dyadic (between two states) conflict. This approach is limited insofar as each relational component is part of a much larger network and thus has implications for the entire system. Some scholars have considered the effects of system-level measures of the Kantian tripod (8, 9), but the outcome of interest is still dyadic. A few studies do consider conflict at the system level (10, 11), but these studies look at the effect of democracy alone, ignoring the other components of the Kantian tripod. Recently, some have challenged these studies' focus on joint democracy, suggesting that the effects attributed to joint democracy may be due to other factors, such as capitalism (12).

We propose that to evaluate the effect of Kant's prescription for peace on international conflict, the three components must be considered collectively. Moreover, as dyadic relations are influenced by, and influence, the other relationships in the system, Kant's prescription should not merely be applied to dyadic conflict; it should have implications for conflict at the system level. We improve upon existing studies by quantifying the nature of interconnectedness of the international system by combining the elements of the Kantian tripod at the system level in a multiplex measure we call "Kantian fractionalization" and by considering the effect of Kantian fractionalization on systemic conflict.

Measuring Kantian Fractionalization

The level and organization of interconnectivity in the international system is indicative of the level of stress exerted on relationships between states. When a dispute arises between states, relationships both within and beyond the dyad are relevant. Connections that encompass more states with lower levels of fractionalization induce less stress on the international system. States will still find themselves in disagreements with one another, but these disputes are less likely to escalate to violence in a system with low fractionalization. When fractionalization in the international system is high, however, greater tension is exerted on the international system. Conflicts that arise in highly tense systems are more likely to escalate to violence as the networked effects of democracy, trade, and IGOs are too weak to mitigate this tension. We refer to the level of division in the trade, democracy, and IGO networks as the system's Kantian fractionalization, and we expect higher levels of Kantian fractionalization will result in higher incidence of interstate conflicts.

To measure the system's Kantian fractionalization, we use the tools of community detection in networks (13, 14). A community in a network is a group of vertices (countries in our case) that are

Significance

Many studies in international relations have investigated relationships between pairs of countries and the likelihood of conflict, yet none have connected the overall structure of the network of relationships between countries with the total level of international conflict. Here, we blaze a new path in the study of international conflict by introducing a measure of the overall fractionalization in the network of international relationships which we call Kantian fractionalization and demonstrating that this measure has been closely correlated with the number of new international conflicts in the following year. Moreover, we show that jointly democratic pairs of countries contribute negligibly to Kantian fractionalization, casting doubt on one of the most prominent concepts in international relations and policy prescriptions in Washington.

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more strongly connected to one another than they are to the rest of the network. One of the dominant methods of community detection, the computational optimization of modularity (15), is a direct quantification of this notion and is calculated as the difference between the total weight of intragroup edges and the expected strength under an appropriate null model. Larger modularity values signal denser, stronger connections between vertices in the same community relative to the network as a whole, with relatively sparser, weaker connections between communities.

Because the network of Kantian ties is multiplex, we use multilayer modularity in its multiplex network form (16), treating each of the three kinds of connections as a layer of the multiplex network. We consider each year of data separately. In this formulation, each state is represented as three (multilayer) vertices that are connected to one another by identity arcs of weight specified by an interlayer coupling parameter. The joint democracy layer is a clique (of unit edge weight) connecting all democracies [states with a Polity IV (17) score greater than or equal to 6, standard in the literature], leaving nondemocracies isolated within the layer. The trade layer is a directed network with nonzero edge weights linearly related to the logarithm of trade value from one country to another. The IGO network layer is an undirected single-mode weighted network with edge weights proportional to the number of common IGO memberships. So that the three layers have similar weights, we scaled the trade and IGO layers to have median present edge weight over time equal to 1. The Kantian fractionalization of the system in a given year is then defined as the maximum obtained value of

$$Q_K = \frac{1}{2\mu} \sum_{ijlr} \left\{ \left(A_{ijl} - \gamma P_{ijl} \right) \delta_{lr} + \delta_{ij} (1 - \delta_{lr}) \omega \right\} \delta\left(g_{il}, g_{jr} \right),$$

where A_{ijl} is the edge weight connecting states i and j in layer l, P_{ijl} is the corresponding null model in layer l [Newman–Girvan (15) for IGO and joint democracy, Leicht-Newman (18) for trade], γ is a resolution parameter, ω is the specified interlayer identity coupling, μ is the total edge weight, g_{il} is the community assignment of vertex i in layer l, g_{jr} is the community assignment of vertex j in layer r, and Kronecker δ indicators equal 1 when their two arguments are identical (0 otherwise). For our principal Q_K specification, we use the default values $\gamma = \omega = 1$. To have confidence in the obtained Q_K values, we run the computational heuristic 100 times with pseudorandom vertex orders and select the maximum observed value, as described in the *SI Appendix* with further details of the measure. We investigated the effects of our parameter and measurement choices on the robustness of our results, as also detailed in the *SI Appendix*.

Measured as such, multilayer modularity captures the level of fractionalization in the system and allows us to consider all components of the Kantian tripod simultaneously. To our knowledge, this is the first use in practical application of multilayer modularity in a multiplex network [that is, separate from the limited demonstration of principle that accompanied the original development of multilayer modularity (16)].

Data and Analysis

We turn now to the relationship between Kantian fractionalization and the prevalence of violent international conflict. To capture decisions to use military force, we examine the number of onsets in a calendar year when violent military force is “explicitly directed towards the government, official representatives, official forces, property, or territory of another state” (ref. 19, p. 163). We include disputes marked by violence ranging in intensity from small skirmishes to full-scale war. We adjust our analyses for the fact that during our period of observation, 1948–2000, the number of states in the system increases from 72 to 191, providing more opportunities for dyadic interstate conflict. We consider the same analyses on only “politically relevant” dyads in the *SI Appendix*.

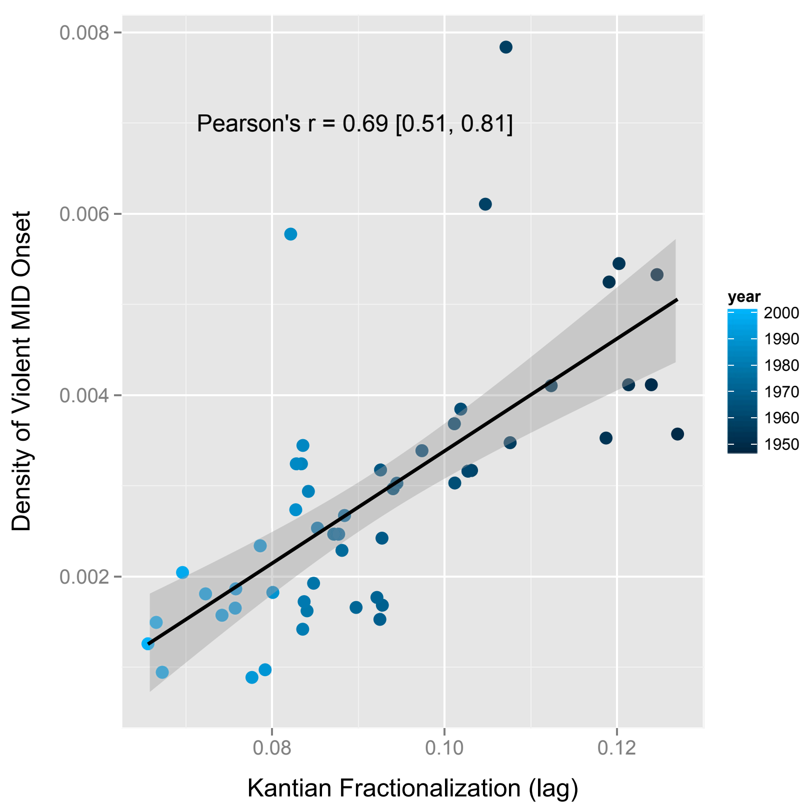

Fig. 1. Kantian fractionalization, lagged by 1 year, and conflict rate, 1948–2000. The line and confidence bands reflect those fit by a bivariate linear model.

Table 1. Quasi-Poisson regression results

Variable	Basic model*		Full model		Without fractionalization	
Kantian fractionalization (lag)	**24.143**	**(3.394)**	**24.817**	**(5.696)**		
Moul polarity			−0.167	(0.202)	**−0.726**	**(0.165)**
Alliance dependency (lag)			2.169	(1.220)	1.624	(1.455)
System movement (5 years)			0.332	(6.690)	**15.177**	**(6.147)**
Lagged outcome	**0.018**	**(0.006)**	**0.013**	**(0.006)**	0.006	(0.007)
(Intercept)	**−8.520**	**(0.366)**	**−9.553**	**(1.072)**	**−5.891**	**(0.804)**
AIC	366.54		364.18		406.67	

*Count models, corrected for overdispersion and including the logarithm of the number of dyads in the system year as an offset. Coefficients and SEs displayed in bold are statistically significant at the $P = 0.05$ level.

In our statistical analyses, we lag the modularity measures one year to ensure temporal precedence of the hypothesized cause to the effect. We also control for several variables common in the international conflict literature (20). First, we include Moul's measure of system polarity (20). This measure divides the number of major power alliance groups by the number of major powers, thus producing a ratio to capture the polarity of the international system. We also include a one-year lagged defensive alliance interdependence (21). To account for the role that the distribution of material capabilities are traditionally thought to play in system stability, we include a five-year rolling average of movement in capability concentration using Ray and Singer's measure (22). Finally, we include a one-year lagged outcome variable to account for the first-order autocorrelation observed in the outcome variables (details in the *SI Appendix*).

Results

The bivariate relationship between Kantian fractionalization and conflict rate is strong and apparently linear (Fig. 1). As Kantian fractionalization increases, so does the rate of conflict. The visual relationship is also borne out statistically ($r = 0.690$, $P < 0.001$).

Poisson regressions of the number of new conflicts per year—offset by the opportunities for conflict (logarithm of the number of dyads in the system year) and including a dispersion parameter to adjust the SEs for the overdispersion present in the annual count of violent conflicts—capture the rate of conflict (Table 1). Comparing a basic model with only our fractionalization measure and a lagged outcome variable to a model that includes all of the controls and a third model with only the controls, Kantian fractionalization consistently maintains a statistically significant and substantively large positive effect on the onset of conflict. The models with Kantian fractionalization also display consistently superior in-sample fit as judged by the Akaike information criterion (AIC). Likelihood ratio tests reveal that restricting the model with controls to exclude Kantian fractionalization is an invalid restriction ($\chi^2 = 44.495$, $P = 2.55 \times 10^{-11}$). These results are robust to substantial permutations in the measurement of modularity, the model specification, and statistical structure of the model (*SI Appendix*).

Our measure and model also strongly aid the forecasting of conflict. We estimate our specifications on the data from the beginning of the period of observation up until year t and then forecast 1, 5, and 10 years ahead, walking this process across the period of observation from beginning to end. The root-mean-squared predictive error drops substantially when we add Kantian fractionalization to the baseline autoregressive model, drops slightly beyond that when we add the usual controls to our measure and the lagged outcome variable, and increases substantially when we exclude Kantian fractionalization (Fig. 2). This indicates that our measure results in a larger predictive gain than all of the controls combined. It also indicates that Kantian fractionalization is a powerful forecasting tool for policy makers. Finally, absent Kantian fractionalization, the usual controls overfit the training data and result in a degradation of predictive performance.

The above tests do not, however, address the issue of whether Kantian fractionalization causes conflict or vice versa. To address this possibility, we conducted a series of Granger causal tests. Variable x is said to Granger cause variable y if lagged values of x are statistically reliable predictors of current values of y, but the reverse is not true (23). Whereas both quantities have been observed to decrease over time during the period studied, the results show quite unambiguously that Kantian fractionalization Granger causes the prevalence of interstate conflict, but not the other way around (Table 2). These results are robust to multiple alternative operationalizations and statistical tests (*SI Appendix*). As such, we may conclude that the empirical relationship between Kantian fractionalization and conflict is consistent with the hypothesized causal relationship.

Lastly, we examine the relative contribution of the three network layers to Kantian fractionalization. This is useful because

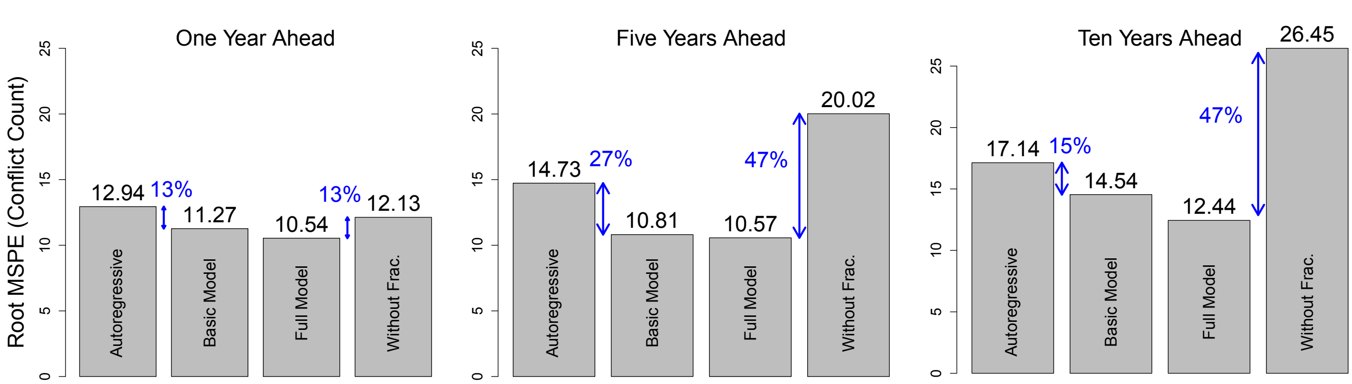

Fig. 2. Out-of-sample (1, 5, and 10 years ahead) forecasting performance. The plots show the root-mean-squared predictive error (MSPE) from a series of forecasts in which the values of conflict count were forecast using only the data available up to, but not including, the period forecast.

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Table 2. Granger causal analysis of violent conflict onset density and Kantian fractionalization, 1948–2000

	Conflict dens. → Kantian frac.		Kantian frac. → Conflict dens.	
Lags	*F* statistic*	*P* value	*F* statistic	*P* value
1	0.024	0.877	**12.123**	**0.001**
2	0.101	0.904	**4.449**	**0.017**
3	0.229	0.876	**3.863**	**0.016**
4	0.901	0.473	**4.375**	**0.005**
5	0.677	0.644	**3.547**	**0.010**
6	0.428	0.855	**2.409**	**0.048**
7	0.700	0.672	**3.044**	**0.015**
8	0.898	0.531	2.036	0.079
9	0.610	0.777	1.260	0.306
10	0.608	0.790	1.046	0.440

**F* statistics and *P* values in bold are statistically significant at or below the $P = 0.05$ level.

theory does not stipulate whether all three are equally important in their contributions to the Kantian peace. In the political science literature, joint democracy enjoys a place of prominence, so much so that the Kantian peace is often reduced to only the democratic peace. This democratic peace has been lauded as the nearest thing to a law of international politics (7), has permeated into the media, and has been cited by multiple Presidents of the United States when discussing foreign policy.

We quantify the contribution from each network layer through a series of tests permuting country identities, calculating the difference between Kantian fractionalization from each layer relative to the mean over permutations. Fig. 3 shows that the large majority of the measure is driven by trade and IGO connections, whereas joint democracy plays little role at all. (As shown in the *SI Appendix*, our results do not change meaningfully if we drop joint democracy; indeed, the predictive models actually perform better.)

Our results suggest, at minimum, that the idea of a democratic peace, although generally thought credible at the dyadic level, does not scale up to become a meaningful predictor of system stability. This is problematic for the claim of a democratic peace because states, their relationships, and broader systemic characteristics are all attributes of the same system; a coherent explanation for conflict requires empirical agreement regardless of the resolution with which we measure the process of interest.

Discussion

Network science has led to many recent advancements (24–26), including in political science (27, 28) and more specifically the

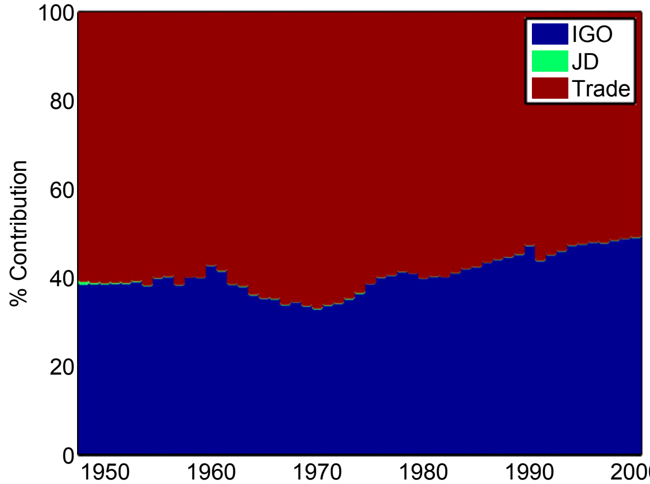

Fig. 3. Relative contribution of the three network layers to our Kantian fractionalization measure. We note in particular that the three layers of the Kantian tripod used here [IGO, joint democracy (JD), trade] have been scaled so that the median present edge weights are the same in each (see *SI Appendix* for details). Nevertheless, the numbers, relative weights, and patterns of connections are such that the relative contributions to Kantian fractionalization are dominated by IGO and trade, with little contribution from JD.

study of international conflict (21, 29, 30). We have introduced a different way of thinking about the systemic manifestations of dyadic phenomena and a new way of measuring the cohesion of the international system. Taken together, our results suggest that (*i*) a relationship between Kantian fractionalization and conflict exists, (*ii*) the correlation seems not to be spurious, (*iii*) Kantian fractionalization does more to improve the out-of-sample predictive performance than all controls combined, (*iv*) our measure is useful for forecasting system stability up to 10 years into the future, (*v*) the temporal dynamics of the relationship are consistent with a causal effect, and (*vi*) the composition of our measure casts doubt on the system-level influence of a democratic peace. These results are robust across multiple operationalizations of Kantian fractionalization, multiple model specifications, and multiple statistical models.

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