Robustness of Empirical Evidence for the Democratic Peace: A Nonparametric Sensitivity Analysis

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Abstract   The democratic peace—the idea that democracies rarely fight one another—has been called "the closest thing we have to an empirical law in the study of international relations." Yet, some contend that this relationship is spurious and suggest alternative explanations. Unfortunately, in the absence of randomized experiments, we can never rule out the possible existence of such confounding biases. Rather than commonly used regression-based approaches, we apply a nonparametric sensitivity analysis. We show that overturning the negative association between democracy and conflict would require a confounder that is forty-seven times more prevalent in democratic dyads than in other dyads. To put this number in context, the relationship between democracy and peace is at least five times as robust as that between smoking and lung cancer. To explain away the democratic peace, therefore, scholars would have to find far more powerful confounders than those already identified in the literature.

The proposition that democratic states do not fight interstate wars against each other is one of the most enduring and influential ideas in international relations. The idea is theoretically rooted in the work of Immanuel Kant, who argued that interactions between states with a republican form of government give "a favorable prospect for the desired consequence, i.e., perpetual peace."[1] This has led to a large literature empirically documenting a negative association between democracy and conflict,[2] leading one scholar to comment that the democratic peace is "the closest thing we have to an empirical law in the study of international relations."[3]

Despite the law-like nature of this association, no scholarly consensus has emerged on whether the observed association reflects a causal relationship or a spurious correlation. According to a recent survey, more than 30 percent of international relations scholars disagree with the democratic peace theory.[4] In particular, skeptics have

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1. Kant 1991, 14.
2. See, for example, Beck, Katz, and Tucker 1998; Bremer 1993; Gelpi and Griesdorf 2001; Gleditsch and Hegre 1997; Hensel, Goertz, and Diehl 2000; Maoz and Abdolali 1989; Maoz and Russett 1992, 1993; Morgan and Campbell 1991; Oneal and Russett 1997, 1999; Oneal et al. 1996; Ray 1993; Rummel 1983; Russett 1994; Russett and Oneal 1999; Senese 1997; Small and Singer 1976; Ward and Gleditsch 1998; Weede 1992.
3. Levy 1989, 662.
4. Gowa and Pratt 2019.

challenged the democratic peace by arguing that alliance structures from the Cold War,[5] capitalism,[6] and contract-intensive economies[7] confound the observed association. These authors find that adding certain confounding variables to regression models eliminates the statistical significance of the estimated coefficient for the joint democracy variable.[8]

How should we resolve this empirical debate regarding the democratic peace?[9] Unfortunately, in the absence of randomized experiments, we can never completely rule out the possible existence of confounding biases that arise from omitted variables. While scholars in this literature have exclusively relied on parametric regression models, this approach requires strong assumptions, namely that the model accurately characterizes the true data-generating process (correct set of variables, right functional form, valid distributional assumption, etc.). Given that these assumptions may not be verifiable from observed data, it is no surprise that various scholars advocate different regression models with diverging sets of variables, resulting in contradictory findings. The difficulty of adjudicating between these alternative modeling approaches has led to the ongoing controversy in the empirical democratic peace literature.

We propose an alternative approach based on nonparametric sensitivity analysis to formally assess the robustness of the empirical evidence.[10] Specifically, we quantify the strength of confounding relationships that could explain away the observed association between democracy and peace. That is, we compute the precise level of unobserved confounding needed to render the observed association between democracy and conflict spurious. The idea is that although not all correlations imply causation, a very strong correlation suggests it. Unlike the parametric regression modeling approach prevalent in the literature, the proposed nonparametric sensitivity approach directly addresses the existence of unobserved confounders without assuming a particular regression model.[11] Although one can never know with certainty from observational data whether democracy causes peace, this nonparametric sensitivity analysis can formally assess the robustness of empirical evidence for the democratic peace.

Our analysis applies the nonparametric sensitivity analysis method originally developed by Cornfield and colleagues, who were concerned with the robustness of the positive association between cigarette smoking and lung cancer in the potential presence of unobserved confounders.[12] The study of the causal relationship between

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5. Farber and Gowa 1997; Gowa 2000.

6. Gartzke 2007.

7. Mousseau 2009, 2013, 2016.

8. We focus on the recent critiques of the democratic peace because our empirical analysis is based on these studies.

9. We focus on the empirical controversy and do not address the theoretical debate about the democratic peace here. See, for example, Russett 1994 and Rosato 2003 for a review of the existing theories and their criticisms, respectively.

10. See, for example, Cornfield et al. 1959; Ding and VanderWeele 2014; Imai and Yamamoto 2010; Rosenbaum 2002.

11. See Ho et al. 2007 for a discussion of the robustness of a nonparametric adjustment.

12. Cornfield et al. 1959.

smoking and lung cancer closely parallels the dispute on the democratic peace. In both cases, randomized experiments cannot be conducted for ethical and logistical reasons, and critics contend that the observed association suffers from confounding biases. While no definitive conclusion can be drawn from observational data, Cornfield and colleagues argue that no existing confounder can explain the strong association between smoking and cancer and therefore this relationship is likely to be causal. Their conclusion is worth quoting here:

> Cigarette smokers have a ninefold greater risk of developing lung cancer than nonsmokers, while over-two-pack-a-day smokers have at least a 60-fold greater risk. Any characteristic proposed as a measure of the postulated cause common to both smoking status and lung-cancer risk must therefore be at least nine-fold more prevalent among cigarette smokers than among nonsmokers and at least 60-fold more prevalent among two-pack-a-day smokers. No such characteristic has yet been produced despite diligent search.[13]

Our application of nonparametric sensitivity analysis to the democratic peace yields striking results. Depending on the definition of democracy, we find that a confounder must be at least forty-seven times more prevalent in democratic dyads than in other types of dyads. Thus, any potential confounder that could explain the democratic peace would have to be at least five times as prevalent as a similar confounder for smoking and lung cancer. In other words, according to our analysis, the positive association between democracy and peace is much more robust than that between smoking and lung cancer.

While no such confounder has yet been found for the relationship between smoking and lung cancer, we examine whether the confounders identified in the democratic peace literature meet the conditions of nonparametric sensitivity analysis. For example, we consider a set of economic confounders proposed by Gartzke who argues that the democratic peace can be explained by capitalism.[14] We also consider other confounders, such as military alliances.[15] Overall, our findings imply that for a potential confounder to explain away the democratic peace, it must be much more strongly associated with regime types and conflicts than the confounders that have been proposed to date. This finding again demonstrates the robustness of empirical evidence for the democratic peace.

Finally, we believe that a nonparametric sensitivity analysis, such as the one we use here, can play an important role in international relations research, where the threat of omitted variable bias is almost always present. Although sensitivity analysis has been applied in international relations, almost all such applications have been based on parametric regression models. In the democratic peace literature, Kadera and

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13. Ibid., 1186.
14. Gartzke 2007.
15. Farber and Gowa 1997; Gowa 2000.

Mitchell conduct a parametric sensitivity analysis in the spirit of Leamer.[16] In addition, Chaudoin, Hays, and Hicks apply a parametric sensitivity analysis of Altonji, Elder, and Taber to the effects of the GATT/WTO, whereas Hegre and Sambanis use the method of Sala-i-Martin to examine the sensitivity of empirical results on civil war onset.[17] The only exception we found is Davis and Shirato, who use a nonparametric sensitivity analysis to assess the robustness of their findings to possible sample selection bias.[18] Unlike parametric approaches, nonparametric sensitivity analyses avoid modeling assumptions and hence offer a robust method to examine the strength of empirical conclusions.

Nonparametric Sensitivity Analysis: A Review

We briefly review the nonparametric sensitivity analysis originally developed by Cornfield and colleagues before applying it to the democratic peace. Consider a potential causal relationship between a binary treatment X and binary outcome Y. Following the smoking and lung cancer example, we define the treatment variable such that it is positively correlated with the negative outcome.[19] In our application, X represents whether a pair of countries are both democratic in a given year ($X = 0$) or not ($X = 1$), and Y indicates whether the dyad has a conflict during the same year ($Y = 1$) or not ($Y = 0$). Finally, U represents a binary variable that confounds the causal relationship between X and Y.[20] Note that because we observe the universe of countries and conflicts rather than a random sample from a target population, we ignore statistical estimation uncertainty that would arise when inferring population characteristics from a sample.[21] This does mean, however, that our empirical conclusions may not generalize beyond the data analyzed in our paper. Our data set covers all dyads used by Gartzke.[22] These data cover dyads with 186 countries between 1950 and 1992.

To formalize the sensitivity analysis advocated by Cornfield and colleagues, we use notation similar to that of Ding and VanderWeele[23] and define the observed relative risk of the nondemocratic dyad X for conflictual relation Y as

$$RR_{XY}^{obs} = \frac{\Pr(Y = 1 \mid X = 1)}{\Pr(Y = 1 \mid X = 0)}. \tag{1}$$

16. Kadera and Mitchell 2005; Leamer 1983; see also Ray 2005.
17. Altonji, Elder, and Taber 2005; Chaudoin, Hays, and Hicks 2018; Hegre and Sambanis 2006; Sala-i-Martin 1997.
18. Davis and Shirato 2007.
19. The substantive results are the same if one uses the opposite correlation.
20. Although we consider the impact of only a single confounder, this confounder can be a function of multiple confounders. We are also agnostic about the source of confounding. For example, it may arise from measurement error of the treatment variable.
21. See Liu, Kuramoto, and Stuart 2013 for an introduction to other sensitivity analysis techniques, several of which assess statistical significance.
22. Gartzke 2007.
23. Ding and VanderWeele 2016.

Without loss of generality, we assume $RR_{XY}^{obs} \geq 1$ (i.e., democratic dyads are more likely to be peaceful), since the democratic peace is represented by a positive association between nondemocratic dyads and conflictual relations. If the association is negative ($RR_{XY}^{obs} < 1$), then there is no democratic peace phenomenon to be explained.

We are interested in knowing whether the following true relative risk is also positive:

$$RR_{XY}^{true} = \frac{\Pr(Y(1) = 1)}{\Pr(Y(0) = 1)}, \tag{2}$$

where $Y(x)$ is the potential outcome that would be realized when the treatment variable X takes the value of $x \in \{0, 1\}$. In our application, $Y(1)$ represents the existence of a conflictual relation between two countries under the scenario that at least one of them is nondemocratic, while $Y(0)$ corresponds to the potential outcome when both are democratic. Note that we observe only one of the two potential outcomes for each country pair, $Y = Y(X)$. For example, if two countries are both democratic, we observe $Y(0)$ but $Y(1)$ remains unknown. This implies that RR_{XY}^{obs} does not necessarily equal RR_{XY}^{true}.

If the regime types are randomly assigned, the observed relative risk RR_{XY}^{obs} equals the true relative risk RR_{XY}^{true}. Unfortunately, the absence of randomized experiments in the democratic peace literature means that there likely exists an unobserved confounding variable U as a common cause of democracy X and peace Y, such as common interests and shared ideology. Following Cornfield and colleagues, we consider a potential confounder U that completely explains away the association. That is, conditional on U, the regime type of a dyad is exogenous to its relationship, as shown formally by

$$\{Y(1), Y(0)\} \perp\!\!\!\perp X \mid U. \tag{3}$$

Cornfield and colleagues show that if a potential binary unmeasured confounder U were to explain away the observed relative risk of X on Y (i.e., $RR_{XY}^{true} = 1$ as implied by Equation (3) although $RR_{XY}^{obs} \geq 1$), then the relative risk of X for U must be greater than or equal to the observed relative risk of X on Y:

$$RR_{XU} = \frac{\Pr(U = 1 \mid X = 1)}{\Pr(U = 1 \mid X = 0)} \geq RR_{XY}^{obs}. \tag{4}$$

For example, if a common interest between two countries explains away the democratic peace as Farber and Gowa suggested,[24] then a nondemocratic dyad must be more likely than a democratic dyad to lack a common interest ($U = 1$) by at least as much as it is more likely to be conflictual.

Importantly, Equation (4) is not the only necessary condition for the unobserved confounder U to explain away the observed correlation between X and Y. This is

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24. Farber and Gowa 1997.

because U has to be a cause of Y as well as of X. Schlesselman further shows that the relative risk of U for Y must be greater than or equal to the observed relative risk of X for Y:[25]

$$\text{RR}_{UY} = \frac{\Pr(Y = 1 \mid U = 1)}{\Pr(Y = 1 \mid U = 0)} \geq \text{RR}_{XY}^{obs}. \tag{5}$$

In the current example, this condition implies that a dyad without a common interest ($U = 1$) must be more likely to have a conflictual relationship than other dyads by at least as much as a nondemocratic dyad is more likely to have a conflictual relationship than a democratic dyad.

Putting Equations (4) and (5) together, we have the classical Cornfield condition

$$\min(\text{RR}_{XU}, \ \text{RR}_{UY}) \geq \text{RR}_{XY}^{obs}. \tag{6}$$

More recently, there have been several refinements of the classical Cornfield condition.[26] In particular, Ding and VanderWeele derive the following additional necessary condition:[27]

$$\max(\text{RR}_{XU}, \ \text{RR}_{UY}) \ \geq \ \text{RR}_{XY}^{obs} + \sqrt{\text{RR}_{XY}^{obs}(\text{RR}_{XY}^{obs} - 1)}. \tag{7}$$

This condition requires the greater of the two relative risks associated with U to exceed RR_{XY}^{obs} by an additional amount, which is an increasing function of RR_{XY}^{obs} and is given by the second term in the right-hand side of Equation (7). Thus, this condition demands that the unobserved variable U is a strong confounder to explain away the observed association between X and Y.

While simple, this nonparametric sensitivity analysis enjoys several advantages over competing alternatives. Chief among these is that sensitivity analysis using the Cornfield condition is nonparametric and does not rely on a regression model. That is, there are no distributional or functional form assumptions (normality, linearity, etc.) invoked at any stage, and the risk ratios used for this method can be easily calculated and intuitively interpreted.

Empirical Evidence

In this section, we apply the Cornfield conditions (Equations (6) and (7)) to the democratic peace debate. While it is widely accepted that democracies seldom fight each other, a substantial debate about the underlying causes of the democratic peace persists. Table 1 gives a partial list of the existing research in the democratic peace literature, including articles that are either supportive or critical of the idea that joint democracy is a core component of that peace. Notably, existing studies consider

25. Schlesselman 1978.

26. See, for example, Flanders and Khoury 1990; Lee 2011; Ding and VanderWeele 2014, 2016.

27. Ding and VanderWeele 2016.

different outcome variables—militarized interstate disputes (MIDs), deadly MIDs (MIDs with casualties), and wars (deadly MIDs with 1,000 or more casualties)— and analyze different, observed potential confounders. In recent years, many of these critiques have focused on the role of economic confounders in explaining the liberal peace.

TABLE 1. *Partial review of articles from the democratic peace literature*

Article	Years	Exposure (X)	Outcome (Y)	Confounder (U)
Critical				
Mansfield and Snyder 1995	1811–1980	Polity II (democracy)	MIDs with 1000+ fatalities	Democracy
Farber and Gowa 1997	1816–1980	Polity II (democracy)	MIDs, wars	Cold War alliance
Green, Kim, and Yoon 2001	1951–1992	Polity III (democracy)	MIDs	Fixed effects
Gartzke 2007	1950–1992	Polity IV (democracy– autocracy)	MIDs, wars, deadly MIDs	Capitalism
Mousseau 2009, 2013, 2016	1951–2001	Polity IV (democracy)	Deadly MIDs, war	Contract-intensive economy
Supportive				
Rummel 1983	1976–1980	Freedom House (political and economic freedom)	Campaigns of violence	
Maoz and Abdolali 1989	1816–1976	Polity (scale of six variables)	MIDs	
Maoz and Russett 1993	1946–1986	Polity II (democracy– autocracy)	MIDs, ICB crises	
Oneal and Russett 1997	1950–1985	Polity III (democracy– autocracy)	MIDs	
Dafoe 2011	1950–1992	Polity IV (democracy– autocracy)	MIDS, deadly MIDs, wars	Replication of Gartzke 2007
Dafoe, Oneal, and Russett 2013	1961–2001	Polity IV (democracy)	MIDs, deadly MIDs	Replication of Mousseau 2013

Note: "Democracy–autocracy" refers to the difference between the Polity democracy and autocracy variables.

Our application of the Cornfield conditions to the study of the democratic peace focuses on three separate studies: Gartzke's capitalist peace,[28] Mousseau's contractualist peace,[29] and the claim by Farber and Gowa that alliance structures confound the democratic peace.[30] In each case, we examine whether the main confounder meets the Cornfield conditions. As noted earlier, although the focus of our analysis is the uncertainty about identification, we do not compute measures of estimation uncertainty. This is because our data set captures the full population of conflict outcomes and is not a random sample of cases from a target population. Our analysis shows that in almost all cases the Cornfield conditions are not satisfied. This suggests that none of these confounders are strong enough to overturn the evidence for the democratic

28. Gartzke 2007.
29. Mousseau 2009, 2013, 2016.
30. Farber and Gowa 1997; Gowa 2000.

peace. Our data set covers all the dyads used by Gartzke.[31] These data cover dyads with 186 countries between 1950 and 1992.

The Capitalist Peace

Gartzke advances the argument that capitalism rather than democracy is responsible for the positive association between democracies and peaceful relations. According to this "capitalist peace" thesis, economic development, free markets, and similar interstate interests all reduce the likelihood of MIDs and wars. Gartzke uses five variables— the IMF financial openness index, trade openness, GDP per capita, the interaction of GDP per capita and geographic contiguity, and interest similarity—as the key confounding variables for the capitalist peace.[32] We investigate whether these confounding variables are sufficient to explain away the democratic peace.

Table 2 presents the main result of this analysis. Following Gartzke, our data come from Zeev Maoz's dyadic MIDs, and we consider three measures of conflict that are commonly used in the literature: MIDs, deadly MIDs, and wars. Our exposure variable is joint democracy (i.e., both members of the dyad are democracies). Following the standard in the democratic peace literature, we employ Polity IV data,[33] and use two different dichotomous versions of joint democracy.[34] The first measure is Gartzke's Both Democ variable, which combines Polity democracy and autocracy variables and classifies whether both dyad members have a monadic score above 6.[35] Our second measure is a more standard measure that defines a democracy as a state with a Polity democracy score of at least 6.[36] For each of the six combinations of exposure and outcome measures, we compute the relative risk RR_{XY}^{obs} (see Equation (1)), the key quantity needed for the Cornfield condition.[37]

It is worth looking at the distribution of relative risk, RR_{XY}^{obs}, closely. First, note that the risk varies significantly with both the conflict and the choice of democracy measure. Overall, using the standard Polity measure tends to yield more robust estimates of the democratic peace over the measure used by Gartzke. The democratic peace result becomes more robust for wars: RR_{XY}^{obs} exceeds 47 with the standard Polity measure, and is infinite using the democracy measure used by Gartzke. To put this result in context, the relative risk of smoking with respect to lung cancer is

31. Gartzke 2007.

32. Although Dafoe 2011 challenges Gartzke 2007's findings based on data quality issues, we use the original data for the sake of comparability.

33. Jaggers and Gurr 1995.

34. Some scholars include the continuous Polity scores of both the higher and lower states in various regression models. However, in virtually all of these studies, including Gartzke's, the authors claim their results are robust to dichotomous versions of joint democracy.

35. Gartzke 2007, 174.

36. There are several thresholds in the literature that have been proposed when using solely the Polity democracy scores. We adopt this threshold because it is the one that appears in the original analysis as the CEDDEM2 variable, and is used in Cederman 2001.

37. In Table A3 (in the online appendix), we repeat this analysis using two alternative measures of joint democracy, from Boix, Miller, and Rosato 2013 and Cheibub, Gandhi, and Vreeland 2010.

TABLE 2. *Sensitivity analysis for capitalist peace*

Outcome (Y)	RR_{XY}^{obs}	Financial openness		Trade dependence		GDP		Contiguity		Affinity		Capitalism	
		RR_{XU}	RR_{UY}	RR_{XU}	RR_{UY}	RR_{XU}	RR_{UY}	RR_{XU}	RR_{UY}	RR_{XU}	RR_{UY}	RR_{XU}	RR_{UY}
Joint democracy from Gartzke 2007													
MIDs	2.38	1.46	2.10	4.08	0.47	4.30	1.18	0.43	47.62	0.81	1.67	4.62	0.08
Deadly MIDs	7.35	1.46	1.91	4.08	0.63	4.30	1.20	0.43	44.79	0.81	1.57	4.62	0.12
War	Inf	1.46	3.23	4.08	1.16	4.30	3.54	0.43	14.83	0.81	1.27	4.62	0.06
Joint democracy from Cederman 2001													
MIDs	2.55	1.24	2.10	1.61	0.47	2.65	1.18	0.64	47.62	0.88	1.67	2.30	0.08
Deadly MIDs	2.71	1.24	1.91	1.61	0.63	2.65	1.20	0.64	44.79	0.88	1.57	2.30	0.12
War	47.78	1.24	3.23	1.61	1.16	2.65	3.54	0.64	14.83	0.88	1.27	2.30	0.06

Notes: Nondemocratic dyad is the treatment (X), and conflict is the outcome (Y). We examine whether any of the confounding variables (U) used by Gartzke meets the Cornfield condition. None of the posited confounders listed here meet the Cornfield conditions, regardless of the measure of democracy or conflict outcome chosen.

approximately 9 for one-pack-a-day smokers, 60 for two-packs-a-day smokers, and 20 for smokers overall. Thus, for an unmeasured confounder to explain the democratic peace, the relative risk of that confounder would have to more than double what we would require for a confounder to explain the relationship between smoking and lung cancer. Stated differently, the democratic peace as measured for wars is about twice as robust as the relationship between smoking and lung cancer.

We next consider five potential confounders proposed by Gartzke: financial openness, trade dependence, GDP per capita, geographic contiguity,[38] and shared interests. While the author uses continuous measures of these variables, we dichotomize them at their median value to construct binary measures of the same concepts.[39] In addition to these five original confounders, we consider a sixth capitalism variable. This binary variable is constructed by first running a factor analysis of the five continuous confounders, and then dichotomizing the factor score at its median. For each observed potential confounder U that is listed, we calculate the relative risks, RR_{XU} and RR_{UY}. Using the quantities calculated in Table 2, we assess whether the Cornfield conditions are met. We consider six different exposure–outcome combinations and assess their sensitivity to the six different potential confounders, for a total of thirty-six possible comparisons. In none of the thirty-six comparisons are the Cornfield conditions met: RR_{XU} or RR_{UY} (or both) is always less than RR_{XY}^{obs}. Thus, none of the posited confounders listed can independently explain the democratic peace, regardless of the measure of democracy or the conflict outcome chosen.

We conduct the same analysis for each decade and for MIDs (top panel) and deadly MIDs (bottom panel), with results shown in Table A1 of the online appendix. For wars using the Gartzke joint democracy variable, RR_{XY}^{obs} is infinite in all decades, so none of the proposed confounders meet the Cornfield conditions. Among a total of seventy-five tests we consider for conflicts other than wars (five potential confounders over five decades with three conflict outcomes), only IMF financial openness in the 1980s for MIDs barely meets the Cornfield conditions, with $\min(RR_{XU}, RR_{UY}) = 1.38 \geq RR_{XY}^{obs} = 1.36$.[40] Such divergent findings may arise due to the small number of observations in some cells. When repeating this test using the joint democracy variable from Cederman, $RR_{XY}^{obs} < 1$ in the 1980s when the outcome is deadly MIDs—that is, there is no observed positive relationship between nondemocracy and conflicts to be explained in that subset of the data. In all other cases, the Cornfield conditions are not met. We also find no clear pattern about how the degree of robustness varies across decades, although there may be a theoretical reason to expect the democratic peace to be strengthened over time.

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38. This partially addresses the argument that the democratic peace is a territorial peace (Gibler 2012; Thompson 1996), although our analysis does not address the issue of reverse causation.

39. Although Gartzke considers the interaction between contiguity and GDP per capita, rather than simple contiguity, we use contiguity alone because the median of GDPPC × Contiguity is simply the contiguity measure itself.

40. This case also meets the additional condition of Ding and VanderWeele 2016, with $\max(RR_{XU}, RR_{UY}) = 2.48$ exceeding the test statistic of 2.06.

We also conduct the same analysis separately for each geographic region (see Table A2 in the online appendix for the results). This analysis suffers from small sample sizes. Nevertheless, we find that only three of the seventy-five comparisons meet the Cornfield conditions: trade dependence for Middle Eastern MIDs, GDP for North American MIDs, and affinity for South American MIDs.[41] In addition, four cases have $RR_{XY}^{obs} < 1$, showing no positive empirical relationship between democracy and peace to be explained. Thus, our findings imply that these observed confounders cannot overturn the democratic peace result even if we examine each decade and each region separately.

Our analysis to this point conditions on each of the five observed confounders individually. Next, we consider these variables jointly by conducting our analysis for each variable within a stratum defined by the values of the other confounding variables. For example, when considering IMF trade openness as a potential confounder, we condition on the values of trade dependence, GDP per capita, affinity, and contiguity. As before, we consider three conflict outcomes (MIDs, deadly MIDs, and wars) and two different measures of democracy, for six separate combinations.

The analysis requires each confounder to be discretized. We trichotomize the trade dependence, GDP per capita, and affinity variables at their values at the thirty-third and sixty-seventh percentile. IMF financial openness is first trichotomized in the same way, but a fourth category is added for missing values. Contiguity is dichotomized to indicate whether there is geographic contiguity. Thus, a total of $3^3 \times 2 = 54$ different analyses can theoretically be conducted for each exposure–outcome combination. However, many of these strata have little or no data as a consequence of conditioning on multiple variables. In fact, for the thirty different exposure–outcome combinations we consider, there would theoretically be 1,620 different strata, but 473 of them have no data.

In each stratum, the denominator is the actual number of cases that had enough data to examine a Cornfield condition, and the numerator is the number of instances in which the Cornfield conditions are met. Thus, using the Gartzke joint democracy measure with MIDs, and considering IMF trade openness, we can say that thirty-four of the fifty-four different combinations of covariates had some data in them that allowed a sensitivity analysis. In five of those thirty-four tests, the Cornfield conditions were met. In total, we are able to conduct 1,147 different comparisons using the five variables, three conflict outcomes, and two measures of joint democracy. And 1,090 (about 95 percent) of the 1,147 analyses fail to satisfy the Cornfield conditions, implying that within those strata the confounder cannot explain away the positive association between joint democracy and the absence of conflicts. Of the remaining fifty-seven cases, only two have $RR_{XY}^{obs} > 1$, meaning that there is a positive association between democracy and peace to be explained.[42] In the other fifty-five, there is a negative association between joint democracy and the absence of conflicts.

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41. Notably, IMF financial openness for North American MIDs meets the original Cornfield condition, but fails the refinement condition in Equation (7).

42. These two cases also meet the Ding and VanderWeele sensitivity condition.

The Contractualist Peace

We now turn to a closely related claim from a series of papers by Mousseau that argue for a "contractualist peace."[43] Similar to Gartzke, Mousseau argues that economic factors underlie the democratic peace. However, Mousseau's specific theoretical argument is that contractual norms between nations confound the democratic peace. To that end, he introduces measures of the "contract-intensive economy" (CIE), which are proxied by insurance contracts subject to third-party state enforcement.

We conduct the same sensitivity analysis using different versions of the Mousseau data. Each of the three Mousseau papers measures the CIE differently and is separately refined to apply different data imputation procedures and account for the informal economy in different ways. The three papers also measure conflict using different outcome variables, separately considering wars, fatal MIDs, and nonfatal MIDs. The papers also employ different measures of joint democracy based on Polity scores. As in our previous analysis, we employ dichotomous measures of the CIE and joint democracy. Consistent with our previous analysis, we also employ the same data set used by Mousseau in each of his analyses, assuming that the variables are measured without error.[44]

The results of this analysis are shown in Table 4. Of the fourteen analyses that most closely parallel those published in the papers we mentioned, thirteen fail to meet the Cornfield conditions. The sole example that meets the Cornfield conditions is using Mousseau's data, using only states that are geographically contiguous, for both fatal and nonfatal MIDs. However, combined fatal and nonfatal MIDs is not Mousseau's preferred outcome measure. Mousseau lists three reasons to suspect bias in analysis of this set of MIDs, arguing that "disputes with at least one fatality … are more likely to reflect confrontations intended by the leaders of both states in a dyad, which is what our theories are designed to model."[45] In conclusion, our sensitivity analysis indicates that the democratic peace is resistant to unobserved confounding whose strength is similar to that of the confounding relationships implied by the contractualist peace thesis.

Military Alliances

Another prominent critique, advanced by Farber and Gowa, is that Cold War alliance structures account for the democratic peace.[46] We examine this possibility by reanalyzing the data from Gartzke. Here, we examine several possible confounders related to military alliances. First, we consider a military-alliance variable that was used as a control variable in the original Gartzke study.[47] We also consider a political-neutrality variable.[48] We look at cases where both members of the dyad are politically

43. Mousseau 2009, 2013, 2016.
44. The quality of the missing-data imputation is disputed by Dafoe, Oneal, and Russett 2013; Mousseau 2018 offers a response to these criticisms.
45. Mousseau 2018, 12.
46. Farber and Gowa 1997; Gowa 2000.
47. The variable was originally used by Oneal and Russett 1997.
48. We thank Joanne Gowa for this suggestion and for sharing her data.

TABLE 3. *Sensitivity analysis conditional on the other confounding variables*

Outcome	IMF financial openness	Trade dependence	GDP	Contiguity	Affinity
Joint democracy from Gartzke 2007					
MIDs	5/34	0/47	5/45	6/67	2/39
Deadly MIDs	0/32	0/44	0/41	0/54	0/37
Wars	0/21	0/24	0/23	0/25	0/20
Joint democracy from Cederman 2001					
MIDs	2/36	0/53	1/47	12/70	4/47
Deadly MIDs	2/34	0/45	3/43	7/55	6/45
Wars	0/23	0/24	0/24	1/25	1/23

Notes: We conduct sensitivity analysis within strata defined by the values of the other confounding variables. In each entry of the table, the numerator is the number of cases that meet the Cornfield conditions, and the denominator is the number of cases. The results are shown only for the strata where sufficient data are available. Across all analyses, only fifty-seven of the 1,147 analyses (about 5 percent) satisfy the Cornfield condition.

neutral, where only one member is neutral, and where any members are neutral. Our sensitivity analysis using these four potential confounders is reported in Table 5, using both measures of democracy and all three measures of conflict, as in our earlier analysis of Gartzke.

TABLE 4. *Sensitivity analysis of contractualist peace advanced by Mousseau*

Data	Exposure (X)	Outcome (Y)	Confounder (U)	RR_{XY}^{obs}	RR_{XU}	RR_{UY}
Mousseau 2009	Polity ≥ 7	No fatal dispute	Both states CIE	4.72	1.30	Inf
Mousseau 2009	Polity ≥ 7	No war	Both states CIE	3.52	1.30	Inf
Mousseau 2013	Polity ≥ 7	No fatal dispute	Both states CIE	2.26	1.24	Inf
Mousseau 2013	Polity = 10	No fatal dispute	Both states CIE	Inf	1.96	Inf
Mousseau 2013	Polity ≥ 7	No fatal + nonfatal	Both states CIE	1.51	1.24	1.37
Mousseau 2013	Polity = 10	No fatal + nonfatal	Both states CIE	2.22	1.96	1.37
Mousseau 2016	Polity ≥ 7	No fatal dispute	Both states CIE	2.34	1.42	Inf
Mousseau 2016	Polity ≥ 7	No fatal + nonfatal	Both states CIE	1.69	1.42	1.50
Contiguous only (Mousseau 2018)	Polity ≥ 7	No fatal dispute	Both states CIE	3.62	3.34	Inf
Contiguous only (Mousseau 2018)	Polity ≥ 7	No fatal + nonfatal	Both states CIE	2.94	3.34	7.13

Notes: CIE = contract-intensive economy. Different data sets using different combinations of joint democracy, conflict, and measurement of confounder are considered. Note that there are changes to the measures across papers, especially for CIE. The Cornfield conditions are met in only the final condition.

Overall, we find that unobserved confounding similar to what would be expected from military alliances cannot explain the democratic peace. Specifically, the original military-alliance variable of Oneal and Russett fails to meet the Cornfield conditions by a large margin.[49] For the three neutrality variables, all results fail to meet the

49. Oneal and Russett 1997.

TABLE 5. *Sensitivity analysis of military alliances*

Exposure	Outcome	RR$_{XY}^{obs}$	Not allies		Both neutral		One neutral		Any neutral	
			RR$_{XU}$	RR$_{UY}$	RR$_{XU}$	RR$_{UY}$	RR$_{XU}$	RR$_{UY}$	RR$_{XU}$	RR$_{UY}$
Joint democracy (Gartzke)	Absence of MIDs	2.38	1.06	0.43	1.02	Inf	1.24	6.97	1.26	7.08
Joint democracy (Gartzke)	Absence of deadly MIDs	7.35	1.06	0.46	1.02	Inf	1.24	Inf	1.26	Inf
Joint democracy (Gartzke)	Absence of war	Inf	1.06	2.03	1.02	Inf	1.24	Inf	1.26	Inf
Joint democracy (Cederman)	Absence of MIDs	2.55	0.98	0.43	1.01	Inf	1.12	6.97	1.12	7.08
Joint democracy (Cederman)	Absence of deadly MIDs	2.71	0.98	0.46	1.01	Inf	1.12	Inf	1.12	Inf
Joint democracy (Cederman)	Absence of war	47.78	0.98	2.03	1.01	Inf	1.12	Inf	1.12	Inf

Note: All variables here fail to meet the Cornfield conditions.

Cornfield conditions. Although the relative risk of neutrality on conflict, RR_{UY}, is extremely large, the magnitude of RR_{XU}, the relative risk of nonjoint democracy on the proposed confounder, is generally quite small. Thus, the analysis suggests that the democratic peace is resistant to unobserved confounding whose magnitude is similar to that due to Cold War alliances. In addition, we partially address McDonald's argument that the existence of democratic peace depends on great power hierarchy.[50] Table A4 in the online appendix shows that this potential confounder of great power hierarchy does not meet the Cornfield conditions. But our empirical conclusions may not apply to the pre-World War I era, as the analysis is confined to 1950 to 1992.

Limitations

Like any method for observational studies, the proposed application of the nonparametric sensitivity analysis has limitations. First, the nonparametric nature of the methodology implies that only a relatively small number of categorical variables can be used as covariates. The method cannot directly accommodate continuous variables without coarsening, and the use of many observed confounding variables requires a large sample size, as seen by some cells in our analysis having few observations, or none. This is often a common feature of nonparametric methodologies such as coarsened exact matching.[51] As a result, dimension reduction may be required prior to the sensitivity analysis. An alternative is a parametric sensitivity analysis that

50. McDonald 2015.
51. Iacus, King, and Porro 2012.

can flexibly allow for many variables of different types but imposes strong modeling assumptions.[52] Thus, there is a clear trade-off between the functional-form assumptions and the ability to handle a large number of variables.[53]

Second, although our focus has been the assessment of how robust the observed associations between regime types and conflicts are, such an analysis gives only a partial examination of the democratic peace debate. Indeed, one cannot draw a more definitive conclusion without understanding more micro-level causal mechanisms.[54] Medical scientists have shown how cigarette smoking led to the formation of covalent bonds between the carcinogens and DNA, resulting in the accumulation of permanent somatic mutations in critical genes.[55] Similarly, settling the democratic peace debate demands the empirical testing of possible causal pathways from democracy to peace.[56]

Finally, like any sensitivity analysis for omitted variable bias, the proposed methodology does not address the problem of causal simultaneity or reverse causation, which some refer to as "endogeneity": democracy and peace might affect each other at the same time. In fact, causal effects are fundamentally unidentifiable in such situations. For example, the assumption of no simultaneity is explicitly made in causal directed acyclic graph models by excluding any cycles.[57] Thus, to directly address this issue, we need alternative research designs and identification assumptions rather than different statistical methods.

Conclusion

Unobserved confounding in observational research is one of the most fundamental methodological problems in social science. Although the randomization of treatments enables the identification of causal effects, such randomization is rarely feasible in many areas of social science, including political science. In such circumstances, different assumptions can yield conflicting results and yet it is impossible to assess the validity of competing assumptions. As a result, scholarly debates often end up in a scientific deadlock in which neither side is able to provide convincing evidence.

We believe that sensitivity analysis can play an essential role in making scientific progress in these difficult situations. While it cannot draw a definitive conclusion about causal relationships, sensitivity analysis allows researchers to evaluate the robustness of empirical findings by quantifying the minimum strength of unobserved confounding that must exist to explain away an observed association. An open-source

52. See, for example, Blackwell 2013; Cinelli and Hazlett 2020; Imai, Keele, and Yamamoto 2010; Imbens 2003.
53. Ho et al. 2007.
54. See, for example, Rosato 2003, for a theoretical critique of the proposed mechanisms.
55. US Department of Health and Human Services 2004.
56. Imai et al. 2011.
57. Pearl 2000.

software package, Evalue, is available for implementing the sensitivity analysis used here.[58]

In this research note, we apply a nonparametric sensitivity analysis to the democratic peace debate in international relations. We find that the positive association between democracy and peace is at least five times as robust as that between smoking and lung cancer. To explain away the democratic peace, researchers would have to find confounders that are many times more strongly associated with democracy and conflicts than the confounders that have been identified until now. Since such confounders have yet to be found, for now we conclude that the existing empirical evidence overwhelmingly supports the democratic peace.

Supplementary Material

Supplementary material for this research note is available at <https://doi.org/10.1017/S0020818321000126>.

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58. Mathur et al. 2019.

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Acknowledgments

Key Words