Supplemental Appendix for "Beyond Ricardo: The Link Between Intra-industry Trade and Peace"

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This supplemental appendix presents several tables of robustness check models. Our results are consistent to specifications in which (1) we account for endogeneity – specifically, reciprocal causation – between intra-industry trade and militarized conflict, (2) we take steps to account for missing data, (3) we adjust our specification to match closely recent studies, and (4) we account for alternate measures of trade interaction.

Robustness Checks

Simultaneous Causation

Reversed or simultaneous causation are important considerations in studies of trade and conflict. As such, we follow Hegre, Oneal, and Russett in constructing simultaneous equations models to examine the potentially reciprocal causation between trade – in this case, intra-industry trade – and conflict.[1] Specifically, in Table A-1, we replicate Hegre et al.'s models using data they make available through the *Journal of Peace Research* data replication site. These models are constructed using Long's trade equation and Russet and Oneal's conflict equation.[2] We specify two variants of simultaneous equations models: (1) using the intra-industry trade index, and (2) using the dyadic flow of trade that flows within industries.[3] In both cases, we replicate Table 3, columns 3 and 4 of Hegre et al.'s models. These models include state and year dummy variables in order to fix the effects both spatially and temporally (although we do not present these dummies due to space considerations; they are available by request from the authors). In accordance with Hegre et al., we estimate these simultaneous models using Keshk's CDSIMEQ package for Stata.[4] For model to converge when fixed effects dummy

variables are included, the DV must vary for each state and each year. As such (and, again, following Hegre et al.), we delete all observations for (1) states that never experience a fatal MID and (2) years in which there are no fatal MIDs. All results are robust when we exclude fixed effects, regardless of whether we include all states and years or exclude those with no fatal MIDs. These additional robustness checks are available by request from the authors.

Intra-industry trade with respect to GDP

Although our primary models include specifications with interactions between the *intra-industry trade index* and *lower dependence*, we also include robustness check models in which we include a single measure of intra-industry trade that represents the lower proportion of GDP composed by intra-industry trade. We present to variants of these robustness checks in Table A-2: (1) excluding *lower dependence*, and (2) including *lower* dependence. This latter specification is useful to determine whether it is dependence on trade overall that results in a pacifying impact, or whether this influence stems only from intra-industry trade. Results are consistent in both of these robustness checks. All results are robust in both of these models.

Missing Data

This is an important issue to address, given that observations are not missing randomly. Instead, it tends to be South-South trade that is under-reported. To test for the robustness of our results, we accounted for missing data by (1) filling in missing values with zero, and (2) using multiple imputation in Stata 11 to fill in missing values. These

results are presented in the third and fourth columns of Table A-2. Neither of these methods is without problems, but we contend that the robustness of our results to both methods provides additional confidence that the pattern we uncover does in fact exist. We explore both methods in detail below.

First, we create a new dyad-year level measure of intra industry trade that is equal to zero if the following conditions are met:

1) our primary intra industry measure has missing data (otherwise, the new measure equals the old measure)
2) we have at least some commodity level data for both dyad members (not necessarily for the dyad, however; it is enough if we have some commodity level data for each member with some third party)
3) the year range falls within 1962-2000, for which Feenstra's commodity-level data is available.

Second, we use multiple imputation in Stata 11. This method replaces missing values with multiple variants of simulated values (we create 5, a number limited by computer power), and then runs our primary models on all 5 variants, adjusting parameter estimates to account for uncertainty associated with missing values.[5] Following Rubin, we do not expect multiple imputation to predict accurately our missing data, but to allow for a more valid statistical inference in our primary models.[6] As with our zero-imputed models, we only impute values if:

1) we have at least some commodity level data for both dyad members
2) the year range falls within 1962-2000, for which commodity-level data is available.

However, we almost certainly violate the assumption that values are missing at random. As mentioned above, it tends to be poorer, less stable states for which we do not have commodity level trade data (as such, we suspect that imputing zeros may actually be more accurate from the standpoint of accuracy). In alternate robustness checks, we attempted to get around this somewhat by creating separate imputations by region/development, assuming that data *within regions* are missing at random (for example, within sub-Saharan Africa) and then combining these imputations - a useful feature that is possible if one runs the imputation stage multiple times on sets of observations restricted by region or GDP per capita).

Additional Specifications

First, we present models in which we replace CINC score-derived capability measures with major power dummy variables in order to prevent multicollinearity between *lower development* (i.e., lower GDP per capita) and our capability measures.[7] Specifically, we remove the *capability ratio* and *higher CINC score* variables, and substitute dummy variables for *one major power*, and *two major powers*, such that *zero major powers* is the null category. Table A-3 presents Models A-7 through A-12: replications of all six of our primary models using this specification. All results are robust to these specifications. Additionally, we find in Model A-12 that *intra-industry trade* has

no significant impact on conflict when *lower development* is held at 0.

Second, in Table A-4, we present additional single-equation robustness checks more closely specified in accordance to models in Hegre et al.[8] Specifically, we add the system size variable included in their models. Ultimately, this variable serves as a strong proxy of time, given the steady increase in the number of states between 1962 and 2000. We present replications of models 1 and 2, each in two forms: (1) only adding the system size variable, and (2) removing our dummy variables for *both democratic* and *both autocratic*, and substituting *lower polity score* and *higher polity score* (using the 21 point combined score from the Polity IV project). These latter specifications using lower and higher polity scores are essentially identical to the conflict models utilized by Hegre et al (2010).[9]

Finally, in Table A-5, we include models using alternate specifications of trade. We code *trade salience*, from Barbieri, as $\sqrt{tradeshare_i * tradeshare_j}$, where trade share is dyadic trade flow divided by each state's total trade.[10] *Trade salience* is a proxy for states' abilities to reroute trade to third parties should dyadic trade terminate. As *trade salience* increases, a larger proportion of both states' total trade flows within the dyad, meaning that, on average, the states have fewer recourses should they need to reroute lost dyadic trade.[11] Although *salience* is not as closely related to *lower development* as is *lower dependence*, there is nonetheless potential for correlation between trade shares and development, given that larger economies tend to have more trade partners.[12] As such, we code *trade efficiency*, the residual from the gravity model of trade, capturing the extent to which dyads trade more or less than would be predicted by the size of each state and the

distance between them.[13] In essence, this variable captures political and economic factors influencing trade not elsewhere coded with explanatory variables. Most importantly, it eliminates the impact of size asymmetries and, particularly, correlation between trade and development.[14]

Table A-1: Simultaneous equation models Fatal MIDs and intra-industry trade (from Hegre, Oneal, and Russet 2010, Table 3, columns 3 and 4). State and year dummies not presented.

	A-1: Intra-industry trade index		A-2: Intra-industry trade flow	
	Fatal MID	IIT	Fatal MID	IIT
		-0.012*		-0.140*
MID with fatalities (instrument)		(0.005)		(0.058)
Intra-industry trade (instrument)	-4.022***		-0.370**	
	(1.258)		(0.133)	
Log smaller GDP		0.019***		0.149***
		(0.003)		(0.037)
Log larger GDP		0.001		-0.014
		(0.003)		(0.033)
Log smaller population		-0.041***		-0.334***
		(0.003)		(0.039)
Log larger population		-0.032***		-0.262***
		(0.003)		(0.038)
Log capabilities of larger country	0.219***		0.217***	
	(0.034)		(0.034)	
Largest's share of total capabilities	-1.114***		-1.089***	
	(0.296)		(0.297)	
Contiguity	1.116***	-0.041***	1.125***	-0.540***
	(0.294)	(0.008)	(0.294)	(0.089)
Log distance	-0.305***	-0.015***	-0.282***	-0.129***
	(0.054)	(0.002)	(0.052)	(0.020)
Joint democracy score		0.023***		0.180***
		(0.002)		(0.028)
Lower democracy score	-0.009		-0.011	
	(0.009)		(0.009)	
Higher democracy score	0.007		0.007	
	(0.007)		(0.007)	
Shared alliance ties	0.212*	0.014***	0.201	0.127***
	(0.103)	(0.002)	(0.103)	(0.024)
Preferential Trade Agreements		.004*		0.030
		(0.002)		(0.020)
Similarity of Alliance Portfolios		0.026***		0.279***
		(0.003)		(0.035)
System size	0.671	-0.106***	0.669	-1.289***
	(0.389)	(0.009)	(0.389)	(0.096)
Peace years	-0.070***	0.0004	-0.072***	0.002
	(0.022)	(0.0004)	(0.022)	(0.004)
Spline 1	5.3e-05	5.29e-06	3.9e-05	4.7e-05
	(0.0002)	(3.16e-06)	(0.0002)	(3.5e-05)
Spline 2	-0.0001	-3.60e-06	-0.0001	-3.3e-05
	(0.0001)	(2.38e-06)	(0.0001)	(2.6e-05)
Spline 3	7.4e-05**	7.91e-07	7.3e-05**	7.87e-06
	(0.0002)	(6.70e-07)	(0.0002)	(7.50e-06)
Constant	1.600*	0.848***	1.359	7.812***
	(0.749)	(0.086)	(0.733)	(0.963)
Observations	61,261		61,261	

Corrected standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05; two-tailed tests

Table A-2: Robustness check models: intra-industry trade with regard to GDP, and missing data

	Intra-industry trade measured relative to states' economies		Missing values filled with zeros	Multiple imputation of missing values†
	A-3	A-4	A-5	A-6
Intra-industry trade			-6.703**	-3.147*
			(2.118)	(1.440)
Lower intra-industry trade dependence‡	1684**	1619*		
	(632.5)	(701.7)		
Lower development	-0.307*	-0.315*	-0.0541	-0.065
	(0.132)	(0.132)	(0.138)	(0.138)
Lower IIT dep. X lower development	-705.3*	-723.4*		
	(283.3)	(325.4)		
Lower dependence		23.12	-20.83	-43.036
		(19.49)	(26.79)	(40.833)
Both democracies	-1.160**	-1.152**	-1.478***	-1.561***
	(0.376)	(0.376)	(0.395)	(0.411)
Both autocracies	-0.408	-0.410	-0.441*	-0.448*
	(0.221)	(0.221)	(0.223)	(0.226)
Contiguity	1.458**	1.443**	0.916	0.916
	(0.488)	(0.490)	(0.750)	(0.745)
ln Distance	-0.238***	-0.238***	-0.386***	-0.385***
	(0.0653)	(0.0654)	(0.0942)	(0.094)
Alliance	0.311	0.311	-0.0745	-0.100
	(0.251)	(0.251)	(0.257)	(0.263)
Higher capability score	9.303***	9.316***	8.002**	7.878**
	(2.161)	(2.162)	(2.599)	(2.622)
Relative capabilities	-1.916**	-1.876**	-2.412**	-2.408**
	(0.630)	(0.631)	(0.786)	(0.793)
Peace years	-0.212**	-0.213**	-0.411***	-0.415***
	(0.0708)	(0.0708)	(0.0682)	(0.069)
Peace years^2	0.0113*	0.0113*	0.0228***	0.023***
	(0.00478)	(0.00478)	(0.00474)	(0.005)
Peace years^3	-0.000170	-0.000170	-0.000350***	-0.0004***
	(8.86e-05)	(8.87e-05)	(8.89e-05)	(0.00009)
Constant	-2.559***	-2.579***	-0.727	-0.716
	(0.737)	(0.738)	(1.000)	(1.002)
Observations	191,175	191,175	236,178	236,178
Model fit	$p(\chi^2) \leq 0.0001$	$p(\chi^2) \leq 0.0001$	$p(\chi^2) \leq 0.0001$	$p(F) \leq 0.0001$

Robust standard errors in parentheses

*** p<0.001, ** p<0.01, * p<0.05; two-tailed tests

† estimated in Stata 11; five imputations of intra-industry trade

‡ mathematically equal to lower dependence X intra-industry trade

Table A-3: Robustness checks using major power status in place of CINC score capability measures

	A-7	A-8	A-9	A-10	A-11	A-12
Intra-industry trade	-6.312***	-5.231**	-4.159*	-4.373*	5.339**	4.346
	(1.877)	(1.770)	(1.969)	(2.005)	(1.859)	(2.314)
Lower development		-0.288*	-0.226	-0.299*	-0.230	-0.187
		(0.135)	(0.143)	(0.135)	(0.137)	(0.147)
Lower dependence		1.988	190.7**	18.21	5.907	154.8*
		(8.514)	(65.89)	(11.58)	(7.941)	(69.76)
Lower development X dependence			-73.74**			-58.50*
			(27.92)			(29.03)
Intra-industry trade X dependence				-127.5		
				(94.45)		
Lower development X intra-industry trade					-3.941***	-3.387**
					(0.943)	(1.124)
Both democracies	-1.266**	-1.183**	-1.159**	-1.172**	-1.094**	-1.103**
	(0.393)	(0.396)	(0.382)	(0.391)	(0.377)	(0.376)
Both autocracies	-0.309	-0.405	-0.404	-0.406	-0.405	-0.403
	(0.216)	(0.236)	(0.240)	(0.237)	(0.237)	(0.240)
Contiguity	1.362**	1.422**	1.402**	1.409**	1.406**	1.394**
	(0.454)	(0.470)	(0.467)	(0.469)	(0.470)	(0.469)
ln Distance	-0.275***	-0.262***	-0.262***	-0.261***	-0.262***	-0.262***
	(0.0612)	(0.0621)	(0.0618)	(0.0620)	(0.0621)	(0.0619)
Alliance	0.179	0.317	0.315	0.312	0.326	0.325
	(0.236)	(0.256)	(0.253)	(0.256)	(0.254)	(0.252)
One major power	0.878***	0.882***	0.900***	0.884***	0.903***	0.914***
	(0.230)	(0.229)	(0.229)	(0.229)	(0.228)	(0.228)
Two major powers	2.674***	2.741***	2.726***	2.737***	2.726***	2.712***
	(0.600)	(0.607)	(0.611)	(0.607)	(0.606)	(0.610)
Peace years	-0.223**	-0.215**	-0.218**	-0.216**	-0.215**	-0.217**
	(0.0713)	(0.0712)	(0.0713)	(0.0711)	(0.0712)	(0.0714)
Peace years^2	0.0117*	0.0116*	0.0119*	0.0117*	0.0116*	0.0118*
	(0.00478)	(0.00481)	(0.00482)	(0.00481)	(0.00481)	(0.00482)
Peace years^3	-0.000176*	-0.000180*	-0.000184*	-0.000180*	-0.000180*	-0.000183*
	(8.89e-05)	(8.96e-05)	(8.98e-05)	(8.96e-05)	(8.96e-05)	(8.99e-05)
Constant	-4.308***	-3.860***	-4.004***	-3.847***	-3.996***	-4.091***
	(0.635)	(0.691)	(0.713)	(0.691)	(0.703)	(0.724)
Observations	191,175	191,175	191,175	191,175	191,175	191,175
$p(\chi^2)$	≤0.0001	≤0.0001	≤0.0001	≤0.0001	≤0.0001	≤0.0001

*** p<0.001, ** p<0.01, * p<0.05; two-tailed test
Robust standard errors in parentheses

Table A-4: Single equation replications of Hegre et al 2010

	A-13	A-14	A-15	A-16
Intra-industry trade	-5.966**	-5.556**	-4.679*	-4.317*
	(1.924)	(1.989)	(1.822)	(1.865)
Lower development			-0.302*	-0.297*
			(0.127)	(0.124)
Lower dependence			-1.115	-0.0643
			(8.852)	(8.719)
Both democracies	-1.292***		-1.203**	
	(0.390)		(0.391)	
Both autocracies	-0.298		-0.397	
	(0.199)		(0.217)	
Lower polity score		-0.0967***		-0.0944***
		(0.0262)		(0.0277)
Higher polity score		0.0324*		0.0386*
		(0.0144)		(0.0157)
Contiguity	1.425**	1.401**	1.480**	1.450**
	(0.459)	(0.458)	(0.472)	(0.471)
ln Distance	-0.305***	-0.309***	-0.295***	-0.300***
	(0.0672)	(0.0681)	(0.0676)	(0.0685)
Alliance	0.185	0.248	0.320	0.376
	(0.229)	(0.228)	(0.244)	(0.241)
Higher capability score	9.238***	8.855***	9.639***	9.232***
	(2.145)	(2.136)	(2.189)	(2.180)
Relative capabilities	-1.810**	-1.669**	-1.909**	-1.767**
	(0.626)	(0.626)	(0.630)	(0.629)
Peace years	-0.229**	-0.240***	-0.221**	-0.231**
	(0.0719)	(0.0720)	(0.0718)	(0.0719)
Peace years^2	0.0115*	0.0117*	0.0114*	0.0116*
	(0.00479)	(0.00476)	(0.00483)	(0.00479)
Peace years^3	-0.000169	-0.000166	-0.000174	-0.000169
	(8.90e-05)	(8.79e-05)	(8.99e-05)	(8.88e-05)
System size	1.687*	1.788*	1.790**	1.931**
	(0.675)	(0.696)	(0.688)	(0.714)
Constant	-2.972***	-3.926***	-2.423***	-3.422***
	(0.664)	(0.635)	(0.703)	(0.668)
Observations	191,175	191,173	191,175	191,173

*** p<0.001, ** p<0.01, * p<0.05; two-tailed test
Robust standard errors in parentheses

Table A-5: Robustness checks using alternate measures of trade

	A-17	A-18	A-19
Intra-industry trade	-5.402**	-4.489*	-5.293**
	(1.872)	(1.780)	(1.828)
Lower development	-0.340**	-0.292*	-0.312*
	(0.129)	(0.126)	(0.128)
ln Trade flow	0.0453*		
	(0.0223)		
Trade salience (Barbieri 1996)		-2.283	
		(4.321)	
Trade efficiency (Hegre 2004)			0.0438
			(0.0856)
Both democracies	-1.167**	-1.155**	-1.159**
	(0.393)	(0.393)	(0.393)
Both autocracies	-0.346	-0.486*	-0.410
	(0.217)	(0.220)	(0.221)
Contiguity	1.423**	1.582**	1.470**
	(0.485)	(0.498)	(0.496)
ln Distance	-0.234***	-0.242***	-0.250***
	(0.0645)	(0.0659)	(0.0662)
Alliance	0.310	0.347	0.324
	(0.250)	(0.248)	(0.254)
Higher capability score	8.230***	9.274***	9.262***
	(2.272)	(2.325)	(2.183)
Relative capabilities	-1.896**	-2.101**	-1.947**
	(0.622)	(0.647)	(0.626)
Peace years	-0.216**	-0.213**	-0.207**
	(0.0708)	(0.0698)	(0.0711)
Peace years^2	0.0112*	0.0113*	0.0109*
	(0.00478)	(0.00477)	(0.00480)
Peace years^3	-0.000165	-0.000168	-0.000162
	(8.85e-05)	(8.89e-05)	(8.88e-05)
Constant	-3.116***	-2.413**	-2.399***
	(0.781)	(0.739)	(0.714)
Observations	191,175	184,810	191,175
$p(\chi^2)$	≤0.0001	≤0.0001	≤0.0001

*** p<0.001, ** p<0.01, * p<0.05; two-tailed test
Robust standard errors in parentheses

1 Havard Hegre, John R. Oneal, and Bruce Russett, 'Trade Does Promote Peace: New Simultaneous Estimates of the Reciprocal Effects of Trade and Conflict', *Journal of Peace Research* 47(2010), pp. 763-74.

2 Andrew Long, 'Bilateral Trade in the Shadow of Armed Conflict', *International Studies Quarterly* 52 (2007), pp.. 81-101; John R. Oneal and Bruce Russett, 'Rule of Three, Let It Be? When More Really Is Better', *Conflict Management and Peace Science* 22 92005), pp. 293-310.

3 This measure is equal to the product of dyadic trade flow and the intra-industry trade index. We take the natural log of the raw value. We also obtain equivalent results in models in which we simply add the intra-industry trade index to the conflict equation in models specified in Hegre, Oneal, and Russett, 'Trade Does Promote Peace'.

4 Omar Keshk, 'CDSIMEQ: A program to implement two-stage probit least squares.', *The Stata Journal* 3 (2003), pp. 1-11.

5 Yulia Marchenko, 'Multiple-imputation analysis using Stata's mi command', 2009 UK Stata Users Group Meeting.

6 Donald B. Rubin, 'Multiple Imputation After 18+ Years', *Journal of the American Statistical Association* 91 (1996), pp. 473- 89.

7 The CINC score incorporates six elements: iron and steel production, military expenditure, military personnel, energy consumption, total population, and urban population. While the CINC score technically excludes GDP, many of its components could conceivably correlate with GDP. The highest correlation in our data 0.45.

8 Hegre, Oneal, and Russett, 'Trade Does Promote Peace'.

9 However, in addition to being single-equation models, our robustness check models utilize cubic polynomials in lieu of cubic splines.

10 Katherine Barbieri, 'Economic Interdependence: A Path to Peace or a Source of Conflict?', *Journal of Peace Research* 33 (1996), pp. 29-49.

11 However, as Crescenzi (2003) points out, this proxy measure does not capture the actual exit cost

associated with terminating dyadic trade. Unfortunately, exit cost data are too limited to be useful in this study, so we rely on this proxy instead.

12 E.g., Erik Gartzke and Quan Li, 'Measure for Measure: Concept Operationalization and the Trade Interdependence-Conflict Debate', *Journal of Peace Research* 40 (2003), pp. 553-71.

13 E.g., Havard Hegre, 'Development and Democracy: What Does it Take to be a Trading State?' *Journal of Peace Research* 37 (2000), pp. 5-30. Specifically, these residuals are obtained from gravity models, run on a yearly basis, regressing (the natural log of) dyadic trade flow on (the natural log of) each state's GDP and the (natural log of the) distance between them. See Hans Linneman, *An econometric study of international trade flows: Contributions to economic* analysis (Amsterdam: North-Holland, 1966); Alan V. Deardorff, 'Determinants of bilateral trade: Does gravity work in a neoclassical world?', in *The regionalization of the world economy,* ed. Jeffrey A. Frankel. (Chicago: University of Chicago Press, 1988), pp. 7-31; Jeffrey H. Bergstrand, 'The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence', *The Review of Economics and Statistics* 67 (1985), pp. 474-81.

14 Overall, the highest correlation among any of our trade variables is 0.45. As noted above, correlation between *lower dependence* and *lower development* is only 0.34. However, there is a close mathematical relationship between the two variables, as both include GDP. This relationship is exacerbated when employing an interaction.