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Virtual water trade and bilateral conflicts

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ABSTRACT

In light of growing water scarcity, virtual water, or the water embedded in key water-intensive commodities, has been an active area of debate among practitioners and academics alike. As of yet, however, there is no consensus on whether water scarcity affects conflict behavior and we still lack empirical research intending to account for the role of virtual water in affecting the odds of militarized disputes between states. Using quantitative methods and data on virtual water trade, we find that bilateral and multilateral trade openness reduce the probability of war between any given pair of countries, which is consistent with the strategic role of this important commodity and the opportunity cost associated with the loss of trade gains. We also find that the substantive effect of virtual water trade is comparable to that of oil and gas, the archetypal natural resources, in determining interstate conflicts' probability.

1. Introduction

According to the World Bank Group (2016a), about 1.6 billion people live in countries with physical water scarcity, and in just two decades this number may double. Water scarcity can hamper growth prospects and some regions could see their growth rates decline by as much as 6 per cent of GDP by 2050 as a result of water-related losses in agriculture, income and property. Yet, whereas over 70% of all (fresh) water is used for agriculture and food production around the world (World Bank Group, 2016b), international trade in *physical* water (in the form of bottled water or bulk water) is a limited phenomenon. Allan (1997) notes that food import of water scarce countries implies an import of the water *embedded* in the traded commodities. *Virtual water trade* (henceforth VWT) is the opportunity to minimize water consumption by increasing the import of goods that require a large amount of water in their production cycle (the so-called water-intensive products) and to limit the export of water-intensive goods. Allan (1998) studies the possibility of importing virtual water as a solution to problems of water scarcity in the Middle East; he furthermore asserts that VWT prevents water crises from becoming water wars. Subsequently, the strategic role of VWT for averting emerging conflicts has been stressed in many studies (Horlemann and Neubert, 2006; Hummel et al., 2006) but none of them using a quantitative approach.

The sheer amount of VWT flows in 2015 alone substantial. The total volume related to agricultural and industrial products was 2320 m^3/y on average in the period 1996–2005 (Hoekstra and Mekonnen, 2012). It may then not come across surprising that recently the concept of VW has featured prominently in scientific and political debates (Allan et al., 2003). Given its importance, a number of recent studies has analyzed VWT using a variety of approaches (see e.g., Hoekstra and Hung, 2002; Lenzen, 2009; Konar et al., 2011; D' Odorico et al., 2012; Carr et al., 2013; Tamea et al., 2013 Porkka et al., 2013; Sartori and Schiavo, 2015; Metulini et al., 2016). Many studies and reports claim that VWT can improve food security by allowing water-scarce countries to benefit from water resources available elsewhere, thus addressing the requirements of a growing population (Godfray et al., 2010; Rosegrant et al., 2002). Water is a very complex natural resource and a recent report of the United Sates Director of National Intelligence also links future shortage of water to an increased risk of armed conflict (DNI, 2012).

In this study we address the following question: to what extent does VWT affect the odds of conflict between states? Our research question lies at the intersection of two separate yet in-

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tertwined strands of research: one on resource scarcity and conflict and one on trade and militarized interstate disputes. On the one hand, the so called "environmental scarcity" argument (see e.g., Homer-Dixon, 1999) claims that a major cause of conflict has to be found in the steady depletion of environmental resources such as water, and the increasing pressure exerted by the overpopulation. Although Homer-Dixon (1999) predicts a steady increase in the incidence of violent conflict in coming decades as a consequence of environmental scarcity, he also acknowledges that there is no clear causal effect. A large literature points out to the role of water scarcity in affecting human security through increased risk of conflict and refugee flows (e.g., Gizelis & Wooden, 2010; Warziniack, 2013). Although traditional sources of conflict still play a major role, there is also ample anecdotal evidence to believe that environmental degradation and contestation of water resources contribute to causing and fuelling many disputes. For example, UNEP (2007) claims that there is a very strong link between land degradation, desertification and conflict in Darfur. The droughts that affected the country in the 1980 s and the ensuing migrations have greatly increased competition for water and land between farmers and herders. Syria is one of the largest consumer of freshwater resources and the lack of rainfall in recent years, combined with rising temperatures, could result in desertification of a great portion of land area. In the words ofDevlin (2014, p.1), "the roots of political rebellion in Syria are integrally linked with access to water".

On the other hand, a well-established literature has explored the Liberal "Kantian Peace" that trade reduces the odds of militarized conflict, in particular between commercial partners (Dorussen, 2006; Hegre et al., 2010). This is because valuable gains from trade, in particular when commodities are strategic, would be lost in a conflict.[1] Goenner (2010) further argues that commodities are heterogeneous in terms of importance, substitutability, and ease of expropriation and therefore have different effects on conflict. Since the 1980 *Carter doctrine,* that claimed that the US would use all necessary means, including military forces, to fight any attempt to gain control of the Persian Gulf, a number of studies have explored the role of exhaustible mineral resources, such as oil and gas, in fuelling conflicts (e.g., Bove et al., 2015).

There are however a number of shortcomings in the above strands of literature. First, most of the studies on the link water scarcity-conflict are case studies, often selected for their salience which may make them unrepresentative of other cases. Only few large-N studies examine the role that resource scarcity or abundance may play in conflicts. Most of these studies focus on water resources (Koubi et al., 2013) – thus further corroborating the prominence of this commodity in affecting violence - but there is ambiguous support for a role of water scarcity on conflicts (Nordås and Gleditsch, 2007). Second, and to the best of our knowledge, there are no empirical studies exploring whether water scarcity has an effect on inter-state wars (as opposed to intra-state wars). Our study is a step in this direction. As water resources became scarce, countries become more likely to compete to secure their access to freshwater. Although water scarcity may not be the trigger of interstate disputes, it can compound other underlying economic factors to increase tensions. The Middle East and North Africa region, an historically arid or semi-arid area, has long been affected by global water crises. Population growth, pollution and weak institutions exacerbate water scarcity and could also make conflict *between states* more likely. For example, one of the causes of the Six Day War in 1976 between Israel and Arab states was the struggle for water resources of the Jordan River and other rivers in the area. The dispute began when Israel attempted to divert the Upper Jordan River to the National Water Carrier, a pipeline which carries water from the Sea of Galilee to the Negev desert (Cohen, 1998). Similarly, despite the presence of a major river, Egypt's supply of water is also very vulnerable as it is a downstream state; in fact, the country had threatened to go to war to protect its rights over the waters of the Nile several times, by e.g., destroying the dams that Ethiopia, a country located upstream, was planning to build (see e.g., Klare, 2001).

Third, although the literature convincingly suggests that water scarcity and conflict are strictly intertwined and that trade matters for international security, little is know about the role of *virtual* water on foreign policy behavior. Going back to Egypt's example, as Garfinkel et al. (2015 p.100) eloquently put it, "the value of water to Egypt and the other up-stream countries depends not only on its importance as a basic need of life that is expected to rise as the populations of these countries continue to grow. It also depends on the degree of trade openness in these countries and the prices of traded goods that use water intensively as an input. For example, the world price of Egyptian cotton, a good that uses water as a main input, affects the value of the Nile's water flow to Egypt." Allan (1997, 2003) claims that water-scarce countries in the Middle-East successfully compensated their fresh water shortages by importing virtual water, in the form of water intensive food products such as wheat and rice. Therefore, the virtual water value of a good or service as well as the relative scarcity of water resources can affect the way water is used and the political relations between trading partners. Securing trade in virtual water becomes extremely important in presence of the current global water scarcity, in particular when imported and exported commodities use higher volumes of freshwater in the various steps of the production chain.

If virtual water is indeed a scarce and strategic resource, and if "trade is more pacifying if states exchange more goods with high opportunity costs" (Dorussen, 2006, p.92), then our main expectation is that virtual water trade reduces the likelihood of interstate conflict. Recent studies have also argued that bilateral and multilateral trade openness might entail different strategic calculations, and that countries open to *global* trade have a *higher* probability of war because multilateral trade openness decreases bilateral dependence to any given country (Martin et al., 2008). We therefore use both measures of dependence to detect potentially different patterns. We find that virtual water is an important commodity and has effects comparable (or even stronger) to other prominent natural resources such as oil and gas in affecting interstate conflicts' probability.

2. Data and methods

Data on VWT are constructed using FAOSTAT commodities data along the period 1986–2000.[2] Data on bilateral trade flows, in particular total trade, oil and gas (sitc4 33 and 34) and footwear (sitc4 85) come from Feenstra et al. (2005). Information on Militarized Interstate Disputes (MIDs) are drawn from the Correlates of War Dataset (COW) and contain five possible hostility levels, ranging from the absence of militarized action (action type 1) to war (action type 5). War is defined as a conflict between two states with at least 1000 battle-deaths among military personnel.[3] We fol-

[1] There are actually two schools of thought. The liberal school emphasizes that trade integration reduces the use of force by increasing its opportunity costs (Levy, 2003), whereas the neo-Marxist school argues that trade integration reduces the dependence of any country from any single trade partner and thus reduces the opportunity costs of conflicts (Barbieri, 1996, 2002).

[2] Since data on total, oil and gas and footwear bilateral trade flows - that we use for comparison - are available until 2000, to make comparable analysis, we use the same period for VWT as well.

[3] Examples of display of force (level 3 of an MID) include a decision of mobilization, a troop or ship movement, a border violation, or a border fortification.

Table 1
Trade and MID: bilateral trade openness.[5]

	1 full	2 rel.dyads	3 contig	4 full	5 rel.dyads	6 contig	7 full	8 rel.dyads	9 contig	10 full	11 rel.dyads
bil_vw	−0.072**	−0.166***	−0.230***								
	(0.033)	(0.042)	(0.062)								
bil_oil&gas				−0.049	−0.218*	−0.082					
				(0.106)	(0.124)	(0.394)					
bil_total							0.005	−0.132	−0.305***		
							(0.069)	(0.081)	(0.104)		
bil_footwear										0.275	0.279
										(0.189)	(0.245)
NYP	−0.020***	−0.013***	−0.015**	−0.025***	−0.025**	−0.109	−0.022***	−0.021***	−0.047***	−0.023**	−0.018
	(0.004)	(0.004)	(0.007)	(0.008)	(0.010)	(0.079)	(0.004)	(0.006)	(0.018)	(0.011)	(0.013)
UNC	−0.988***	−0.748**	−0.949*	0.231	−0.479	−1.159	−0.615**	−0.406	0.415	−0.535	−1.565
	(0.290)	(0.362)	(0.573)	(0.556)	(0.663)	(4.001)	(0.302)	(0.346)	(0.619)	(0.981)	(1.049)
SDI	−0.013	−0.107	−0.244	0.330	0.077	0.831	0.524**	0.421	0.388	0.641	1.290
	(0.240)	(0.282)	(0.373)	(0.476)	(0.665)	(1.144)	(0.260)	(0.318)	(0.422)	(0.913)	(1.384)
NOW	0.247***	0.213***	0.107**	0.297***	0.300***	0.289*	0.292***	0.288***	0.199***	0.261***	0.199**
	(0.021)	(0.053)	(0.045)	(0.036)	(0.066)	(0.152)	(0.019)	(0.033)	(0.037)	(0.068)	(0.100)
DNW	−0.140	−0.429***	−0.517**	0.213	−0.689**	−2.311**	−0.240	−0.573***	−0.822***	−0.203	−0.823**
	(0.140)	(0.162)	(0.201)	(0.332)	(0.350)	(1.094)	(0.179)	(0.205)	(0.308)	(0.458)	(0.362)
SAR	0.090*	0.118	0.127	0.068	0.363***	1.128	0.094	0.092	0.269	0.208	0.217
	(0.049)	(0.073)	(0.120)	(0.078)	(0.137)	(0.745)	(0.057)	(0.096)	(0.188)	(0.138)	(0.210)
MME	0.478**	0.486**	0.573**	0.768**	0.812**	−1.598	0.615**	0.743***	0.560	−0.131	−0.345
	(0.218)	(0.234)	(0.249)	(0.322)	(0.363)	(1.293)	(0.256)	(0.262)	(0.400)	(0.608)	(0.710)
DIST	−0.693***	−0.658***	−0.592*	−0.850***	−1.359***	−4.763**	−0.785***	−0.615**	−0.821	−0.712*	−0.758*
	(0.157)	(0.201)	(0.359)	(0.279)	(0.389)	(2.165)	(0.173)	(0.263)	(0.657)	(0.420)	(0.449)
COM	0.375	0.291	0.189	0.538	0.829	1.722	0.870***	0.919**	0.377	0.368	1.138
	(0.260)	(0.269)	(0.302)	(0.576)	(0.681)	(1.743)	(0.307)	(0.396)	(0.519)	(0.774)	(0.697)
CON	0.892***	0.784**	\	0.080	0.307	\	0.812**	1.033**	\	0.045	0.367
	(0.312)	(0.380)	\	(0.482)	(0.470)	\	(0.355)	(0.414)	\	(0.844)	(0.743)
COL	0.815***	0.260	0.674*	0.354	−0.195	−0.818	0.360	−0.036	0.035	0.829	−0.190
	(0.261)	(0.267)	(0.350)	(0.455)	(0.511)	(0.848)	(0.298)	(0.301)	(0.392)	(0.969)	(1.043)
CCL	0.385	0.286	0.132	\	\	\	0.112	0.083	−0.240	\	\
	(0.316)	(0.392)	(0.405)	\	\	\	(0.417)	(0.539)	(0.557)	\	\
FTA	−0.187	−0.203	−0.143	−1.006*	−0.279	2.305	−0.542	−0.672	−0.101	−1.069	−0.618
	(0.347)	(0.329)	(0.409)	(0.599)	(0.675)	(2.930)	(0.488)	(0.493)	(0.609)	(0.930)	(1.064)
GAT	0.196	0.094	0.030	0.094	−0.135	−1.254	0.126	0.072	−0.006	−0.246	−1.183**
	(0.181)	(0.198)	(0.206)	(0.355)	(0.502)	(1.072)	(0.211)	(0.255)	(0.310)	(0.591)	(0.594)
Obs.	37,398	7385	1633	6675	2577	555	42,061	6928	1174	3781	1516
# MID = 1	315	225	137	118	93	37	260	166	86	60	53
dummies t	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DWL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.568	0.466	0.410	0.562	0.539	0.640	0.612	0.521	0.505	0.433	0.406

Robust standard errors in parentheses
*** $p < 0.01$
** $p < 0.05$
* $p < 0.1$

low Martin et al. (2008) approach and consider interstate conflicts all instances of militarize disputes with an hostility level above or equal to 3. Since the presence/absence of conflict within the same country pair over several years is likely to lead to serial correlation due to e.g., long-lasting disputes, we compute a second conflict variable measuring the onset of a conflict. After merging Feenstra et al. (2005) dataset with virtual water trade data, we end up with 175,357 observations, of which 0.444% (779) experienced an interstate war.[4]

To quantify the impact of VWT on bilateral conflicts, we build on Martin et al. (2008), who offer a recent and comprehensive empirical analysis of the determinants of interstate conflict. We estimate a simple logit model with robust standard errors adjusted for clustering by dyads. The model takes the following form:

$$\begin{aligned} \mathrm{Logit}(p_{ijt}) = \alpha_t &+ \beta_1 \mathrm{NYP}_{ijt} + \beta_2 \mathrm{UNC}_{ijt} + \beta_3 \mathrm{SDI}_{ijt} + \beta_4 \mathrm{NOW}_{ijt} \\ &+ \beta_5 \mathrm{DNW}_{ijt} + \beta_6 \mathrm{SAR}_{ijt} + \beta_7 \mathrm{MME}_{ijt} + \beta_8 \mathrm{DIST}_{ij} \\ &+ \beta_9 \mathrm{COM}_{ij} + \beta_{10} \mathrm{CON}_{ij} + \beta_{11} \mathrm{COL}_{ij} + \beta_{12} \mathrm{CCL}_{ij} \\ &+ \beta_{13} \mathrm{FTA}_{ij} + \beta_{14} \mathrm{GAT}_{ijt} + \beta_{15} \mathrm{DWL}_{ijt} \\ &+ \beta_{16} \mathrm{TRADE}_{ijt} + \varepsilon ijt \end{aligned} \quad (1)$$

Our model also includes the number of years of peace between i and j (NYP); the level of political affinity between i and j (UNC) the democracy index (SDI); the total number of MIDs (excluding their potential bilateral MID) which the countries of the pair are involved in at time t (NOW); the distance to the nearest current war which does not involve i or j (DNW); the sum of areas of the two countries (SAR, in logarithmic form); a dummy equal to 1 if i and j belong to a military alliance (MME). Moreover, the likelihood of military contests between pairs of countries is a function of a number of traditional gravity controls, such geographic distance (DIST, in logarithmic form), common language (COM), geographical contiguity (CON), colonial relationship (COL and CCL), free trade agreements (FTA) and the number of GATT/WTO (GAT) members in the country pair. We also control for the temporal autocorrelation in military conflict by including a set of 10 different dummies equal to 1 when the country pair was in MID in $t-1$, $t-2$, $\dots t-10$, in order to address the crucial role of long lasting

These are government-approved and un-accidental decisions. Examples of use of force (level 4 of a MID) include a blockade, an occupation of territory, or an attack.

[4] We use STATA 13 to carry the analyses.

[5] When the coefficient is not estimated because of multicollinearity issue, we report a text line break

Table 2
Trade and MID: interactions between bilateral trade openness and contiguity.

	1 vw	2 oil&gas	3 Total	4 footwear
bil_vw	0.006 (0.034)			
bil_oil&gas		0.048 (0.125)		
bil_total			0.119 (0.079)	
bil_footwear				0.250 (0.195)
interaction bil_vw /CON	−0.271*** (0.073)			
interaction bil_oil&gas/CON		−0.269 (0.166)		
interaction bil_total/CON			−0.394*** (0.131)	
interaction bil_footwear/CON				0.186 (0.376)
NYP	−0.019*** (0.004)	−0.024*** (0.008)	−0.021*** (0.004)	−0.023** (0.011)
UNC	−1.037*** (0.281)	0.227 (0.553)	−0.538* (0.303)	−0.582 (0.972)
SDI	−0.052 (0.241)	0.380 (0.457)	0.508* (0.260)	0.669 (0.907)
NOW	0.245*** (0.021)	0.290*** (0.036)	0.295*** (0.019)	0.260*** (0.067)
DNW	−0.150 (0.139)	0.219 (0.330)	−0.201 (0.176)	−0.199 (0.453)
SAR	0.099** (0.050)	0.080 (0.077)	0.086 (0.056)	0.213 (0.144)
MME	0.425** (0.205)	0.724** (0.315)	0.553** (0.258)	−0.146 (0.585)
DIST	−0.691*** (0.152)	−0.762*** (0.269)	−0.751*** (0.170)	−0.735* (0.433)
COM	0.405* (0.240)	0.552 (0.566)	0.862*** (0.302)	0.369 (0.770)
CON	4.688*** (1.034)	−1.678 (1.315)	−0.942 (0.665)	1.658 (2.965)
COL	0.904*** (0.252)	0.489 (0.459)	0.346 (0.291)	0.866 (0.970)
CCL	0.311 (0.326)	\ \	−0.087 (0.483)	\ \
FTA	−0.011 (0.349)	−0.852 (0.603)	−0.372 (0.475)	−1.057 (0.934)
GAT	0.114 (0.178)	−0.055 (0.338)	0.038 (0.210)	−0.255 (0.591)
Obs.	37,398	6675	42,061	3781
# MID = 1	315	118	260	60
dummies t	yes	yes	Yes	yes
DWL	yes	yes	Yes	yes
Pseudo R^2	0.573	0.564	0.615	0.434

Robust standard errors in parentheses
*** $p < 0.01$,
** $p < 0.05$,
* $p < 0.1$

disputes (DWL). Table A.1 gives information on the name and definition of all the dependent and independent variables, including their sources. Our main explanatory variable is TRADE, which can be either bilateral trade openness (Bil_trade) or multilateral trade openness (Multi_trade). Bilateral trade openness is calculated in the following way:

$$\mathrm{Bil\_trade}_{ijt} = \ln\left(\mathrm{imp}_{ijt}\ /\mathrm{GDP}_{jt} + \mathrm{imp}_{jit}/\mathrm{GDP}_{it}\right). \quad (2)$$

This is the natural logarithm of the sum of imports that j receives from i over the GDP of the importing country j, and the imports that i receives from j over the GDP of the importing country i (see Martin et al., 2008). Multilateral trade openness is calculated as follows:

$$\mathrm{Multi\_trade}_{ijt} = \ln\left(\sum_{h\neq i} \mathrm{imp}_{hjt}/\mathrm{GDP}_{jt} + \sum_{k\neq j} \mathrm{imp}_{kit}\ /\mathrm{GDP}_{it}\right). \quad (3)$$

This is natural the logarithm of the sum of imports j receives from all exporters h (excluding i) divided by the GDP of the importing country j, plus the sum of imports i receives from all exporters k (excluding j) divided by the GDP of the importing country i:

We construct these measures for both total trade, oil and gas trade as well as VWT. When dealing with VWT, note that this is expressed in quantity. Therefore, we divide bilateral and mul-

Table 3
Trade and MID: multilateral trade openness.

	1 full	2 rel.dyads	3 contig	4 full	5 rel.dyads	6 contig	7 full	8 rel. dyads	9 contig	10 full	11 rel. dyads
multi_vw	−0.118**	−0.204***	−0.212***								
	(0.052)	(0.063)	(0.079)								
multi_oil&gas				−0.061	−0.238*	−0.532					
				(0.114)	(0.137)	(0.387)					
multi_total							0.398**	0.579**	−0.855		
							(0.187)	(0.229)	(0.552)		
multi_footwear										0.682*	0.702**
										(0.377)	(0.331)
NYP	−0.020***	−0.014***	−0.016**	−0.026***	−0.024**	−0.112	−0.022***	−0.021***	−0.046**	−0.021**	−0.017
	(0.004)	(0.004)	(0.007)	(0.008)	(0.010)	(0.086)	(0.004)	(0.006)	(0.018)	(0.011)	(0.012)
UNC	−0.976***	−0.630*	−0.912	0.393	0.134	0.804	−0.780**	−0.648*	0.629	−1.435	−2.571**
	(0.292)	(0.357)	(0.583)	(0.513)	(0.688)	(3.808)	(0.304)	(0.360)	(0.669)	(1.252)	(1.237)
SDI	−0.050	−0.182	−0.319	0.338	0.195	1.341	0.475*	0.257	0.246	0.599	1.255
	(0.243)	(0.281)	(0.373)	(0.494)	(0.671)	(1.153)	(0.262)	(0.335)	(0.396)	(0.911)	(1.452)
NOW	0.248***	0.207***	0.107**	0.300***	0.290***	0.341*	0.292***	0.283***	0.193***	0.249***	0.202*
	(0.021)	(0.051)	(0.046)	(0.037)	(0.059)	(0.179)	(0.019)	(0.034)	(0.041)	(0.066)	(0.107)
DNW	−0.181	−0.461***	−0.500**	0.193	−0.683*	−2.701**	−0.196	−0.543***	−1.013***	−0.156	−0.919**
	(0.151)	(0.172)	(0.214)	(0.337)	(0.370)	(1.341)	(0.176)	(0.201)	(0.355)	(0.528)	(0.385)
SAR	0.065	0.074	0.043	0.071	0.310**	1.297*	0.117**	0.115	0.271	0.214	0.247
	(0.051)	(0.074)	(0.123)	(0.078)	(0.133)	(0.783)	(0.057)	(0.096)	(0.205)	(0.132)	(0.198)
MME	0.468**	0.443**	0.602**	0.738**	0.681*	−1.785	0.635**	0.781***	0.487	0.393	0.274
	(0.207)	(0.219)	(0.249)	(0.332)	(0.355)	(1.263)	(0.257)	(0.253)	(0.403)	(0.527)	(0.593)
DIST	−0.662***	−0.532***	−0.328	−0.807***	−0.955**	−4.753**	−0.807***	−0.497*	−0.787	−0.972***	−1.020**
	(0.157)	(0.192)	(0.380)	(0.306)	(0.431)	(2.261)	(0.171)	(0.261)	(0.791)	(0.352)	(0.433)
COM	0.350	0.252	0.085	0.514	0.674	1.404	0.834***	0.770**	0.535	0.528	1.324*
	(0.257)	(0.270)	(0.314)	(0.565)	(0.637)	(1.638)	(0.314)	(0.383)	(0.520)	(0.812)	(0.730)
CON	0.782**	0.596*	\	0.159	0.557	\	0.841**	1.232***	\	0.391	0.765
	(0.305)	(0.346)	\	(0.496)	(0.552)	\	(0.357)	(0.429)	\	(0.864)	(0.805)
COL	0.781***	0.155	0.457	0.240	−0.486	−1.744	0.438	−0.012	−0.008	0.861	−0.232
	(0.266)	(0.270)	(0.331)	(0.458)	(0.570)	(1.073)	(0.307)	(0.323)	(0.392)	(0.999)	(1.022)
CCL	0.433	0.319	0.228	\	\	\	0.154	0.356	−0.054	\	\
	(0.314)	(0.377)	(0.377)	\	\	\	(0.411)	(0.482)	(0.432)	\	\
FTA	−0.203	−0.247	−0.233	−1.070*	−0.399	2.338	−0.521	−0.650	−0.345	−1.257	−0.753
	(0.345)	(0.326)	(0.386)	(0.572)	(0.632)	(2.559)	(0.473)	(0.479)	(0.655)	(0.923)	(1.190)
GAT	0.172	0.045	0.036	0.142	−0.135	−1.607*	0.210	0.240	0.030	−0.113	−1.101*
	(0.180)	(0.200)	(0.206)	(0.354)	(0.494)	(0.877)	(0.210)	(0.265)	(0.308)	(0.591)	(0.669)
Obs.	37,036	7365	1619	6637	2550	539	42,058	6927	1173	3758	1503
# MID = 1	315	225	137	118	93	37	260	166	86	60	53
dummies t	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DWL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.570	0.461	0.397	0.566	0.545	0.653	0.614	0.526	0.501	0.444	0.420

Robust standard errors in parentheses
*** $p < 0.01$,
** $p < 0.05$,
* $p < 0.1$

tilateral openness by total renewable water resource (TRWR) in order to standardize a measure expressed in quantity by another measure expressed in quantity (GDP is in terms of value).[6] Note that we do not estimate bilateral and multilateral trade openness jointly in the same model as these measures are highly correlated, as Table A.2 in the appendix shows. As a robustness check, we restrict the sample to politically relevant dyads, when i and j are contiguous or when one of them is a major power. This sample restriction is often used by conflict researchers as such dyads are supposed to be more at risk of international conflict (e.g., Lemke and Reed, 2001; Bove and Gokmen, 2016). Note also that wars are overall rare events and many country pairs have zero bilateral trade flows. The maximum likelihood estimation of the logistic model suffers from small-sample bias, which is aggravated by the rarity of ones in the sample. To mitigate the risk of bias due to the rare event distribution of our dependent variable, we adopt the bias correction approach proposed by Tomz et al. (2003), the so-called relogit, as an additional robustness check.

The occurrences of conflict in the same country-pair are likely to be correlated due to long term disputes over several years. Although we address this issue by using the DWL dummies, we also estimate a logit model with onset of a conflict as a dependent variable, where MID_{onset} is equal to 1 only if a specific dispute started at time t and zero otherwise (so both the absence of war and the continuation of existing wars are coded as zero). Finally, we introduce interaction terms between bilateral trade and contiguity, and between multilateral trade and contiguity, as the geographic proximity is likely to condition whether and how trade affects conflict (see e.g., Martin et al., 2008). The intuition is that the effect of trade on conflicts is stronger for contiguous pairs.

3. Results and discussion

We start by looking at the effect of bilateral trade openness on bilateral conflict (Table 1), using data on VWT (columns 1–3), Oil and gas (columns 4–6), total trade (columns 7–9) and footwear

[6] We use the following transformation: Bil_tradeijt = ln (impijt / TRWRjt + impjit / TRWRit); Multi_tradeijt = ln (Σh≠i imphjt / TRWRjt + Σk≠j impkit / TRWRit).

Table 4
Trade and MID: interactions between multilateral trade openness and contiguity.

	1 vw	2 oil&gas	3 total	4 footwear
multi_vw	−0.035 (0.055)			
multi_oil&gas		0.020 (0.139)		
multi_total			0.456** (0.181)	
multi_footwear				0.664 (0.415)
Interaction multi_vw/CON	−0.219** (0.085)			
Interaction multi_oil&gas/CON		−0.240 (0.237)		
Interaction multi_total/CON			−0.590 (0.400)	
Interaction multi_footwear/CON				0.106 (0.616)
NYP	−0.019*** (0.004)	−0.025*** (0.008)	−0.022*** (0.004)	−0.021** (0.011)
UNC	−1.010*** (0.289)	0.360 (0.513)	−0.808*** (0.311)	−1.436 (1.253)
SDI	−0.092 (0.244)	0.369 (0.487)	0.445* (0.263)	0.594 (0.913)
NOW	0.245*** (0.021)	0.300*** (0.038)	0.293*** (0.019)	0.248*** (0.067)
DNW	−0.193 (0.150)	0.146 (0.346)	−0.220 (0.179)	−0.148 (0.521)
SAR	0.081 (0.050)	0.074 (0.076)	0.113** (0.056)	0.216 (0.135)
MME	0.456** (0.204)	0.751** (0.336)	0.614** (0.265)	0.404 (0.536)
DIST	−0.684*** (0.154)	−0.784** (0.307)	−0.808*** (0.171)	−0.977*** (0.358)
COM	0.350 (0.253)	0.533 (0.568)	0.851*** (0.314)	0.545 (0.789)
CON	4.683*** (1.581)	−0.499 (0.894)	0.703** (0.354)	1.034 (3.926)
COL	0.809*** (0.262)	0.250 (0.477)	0.446 (0.306)	0.838 (1.035)
CCL	0.387 (0.320)	\ \	0.076 (0.428)	\ \
FTA	−0.160 (0.345)	−1.077* (0.569)	−0.523 (0.474)	−1.254 (0.911)
GAT	0.134 (0.180)	0.065 (0.359)	0.172 (0.209)	−0.127 (0.603)
Obs.	37,036	6637	42,058	3758
# MID = 1	315	118	260	60
dummies t	Yes	Yes	Yes	Yes
DWL	Yes	Yes	Yes	Yes
Pseudo R^2	0.571	0.567	0.615	0.444

Robust standard errors in parentheses
*** $p < 0.01$,
** $p < 0.05$,
* $p < 0.1$.

(columns 10–11).[7] We first estimate the model using the full sample, and then consider two sub-samples of politically relevant dyads and contiguous pairs. Estimated coefficients for the other covariates present, globally, signs similar to those in Martin et al. (2008). In particular, number of peaceful years (NYP), distance (DIST) and free trade agreements (FTA) present a negative effect on bilateral conflict, while number of other wars (NOW), sum of areas (SAR) and dummy variables such as common language (COM), geographical contiguity (CON) and colonial relationship (COL and CCL) have positive effects.

The coefficient for bilateral VW trade (bil_vw) is negative and significant at the one percent level across all samples. We also find a negative, albeit generally insignificant, effect of oil trade (bil_oil&gas) on conflict. This is consistent with previous findings on the pacifying effect of trade, in particular trade in strategic commodities (Dorussen, 2006; Hegre et al., 2010). The impact of total trade (bil_total) on conflict is statistically significant at convention level only in the sample of contiguous countries (column 9). Finally, when we consider a non-strategic commodity, footwear, we find that the effect of footwear trade (bil_footwear) on militarized dispute is not distinguishable from zero. This first round of results suggests that the prospects of an interruption of trade when goods are strategic and hard to substitute due e.g., to a relatively small number of sources, can deter bilateral conflict.

[7] Convergence is not achieved in the model using contiguous pairs and the measure of footwear trade

Table 5
First difference estimates based on Tables 1 and 3.

Virtual Water	Full sample						Relevant dyads					
	bilateral			multilateral			bilateral			multilateral		
	First Dif.	CI low	CI up	First Dif.	CI low	CI up	First Dif.	CI low	CI up	First Dif.	CI low	CI up
bil_trade	−0,18	−0,30	−0,03				−3,50	−7,37	−1,21			
multi_trade				−0,14	−0,30	−0,03				−2,06	−4,14	−0,70
NYP	−0,29	−0,45	−0,16	−0,28	−0,45	−0,16	−0,91	−1,50	−0,38	−0,98	−1,54	−0,46
UNC	−0,21	−0,39	−0,07	−0,20	−0,39	−0,07	−0,77	−1,71	−0,11	−0,63	−1,44	−0,04
SDI	0,00	−0,09	0,04	−0,01	−0,09	0,04	−0,15	−0,81	0,32	−0,28	−0,99	0,24
NOW	99,59	98,77	99,92	99,59	98,77	99,92	96,22	77,71	99,84	95,63	74,63	99,83
DNW	−0,04	−0,13	0,02	−0,05	−0,13	0,02	−0,86	−1,55	−0,34	−0,96	−1,72	−0,37
SAR	0,13	−0,03	0,21	0,09	−0,03	0,21	0,96	0,00	2,33	0,56	−0,36	1,64
MME	0,04	0,01	0,09	0,04	0,01	0,09	0,28	0,06	0,55	0,25	0,04	0,48
DIST	−1,15	−2,25	−0,31	−0,98	−2,25	−0,31	−5,62	−13,20	−1,29	−3,64	−8,63	−0,76
COM	0,03	−0,01	0,08	0,03	−0,01	0,08	0,16	−0,06	0,44	0,14	−0,10	0,44
CON	0,12	0,02	0,21	0,10	0,02	0,21	0,51	0,08	1,11	0,37	0,01	0,86
COL	0,10	0,03	0,18	0,09	0,03	0,18	0,17	−0,09	0,48	0,12	−0,11	0,45
CCL	0,04	−0,01	0,11	0,04	−0,01	0,11	0,21	−0,16	0,75	0,22	−0,15	0,77
FTA	−0,01	−0,04	0,03	−0,01	−0,04	0,03	−0,07	−0,30	0,21	−0,09	−0,31	0,19
GAT	0,02	−0,02	0,05	0,02	−0,02	0,05	0,06	−0,29	0,32	0,01	−0,37	0,29
Oil&gas	**Full sample**						**Relevant dyads**					
	bilateral			multilateral			bilateral			multilateral		
	First Dif.	CI low	CI up	First Dif.	CI low	CI up	First Dif.	CI low	CI up	First Dif.	CI low	CI up
Bil_trade	−0,06	−0,42	0,25				−0,74	−2,18	−0,03			
Multi_trade				−0,10	−0,39	0,09				−0,41	−1,09	−0,02
NYP	−0,61	−1,14	−0,26	−0,62	−1,14	−0,27	−0,70	−1,33	−0,27	−0,71	−1,40	−0,24
UNC	0,02	−0,17	0,20	0,05	−0,10	0,19	−0,10	−0,57	0,24	0,07	−0,27	0,44
SDI	0,03	−0,16	0,18	0,04	−0,12	0,19	−0,06	−0,64	0,32	−0,02	−0,58	0,34
NOW	80,44	52,69	95,73	79,97	52,84	95,87	73,91	28,74	97,79	69,81	22,84	96,64
DNW	0,17	−0,12	0,73	0,18	−0,13	0,80	−0,56	−1,40	−0,10	−0,58	−1,41	−0,11
SAR	0,20	−0,06	0,58	0,17	−0,12	0,52	2,79	0,41	7,97	2,10	0,24	6,78
MME	0,09	0,01	0,22	0,08	0,01	0,21	0,11	0,00	0,27	0,09	0,00	0,24
DIST	−1,83	−5,08	−0,29	−1,72	−5,27	−0,17	−12,61	−38,60	−1,24	−5,83	−21,20	−0,23
COM	0,11	−0,03	0,31	0,10	−0,01	0,30	0,17	−0,05	0,49	0,13	−0,06	0,40
CON	0,03	−0,05	0,16	0,04	−0,06	0,20	0,06	−0,07	0,24	0,11	−0,05	0,34
COL	0,04	−0,04	0,18	0,03	−0,05	0,14	−0,03	−0,16	0,09	−0,06	−0,17	0,06
CCL	\	\	\	\	\	\	\	\	\	\	\	\
FTA	−0,09	−0,18	0,00	−0,09	−0,18	−0,01	−0,05	−0,25	0,11	−0,07	−0,26	0,07
GAT	0,01	−0,15	0,12	0,01	−0,14	0,11	−0,12	−0,80	0,18	−0,09	−0,62	0,19

Coefficients are multiplied by 100 to facilitate the interpretations
CI lower and CI upper pertain to 90 percent confidence intervals.

To dig deeper into the relationship between trade and conflict, models in Table 2 replicate the models in Table 1 that make use of the full sample (i.e., columns 1, 4, 7 and 10), but introduce the interaction between contiguity and bilateral trade. Results clearly show how the effect of trade openness on conflict is higher for contiguous pairs. In fact, in this model bilateral trade openness is not significant, but the coefficient of the interaction term is negative and statistically different from zero for VWT as well as for total trade. Thus, virtual water trade decreases the likelihood of war conditional on geographic proximity. The role of footwear trade and oil is still insignificant.

As a first robustness check, we estimate the logit model without interaction terms as described above, by replacing the dependent variable MID with its onset. Because of space limitations, the results are provided in the Appendix (Table A.3). Our previous findings on the importance of virtual water are strongly borne out by this new set of empirical results. Countries that trade more virtual water bilaterally have a lower likelihood of war because of the opportunity costs associated with the loss of trade gains, in particular when supply may not easily respond to a loss of markets. As we mentioned above, the number of active militarized disputes is quite low, especially when we only take into account contiguous pairs. We therefore run a rare event logit model (Table A.4 in the appendix) on the full sample and on the relevant dyads using either virtual water trade or total trade and our results confirm the previous findings.[8]

Another important question is whether multilateral trade openness, rather than bilateral dependence, can affect the odds of war between countries. Therefore, models in Table 3 replicate those in Table 1 but replaces bilateral trade with multilateral trade. We consider the full sample model, a sub-sample of relevant dyads, and one of contiguous pairs. The purpose of this extension is both to explore the robustness of the previous findings to changes in the way dependence is measured, and also to delve deeper into the underlying mechanisms for the results.

The coefficients of VWT are all consistently negative and significant, suggesting that high level of both bilateral and multilateral trade openness decreases the probability of armed conflict. Oil has a similar negative coefficient, albeit insignificant in all but one sample (relevant dyads). Interestingly, when we move from strategic commodities to aggregate trade or non-strategic goods (i.e., footwear) multilateral trade openness decreases the probability of conflict, perhaps by reducing bilateral dependence to any

[8] Convergence is not achieved in models using contiguous pairs and measures of trade in oil and footwear.

given country and therefore the cost of a bilateral conflict, as Martin et al. (2008) suggests. One of the reason behind this discrepancy may be the fact that multilateral trade openness does not necessarily increase the autonomy of countries when they are heavily dependent on key commodities. In fact, losing an important supplier of oil or virtual water might cause high costs, even in presence of multiple trading partners, in particular in light of growing water scarcity.

Finally, Table 4 explores the effect of the interaction between multilateral trade and the contiguity dummy on conflict. Using data on VWT, we find that high level of multilateral trade openness decreases the probability of MID for proximate countries, whereas the interaction is insignificant for all the other types of trade.

As the coefficients in such non-linear models cannot be interpreted as slopes or elasticities (only their signs and standard errors allow for a direct reading), we present substantive quantities of interest, or marginal effects. We first analyze the marginal effect of bilateral trade openness for the coefficients reported in Table 1 (see Table 5, columns 1–3 and 7–9) using the full sample, as well as the relevant dyads sample and restricting the sample to contiguous pairs only. Although the absolute probabilities are small as wars between countries are rare overall, the likelihood of MID in the full sample decreases by a factor of about 0.19 when bilateral VWT is raised from its minimum to its maximum. Considering the relevant dyads only, the likelihood of MID decreases by a factor of 3.50. Moving to the multilateral trade effect (Table 5, columns 4–6 and 10–12), the likelihood of MID decrease by 0.14 percentage points in the full sample and 2.14 points in the sample of relevant dyads when multilateral VWT openness is raised from its minimum to its maximum. Moreover, the effects of VWT and oil&gas trade on conflict are of similar magnitude (and actually the magnitude of the effect of VWT is slightly larger that of oil&gas trade), as we can see from results reported in Table 5. In Tables A.5 and A.6 we report the marginal effects that largely corroborate our previous findings.

4. Conclusions

Water scarcity is one of the main challenges for sustainable development, and this problem is likely to exacerbate as a result of climate change, population growth, rapid urbanization in many countries and the pollution of rivers and lakes in developing economies. Failing to address this issue can have important consequences on human security and geopolitical stability. Many countries, in particular those in arid regions, depend heavily on importing hidden virtual water, the freshwater used to produce goods in the exporting country. We explore whether and to what extent virtual water trade affects the odds of interstate conflicts. We investigate the role of both bilateral and multilateral trade openness and compare virtual water to another strategic commodity, oil, and to a non-strategic commodity, footwear. We find that bilateral virtual water trade openness reduces the chances that countries are involved into bilateral wars by affecting the opportunity costs of the conflict. The effect is particularly pronounced for relevant dyads, i.e., contiguous states and the superpowers. We also find that the impact of virtual water is comparable to that of oil.

As bilateral trade openness alone may not efficiently capture the complex interdependencies between states, we also use a measure of multilateral trade openness and find that it has the same effect of decreasing the propensity of conflict when it is computed using data on virtual water. This last result stands in contrast to the effect of multilateral total trade openness, which has a positive impact on conflict, as it reduces the opportunity cost with any given country, as the recent research on this topic suggests. As such, our study help shedding light on the heterogeneity of trade effects when moving from total trade to lower levels of aggregation.

Although militarized disputes are rare events (only 0.4 percent of the cases in our sample are coded as 1) and the probabilities estimated by any statistical model are small, we find that – among relevant dyads - the magnitude of the effect stands to about 3.5 percentage point decrease in the likelihood of conflicts when bilateral VWT is raised from its minimum to its maximum. Overall, our results hold up well to a series of specification checks. Because of the limited number of empirical works and the lack of consensus on whether water scarcity affects conflicts, we believe there is an interesting agenda for future research in this topic area. Given a lack of more disaggregated data, we are unable to investigate the mechanisms underlying the effect of VWT on conflict. We do not know, for example, to what extent virtual water trade depends on water-intensive food more specifically. Food insecurity can be the cause of conflict and trigger an array of responses. Due to likely different theoretical mechanisms than those we presented here, examining this important channel is beyond the scope of this article, but we hope to address this in future work.

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Appendix

Table A.1, Table A.2, Table A.3, Table A.4, Table A.5, Table A.6.

Table A.1
List of explanatory variables.

Variable	Description	Sources and notes
MID	1 = No militarized action, 2 = Threat to use force, 3 = Display of force, 4 = Use of force, and 5 = War. Ratio of ones: 0.444% (total of 779)	Correlates of War Dataset (COW)
MID_{onset}	It takes on value 1 only when in year t the country has MID = 1 and in t-1 MID = 0 (no conflicts) Ratio of ones: 0.244% (total of 428)	
DIST	Geodesic distances, calculated following the great circle formula, which uses latitudes and longitudes of the most important cities/agglomerations (in terms of population)	CEPII, geodist database (Mayer and Zignago, 2011) (www.cepii.fr/anglaisgraph/bdd/distances.htm, accessed on 02/2015)
COL	A country pair dummy representing whether one was a colony of the other at some point in time.	
CON	Country pair dummy represents whether the two countries have a common border	
CCL	Country pair dummy represents whether the two have been colonized by a same third country	
COM	Country pair dummy represents whether the two countries speak the same official language.	
RTA	Common membership in a regional trade area	
NYP	The number of years of peace between the two countries	Martin et al. (2008)
SDI	The democracy index for each country, taken from the Polity IV database. We use the composite index that ranks each country on a − 10 to + 10 scale in terms of democratic institutions.	
UNC	The correlation between countries' positions during votes on resolutions in the General Assembly of the United Nations.	
NOW	The total number of MIDs (excluding their potential bilateral MID) which the countries of the pair are involved in at time*t*.	
DNW	The distance to the nearest current war which does not involve a country from the pair	
SAR	The sum of areas of the two countries (in log).	
MME	A dummy for those country pairs belonging to a military alliance	
GAT	A variable counting the number of General Agreement on Tariffs and Trade/World Trade Organization (GATT/WTO)	
DWL	List of dummies expressing whether a conflict was present in the dyad 1, 2, …, t years before.	
Bil_trade	The ratio of imports j receives from i over the GDP of the importing country j, computed in different times t.	Imports: NBER-UN Trade Data set (http://cid.econ.ucdavis.edu/data/undata/undata.html, accessed on 04/2015, Feenstra et al., 2005). Data on oil and gas trade are extracted based on the SITC4 codes of the commodities traded[a]. Data on VWT are based on the commodity trade dataset of the Food and Agricultural Organization of the United Nations (FAO, Statistics Division. FAOSTAT online database. (http://faostat3.fao.org/home/index.html, accessed on 9/2013.). Detailed international trade is available at the annual time scale from 1986 to 2011 and express the quantity of agricultural commodity*k*traded in year*t*from country*i*to country*j*. Trade data are converted into virtual water flows by multiplying traded quantities by the crop virtual water content (in m^3), assuming that commodities are produced in the countries of origin of the flows. The total VW trade is then obtained by summing across allcommodities, i.e. The considered crop virtual water content is the sum of green and blue water[b] GDP: World Bank (http://data.worldbank.org/indicator/NY.GDP.MKTP.CD, accessed on 02/2015.) GDP at current price (US $)
Multi_trade	The sum of imports j receives from all exporters h (excluding i) divided by the GDP of the importing country j computed in different times t.	
TRWR	The sum of internal renewable water resources (IRWR) and external renewable water resources (ERWR). It corresponds to the maximum theoretical yearly amount of water available for a country at a given moment and it is calculated as total renewable surface water + total renewable groundwater - the overlap between surface water and groundwater.	Data are in 10^9 m^3/yr and comes from AQUASTAT FAO main database (http://www.fao.org/nr/water/aquastat/data/query/index.html, accessed on 03/2016). Data are averaged over 5- years period (1988–1992, 1993–1997, 1998–2002).

[a] Data utilized for the category "trade in oil and gas" are those extracted under the SITC4 code Division: 33 ("Petroleum, petroleum products and related materials") and Division: 34 ("Gas, natural and manufactured").
[b] The water footprint of a product is the volume of water needed to produce the product. The 'blue' water footprint refers to the volume of surface and groundwater consumed (evaporated) as a result of the production of a good; the 'green' water footprint refers to the rain-water consumed. The 'grey' water footprint of a product refers to the volume of freshwater that is required to assimilate the load of pollutants based on existing ambient water quality standards – please see Mekonnen and Hoekstra (2011).

Table A.2
Correlation coefficients among bilateral trade and multilateral trade openness measures, using the full sample.

	multi_footwear	multi_oil&gas	multi_total	multi_vw	bil_vw	bil_oil&gas	bil_total
multi_oil&gas	0.117						
multi_total	0.335	0.617					
multi_vw	0.093	0.380	0.444				
bil_vw	0.037	0.281	0.339	0.602			
bil_oil&gas	−0.028	0.219	0.223	0.045	0.415		
bil_total	−0.113	0.134	0.220	0.123	0.489	0.654	
bil_footwear	0.127	0.029	0.123	0.118	0.296	0.345	0.410

Table A.3
Trade and MID: bilateral trade openness. MID_{onset} is the dependent variable.

	1 full	2 rel. dyads	3 contig	4 full	5 rel. dyads	6 contig	7 full	8 rel. dyads	9 contig	10 full	11 rel. dyads
bil_vw	−0.052	−0.142***	−0.245***								
	(0.036)	(0.045)	(0.071)								
bil_oil&gas				0.009	−0.157	0.075					
				(0.103)	(0.123)	(0.610)					
bil_total							0.015	−0.138	−0.330**		
							(0.078)	(0.086)	(0.145)		
bil_footwear										0.123	0.203
										(0.172)	(0.238)
NYP	−0.016***	−0.011**	−0.013*	−0.024***	−0.028**	−0.104	−0.017***	−0.018***	−0.045***	−0.026*	−0.023
	(0.004)	(0.004)	(0.007)	(0.009)	(0.012)	(0.073)	(0.004)	(0.006)	(0.017)	(0.014)	(0.017)
UNC	−0.951***	−0.694*	−1.160*	0.056	−0.606	1.081	−0.709**	−0.390	−0.085	0.077	−0.626
	(0.313)	(0.382)	(0.603)	(0.565)	(0.668)	(4.623)	(0.334)	(0.366)	(0.719)	(0.965)	(1.096)
SDI	0.124	0.181	−0.044	0.713	0.286	−0.195	0.510	0.561	0.798	0.871	1.855
	(0.275)	(0.321)	(0.422)	(0.491)	(0.740)	(1.774)	(0.328)	(0.418)	(0.556)	(0.912)	(1.544)
NOW	0.224***	0.182***	0.083**	0.288***	0.291***	0.252	0.267***	0.258***	0.164***	0.230**	0.155
	(0.021)	(0.054)	(0.037)	(0.039)	(0.052)	(0.169)	(0.017)	(0.027)	(0.041)	(0.095)	(0.102)
DNW	−0.096	−0.379**	−0.426**	0.165	−0.785*	−1.377	−0.218	−0.564**	−0.729**	0.041	−0.581*
	(0.174)	(0.191)	(0.210)	(0.374)	(0.406)	(1.234)	(0.206)	(0.233)	(0.333)	(0.485)	(0.348)
SAR	0.114**	0.135	0.032	0.116	0.375**	0.693	0.150**	0.160*	0.190	0.268	0.275
	(0.053)	(0.087)	(0.133)	(0.087)	(0.146)	(0.802)	(0.058)	(0.096)	(0.222)	(0.204)	(0.261)
MME	0.328	0.225	0.319	0.608	0.814	−1.537	0.518*	0.481	0.240	0.274	0.223
	(0.260)	(0.278)	(0.306)	(0.415)	(0.504)	(1.461)	(0.307)	(0.364)	(0.553)	(0.707)	(0.856)
DIST	−0.786***	−0.806***	−0.431	−0.836***	−1.264***	−2.877	−0.886***	−0.696***	−0.263	−0.916*	−0.847
	(0.163)	(0.218)	(0.413)	(0.299)	(0.448)	(1.805)	(0.180)	(0.270)	(0.715)	(0.473)	(0.635)
COM	0.123	0.127	−0.061	0.332	0.691	2.317	0.438	0.483	0.055	0.278	1.180
	(0.321)	(0.337)	(0.379)	(0.656)	(0.812)	(1.972)	(0.352)	(0.432)	(0.691)	(0.789)	(0.817)
CON	1.091***	0.866**	\	−0.216	0.167	\	0.812*	1.149**	\	0.135	0.367
	(0.389)	(0.432)	\	(0.607)	(0.626)	\	(0.443)	(0.471)	\	(1.136)	(0.892)
COL	0.586	0.096	0.560	0.148	−0.538	−1.161	0.339	−0.099	−0.201	0.703	−0.498
	(0.357)	(0.328)	(0.403)	(0.641)	(0.701)	(1.345)	(0.389)	(0.352)	(0.461)	(1.003)	(0.989)
CCL	0.500	0.225	0.139	\	\	\	0.346	0.167	0.077	\	\
	(0.402)	(0.478)	(0.535)	\	\	\	(0.570)	(0.659)	(0.795)	\	\
FTA	−0.047	−0.145	0.247	−1.082	−0.461	1.017	−0.525	−0.691	0.021	−1.568	−1.318
	(0.360)	(0.389)	(0.482)	(0.699)	(0.810)	(3.669)	(0.534)	(0.621)	(0.910)	(0.995)	(1.134)
GAT	−0.037	−0.115	−0.215	−0.439	−0.722	−1.140	−0.173	−0.196	−0.584	−0.472	−1.556**
	(0.198)	(0.215)	(0.245)	(0.326)	(0.491)	(0.856)	(0.220)	(0.265)	(0.374)	(0.647)	(0.748)
Obs.	37,398	7385	1633	6675	2383	440	42,061	6928	1109	3484	1364
# MID = 1	185	132	75	79	62	21	158	100	46	43	38
dummies t	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DWL	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.409	0.301	0.245	0.510	0.505	0.585	0.483	0.386	0.356	0.385	0.385

Robust standard errors in parentheses
*** $p < 0.01$
** $p < 0.05$
* $p < 0.1$

Table A.4
Trade and MID: bilateral trade openness. Relogit.

	1 full	2 rel. dyads	3 full	4 rel.dyads
bil_vw	−0.070**	−0.159***		
	(0.033)	(0.042)		
bil_total			0.011	−0.120
			(0.069)	(0.081)

(*continued on next page*)

Table A.4 (*continued*)

	1 full	2 rel. dyads	3 full	4 rel.dyads
NYP	−0.020***	−0.014***	−0.023***	−0.021***
	(0.004)	(0.004)	(0.004)	(0.006)
UNC	−0.984***	−0.723**	−0.620**	−0.416
	(0.290)	(0.360)	(0.302)	(0.344)
SDI	0.025	−0.125	0.490*	0.364
	(0.239)	(0.280)	(0.260)	(0.315)
NOW	0.241***	0.203***	0.283***	0.268***
	(0.021)	(0.053)	(0.019)	(0032)
DNW	−0.125	−0.402	−0.217	−0.516***
	(0.140)	(0.161)	(0.179)	(0.203)
SAR	0.090*	0.117	0.093	0.090
	(0.049)	(0.073)	(0.057)	(0.095)
MME	0.470**	0.474**	0.605**	0.710***
	(0.218)	(0.232)	(0.256)	(0.260)
DIST	−0.691***	−0.646	−0.777***	−0.613**
	(0.157)	(0.200)	(0.173)	(0.261)
COM	0.379	0.291	0.860***	0.889**
	(0.260)	(0.267)	(0.306)	(0.394)
CON	0.872***	0.754**	0.789**	0.945**
	(0.311)	(0.378)	(0.354)	(0.411)
COL	0.805***	0.265	0.343	−0.021
	(0.260)	(0.265)	(0.298)	(0.299)
CCL	0.391	0.294	0.130	0.082
	(0.316)	(0.389)	(0.416)	(0.535)
FTA	−0.162	−0.175	−0.401	−0.580
	(0.347)	(0.327)	(0.487)	(0.489)
GAT	0.174	0.069	0.094	0.036
	(0.466)	(0.197)	(0.211)	(0.255)
Obs.	37,398	7385	42,061	6928
# MID = 1	315	225	260	166
dummies t	yes	yes	yes	yes
DWL	yes	yes	yes	yes
Pseudo R^2	0568	0466	0612	0521

Robust standard errors in parentheses
*** $p < 0.01$,
** $p < 0.05$,
* $p < 0.1$

Table A.5
Marginal effects of coefficients in Table 1.

	1 full	2 rel. dyads	3 contig	4 full	5 rel. dyads	6 contig	7 full	8 rel. dyads	9 contig
bil_vw	−5.36e-05**	−0.000803***	−0.00486***						
	(2.61e-05)	(0.000242)	(0.00155)						
bil_oil&gas				−5.21e-05	−0.000352*	−5.69e-06			
				(0.000111)	(0.000199)	(2.15e-05)			
bil_total							1.72e-06	−0.000283	−0.00172*
							(2.54e-05)	(0.000191)	(0.00102)
NYP	−1.47e-05***	−6.35e-05***	−0.000321**	−2.68e-05***	−3.98e-05**	−7.54e-06	−8.20e-06***	−4.42e-05***	−0.000265**
	(3.06e-06)	(1.88e-05)	(0.000126)	(8.17e-06)	(1.56e-05)	(2.30e-05)	(1.86e-06)	(1.16e-05)	(0.000105)
UNC	−0.000735***	−0.00362*	−0.0201*	0.000247	−0.000773	−8.02e-05	−0.000227*	−0.000872	0.00234
	(0.000251)	(0.00189)	(0.0121)	(0.000599)	(0.00113)	(0.000525)	(0.000120)	(0.000807)	(0.00368)
SDI	−9.81e-06	-0.000519	-0.00515	0.000352	0.000124	5.75e-05	0.000193*	0.000905	0.00219
	(0.000178)	(0.00137)	(0.00809)	(0.000523)	(0.00108)	(0.000267)	(0.000105)	(0.000749)	(0.00277)
NOW	0.000183***	0.00103***	0.00226**	0.000316***	0.000484**	2.00e-05	0.000108***	0.000618***	0.00112
	(3.34e-05)	(0.000255)	(0.00104)	(0.000109)	(0.000222)	(7.00e-05)	(2.30e-05)	(0.000187)	(0.000713)
DNW	−0.000104	−0.00208**	−0.0109**	0.000227	−0.00111*	−0.000160	−8.85e-05	-0.00123**	-0.00464
	(0.000104)	(0.000831)	(0.00472)	(0.000368)	(0.000652)	(0.000568)	(6.63e-05)	(0.000528)	(0.00329)
SAR	6.67e-05*	0.000571	0.00269	7.26e-05	0.000586	7.80e-05	3.46e-05*	0.000197	0.00152
	(3.70e-05)	(0.000364)	(0.00262)	(8.56e-05)	(0.000360)	(0.000251)	(2.07e-05)	(0.000193)	(0.00124)
MME	0.000355**	0.00235**	0.0121**	0.000818*	0.00131	-0.000111	0.000227**	0.00160**	0.00316
	(0.000177)	(0.00112)	(0.00595)	(0.000460)	(0.000828)	(0.000358)	(0.000109)	(0.000687)	(0.00322)
DIST	−0.000515***	−0.00318***	−0.0125	−0.000906**	−0.00219*	−0.000329	−0.000290***	-0.00132**	-0.00463
	(0.000134)	(0.00106)	(0.00818)	(0.000394)	(0.00120)	(0.00111)	(7.77e-05)	(0.000590)	(0.00457)
COM	0.000279	0.00141	0.00400	0.000574	0.00134	0.000119	0.000321**	0.00197*	0.00212
	(0.000194)	(0.00132)	(0.00622)	(0.000598)	(0.00102)	(0.000415)	(0.000129)	(0.00111)	(0.00308)
CON	0.000663**	0.00379**	\	8.49e-05	0.000496	\	0.000300*	0.00222*	\
	(0.000279)	(0.00187)	\	(0.000517)	(0.000803)	\	(0.000153)	(0.00116)	\

(*continued on next page*)

Table A.5 (*continued*)

	1 full	2 rel. dyads	3 contig	4 full	5 rel. dyads	6 contig	7 full	8 rel. dyads	9 contig
COL	0.000606***	0.00126	0.0142*	0.000378	-0.000315	-5.65e-05	0.000133	-7.83e-05	0.000200
	(0.000228)	(0.00137)	(0.00752)	(0.000487)	(0.000840)	(0.000245)	(0.000114)	(0.000642)	(0.00220)
CCL	0.000286	0.00139	0.00280	\	\	\	4.14e-05	0.000177	-0.00136
	(0.000244)	(0.00191)	(0.00859)	\	\	\	(0.000154)	(0.00116)	(0.00314)
FTA	−0.000139	−0.000982	−0.00301	−0.00107	−0.000451	0.000159	−0.000200	-0.00144	-0.000571
	(0.000258)	(0.00159)	(0.00860)	(0.000789)	(0.00121)	(0.000421)	(0.000182)	(0.00117)	(0.00357)
GAT	0.000146	0.000453	0.000644	9.98e-05	−0.000217	−8.67e-05	4.65e-05	0.000154	-3.59e-05
	(0.000133)	(0.000938)	(0.00435)	(0.000380)	(0.000810)	(0.000278)	(7.76e-05)	(0.000544)	(0.00175)

Robust standard errors in parentheses
*** $p < 0.01$,
** $p < 0.05$,
* $p < 0.1$

Table A.6
Marginal effects of coefficients in Table 3.

	1 full	2 rel. dyads	3 contig	4 full	5 rel. dyads	6 contig	7 full	8 rel. dyads	9 contig
multi_vw	−8.61e-05**	−0.00101***	−0.00503**						
	(3.96e-05)	(0.000356)	(0.00211)						
multi_oil&gas				−6.39e-05	−0.000392	−2.35e-05			
				(0.000120)	(0.000274)	(9.08e-05)			
multi_total							0.000143**	0.00117**	-0.00506
							(7.21e-05)	(0.000528)	(0.00446)
NYP	−1.44e-05***	−6.75e-05***	−0.000376***	−2.66e-05***	−3.97e-05**	−4.96e-06	−7.91e-06***	-4.32e-05***	-0.000273***
	(3.06e-06)	(1.93e-05)	(0.000141)	(8.16e-06)	(1.69e-05)	(1.65e-05)	(1.85e-06)	(1.14e-05)	(0.000104)
UNC	−0.000713***	−0.00313*	−0.0216	0.000409	0.000220	3.55e-05	−0.000281**	-0.00131*	0.00372
	(0.000247)	(0.00184)	(0.0138)	(0.000550)	(0.00114)	(0.000121)	(0.000120)	(0.000798)	(0.00461)
SDI	−3.65e-05	−0.000903	−0.00755	0.000352	0.000321	5.91e-05	0.000171*	0.000521	0.00146
	(0.000178)	(0.00141)	(0.00929)	(0.000529)	(0.00111)	(0.000260)	(0.000103)	(0.000710)	(0.00237)
NOW	0.000181***	0.00103***	0.00253**	0.000312***	0.000477**	1.50e-05	0.000105***	0.000575***	0.00114
	(3.39e-05)	(0.000253)	(0.00112)	(0.000109)	(0.000220)	(5.73e-05)	(2.26e-05)	(0.000167)	(0.000699)
DNW	−0.000133	−0.00228**	−0.0118**	0.000201	−0.00112*	−0.000119	−7.04e-05	-0.00110**	-0.00599
	(0.000111)	(0.000893)	(0.00540)	(0.000365)	(0.000655)	(0.000451)	(6.32e-05)	(0.000467)	(0.00387)
SAR	4.72e-05	0.000366	0.00103	7.38e-05	0.000509	5.72e-05	4.22e-05**	0.000233	0.00160
	(3.70e-05)	(0.000367)	(0.00296)	(8.39e-05)	(0.000343)	(0.000207)	(2.02e-05)	(0.000184)	(0.00150)
MME	0.000342**	0.00220**	0.0143**	0.000768*	0.00112	−7.87e-05	0.000229**	0.00158**	0.00288
	(0.000167)	(0.00108)	(0.00710)	(0.000455)	(0.000802)	(0.000283)	(0.000108)	(0.000649)	(0.00326)
DIST	−0.000484***	−0.00264***	−0.00778	−0.000840**	−0.00157	−0.000210	−0.000291***	-0.00101*	-0.00465
	(0.000129)	(0.000998)	(0.00932)	(0.000405)	(0.00106)	(0.000769)	(7.78e-05)	(0.000550)	(0.00562)
COM	0.000256	0.00125	0.00201	0.000534	0.00111	6.19e-05	0.000300**	0.00156	0.00316
	(0.000189)	(0.00137)	(0.00735)	(0.000579)	(0.00102)	(0.000234)	(0.000123)	(0.000955)	(0.00328)
CON	0.000572**	0.00295*	\	0.000166	0.000916	\	0.000303**	0.00250**	\
	(0.000267)	(0.00170)	\	(0.000522)	(0.000924)	\	(0.000149)	(0.00113)	\
COL	0.000571**	0.000770	0.0108	0.000249	-0.000799	-7.69e-05	0.000158	-2.41e-05	-4.49e-05
	(0.000225)	(0.00139)	(0.00805)	(0.000480)	(0.000907)	(0.000298)	(0.000116)	(0.000655)	(0.00232)
CCL	0.000317	0.00158	0.00540	\	\	\	5.56e-05	0.000722	-0.000319
	(0.000239)	(0.00188)	(0.00890)	\	\	\	(0.000149)	(0.000987)	(0.00257)
FTA	−0.000148	−0.00123	−0.00552	−0.00111	−0.000656	0.000103	−0.000188	-0.00132	-0.00204
	(0.000253)	(0.00161)	(0.00896)	(0.000745)	(0.00119)	(0.000322)	(0.000173)	(0.00106)	(0.00440)
GAT	0.000126	0.000224	0.000863	0.000148	-0.000222	-7.09e-05	7.56e-05	0.000487	0.000177
	(0.000130)	(0.000979)	(0.00487)	(0.000368)	(0.000814)	(0.000271)	(7.61e-05)	(0.000534)	(0.00182)

Robust standard errors in parentheses
*** $p < 0.01$,
** $p < 0.05$,
* $p < 0.1$

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