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From toys to warships: Interdependence and the effects of disaggregated trade on militarized disputes

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Abstract

The United States recently proposed to sell Saudi Arabia advanced weaponry worth 20 billion dollars over the next 10 years. The volume of trade, while significant, is second in the news headline that the United States would provide Saudi Arabia with precision-guided bombs, upgrades to its fighters, and new naval vessels. Trade of strategic commodities, such as armaments, suggests a strong interdependence between countries, which may influence international relations differently than the same volume of toys traded between nations. The author posits the volume and pattern of commodities that countries trade with each other are both relevant to interstate conflict. Commodities are heterogeneous and thus vary in terms of their strategic importance, substitutability, and ease of expropriation. This heterogeneity, along with the volume of trade, influences the opportunity cost of lost trade caused by conflict. This article empirically examines whether the pattern of trade is relevant to conflict for the period 1962–2000. The results from both single and simultaneous equations models indicate that increasing the share of bilateral trade in energy, non-ferrous metals, and electronics increases conflict, whereas for chemicals and arms it reduces conflict. Differences in these strategic commodities' elasticity of import demand and export supply, along with their ease of expropriation, contribute to the heterogeneous effects.

Keywords

Interdependence, militarized disputes, pattern of trade, strategic trade

Introduction

There is a general belief that globalization benefits developed and developing countries by connecting people from around the globe through increased movement across borders of traded goods, financial and physical capital, and ideas. One can point to the rapid rise in the volume of international trade over the last 200 years as evidence of increased global integration. Maddison's (1995) historical dataset shows trade has increased by 520 times over the period 1820–1992. In the post-World War II period, 1950–1992, exports have grown more rapidly at 5.3% per year than GDP at 3.4%. Part of the growth in trade is tied to falling transportation costs, liberalization of tariffs, and stabilization of foreign exchange rates. Trade provides countries economic benefits by allowing them to specialize in producing goods where they have a comparative advantage. Comparative advantage is formed by relative differences across countries in technological and factor endowments. For example, the United States, possessing a relatively large capital stock, benefits from exporting aircraft and importing labor intensive commodities from developing countries.

The level of integration, while on the rise, is concentrated in a small number of mostly developed countries. According to the OECD Factbook (2007), 75% of OECD exports and 67% of imports were with other OECD countries in 2005. Many therefore wonder whether globalization, and trade in particular, will improve the opportunity for peace among countries or instead threatens conflict with those left out. Most researchers (Oneal & Russett, 1997, 1999; Russett & Oneal, 2001) have empirically found that trade interdependence significantly reduces conflict. Barbieri (1996, 2002) and Gasiorowski (1986) provide evidence to the contrary that interdependence increases conflict, while Beck, Katz & Tucker (1998) and Goenner (2004) find no statistical relation between the two. A possible explanation for the difference in findings is that interdependence created by trade is more complex than the volume of bilateral trade used in most studies. The opportunity cost of lost trade depends on the ability of countries to find alternative trading partners, which is determined by the

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volume of trade along with what commodities they trade. Policymakers in the United States clearly recognize that the latter is also important to international relations. Strengthening relations is a key motivation behind the recently approved nuclear agreement between India and the United States, which allows trade of nuclear materials after a 30-year ban. In some cases, the volume of bilateral trade may be minimal relative to the size of total trade or the economy, but the particular commodities traded are of critical importance. Different commodities offer different gains from trade, thus interdependence does not only depend on how much countries trade, but also depends on the pattern of what they trade.

The pattern of trade we examine is based on the bilateral trade of strategic commodities. We believe trade of strategic commodities, in particular energy, non-ferrous metals, chemicals, electronics, nuclear materials, and arms, is more relevant than non-strategic flows in creating ties between countries – ties that could increase or decrease conflict depending on the substitutability and ease of expropriating the commodities that countries trade. To study these effects, we use bilateral trade flow data from the United Nations, collected by Feenstra and colleagues (2005) at the National Bureau of Economic Research (NBER), which are disaggregated by commodity. The results show the pattern of trade is important to the relationship between trade and conflict, as increasing the share of bilateral trade in some strategic commodities (energy, metals, and electronics) increases conflict and in others (chemicals and arms) reduces conflict.

Benefits of trade and cost of conflict

A benefit of trade is that it allows countries to lower their opportunity cost of production and expand consumption possibilities. This is possible because countries that trade are able to specialize in producing goods where they have a comparative advantage given their resources. Countries with a relative abundance of capital will export capital-intensive goods, while importing labor-intensive goods. Differences in comparative advantage create inter-industry trade, where countries trade with each other different types of goods. Trade also provides access to additional markets that create economies of scale, which allow countries to benefit from trade with countries with similar endowments. For example, trade of autos between the United States, Germany, and Japan allows each country's automakers to focus on producing a smaller number of models, producing each at a larger scale, while giving their consumers a wider variety of domestic and import models to choose from. With respect to conflict, it is typically assumed that the more two countries trade the less likely they are to engage in conflict that inhibits the benefits of trade. In their expected utility model, Polachek (1980) and subsequent coauthors (Polachek, Robst & Chang, 1999; Robst, Polachek & Chang, 2007) assume that the level of trade directly increases the cost of conflict. Dorussen & Hegre's (2003) multi-country model of trade and conflict also assumes that disrupting trade increases the cost of conflict by influencing the probability of stalemate and the value of victory and defeat from conflicts.

Researchers typically use the volume of bilateral trade by itself or as a fraction of GDP or total trade to empirically measure the interdependence of countries. This disregards the strategic importance of some goods and suggests that 20 billion dollars worth of toys traded by the United States and China would have the same impact on interdependence and conflict as 20 billion in arms traded by the United States and Saudi Arabia. Gasiorowski (1986) believes that measures of aggregate bilateral trade reflect interconnectedness and not interdependence between countries. The distinction being that interdependence relates to trade flows where there are significant gains and countries are vulnerable to its disruption and conflict. Gasiorowski (1986) argues the vulnerability associated with interdependence is based on the pattern of trade. Trade is more vulnerable to disruption if a country has only a few trading partners, trades a small number of commodities, or trades commodities with few substitutes. Gasiorowski's analysis demonstrates that trade can have both positive and negative effects on conflict. While the volume of trade (interconnectedness) significantly reduces conflict, concentration in a few export commodities and import partners (interdependence) increases conflict.

Vulnerability caused by trade reflects sensitivity to interdependence, which is difficult to alter or reverse in the long run (Borrus & Zysman, 1992; Ripsman & Blanchard, 1996/7). Whether trade leads to vulnerability depends on the composition of domestic production and the pattern of commodities that countries trade. According to Sen (1984), a country's development of strategic industries leads to economic self-sufficiency, which promotes security by providing protection from economic disruption. Further, state intervention and protection of strategic industries can provide long-term advantages to domestic firms that significantly influence the trajectory of production and development. Supporting strategic industries in their infancy allows firms to achieve economies of scale and improves their competitiveness with foreign producers – an important point, since development depends on the current composition of production (Weber & Zysman, 1992) as certain industries, such as technology, are more important to the growth of other industries, including those related to defense. For this reason, Borrus & Zysman (1992: 52) argue that access to technology is increasingly at the center of trade disputes. In addition, Weber & Zysman (1992: 183) contend 'the potential for national conflicts of interest in the support of high-technology industries is particularly high because knowledge does not in practice diffuse easily, and because such industries are never perfectly competitive'. This suggests vulnerability created by trade interdependence may not reduce conflict.

Polachek (1980: 67) recognized that trade's effect on conflict should vary with the commodities that countries trade. '*Conflict would be most sensitive to trade of commodities particularly strategic to an economy*. The reason is obvious. Even small amounts of trade of essential commodities yield high welfare gains' (italics original). Lacking disaggregated data, Polachek's (1980) analysis relied on aggregate bilateral data of exports and imports to analyze the effects on conflict. Dorussen (2006), using bilateral trade data disaggregated by industries, is able to examine whether trade's effect varies across industries. The data used by Dorussen were collected by Statistics Canada from UN sources and are aggregated across commodities into 35 industry classifications for the period 1970–1997. The dataset is further aggregated by Dorussen into 10 categories to examine the relationship between bilateral trade of goods in these industries and militarized interstate disputes (MIDs). Dorussen hypothesizes trade will reduce conflict regardless of the goods traded, but the magnitude of the effect depends on the characteristics of the goods in each industry. He asserts trade of more inelastic goods imposes higher opportunity costs if disrupted and is therefore expected to have more of an impact on reducing conflict. Further, he asserts goods that are easier to expropriate by force are expected to have less of an impact.

Dorussen's results confirm that the magnitude of interdependence's effect varies by industry, and the effect is statistically significant for industries producing apparel, low-tech, high-tech, and machinery. Somewhat puzzling is the finding that chemicals and electronics, which have high opportunity costs and are difficult to expropriate, are both insignificant and run counter to Dorussen's expectations. Part of the problem may be tied to the level of aggregation, as goods within categories vary significantly in terms of strategic importance, substitutability, and ease of expropriation. As Dorrussen (2006: 98) notes, the machinery category includes 'lawnmowers and battleships'. Also noteworthy is that nuclear reactors are aggregated into Dorussen's 'low tech' industry category.

Strategic trade and interdependence

The analysis that follows uses more disaggregated trade data to examine further whether the pattern of commodities that countries trade influences militarized disputes. The bilateral trade dataset used is from the NBER-UN and assembled by Feenstra et al. (2005).[1] The dataset covers the period 1962–2000 and updates the World Trade Database produced by Statistics Canada, which covered 1970–1992. The data are disaggregated by commodity at the 4-digit SITC revision 2 level. This provides access to detailed bilateral trade flows of approximately 750 commodities as diverse as toys (SITC 8942), groundnuts (2221), nuclear reactors (7187), and warships (7931). By using commodity-level trade data, we are able to pay particular attention to the pattern of strategic trade that determines the influence of trade interdependence on conflict.

Certain commodities are strategic in nature because they are more important to a country's economic and military strength. There is no general agreement on a list of strategic commodities (Reuveny & Kang, 1998). Sen (1984) characterizes industries as strategic if they promote self sustained economic growth. These are industries with (1) significant backward and forward linkages to other industries, (2) economies of scale, and (3) importance to growth. Sen (1984: 59) lists six industries meeting these criteria: iron and steel, chemicals, textiles, machinery, paper products, and transport equipment. One could add petroleum to this list based on Chenery's (1960) results. Ripsman & Blanchard's strategic goods test considers (1) the need of goods for survival, (2) the extent to which goods are externally acquired, (3) the volume of trade disrupted, (4) substitution capabilities, and (5) whether deficiency is sufficient to create vulnerability. During World War I, their list of strategic commodities includes chromium, coal, copper, foodstuffs, iron ore, lead, manganese, money, nickel, nitrates, oil, rubber, and sulphur-pyrites. In World War II, Ripsman and Blanchard's list of strategic commodities expanded to also include bauxite, magnesium, mercury, tungsten, and zinc.

Here we categorize and aggregate strategic commodities into six groups, which include energy, non-ferrous metals, chemicals, electronics, nuclear materials, and armaments. Table I provides for each strategic category the list of commodities it includes and their SITC codes.[2] Energy and metals are typically viewed as strategic, given their important role in production and concentration in a few countries. Subsequent to the first Arab oil embargo and quadrupling of the price of oil, the United States government authorized the Department of Energy in 1975 to establish a strategic petroleum reserve of 700 million barrels to be used to ensure the nation's security and economic well-being. The Department of Defense was similarly tasked in 1978 with creating a strategic stockpile of metals, minerals, and ores to counter vulnerability on foreign supply.[3] Other commodities may be less important to the global economy, but are strategic because they have dual uses that can threaten a nation's security if shared with others via trade. In the United States, the Bureau of Industry and Security, which is part of the Department of Commerce, maintains a list of sensitive commodities with export restrictions. The commerce control list includes certain nuclear materials, weapons, chemicals, machinery, electronics, navigation equipment, and marine- and space-related items.

Commodities were selected for each category such that their strategic importance is relatively homogenous within a given category. Metals, for example, vary significantly in terms of their availability and importance to industrial production. Here we focus on trade of non-ferrous metals, because they are

[1] Complete bilateral export and import data are available for 72 countries, which account for 98% of world exports in the last five years. This implies trade flows are not available when both countries are not on the list, which primarily impacts pairs of countries from Africa.

[2] The digits in SITC codes represent different levels of aggregation in the data. For brevity, the highest SITC level is reported when all subgroups beneath are included.

[3] The Strategic and Critical Materials Stock Piling Act of 1978 (50 USC 98).

Table I. Classification of strategic goods

Strategic category	*Commodity SITC Code*	*Description*
Energy	32	Coal, coke & briquettes
	33	Petroleum, petroleum products & related material
	34	Gas: natural & manufactured
	35	Electric current
Non-ferrous metal	287	Ores & concentrates of base metals n.e.s.
	681	Silver, platinum & other metals of the platinum group
	682	Copper
	683	Nickel
	684	Aluminum
	685	Lead
	686	Zinc
	687	Tin
	689	Misc. non-ferrous base metals employed in metallurgy
Chemicals	51	Organic chemicals
	522	Inorganic chemical elements, oxides & halogen salts
	523	Other inorganic chemicals
Electronics	87	Professional, scientific & controlling instruments
	764	Telecommunications equipment & parts
	77	Electrical machinery, apparatus & appliances n.e.s.
Nuclear	286	Ores & concentrates of uranium & thorium
	524	Radio-active & associated materials
	7187	Nuclear reactors & parts
Armaments	792	Aircraft & associated equipment & parts
	7931	Warships of all kinds
	9510	Armored fighting vehicles, arms of war & ammunition

rare, lack substitutes, and are needed to produce stainless steel, turbines, electronics, chemicals, and durable goods. The strategic category for energy includes trade of coal, oil, natural gas, and electricity. Chemicals include organic and inorganic chemicals. Electronics includes circuitry, professional scientific and controlling instruments, and telecommunications equipment. Nuclear materials include nuclear reactors and parts, radioactive materials, depleted uranium, and radioactive ores. Armaments include aircraft, helicopters, warships, weapons, and armored vehicles. Unfortunately, the data do not distinguish between military and civilian aircraft, so perhaps this category should be thought of as armaments and aircraft, but for brevity's sake it will be referred to as armaments. This list of strategic commodities is hardly exhaustive, but they do represent commodities that are likely to offer relatively more gains from trade and are relatively more important to economic and military security. Therefore we intend to test whether:

> *Hypothesis 1*: Conflict is influenced by the volume and particular commodities that countries trade bilaterally, where conflict is particularly sensitive to the share of trade in strategic commodities.

Strategic commodities are not uniform in their characteristics and can vary significantly in terms of their substitutability. Conflict between countries disrupts trade, by reducing a country's supply of imports and the demand for their exports. This in turn increases the price paid domestically for imported goods and decreases the price received for exported goods, which creates the economic costs associated with conflict. The magnitude of this disruption depends in part on the ability of a country to substitute their imports and exports between alternative countries. A country's elasticity of import demand measures the impact on price due to a change in the supply of imports. The more elastic import demand is, the easier it is for a country to find an alternative producer, and the less effect there is on price. Similarly, the elasticity of export supply measures the impact of a change in the demand for goods exported abroad. The more elastic a country's export supply is, the easier it is for them to find alternative markets to sell their products and the less prices fall domestically.

Recent research (Broda & Weinstein, 2006; Broda, Greenfield & Weinstein, 2006; Broda, Limao & Weinstein, 2008) shows, while the elasticities of both export supply and import demand vary across countries, commodities, and time, generalizations of the elasticities can be made by commodity. Broda, Greenfield & Weinstein (2006) report elasticities of import demand for commodities measured at the 3-digit Harmonized System level and 73 countries. Based on their estimates, there exists across most countries a strong relationship between elasticity estimates for a particular commodity.[4] Of the 73 countries, 60 show a positive and statistically significant relationship at the 10% level.[5] Across time, the elasticity of import demand also appears to be stable according to Broda & Weinstein's (2006) estimates for the United States at the 4-digit SITC level over the periods of 1972 to1988 and 1990 to 2001. Regressing the natural log of one period's elasticity estimates on the other period reveals a strong positive relationship between the two with a t-statistic of 4.38.[6] Elasticity of supply estimates reveal similar relationships. Broda, Limao & Weinstein (2008) provide elasticity of export supply estimates at the 4-digit Harmonized Trade System (HTS) level for the United States and 15 countries, not

[4] This can be shown by regressing, for each country, the natural log of a country's elasticity estimates on the mean of the natural log of the elasticity estimates of the other countries, where each observation represents a commodity. Results are available in the web appendix.
[5] Small island nations are 8 of the 13 insignificant results.
[6] Results are available in the web appendix.

Table II. Elasticity of import demand and export supply by strategic group

	Import elasticity of demand		*Export elasticity of supply*		*Overall* elasticity ranking*	
	Average	*Median*	*Average*	*Median*	*Average*	*Median*
Energy	8.47	3.70	3.89	1.79	H	MH
Non-ferrous metal	8.73	2.92	9.01	2.27	H	MH
Chemicals	2.08	1.86	6.35	1.10	MH	LM
Electronics	2.94	1.52	0.66	0.15	M	L
Nuclear	2.06	2.20	0.47	0.31	LM	LM
Armaments	9.87	5.76	0.49	0.30	M	M
66th percentile	1.98		0.50			
33rd percentile	3.39		1.87			

* The overall ranking is based on the tercile rankings for Elasicity of Demand and Supply

members of the World Trade Organization.[7] The elasticity estimates of export supply for commodities are also strongly correlated across countries, where each of the estimates is highly statistically significant.

The elasticity of supply and demand estimates indicate they vary by the characteristics of a good. Therefore a country's ability to substitute trade between two countries will depend on the goods they trade. Certain goods are the same, independent of where produced, and thus tend to be traded on financial exchanges. Examples include agricultural products, metals, and oil. Homogeneity implies oil imported from Venezuela can be substituted with oil from Mexico or elsewhere, increasing its elasticity of import substitution. The number of producers also influences import elasticity. More suppliers of a commodity means less disruption is caused by the lost supply from one. Khan (1975) finds that import elasticity also depends on the capital intensity of production. Capital intensive goods, such as machinery, tend to have more inelastic demand relative to labor intensive goods like food. The elasticity of export supply also depends on the homogeneity of goods produced across countries. Broda, Limao & Weinstein (2008) find that the elasticity of export supply is larger for homogenous commodities than differentiated products. Differentiated products are more likely to be produced for a particular market or set of countries, thereby decreasing the elasticity of their export supply.

With respect to pairs of countries and their bilateral trade, conflict should be least (most) sensitive to trade of commodities where import demand and export supply are both highly elastic (inelastic). In cases where the elasticities differ across exports and imports, the impact of bilateral trade on conflict is less clear as it will depend on the distribution of trade between bilateral exports and imports and their respective elasticities. Table II provides elasticity estimates of the import demand and export supply for the goods in each of the strategic groups. The import values are based on Broda & Weinstein's (2006) estimates for the United States at the 4-digit SITC level over the period 1990 to 2001, and the export supply estimates for the United States are from Broda, Limao & Weinstein (2008) over the period 1994 to 2003, where we used a concordance to relate the original HTS classification to SITC. We report the average and median of the elasticities for each of the commodities within a strategic group. The group elasticity values are also ranked as high, medium, and low, based on the tercile values found over all estimates. The estimates indicate that energy and non-ferrous metals are more elastic than chemicals, nuclear materials, electronics, and arms. This relationship we would expect because energy and metals are homogenous commodities, and chemicals, nuclear materials, electronics, and arms are capital intensive and highly differentiated across countries.

Certain goods are by their very nature more substitutable than others and therefore trade of these commodities should have less impact on conflict. We see in Table II that energy and non-ferrous metals, both homogenous commodities, have more elastic import demand and export supply than the differentiated goods of chemicals, electronics, nuclear materials, and arms. We test whether:

> *Hypothesis 2*: Bilateral trade of energy and non-ferrous metals, where import demand and export supply are both highly elastic, is less likely to reduce conflict than trade of more differentiated products including chemicals, electronics, nuclear materials, and arms.

This would imply, for example, that bilateral trade of oil between the United States and Saudi Arabia is less relevant to reducing dyadic conflict than the same value of chemicals exchanged.

Interdependence of strategic trade creates vulnerability to economic and military security that may be overcome by expropriation. Liberman (1996) makes the point that occupation and coercion can lead to expropriation of economic resources, which benefit the conquering country more than achieved through trade. This conclusion is based on his review

[7] The 15 countries are Algeria, Belarus, Bolivia, China, Czech Republic, Ecuador, Latvia, Lebanon, Lithuania, Oman, Paraguay, Russia, Saudi Arabia, Taiwan, and Ukraine.

of 5 case studies involving the occupation of industrial societies. From these cases, one sees the need for energy (coal and oil) and metals is often an important motivation behind occupation. Nazi occupation of Western Europe, Liberman notes, allowed Germany to acquire French iron ore for nothing, which could be then diverted to Germany for more efficient production. Similar in motivation, French occupation of the Ruhr and Rhineland after World War I allowed France to expropriate coal which was in desperate demand to rebuild their economy. The Soviet Union, also faced with rebuilding after World War II, took advantage of their occupation of Eastern Europe by purchasing coal from Poland at one-tenth of the world price.[8] In yet another case examined by Liberman, Japan's occupation of Manchuria and Indochina was dominated by their complete dependence on foreign sources of oil, coal, and metals, which led to a desire to stabilize trade and lessen the effects of blockades by expansion. Liberman (1996: 101) cites this expansion was possible because of the belief that 'conquest would pay for itself' – belief based in part on experience of occupation that did not result in work stoppages and lost output. In the case of extractive industries, occupation can produce efficiently for a conquering country. For example, Liberman (1996: 53) notes mining in Nazi-occupied France in 1943 extracted bauxite and coal beyond the prewar level and iron ore at 95% of the level. The Germans also learned from their occupation of Belgium during World War I that extractive industries could still be exploited when others could not.[9] Plant and equipment that were stripped from Belgium factories often went unused, as were those from Eastern Europe. In the later case, Liberman (1996: 127) suggests two-thirds of the Soviet's plunder after the war was wasted.

Based on Liberman's case studies, it is clear that expropriation can result in increased gains relative to trade and that these gains are most tied to plunder of strategic commodities in extractive industries, such as energy and non-ferrous metals. Trade of these commodities may indicate a relationship that can be improved by plunder. The concentration of production of certain strategic commodities may also contribute to expropriation of resources via conflict. As Liberman's case studies noted, conflict and conquest is often over regions, such as the Ruhr, where strategic resources are concentrated. Therefore, trade of strategic commodities, where production tends to be concentrated within a country, may motivate conflict as a result of the increased benefits of plunder. The Herfindahl Hirschman Index (HHI) of a country's exports can be used to measure the concentration of production within a country (Rose & Engel, 2002). The HHI is calculated for a given country (*i*) and year (*t*) as the sum of the squares of each exported commodity's share of a total exports:

$$HHI_{i,t} = \sum_{j=1}^{n} \left(\frac{x_{i,t,j}}{X_{i,t}} \right)^2, \qquad (1)$$

where $x_{i,t,j}$ is the value of each 4-digit SITC commodity ($j = 1 \ldots n$) exported from country i in year t and $X_{i,t}$ is total exports of country i in year t. The HHI ranges from 0 to 1, where a value of 1 indicates reliance on a single commodity for export. Countries that specialize in production tend to be dependent on the production and export of energy, non-ferrous metals, and nuclear materials,[10] trade of which is likely to indicate a potential target of plunder. Therefore our final test is to determine whether:

Hypothesis 3: Trade of strategic commodities that can be plundered by being concentrated in production is more likely to lead to conflict.

Data description

The framework used here is typical to the study of trade interdependence and interstate conflict, where our unit of observation is a non-directed dyad-year. Conflict between countries is measured by the initiation of militarized interstate disputes (MIDs), as defined by the Correlates of War (COW) project (Gochman & Maoz, 1984) to include the threat, display, and use of force. The dependent variable measuring conflict is binary and takes the value of 1 for the first year a militarized dispute takes place between a pair of countries. Subsequent years of the same dispute are discarded from the analysis. The dyadic COW MID version 3.10 data were obtained using EUGene (Bennett & Stam, 2000) with the Maoz construction of dyadic disputes for 1816–1992. The independent variables, other than the trade measures, are also drawn from EUGene. These variables control for the willingness and ability of countries to engage in militarized conflict. Motivation influences whether conflict of a certain type is politically feasible, while capability constraints determine if action is physically feasible.

The Kantian notion of a liberal peace suggests that trade and democracy create ties that reduce conflict. Shared democratic norms and institutions are believed to allow pairs of democracies to settle their disputes peacefully. Empirical research (Barbieri, 1996; Goenner, 2004; Oneal & Russett, 1999) has shown consistently that democratic dyads are less likely to engage in conflict. Regime-type data are from Polity

[8] Liberman (1996: 128) discusses that the Soviet Union also manipulated trade between occupied countries, creating a bid-and-ask spread between the price an occupied country in the bloc paid and the price another received, which was the profit earned by the occupier.

[9] Coal mining was the only area the Germans were able to exploit in Belgium. Liberman (1996: 75) finds that overall production in Belgium fell to 29% of the prewar level in 1918, whereas coal production was 60 to 75%.

[10] The correlation between a country's level of specialization and its export share of a particular commodity is .47 for energy, .07 for non-ferrous metals, and .11 for nuclear materials. Correlations for the other strategic groups are negative. Each is significant at less than the 1% level.

Table III. Logistic regression estimates of militarized disputes, 1962–2000

	Model 1		*Model 2*	
Independent variables	*Coefficient*	*Robust std error*	*Coefficient*	*Robust std error*
Constant	0.6587	0.6617	0.7232	0.6670
Joint dem	−0.0020**	0.0006	−0.0018**	0.0006
Allies	0.0117	0.1383	0.0295	0.1377
Contiguity	2.0315**	0.1794	2.0262**	0.1776
Distance	−0.4967**	0.0804	−0.5120**	0.0811
Capability ratio	−0.2427**	0.0419	−0.2589**	0.0425
Major power	2.2204**	0.1613	2.2804**	0.1601
Interconnectedness level	−18.2297**	8.1121	−19.4148**	7.3394
Interconnectedness asym	20.0858**	8.2688	21.1716**	7.4684
Growth rate	−1.1904*	0.6372	−1.1493*	0.6427
Peace years	−0.4876**	0.0318	−0.4824**	0.0318
Spline1	−0.0026**	0.0003	−0.0026**	0.0003
Spline2	0.0013**	0.0002	0.0013**	0.0002
Spline3	−0.0001**	3.0E-05	−0.0001**	3.0E-05
Energy level			14.5970**	5.9594
Metals level			72.0311**	16.1472
Chemicals level			−265.0100**	89.2303
Electronics level			45.5240**	19.5091
Nuclear level			−131.4453	96.4777
Armaments level			−2052.0370*	1121.9930
Non-strategic level			−1.3475	2.2540
Energy asym			−14.7963**	6.8320
Metals asym			−71.7737**	17.0378
Chemicals asym			286.6093**	91.3597
Electronics asym			−64.9068**	25.4581
Nuclear asym			131.5833	96.7168
Armaments asym			1914.6640	1264.1920
Non-strategic asym			2.7440	2.6254
Log likelihood	−4546		−4522	
Pseudo R2	.3880		0.3912	
N	298,170		298,170	

*$p \leq .1$, **$p \leq .05$.

IV (Jaggers & Gurr, 1995), where countries range from democratic (+10) to non-democratic (–10). The dyadic measure of joint democracy, *JNTDEM*, used here is the product of both countries' measures after adding 10 to each.

Allies are defined by the COW project as nations that have formally agreed to a defense pact, neutrality pact, or entente. The binary variable *Allies* take the value 1 if regimes within the dyad are allied with each other. Formation of an alliance requires agreement on a common goal. Common interests increase the benefits of compromise, thus one expects allies to be more peaceful. Contiguity and distance capture the idea that conflicts of interest typically involve a neighboring country. Most interactions between regimes are regional in nature, owing to the positive relation between distance and interaction cost, thus giving contiguous countries the motive and opportunity for conflict. *Contiguity* is a binary variable that takes the value 1 if countries share a border or are separated by less than 150 miles of water either directly or indirectly via dependencies. *Distance* measures the natural logarithm of the great circle distance between capital cities or, in some cases, major ports.

Capability ratio is used to measure a country's means to engage in military war. The ratio is derived from COW data using each country's share of its military personnel, military expenditures, iron and steel production, energy consumption, urban population, and total population. The variable *Capability ratio* is the natural logarithm of the ratio of the larger to lower value. *Major dyad* is a binary variable that takes the value 1 if either country within the dyad is a major power (Small & Singer, 1982).[11] These are countries that are assumed to be the most active in global affairs. We also control for the growth rate of real GDP of the slowest growing country within the dyad. *Growth rate* measures the average value over the three previous years. GDP in nominal dollars is obtained from Gleditsch (2002). Nominal values are transformed to real values (year 2000 dollars) using the average of the US CPI for

[11] The major powers throughout the period examined are the USA, China, USSR, UK, and France.

the various years. The expectation is that increasing growth rates within the dyad will reduce conflict.

The model specification also includes four variables that are designed to control for the duration dependence of observations. The idea is that pairs of countries that have previously interacted peacefully are less likely to engage in conflict. Following the recommendation of Beck, Katz & Tucker (1998), a natural cubic spline of the previous years of peace is formed with three knots, which generates the four peace-year variables (*Peaceyrs, Spline1, Spline 2, Spline 3*).

Separate measures of trade interconnectedness and interdependence are included in our models' specifications to reflect the complex effects that trade has on conflict. Interconnectedness captures the magnitude of interactions formed by trade and is based on the volume of bilateral trade, whereas interdependence reflects the importance of the commodities that countries trade and is based on the volume of particular commodities traded. Each of the measures we use is detailed further below.

Single equation model specification and results

The dependent variable is binary and therefore logistic regression is used to estimate the probability of conflict in our single equation model. The independent variables, excluding the peace year variables, have all been lagged one year to reduce problems associated with regressors, such as trade, being influenced by the initiation of conflict at time *t*. Huber robust standard errors that cluster on each dyad are provided along with the coefficient estimates.

The first model specification is a baseline and includes controls typically used to analyze the liberal peace. In this specification, the effects of trade are captured by the level and asymmetry of interconnectedness, which depend on each dyad member's bilateral trade-to-GDP ratios. The level of dyadic interconnection is the sum of the dyad members' bilateral trade-to-GDP ratios, while the absolute value of their difference is used to capture asymmetry in the relation.[12] Estimates using the NBER-UN trade data, which appear in Model 1 of Table III, confirm the typical empirical finding that joint democracy and the level of trade interconnectedness significantly reduce conflict, whereas asymmetry of interconnectedness increases conflict. The estimates of the other controls are largely what one expects. Dyads that contain a major power or are contiguous are found to be more likely to engage in conflict, while larger distance and higher capability ratio reduce conflict. Sharing an alliance did not have a significant impact on conflict.

The second model specification adds to the baseline model the pattern of disaggregated bilateral trade to control for the effect of trade interdependence, which depends on the pattern of trade. The level of dyadic interdependence in a commodity group is equal to the sum of each dyad member's bilateral trade of the commodity to total trade ratio, while the absolute value of their difference is used to capture asymmetry. This specification includes the level and asymmetry of interdependence in each of the six strategic and non-strategic commodity groups. We do not need to drop one of the groups in the analysis because interdependence is measured relative to total trade, whereas interconnectedness is relative to GDP.[13] The logistic regression results appearing in Model 2 of Table III indicate that the pattern of trade also matters to the study of conflict. A Wald test of whether the coefficients for the levels of strategic trade are jointly equal to zero is rejected at less than the .1% level, whereas the trade level of non-strategic goods is insignificant. These coefficients indicate bilateral trade in strategic commodities is relevant to conflict, whereas the share of non-strategic commodities is not. This supports our first hypothesis that the volume of bilateral trade and pattern of strategic trade are both relevant to conflict.

The signs of the coefficients vary across commodity groups and show trade's heterogeneous effect on conflict. Holding the level of bilateral trade constant, increasing the level of trade interdependence in energy, non-ferrous metals, and electronics is associated with more conflict, whereas for chemicals, nuclear materials, armaments, and non-strategic trade there is less. The effect is statistically significant for energy, non-ferrous metals, chemicals, and electronics at the 5% level and armaments at the 10% level. Energy and non-ferrous metals both have elastic import demand and export supply, therefore based on the second hypothesis, we expect trade of these commodities to reduce conflict less than other goods. Since these two commodities are also subject to plunder, the third hypothesis suggests trade of these goods indicates a dyad that is more vulnerable to conflict. Armaments, chemicals, and electronics are more inelastic and less likely to be concentrated, thus we expect trade of these commodities to be associated with less conflict. However, trade of electronics significantly increases conflict. This result empirically supports Weber and Zysman's (1992: 177) speculation that disputes over trade of high-technology industries could lead to a resurgence in mercantilism and thus conflict in the 21st century. Nuclear materials, which are inelastic but tend to be concentrated, reduce conflict, with the effect not statistically significant. The asymmetry found in the pattern of trade is also relevant to conflict. Asymmetric trade of energy, metals, and electronics significantly reduces conflict and asymmetric trade of chemicals increases conflict. The estimates of the other controls are similar to the baseline model. Controlling for the pattern of trade, the estimates of the level and asymmetry of interconnectedness remain

[12] These measures control for the same effects as the lower and higher values of interdependence used by Oneal and Russett (1999). The difference is they allow for easier interpretation of the independent effects that the level and asymmetry of interconnectedness have on conflict.

[13] Dropping the non-strategic group from the analysis did not qualitatively change the results.

significant. This indicates that the volume and pattern of commodities traded between countries are both independently relevant to interstate conflict.

The results from the specification are used to determine the marginal impacts of trade of the various commodities on the probability of militarized disputes and appear in Table IV. The baseline probability for a dyad that is a major power, not aligned, and not contiguous, using the mean values of the variables, equals .0064. Increasing the level of interconnectedness by 10%, holding the other trade measures constant, reduces conflict by .76%. Of the strategic commodities, increasing the trade share of non-ferrous metals has the largest impact on increasing conflict, and chemicals have the largest impact on reducing conflict. A 10% increase in the share of metals increases conflict by .41%, while a 10% increase in the share of chemicals reduces conflict by .74%.

Table IV. Marginal effects of trade on the probability of MID, 1962–2000

10% increase	*% change MID*
Interconnectedness level	−0.755
Energy level	0.280
Non-ferrous metals level	0.414
Chemicals level	−0.735
Electronics level	0.289
Nuclear materials level	−0.064
Armaments level	−0.237

Baseline is a major dyad, non-allied and non-contiguous. All other values held at mean of group.

Simultaneous equations model specification and results

In the model specifications used above, bilateral trade is modeled as a cause of conflict. As noted, classical liberals typically assume conflict disrupts trade and creates economic costs, such that the more countries depend on trade, the less likely they are to engage in conflict. This suggests the possibility of a simultaneous relationship between conflict and the volume of bilateral trade. To limit this effect, the above specifications, similar to much of the literature, lag the measure of bilateral trade. This eliminates the possibility of conflict in one period influencing trade in the same period, but also eliminates the opposite effect, which is of interest. Using Granger causality tests, Reuveny & Kang (1996, 1998) have found evidence suggesting bilateral trade and conflict are simultaneous for some dyads, and the effect varies by the commodities countries trade.[14]

To ensure the conclusions drawn above are not sensitive to our treatment of endogeneity, we also provide results from a simultaneous equations model similar to Keshk, Pollins & Reuveny (2004) and Kim & Rousseau (2005). The model treats both the level of real bilateral trade and incidence of militarized interstate disputes as endogenous.[15] We specify separate structural equations for each and analyze non-directed dyads for the period 1962–2000.

The model specification of conflict includes the same variables controlled for in the analysis above. Simiar to Keshk, Pollins & Reuveny's specification, we control for trade interconnectedness by including real bilateral trade *(Bilateral trade)* and the natural log of the higher real GDP (*rGDPH*) within the dyad.[16] The conflict equation for the base model, which is later modified, is given by Equation 2:

$$\begin{aligned} Conflict_t = {} & b_{10} + \alpha_1 \ln(Bilateral\ trade)_t + b_{11} Growth\ rate_t \\ & + b_{12} Major\ dyad_t + b_{13} \ln(Capability)_t \\ & + b_{14} Contiguity_t + b_{15} \ln(rGDPH)_t \\ & + b_{16} JNTDEM_t + b_{17} Allies_t \\ & + b_{18} \ln(Distance) + \delta_{11} Peaceyrs + \delta_{12} Spline1 \\ & + \delta_{13} Spline2 + \delta_{14} Spline3 + u_2 \end{aligned} \tag{2}$$

The structural model of bilateral trade is based on the gravity model (Anderson, 1979; Bergstrand, 1985; Linnemann, 1966; Tinbergen, 1962), where trade is a function of the size of the two countries within each dyad and factors, such as distance, which create resistance to trade. The model is typically specified in terms of natural logs, which creates a problem for observations where bilateral trade is zero. Nearly two-thirds of the observations we use have zero bilateral trade flows. Frankel (1997: 145–146) discusses three approaches typically used in the trade literature to remedy the issue. The first involves transforming zero trade values to some arbitrarily low value.[17] The second is to drop observations where values are zero, and the third involves estimating the model without taking logs. There is no best approach, so Frankel stresses the importance of testing the robustness of the results. In the basic model, real bilateral trade at time t is modeled as being simultaneous with the onset of a militarized dispute at time t, which was previously defined. Similar to Keshk, Pollins & Reuveny, we include in the specification the lagged value of bilateral trade to control for temporal dynamics. To control for size, we add the real GDP for each country within the dyad (*rGDPA, rGDPB*)

[14] The Granger causality test does not test for causality, but instead tests to see whether a change in one variable consistently precedes another. Reuveny & Kang (1998) find simultaneity between trade and conflict is strongest for trade of food, basic manufactures, and mineral fuels.

[15] Keshk, Pollins & Reuveny do the same in their analysis, whereas Kim & Rousseau treat the ratio of bilateral trade to the actor's GDP as endogenous and analyze directed dyads. We did not model our measure of interconnectedness as endogenous because theory suggests the volume of bilateral trade is influenced by conflict. The impact of conflict on the ratios of bilateral trade to GDP is not clear. For example, interdependence could remain the same if bilateral trade and GDP both decline as a result of conflict.

[16] Increasing the higher GDP within the dyad, holding bilateral trade constant, decreases Oneal & Russett's (1997) measure of trade interdependence.

[17] Keshk, Pollins & Reuveny convert zero trade values to 1,000 dollars and then take the log.

and add their populations (*PopA, PopB*) to control for the level of development. The log of distance, joint democracy, and a dichotomous indicator of alliance membership measure the impact caused by resistance to trade. We also add contiguity, which Frankel (1997) notes is a standard in the gravity equation. The equation below is in log form, where we have taken the natural log of bilateral trade, its lagged value, real GDPs, and population. We will also use this specification with the levels of these variables.

$$\begin{aligned}\ln(Bilateral\ trade)_t = b_{20} &+ \alpha_2 Conflict_t \\ &+ b_{21}\ln(Bilateral\ trade)_{t-1} \\ &+ b_{22}\ln(rGDPA)_t \\ &+ b_{23}\ln(rGDPB)_t + b_{24}\ln(PopA)_t \\ &+ b_{25}\ln(PopB)_t + b_{26}JNTDEM_t \\ &+ b_{27}\ln(Distance)_t \\ &+ b_{28}Allies_t + b_{29}Contiguity_t + u_1\end{aligned} \tag{3}$$

The simultaneous equations model specified by Equations 2 and 3 features a continuous endogenous variable, *bilateral trade*, and a dichotomous endogenous variable, *conflict*. The dichotomous variable *conflict* takes the value 1 when the number of disputes is positive, and 0 otherwise. Here we use the STATA routine, CDSIMEQ, written by Keshk (2003), to implement the two-stage estimation procedure outlined by Maddala (1983: 244–245). Estimating the base model, with zero bilateral trade transformed to $1000, indicates conflict reduces bilateral trade and bilateral trade reduces conflict, with both significant at the 5% level. The results of this specification appear in Table V. The latter result differs from Keshk, Pollins & Reuveny's finding that bilateral trade increases conflict for the period 1950–1992, where the result is nearly significant (*p*-value .118). The sign and significance of the other coefficient estimates are largely consistent with Keshk, Pollins & Reuveny's results and are consistent with theory. One difference is that we find allies are less likely to trade and the result is statistically significant.[18]

In the analysis that follows, we incorporate the pattern of trade into the simultaneous equations model. At first we assume that total bilateral trade is endogenous, but the pattern of trade is exogenous and determined by differences in comparative advantage. In effect we are assuming size, distance, and international relations determine whether and how much countries trade, while comparative advantage determines what commodities they trade. This implies differences in factor endowments cause Brazil to export autos to Argentina and import wheat. If Brazil and Argentina engage in conflict then they will trade less with each other, but which commodities they trade less of will primarily depend on comparative advantages and what they trade to begin with. To control for the effect of the pattern of trade on conflict, we add to the conflict equation the bilateral trade flows for each of the strategic commodities, the coefficients of which are interpreted as measuring the impact of altering the share of trade in strategic commodities. Increasing bilateral trade of energy, holding the aggregate level constant, implies the trade share in energy increases.

The estimates from the trade equation with the log transform, which appear in Table V, are similar to the base model. Controlling for the pattern of strategic trade, one finds that the level of bilateral trade has a negative and statistically significant effect on conflict. At the disaggregated level, bilateral trade of energy, non-ferrous metals, electronics, and nuclear materials increases conflict, whereas trade of chemicals and arms reduces conflict, the effects of which are statistically significant at the 5% level for energy, non-ferrous metals, chemicals, electronics, and nearly so for arms (*p*-value .09). These results suggest the pattern of strategic bilateral trade influences conflict when assumed to be exogenous and total bilateral trade and conflict are modeled as endogenous. These predictions are similar to those from the single equation model used above.[19]

While it seems reasonable to assume that comparative advantage largely determines what commodities countries trade, it also seems likely that international relations play some role. For example, reducing or eliminating the flow of oil and natural gas is a commonly used method by Russia to show disdain for the policies of its neighbors. This might suggest bilateral trade of energy and conflict are both endogenous. We examine this relationship below, as well as the potential simultaneity of the other strategic trade flows with conflict. The base model is modified to allow trade of a strategic commodity to be endogenous along with conflict, while the level of trade is assumed to be exogenous in the conflict equation.[20] Here we focus only on the level of trade and not its log, because the vast majority of observations have strategic trade flows equal to zero. Holding the level of bilateral trade constant, increasing trade of a strategic commodity increases its share of trade. Our results indicate

[18] To check robustness, we estimate the base model using levels of bilateral trade, its lag, population, and real GDP and estimate the model with logs that drops observations equal to zero. These results are available in the web appendix. Using the specification with levels, our result is similar to those using logs. Dropping observations with zero bilateral trade, we use 189,000 fewer observations. The results of this specification also reveal trade decreases conflict (*p*-value .04). The difference is that conflict increases trade (*p*-value .083). Across all three specifications, we find that trade interdependence and shared democracy decrease conflict.

[19] To check robustness, we estimate the model, controlling for the pattern of trade, using levels in the trade model and the specification with logs that drops observations equal to zero. These results are again available in the web appendix. Both specifications indicate trade reduces conflict, but the effect is not significant. The model that drops zero values again finds that conflict increases trade. In both models the shares of non-ferrous metals and chemicals are significant, which confirms that trade has a heterogeneous effect on conflict.

[20] Modeling the endogeneity of conflict with the level and pattern of trade is left for future research.

Table V. Simultaneous equation model of trade and conflict: ln transform+

	Base model		*Pattern of trade endogenous*	
	Coefficient	*Std error*	*Coefficient*	*Std error*
Conflict equation				
Constant	−5.0065**	0.3706	−4.7641**	0.3759
Bilateral trade+	−0.0656**	0.0107	−0.0542**	0.0112
Joint democracy	−0.0006**	0.0002	−0.0005**	0.0002
Allies	−0.0135	0.0375	−0.0027	0.0378
Contiguity	0.7692**	0.0407	0.7832**	0.0408
Distance	−0.3602**	0.0248	−0.3490**	0.0252
Capability ratio	−0.2246**	0.0169	−0.2209**	0.0172
Major power	0.5304**	0.0476	0.5469**	0.0480
Real GDP (higher dyad)	0.3537**	0.0285	0.3320**	0.0291
Growth rate (lower dyad)	−0.0809	0.2849	−0.1623	0.2871
Peace years	−0.1671**	0.0087	−0.1680**	0.0088
Spline1	−0.0008**	0.0001	−0.0008**	7.8E-05
Spline2	0.0004**	0.0001	0.0004**	5.3E-05
Spline3	−3.0E-05**	1.0E-05	−3.0E-05**	1.2E-05
Bilateral trade of energy			4.2E-08**	1.8E-08
Bilateral trade of metals			3.4E-07**	8.5E-08
Bilateral trade of chemicals			−8.4E-07**	1.4E-07
Bilateral trade of electronics			3.4E-08**	1.6E-08
Bilateral trade of nuclear			6.1E-08	3.6E-07
Bilateral trade of armaments			−5.6E-06*	3.3E-06
Trade equation				
Constant	−36.2548**	0.1563	−36.0661**	0.1543
Conflict	−0.0901**	0.0216	−0.0387*	0.0212
Bilateral trade level (lagged)+	3.7E-08**	2.01E-09	3.7E-08**	2.0E-09
Real GDP A+	−0.9714**	0.0100	−0.9782**	0.0099
Real GDP B+	−0.6666**	0.0073	−0.6668**	0.0071
Population A+	2.0399**	0.0073	2.0381**	0.0072
Population B+	1.7438**	0.0070	1.7406**	0.0069
Distance	−1.3966**	0.0124	−1.3807**	0.0123
Joint democracy	0.0052**	0.0001	5.2E-03**	6.4E-05
Allies	−0.2564**	0.0288	−0.2533**	0.0286
Contiguity	0.0745	0.0476	0.02806	0.0472
N	300,749			

+Natural logs of these variables are used.
*$p \leq .1$, **$p \leq .05$.

conflict significantly reduces trade of metals and electronics at the 5% level and chemicals at the 10% level.[21] We also find bilateral trade of non-ferrous metals significantly increases conflict and trade of chemicals significantly reduces conflict, when each is modeled as endogenous. Again, the results confirm that the effects of trade vary across the commodities countries trade. Further, bilateral trade in general reduces conflict. In five of the six specifications, where trade of a strategic commodity is endogenous, the level of aggregate trade has a negative effect on conflict, with the result significant at the 5% level in four specifications.

[21] Results are available in the web appendix.

Conclusion

The continued growth of world trade relative to GDP indicates countries are becoming more interconnected. A liberal peace, where trade and democracy bring countries together in peaceful relations, is possible, but depends on the volume and pattern of trade.

The main contribution of this article is the empirical finding that the effects of trade vary by commodity and the variation is largely explained by the strategic importance of commodities and the ease with which they can be substituted and expropriated. The results indicate trade of energy, metals, and electronics creates vulnerability between countries which is associated with increased conflict, while trade of chemicals and arms is associated with less conflict.

The models' coefficients indicate there are significant associations between the commodities that countries trade and the probability of conflict. Increased trade of warships, *ceteris paribus*, is associated with less conflict. The policy implication one might then draw is that the United States reduces the probability of future conflict with Saudi Arabia by increasing arms sales. A causal inference, such as this, must be made with caution. In our dataset, the more arms two countries trade, the less they engage in conflict, but do we believe increasing trade of arms is the cause of peace? It is possible our model suffers from an omitted variable, such as the shared interests of regimes, which is the underlying cause behind the trade of arms and reduced conflict. If this were the case, we would not expect the West to pursue peace with North Korea by increasing trade of arms without also a significant change in North Korea's interests.

Causal inferences based on trade of the other strategic commodities are less likely to be affected by this problem as the link where shared interests may determine the trade of arms is reversed. Trade of other commodities results in relatively more economic than military gains, which create shared economic interests that affect conflict. Nuclear materials, such as nuclear reactors, while potentially used for dual purposes, offer large civilian gains that may overshadow their use in creating weapons of mass destruction. Countries export this technology in part to create dependence and influence the interests of other countries, with the hope of reducing conflict, which our single equation results confirmed, but our simultaneous equations estimates did not.

The results clearly demonstrate that increasing the volume of trade does not necessarily reduce conflict as the impact also depends on the pattern of trade, the limitation being that trade reduces conflict, when the pattern of trade remains constant. This implies that a dyad that increases bilateral trade of each commodity by 5% will be less likely to engage in conflict. Altering the commodities they trade will influence their likelihood of conflict. If the volume of bilateral trade remains constant, but the share of trade in metals (chemicals) increases relative to the share of non-strategic trade, then conflict will increase (decrease). To control for the interdependence created by trade, researchers should account for how much and what countries trade

Data replication

The data used in this article can be obtained from http://www.business.und.edu/goenner/research/data.htm or http://www.prio.no/jpr/datasets.

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