Global Arms Trade and Oil Dependence*

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We investigate how oil dependence affects the trade of weapons between countries. We argue that oil-dependent economies have incentives to transfer arms to oil-rich countries to reduce their risk of instability and, as a result, the chances of disruption in the oil industry. We employ gravity models of the arms trade and estimate the effect of both a local as well as a global oil dependence. Two key results emerge. First, the volume of arms transfers to a specific country is affected by the degree of dependence on its supply of oil. Second, global oil dependence motivates arms export to oil-rich countries even in absence of a direct bilateral oil-for-weapons exchange. Our results point consistently toward the conclusion that the arms trade is an effective foreign policy tool to securing and maintaining access to oil. (*JEL* F10, F50, H56, Q34)

1. Introduction

The international transfers of major conventional weapons is one of the most dynamic sector of international trade. Although the 2008 financial crisis has affected many industries worldwide and has caused a general reduction in government spending, the global volume of arms transfers has grown by 14% between 2004–8 and 2009–13, according to the 2014

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report by the Stockholm International Peace Research Institute (Wezeman and Wezeman 2014). Most of the countries in the world import weapons, and between 2004–8 and 2009–13 imports increased by a staggering 53% in Africa, by 34% in Asia, by 10% in the Americas, by 3% in the Middle East, and decreased by 25% in Europe.[1]

The arms trade is a very controversial issue with many economic and strategic implications on both sides of the transaction. On the demand side, countries import weapons for reasons of national security, but a combination of prices, income, and international political relations affects the optimal bundle of domestic production—sometimes in collaboration with other partners—and import of weapon systems. Using network analysis, Akerman and Seim (2014) show that in the last six decades, the global arms trade network has become more dense, clustered, and decentralized over time. Particularly since the end of the Cold War, the market has become more globalized, with increasing interdependence and cooperation. Today, virtually no states are self-sufficient in arms production, including the United States, and self-produced arms need to be complemented by imported weapons or components (see Brauer 2007). As such, arms import is an essential component of the defense budget.

On the supply side, countries sell weapons for economic reasons, and defense industries are economically strategic in terms of R&D intensity, spin-offs, and decreasing unit costs (Sandler and Hartley 1999; Garcia-Alonso and Levine 2007). Although producing weapons can be inefficient for some countries, many developed economies maintain a domestic defense industrial base for economic and strategic needs, that is, to protect and promote the so-called "national champions" and ensure a level of autonomy. At the same time, subsidies to the domestic arms manufacturers often increase their international market share. Yet, economic motivations are frequently accompanied by political interests; in fact, by exporting weapons, countries also seek to improve the military capabilities of the recipient states. As a necessary adjunct of national policy and strategic doctrine, weapons are often given only to close allies and it is not unusual to observe arms transferred free to allies, under the umbrella of military aid. By the same token, the absence of trade between pairs of country can reflect arms denial and constraints on transfers to specific recipients so as to safeguard national security.[2]

The arms trade has both a political and economic component, and the question of which factors are more likely to affect the bilateral flows of weapons is a timely and important issue. Given its size and scope, there is

1. In the period 2009–13, the top 10 major suppliers of weapons were the United States, Russia, Germany, China, France, United Kingdom, Spain, Ukraine, Italy, and Israel while the top 10 recipients were India, China, Pakistan, the United Arab Emirates, Saudi Arabia, United States, Australia, South Korea, Singapore, and Algeria.

2. Interestingly, however, arms exports may generate negative externalities when, for example, the importing nation becomes a future threat (see Garcia-Alonso and Levine 2007).

surprisingly little empirical research on the arms trade, particularly on its determinants (see Bergstrand 1992; Smith and Tasiran 2005, 2010; Comola 2012; Akerman and Seim 2014). Against this backdrop, we show that the arms trade lies at the intersection of foreign policy and economic concerns and it is an active tool of both geopolitical and economic competition. We use the most economically and politically prominent energy source, oil, and demonstrate how oil interdependence is a critical determinant of the volume of the arms trade between countries.

A recent theoretical model by Garfinkel et al. (2015) explores the consequences of interstate disputes over contested resources, such as oil, for defense spending and trade flows. Contestation of natural resources plays a big role in many interstate disputes and shapes the security policies of the countries involved. Oil, in particular, is a highly "politicized" commodity and responds to international political relations even in times of peace (Mityakov et al. 2013). Civil wars, violent regime changes, and regional instabilities have long been a significant cause of oil shocks, in particular when involving oil-abundant regions. Since the end-use of arms export concerns the security of the recipients, we claim that oil-dependent economies have strong incentives to give away arms to reduce the risk of instability in oil-rich and potentially unstable regions. Specularly, oil-rich countries are more likely to receive weapons by oil-dependent economies.

We estimate the effects of oil interdependence using a gravity model of international trade and explore the extent to which the economic and political characteristics of the client and the supplier, and the connections between them, affect the bilateral arms trade. Deciphering the impact of oil dependence on the arms trade is complicated by the fact that oil and weapons could be simultaneously determined and our model could potentially omit relevant confounders affecting both variables. On the one hand, establishing a relationship between the two variables leaves open the question of whether "oil causes weapons" or vice versa. We strive to include plausibly exogenous variables, such as indicators for the known amount of oil reserves, information on natural resource windfalls—those arising from the discoveries of new oil fields as well as giant oilfields—and oil price shocks.

On the other hand, there are a number of important confounding factors, whose omission could bias the estimates. For example, developed countries that rely on the manufacturing sector might be more likely to be arms producers and at the same time to be net importers of oil. More generally, the presence of specialization and comparative advantages could bias our estimates. We therefore control for multilateral resistance terms, that is, importer-time- and exporter-time-fixed effects (see e.g., Anderson and van Wincoop 2003), which flexibly account for time-varying country-specific unobservables. Also, in some specifications, we include country-pair-fixed effects to capture all time-invariant unobservable bilateral factors influencing arms trade flows. Finally, we implement a battery of robustness checks to support our identifying assumption, including placebo regressions where we use exports of machinery and transport equipment with high levels of sophistication as outcome variable. These additional models help us clarify whether arms are indeed a special commodity with exceptional implications for the type and quality of bilateral economic and political relations.

To anticipate, our empirical analysis paints a clear picture and supports our claim that oil is a crucial factor affecting the volume of arms flows on both sides of the transaction. We proceed as follows: Section 2 provides a brief overview of the latest theoretical and empirical literature on the arms trade and elaborate on our hypothesized mechanism. Section 3 presents the data and the empirical strategy. Section 4 discusses our main empirical results. Section 5 concludes.

2. Energy Security and the Demand and Supply for Weapons

The majority of scholarly research on the arms trade takes the form of theoretical models, which usually focus on the strategic interactions between exporters and importers, and the implications for arms races and arms proliferation—see, foe example, the seminal dynamic models offered by Levine and Smith (1995, 1997, 2000b), who also discuss possible common control regimes. Levine and Smith (2000a), in particular, integrate economic and strategic incentives within a unified framework, and analyze national and international regulatory regimes and market structures. They find that whereas prices have dampening effects on arms race, regulatory regimes can have either positive or negative effects on domestic production and arms imports. Garcia-Alonso and Levine (2007) build on the above models to discuss the main strategic characteristics of the arms trade and to examine the determinants of market structure in the military sector. Sandler (2000) explores collective action failures in relation to arms control and security. Kollias and Sirakoulis (2002) model the effects that arms imports have on the military balance between two antagonistic regional players. Finally, Seitz et al. (2015) provide a model of trade, conflict, and defense spending with an arms race and determine the magnitude of welfare gains due to reductions in the likelihood of conflict and defense spending cuts.

Empirical works on the decision-making processes behind the arms trade and on the characteristics and relations between suppliers and recipients are scant at best.[3] Bergstrand (1992) estimates the effects of arms reduction on world trade using data for 17 OECD countries over the 1975–85 period. He also uses a gravity model for gaining insight in the economic determinants of the arms trade and finds that the model is limited in its capacity to explain this sort of trade, as it is “determined

3. A number of empirical studies reverse the causal arrow and look at the effects of arms transfer on several outcomes, such as interstate conflict, ethnic uprisings, and repression; Kinsella (2011) offers a comprehensive and recent review of this strand of the literature.

largely by political, military or other non-economic factors" (Bergstrand 1992: 137). Blanton (2000, 2005) explores the impact of human rights and democracy on the eligibility of a country to receive weapons from the United states. Smith and Tasiran (2005, 2010) examine the factors affecting the elasticity of arms imports with respect to military expenditure, *per capita* income, and the price of arms imports, and address issues of measurement errors, non-linearity, and dynamic specification. Comola (2012) explores the existence of political cycles in arms exports using data on the top 20 major exporters over the period 1975–2004; she finds that right-wing incumbents increase arms exports, whereas higher concentration of power and incumbents serving the last year of their term and potentially running for re-election have the opposite effect. Finally, Akerman and Seim (2014) find a negative relationship between differences in the polity and the likelihood of the arms trade during the Cold War.

We advance the relevance of geo-economic and geo-strategic considerations and suggest that energy interdependence is a major factor explaining the volume of arms transfers between states. In doing so, we expand the range of perspectives on the arms trade beyond questions of economic and political determinants at the national level to issues of energy dependence at the international level.

The arms trade, security, and energy dependence are heavily interconnected. On the demand side, recipients receive weapons mainly for reasons of national security as the acquisition of new equipments improves their defense capabilities (e.g., Levine and Smith 2000b). Although other reasons for importing weapons exist, security is usually the main objective. On the supply side, arms are exported to support the security needs of friends and allies, and to strengthen security links. Moreover, many countries receive military aid to buy weapons and equipment from the donor country. The United States is the largest supplier of military aid to over 150 foreign countries in the world, with the explicit goal of contributing to regional and global stability, strengthening military support for democratically elected governments, and containing transnational threats.[4]

Therefore, the end-use of the arms trade concerns the security of the recipients. We claim that this is particularly crucial when the recipient state is a main supplier of energy and when the arms exporter is dependent on it. Conspiracy theorists have long insisted that modern wars revolve around oil, the main energy source worldwide. The post-WWII period has many instances of military intervention in oil-rich states, such as in Angola, Chad, Guatemala, Indonesia, Mali, Nigeria, Sudan, and the Philippines. Recent events include the military intervention in Libya in 2011 by a coalition comprising most of NATO oil-dependent economies, or the US campaign against Isis in northern Iraq. Bove et al. (2015) find

4. USAID Economic Analysis and Data Services (2012): *US Overseas Loans and Grants, Obligations and Loan Authorizations Greenbook* (http://pdf.usaid.gov/pdf_docs/PNAEC300.pdf).

that the likelihood of a third-party intervention in civil war increases when the country at war has large reserves of oil and such interventions are more likely to be carried out by countries that highly depend on oil imports. Yet, military intervention is expensive and risky and can easily cause domestic backlash if the benefits are not clear-cut. To support the security needs of allies and strategic partners, countries can resort to alternative, less invasive, foreign policy tools.

We argue that the provision of security extends beyond direct military intervention and war times and that the export of arms is an effective substitute for costlier forms of assistance. The arms trade therefore contributes to counter local threats, to inhibit or reduce the risk of political instabilities and, as a result, the chances of disruption in the oil trade. Violent events such as civil wars or terrorist incidents are often accompanied by surging oil prices, or more generally insecurity in the supply of oil; this was the case in many recent wars, such as during the Gulf War, 9/11, the Iraq War, the Lebanon Conflict, and the political unrests in Venezuela in 2003. Political instabilities do not necessarily cause disruptions in oil production, yet they can affect prices and/or future supplies. Kilian (2009) explores exogenous political events in the Middle East and finds that wars or revolutions affect the real price of oil through "their effect on precautionary demand for oil. The latter channel can produce immediate and potentially large effects on the real price of oil through shifts in the uncertainty about future oil supply shortfalls, even when crude oil production has not changed" (Kilian 2009: 1064). The prospects of energy supply disruptions and increases in oil prices can easily put at risk fragile economies while posing significant costs for more developed countries. Disruptions in the oil industry and higher oil prices may in fact negatively affect the real GDP growth, the real wages, and increase the short-term interest rates (e.g., Kilian 2008; Lippi and Nobili 2012). These negative effects are more likely to materialize in oil-importing countries, which therefore have incentives to reduce the risk of instabilities in oil-rich countries.

A seminal study by SIPRI (1971) identifies, among the purposes of arms supply, a "hegemonic" aim: countries can use arms transfers to "support a particular group in power, or to prevent the emergence of an alternative group" (SIPRI 1971: 17). This is consistent with recent studies which provide convincing evidence that military aid can be effective at keeping terrorist groups out of power (see Bapat 2011). Therefore, the deliveries of major conventional weapons can be put forward as evidence of the supplier's commitment to the security and military advantage of the recipient state. In most of the wars fought in the last few decades and in most of the confrontations between states and terrorist groups, foreign arms, or restraints on arms supplies, have played a central role in determining the success of the combatants. Ensuring the military advantage of a country against domestic and external threats is all the more important when this country is a key supplier of oil and when the arms supplier is dependent on oil. Improving the security of the oil-rich economies makes them more reliable suppliers of oil, and, at the same time, reduces the uncertainty about shortages in future oil supplies, which affect oil prices (Kilian 2009).

Note, however, that we are not suggesting the sole existence of a direct oil-for-weapons mechanism. By providing weapons, the oil-dependent country seeks to contain the risk of instabilities in an oil-rich country; yet, the latter does not necessarily need to be its *direct* oil supplier, because disruptions in the production of oil in this country are very likely to affect oil prices worldwide. In sum, we seek to test two related expectations, or hypotheses:

> H1 (local dependence): The larger the amount of oil imported from a country, the higher the volume of arms exported to the same country.
>
> H2 (global dependence): The larger the level of global oil dependence, the higher the volume of arms exported to oil-rich countries.

Although theoretically intertwined, the two mechanisms require two substantially different empirical models, the issue considered next.

3. Data and Empirical Strategy

To measure the volume of international transfers of arms we use the SIPRI Arms Transfers Database, which contains information on all transfers of major conventional weapons since 1950. SIPRI has developed a unique system that uses a common unit, the trend-indicator value (TIV), to permit comparisons between deliveries of different weapons. The TIV is based on the known unit production costs of a core set of weapons and is useful to estimate the transfer of military resources rather than the financial value of the transfer. The TIV fits well with the purpose of our analysis, explaining the quantities of arms transfers rather than the contracted prices, which can be as low as zero in the case of military aid.[5]

To measure oil dependence, we assemble a very comprehensive dataset on stock variables such as oil reserves and new oil discoveries, as well as on flow variables, in particular oil imports and exports. Data on oil reserves and on new oil discoveries in thousand million barrels come from Cotet and Tsui (2013), who draw information from the Association for the Study of Peak Oil and Gas, the BP Statistical Review of World Energy, and the Oil & Gas Journal. In addition, we use data on giant oilfield discoveries from Lei and Michaels (2014), where giant oilfields are those containing ultimate recoverable reserves (URRs) of 500 million barrels (bbl) equivalent or more before extraction begins.

5. More details are available on SIPRI's website (http://www.sipri.org/databases/armstransfers).

To test Hypothesis 1, we first construct a measure of net oil import, using disaggregated bilateral trade flows from Feenstra et al. (2005). This measure indicates the volume of net import of oil of the arms exporter (i.e., the oil-dependent country) from the arms importer (i.e., the oil-rich country). Note that this variable can be thought of as being made by two components. The first is whether the country-pair includes an oil-producing and an oil-dependent country, otherwise net imports would be zero; the second is whether the pair of countries actually has an established trading relationship, which is related to whether they are economic partners and/or political allies. The data are organized by four-digit SITC Revision 2 and cover trade flows reported by 149 countries (98% of world exports) for the period from 1962 to 1999. The availability of data on oil flows limits our study to the same period.[6]

We then estimate the effect of net oil import on the arms trade between countries using a gravity equation model and the Poisson Pseudo Maximum-Likelihood (PPML) estimator developed by Santos Silva and Tenreyro (2006).[7] The gravity equation takes the following form:

$$Y_{ijt} = \alpha \ \exp(\beta \ \text{Net oil import}_{ijt} + G'_{ij} \ \delta + D'_{ijt} \ \lambda + \theta_{it} + \tau_{jt}) \ \epsilon_{ijt}, \qquad (1)$$

where Y_{ijt} is the volume of major weapons transfers from country i to country j at time t and Net oil import_{ijt} is our variables of interest, the degree of oil dependence of country i from country j at time t. The vector G'_{ij} includes the classical impediments or facilitating factors in a list of time-invariant gravity controls, namely: the capital-to-capital distance; a measure of religious distance; a set of binary variables taking value 1 if i and j have a common language, common ethnicity, or colonial history. The vector D'_{ijt} includes a number of time-varying gravity controls, in particular a binary variable taking value 1 if i and j have a common

6. Note that the limit of the sample is not particular to our study, and most other studies use the Feenstra et al. (2005)'s data for similar analyses. As Baier et al. (2014: 344) puts it, Feenstra et al. (2005) is "the most disaggregated publicly available data set for bilateral trade flows for a large number of years and a large number of country pairs, constructed on a consistent basis".

7. There are several advantages of using the PPML over alternative models. First, the value of our dependent variable is most often zero, and the classical log–log gravity model is unsuitable when Y_{ijt} is zero. Dropping all the observation with no trade induces a sample selection issue, and we would lose a number of important information on cases of arms denial and constraints on the export of weapons to specific states. Using the logarithm of $Y_{ijt}+1$ as the dependent variable generates inconsistency in the parameter of interest (Santos Silva and Tenreyro 2006). Moreover, our dependent variable is highly heteroskedastic; we have small deviation when i and j are small countries with no political relations, whereas large values and large dispersions around the mean are observed when i and j are powerful and connected. Under heteroskedasticity, estimating log-linearized equation by OLS leads to significant biases. However, the PPML estimator is robust to different patterns of heteroskedasticity, provides a natural way to deal with zeros in trade data, and is resilient to measurement error of Y_{ijt}, which can potentially contaminate our analysis (see Santos Silva and Tenreyro 2006, 2011). A recent article by Fally (2015) also argues in favor of the PPML and gives additional motivation for using it.

currency, and a dummy that equals 1 for regional trade agreements (RTAs) in force. Moreover, we include information on military alliances and political affinities; the latter measures the preferences of each state, or more precisely, the interest similarity among pairs of states on the basis of voting patterns at the UN General Assembly [see Voeten and Merdzanovic (2009) for further details]. θ_{it} and τ_{jt} serve, respectively, as exporter-time- and importer-time-fixed effects, accounting for the multilateral resistance terms. Note that the inclusion of importer-time- and exporter-time-fixed effects addresses endogeneity bias that might arise from the omission of important determinants of arms export. These are meant to capture all unobservable time-varying characteristics for both country *i* and *j*, for example, the relevance of the manufacturing sector, which is energy-intensive, or the presence of specialization and comparative advantages. To further address endogeneity concerns, in some specifications, we include country-pair-fixed effects which allow to take into account all time-invariant bilateral factors (e.g., any form of connections between countries) affecting arms trade flows and year-fixed effects. We also include year-fixed effects to deal with the potential co-evolution of arms transfers and net oil import over time. Finally, ϵ_{ijt} is a multiplicative error term with $E(\epsilon_{ijt}|\text{Net oil import}_{ijt}, G'_{ij}, D'_{ijt}, \theta_{it}, \tau_{jt}) = 1$, assumed to be statistically independent of the regressors. We report robust standard errors clustered at the country-pair level to allow for the variance to differ across pairs; this further addresses the issue of heteroskedasticity in the error terms and controls for autocorrelation by allowing an unstructured covariance within the clusters.

Although Equation (1) is our preferred specification, we also estimate a less stringent version of it, where we replace multilateral resistance terms with a set of country *i*'s and country *j*'s characteristics, respectively. More specifically, the set of country *i*'s characteristics includes real GDP to capture the economic size of the country (larger countries should import higher volumes of weapons); the level of democracy (the Polity IV indicator) to capture the degree of institutional development; the level of military spending in % of the GDP and the number of armed forces in % of the population; and the membership in NATO or the Warsaw pact. The set of country *j*'s characteristics includes all the above variables and additional controls to account for any form of intra-state and inter-state conflict involving country *j*; the number of wars in its neighborhood to pick up additional security threats; and the presence of an international arms embargo on *j*. Tables A1 provides information on the name, definition, and source of all the above variables and Tables A2 contains the summary statistics.[8]

8. Note that since the algorithm does not converge when the dependent variable has large values, we follow Santos Silva and Tenreyro's (2006) advice and rescale it. Rescaling arms transfers does not affect the substantive interpretation of the coefficients of interest.

Hypothesis 2 states that oil-dependent countries are more inclined to export arms to oil-rich countries, in order to safeguard its political stability and, as a consequence, prevent oil shocks and higher oil prices in international markets. To test Hypothesis 2, we augment Equation (1), with an interaction between a dummy indicating whether the arms exporter is an oil-dependent country in the global system and a dummy indicating whether the arms importer is an oil-rich country in the global system. This simple strategy allows us to disentangle the effect on the arms trade of a global oil dependence, when the arms exporter wants to keep global oil prices stable in international markets, from that of a local oil dependence, when the arms exporter wants to safeguard the supply of oil from a particular country. We therefore estimate the following model:

$$Y_{ijt} = \alpha \exp(\beta \text{ Net oil import}_{ijt} + \gamma \text{ Oil dependent}_{it} * \text{Oil rich}_{jt} + \\ + G'_{ij}\ \delta + D'_{ijt}\ \lambda + \theta_{it} + \tau_{jt})\ \epsilon_{ijt}, \qquad (2)$$

where Oil dependent_{it} is a dummy that takes value 1 if country i is net importer of oil in the global system, that is, when the balance of global trade in oil (the difference between global volumes of oil import and oil export) is negative. Oil rich_{jt} is a dummy that takes value 1 if country j is rich in oil. As a proxy for the abundance of oil in country j, we use stock variables such as oil reserves and new oilfield discoveries at time t in lieu of flow variables like oil production which could be potentially endogenous to arms import.

On the one hand, the timing and relative size of new oilfield discoveries are mostly random, at least in the short-medium run, as prospecting for oil is highly uncertain, and countries have generally little control over the timing of such discoveries (see e.g., Lei and Michaels 2014). Moreover, oil discoveries convey important information about the potential for oil production in the very near future. Cotet and Tsui (2013) and Lei and Michaels (2014), among others, discuss how (unexpected) oil discoveries generate exogenous variation in oil wealth and increase *per capita* oil production and oil exports. On the other hand, to ensure that our results are not driven by this particular operationalization, we also use alternative definitions of the oil rich dummy, which takes the value 1 if a country's total amount of oil reserves belongs to the 75th, 90th, 95th, or 99th percentile of the total (global) oil reserves at time t. This stock variable should be less vulnerable to endogeneity concerns than oil production, as reserves depend on geological features and previous exploration efforts. Our parameter of interest is now γ as it speaks to the issue of global oil interdependence (Hypothesis 2), whereas β speaks to the issue of local dependence (Hypothesis 1).

4. Empirical Results

4.1 Arms Transfers and Local Oil Dependence

Tables 1 and 2 provide the main tests of Hypothesis 1, a direct oil-for-weapons exchange. Before moving to the most stringent specification, that

Table 1. Arms Transfers and Net Oil Import, PPML Estimates

	Arms transfers$_{ijt}$				
	(1)	(2)	(3)	(4)	(5)
Net oil import$_{ijt}$	3.625***	1.358**	1.731***	1.662***	1.695***
	(0.535)	(0.653)	(0.600)	(0.601)	(0.594)
Country i*'s characteristics*					
GDP		3.461***	4.325***	5.768***	5.125***
		(0.225)	(0.303)	(0.495)	(0.373)
Democracy		0.026	0.027	0.017	0.014
		(0.022)	(0.020)	(0.017)	(0.017)
NATO		1.557***	1.554***	1.270***	1.293***
		(0.207)	(0.219)	(0.200)	(0.199)
Warsaw pact		−1.274**	−1.215**	−1.488***	−1.482***
		(0.507)	(0.488)	(0.467)	(0.469)
Military burden		0.011***	0.011***	0.009***	0.010***
		(0.001)	(0.001)	(0.001)	(0.001)
Soldiers *per capita*		−19.478**	−13.968*	−26.424***	−27.176***
		(7.663)	(7.463)	(9.263)	(8.294)
Country j*'s characteristics*					
GDP		2.927***	3.446***	4.582***	4.171***
		(0.626)	(0.413)	(0.555)	(0.488)
Democracy		0.018	−0.007	−0.000	0.003
		(0.021)	(0.016)	(0.014)	(0.015)
NATO		0.414	−0.201	−0.262	−0.249
		(0.422)	(0.383)	(0.307)	(0.343)
Warsaw pact		−1.166	−1.038	−1.257	−1.110
		(0.905)	(0.834)	(0.853)	(0.846)
Military burden		0.002***	0.003***	0.002***	0.003***
		(0.001)	(0.000)	(0.001)	(0.001)
Soldiers *per capita*		26.928***	22.642***	18.253***	19.595***
		(9.394)	(6.576)	(5.523)	(6.086)
War		0.073	0.071	0.003	0.075
		(0.200)	(0.146)	(0.176)	(0.156)
Neighboring wars		0.164*	0.210***	0.226***	0.234***
		(0.092)	(0.068)	(0.070)	(0.069)
Arms embargo		−0.887	−0.942	−0.699	−0.830
		(0.612)	(0.614)	(0.656)	(0.655)
Country-pair's characteristics					
Military alliance			1.140***	0.826***	0.935***
			(0.369)	(0.300)	(0.331)
Political affinity			1.268***	1.452***	1.161***
			(0.205)	(0.214)	(0.186)
Year trend					−0.047***
					(0.008)
Gravity controls	No	No	Yes	Yes	Yes
Year-fixed effects	No	No	No	Yes	No
Clusters	8765	8765	8765	8765	8765
Observations	66,037	64,531	64,531	64,531	64,531

Notes: Robust standard errors in parentheses are clustered at country-pair level. The dependent variable, Arms transfers$_{ijt}$, measures the volume of major weapons transfers from country *i* to country *j* at time *t*. Net oil import$_{ijt}$ measures the net oil import (import–export) of country *i* from country *j* at time *t*. Gravity controls include distance, common colony, common currency, common ethnicity, common language, common religion, and RTAs.
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 2. Arms Transfers and Net Oil Import, PPML Estimates with Fixed Effects

	Arms transfers$_{ijt}$		
	(1)	(2)	(3)
Net oil import$_{ijt}$	1.112***	1.615**	0.987***
	(0.325)	(0.627)	(0.378)
Military alliance	0.911***	0.808***	0.812*
	(0.298)	(0.281)	(0.484)
Political affinity	0.861***	2.232***	2.245***
	(0.192)	(0.581)	(0.372)
Gravity controls	Yes	Yes	Yes
Year trend	Yes	No	No
Year-fixed effects	No	No	Yes
(*i*)- and (*j*)-fixed effects	Yes	No	No
(*it*)- and (*jt*)-fixed effects	No	Yes	No
(*ij*)-fixed effects	No	No	Yes
Clusters	8765	8919	1112
Observations	64,531	63,129	32,573

Notes: Robust standard errors in parentheses are clustered at country-pair level. The dependent variable, Arms transfers$_{ijt}$, measures the volume of major weapons transfers from country *i* to country *j* at time *t*. Net oil import$_{ijt}$ measures the net oil import (import–export) of country *i* from country *j* at time *t*. Gravity controls include distance, common colony, common currency, common ethnicity, common language, common religion, and RTAs.
*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

is, a model with multilateral resistance terms in Equation (1), we start with less demanding models. Column (1) in Table 1 provides an initial test of the impact of net oil import on the volume of the arms trade, when no other control variables are included. The estimated coefficients for net oil import is positive and significantly discernible from zero at the 1% level. In Column (2) we include the set of monadic controls (i.e., country *i*- and country *j*-specific characteristics). In Column (3) we add the set of dyadic controls (i.e., country-pair characteristics). In Column (4) we control for year dummies, and in Column (5) for a linear time trend. Our coefficient of interest, β, is remarkably stable across model specifications and remains positive and statistically significant at the 1% level. The PPML specification allows for direct reading of the coefficients, and the substantive interpretation is similar to a semi-elasticity. Net oil import is measured in 10 million metric tons with a mean value of 0.0028 (28,000 metric tons) and a standard deviation of 0.0048 (48,000 metric tons). Based on the estimate in Column (4), this means that a one-standard deviation increase in the net oil import of country *i* from country *j* will lead to a 21% increase in the volume of arms transfers from *i* to *j*.[9] These findings provide a first corroboration of the thesis outlined by Hypothesis 1 and demonstrates that the higher is the net oil import of country *i* from country *j*, that is, its local oil dependence on country *j*, the higher is its exports of arms to *j*.

9. One metric ton corresponds to 8.45 barrels. The semi-elasticity needs to be computed as $\exp^{\hat{\beta}} - 1$.

We now briefly turn to our contextual covariates on the supply and demand side of the arms trade. We find that the arms trade is a positive function of both *i*'s and *j*'s real GDP. It is not however associated with the level of democracy in the exporting and importing country. We include the military spending in % of the GDP to capture military capabilities on the supply side, and perception of threats on the demand side, when it is not adequately picked up by the war variables. Military spending displays a positive effect, significant at conventional levels, on both sides. We also include the number of armed forces in % of the population for both *i* and *j*, a proxy of the labour intensity of a country's force structure (see, e.g., Smith and Tasiran 2005, 2010). Whereas this is negative on the supply side, it is positive on the demand side, reflecting the modernization of labor-intensive armed forces. Note also that being a member of NATO (or the Warsaw pact) increases (decreases) the volume of arms export, but it does not significantly affect the demand for weapons. As one would expect, the number of wars in the immediate vicinity of *j* (neighboring wars) increases its import of weapons while domestic war is not significantly different from zero.

On the demand side, results mirror previous studies on the decision to import arms, which reflects threats, proxied here by wars or military spending, and the size of a country, proxied by the GDP (see Smith and Tasiran 2010). The presence of international arms embargo against the importing country reduces its level of arms import, due to possible compliance dynamics, but it fails to achieve statistical significance. Our two measures of connectedness, military alliances, and political affinity, display a positive sign; this indicates that arms transfers between two states depend on the presence and strength of cordial diplomatic and military relations. Following the traditional literature on the determinants of bilateral trade, we also include customary control variables, such as the geographic distance, the presence of a common religion, a common ethnicity, a common language, a common colonial history, and a RTA. We omit these additional rows due to space limitations, although the full results can be produced with our replication material.[10]

Although we strive to control for a host of determinants of the arms trade and get as close of an estimate as possible of a pure "local oil dependence" effect, it is still possible that unobservable factors affect both the transfers of arms and the net import of oil. In such a case, the PPML estimation might produce biased estimates. To address these endogeneity concerns, in Table 2, Column (1), we include country-specific (*i* and *j*)-fixed effects to account for time-invariant unobservables at the country

10. Whereas the effect of most of these variables is in the expected direction, geographic distance is often insignificant or positive. Bergstrand (1992) finds a negative effect of distance on the arms trade, yet he uses only 17 OECD countries. A negative effect could be driven by countries' strategic decision to deny arms transfers to potential regional competitors. Interestingly, distance becomes negative in Table 5 when we exclude major players.

level. While the omitted variable bias generated by stable unit-level confounders is handled in the fixed-effects model reported in Column (1), this does not guard against confounders that are time varying. Therefore in Column (2) we estimate Equation (1), a specification with the inclusion of *it*- and *jt*-fixed effects (i.e., the multilateral resistance terms) to flexibly capture all the time-varying barriers to trade that each country faces with all its trading partners every year. This specification soaks up all the effects of country *i*'s and country *j*'s characteristics in the *it*- and *jt*-fixed effects. In addition to this, in Column (3) we run a specification with country-pair-fixed effects to absorb time-invariant characteristics at the dyadic level.[11] Note that this model requires us to exclude all dyads where we do not observe variation in arms transfers over time, in our case almost half of the total number of observations. Results in Table 2 show that our coefficient of interest remains statistically significant when taking into account additional unobservables. Reading across the first row of results in Table 2, we find that a standard deviation increase in the volume of net oil import increases the bilateral arms transfer by a minimum of 8%.

4.2 Arms Transfers and Global Oil Dependence

Table 3 offers a direct test of Hypothesis 2, on the effect of global oil dependence, while keeping local oil dependence (i.e., net oil import) constant. We also control for the full set of country-pair's characteristics and estimate models with multilateral resistance terms. Reading across the first row of results, we find that net oil import continues to exert a positive, significant, and substantive effect on the volume of arms transfers; the coefficients are similar in magnitude to those in Table 2, Column (2), which makes use of the same conservative specification with multilateral resistance terms.

The second row presents an interaction between the Oil dependent dummy, on the supply side, and the Oil rich dummy, on the demand side. Whereas defining an oil-dependent economy is quite straightforward (i.e., whether it is a net importer of oil or not), we use alternative definitions of an Oil rich economy. In Column (1) we look at whether *j* has a positive discovery of oil at time *t* and we find that its interaction with Oil dependent is associated with a 56% increase in the quantity of arms transfers. Columns (2)–(5) display the results of four alterations of the definition of Oil rich, according to the percentile distribution of oil reserves in country *j*, which provides an additional exogenous source of variation. As one moves across the columns of the table, the stringency of this definition gradually builds up and we find that only countries belonging to the 95th or 99th percentile of oil reserves at time *t* receive higher amount of arms, and that this effect is conditional on whether the arms exporter is oil-dependent. Interestingly, the size of the marginal effect in Column (4) is

11. Note that we do not have enough variation in the data to estimate a model that includes *it*-, *jt*-, and *ij*-fixed effects simultaneously (see summary statistics in Table A2).

Table 3. Arms Transfers, Net Oil Import, and Global Oil Dependence

	Arms transfers$_{ijt}$				
	Oil rich$_{jt}$ = 1 if new oil discoveries$_{jt}$ > 0	Oil rich$_{jt}$ = 1 if oil reserves$_{jt}$ ≥			
		*p*75	*p*90	*p*95	*p*99
	(1)	(2)	(3)	(4)	(5)
Net oil import$_{ijt}$	1.602***	1.574**	1.530**	1.458**	1.326**
	(0.614)	(0.632)	(0.622)	(0.616)	(0.600)
Oil dependent$_{it}$ * Oil rich$_{jt}$	0.454**	0.232	0.269	0.542**	0.935***
	(0.203)	(0.248)	(0.256)	(0.262)	(0.288)
Military alliance	0.808**	0.834***	0.810**	0.794**	0.761**
	(0.323)	(0.312)	(0.317)	(0.309)	(0.305)
Political affinity	2.232***	2.240***	2.217***	2.214***	2.147***
	(0.320)	(0.319)	(0.318)	(0.314)	(0.308)
Gravity controls	Yes	Yes	Yes	Yes	Yes
(*it*)- and (*jt*)-fixed effects	Yes	Yes	Yes	Yes	Yes
Clusters	8919	8919	8919	8919	8919
Observations	63,129	63,129	63,129	63,129	63,129

Notes: Robust standard errors in parentheses are clustered at country-pair level. The dependent variable, Arms transfers$_{ijt}$, measures the volume of major weapons transfers from country *i* to country *j* at time *t*. Net oil import$_{ijt}$ measures the net oil import (import–export) of country *i* from country *j* at time *t*. Oil dependent$_{it}$ is a dummy variable that takes value equal to 1 if country *i* is a net oil importer in the global system at time *t*. Oil rich$_{jt}$ is a dummy variable that takes value equal to 1 if country *j* has a new oil discovery at time *t*, in Column (1). In Columns (2)–(5), Oil rich$_{jt}$ is redefined equal to 1 if country *j*'s total amount of oil reserves belongs to the 75th, 90th, 95th, and 99th percentile of the global oil reserves at time *t*, respectively. Gravity controls include distance, common colony, common currency, common ethnicity, common language, common religion, and RTAs.
*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

very similar to that of Column (1), around 0.5, although they use quite different operationalizations of Oil rich. The other contextual variables all continue to add significantly to the fit of the model in the same direction. This provides further evidence that global oil dependence does matter, and that the volume of the arms trade is systematically higher when the exporter is an oil-dependent economy and the importer is an oil-rich country.

4.3 Robustness Checks

We test the robustness of our findings in a number of additional ways. First, we ask whether the potential failure to fully address endogeneity concerns might introduce bias into our estimated models. Therefore, in Table 4 we estimate a series of regressions as in Equations (1) and (2) using alternative exogenous sources of variation in local and global oil dependence. In particular, following Brückner et al. (2012) and Bazzi and Blattman (2014), we use changes in international oil prices over time to capture variation in the local oil dependence. We examine the interaction between Avg. Net oil import$_{ij}$, the oil dependence of country *i* from country *j* over the whole time period considered, and Δ ln oil price$_t$, the

Table 4. Robustness Checks

	Arms transfers$_{ijt}$			
	(1)	(2)	(3)	(4)
Avg. Net oil import$_{ij}$ * Δ ln oil price$_t$	1.080***	1.200**	1.248**	1.060**
	(0.488)	(0.488)	(0.491)	(0.488)
Oil dependent$_{it}$ * Oil rich$_{jt}$		0.488**		
		(0.203)		
Oil dependent$_{it}$ * Oil rich$_{jt}$ (2nd def.)			0.449**	
			(0.227)	
Oil dependent$_{it}$ * Oil rich$_{jt}$ (3rd def.)				0.436*
				(0.261)
Military alliance	0.625**	0.616**	0.643**	0.625**
	(0.309)	(0.308)	(0.309)	(0.308)
Political affinity	2.155***	2.187***	2.117***	2.152***
	(0.326)	(0.327)	(0.328)	(0.326)
Gravity controls	Yes	Yes	Yes	Yes
(*it*)- and (*jt*)-fixed effects	Yes	Yes	Yes	Yes
Clusters	8919	8919	8919	8919
Observations	63,129	63,129	63,129	63,129

Notes: Robust standard errors in parentheses are clustered at country-pair level. The dependent variable, Arms transfers$_{ijt}$, measures the volume of major weapons transfers from country *i* to country *j* at time *t*. Avg. Net oil import$_{ij}$ measures the average value of net oil import of country *i* from country *j* over the whole sample period (1962–1999). Δ ln oil price$_t$ measures the ln-change in international oil prices between *t*–1 and *t* so as an increase in Δ ln oil price$_t$ implies a reduction in international oil prices over time. Therefore, the interaction term Avg. Net oil import$_{ij}$ * Δ ln oil price$_t$ captures how variations in international oil prices affect the net oil import of country *i* from country *j* over time (i.e., country *i*'s local oil dependence from country *j* at time *t*). In Column (2) the interaction Oil dependent$_{it}$ * Oil rich$_{jt}$ is the one used in Column (1) of Table 3. In Column (3) this interaction is between an indicator for countries with no oilfield discovery between time *t* and *t*–10 (as proxy for Oil Dependent$_{it}$) and an indicator for countries with a giant oilfield discovery (with size in top quartile) between time *t* and *t*–3 (as proxy for Oil rich$_{ij}$). In Column (4), the interaction is between an indicator for countries with a share of the global cumulative oil discoveries below the median at time *t* (as proxy for Oil dependent$_{it}$) and an indicator for countries with a share of the global cumulative oil discoveries above the 99th percentile at time *t* (as proxy for Oil rich$_{jt}$). Gravity controls include distance, common colony, common currency, common ethnicity, common language, common religion, and RTAs.
*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

ln-change in international oil prices over time. As Brückner et al. (2012: 390) put it, "this formulation captures that the impact of international oil price shocks should be greater in countries with greater net oil exports over GDP". In other words, as "the economy is most sensitive to commodity price shocks in commodity-dependent nations" (Bazzi and Blattman 2014: 8), oil price shocks should be felt more strongly in countries with greater bilateral oil dependence.[12] Moreover, to further guard against bias in estimating the effect of global oil dependence on the arms trade, our second hypothesis, we use alternative definitions of Oil dependent$_{it}$ and Oil rich$_{jt}$. In Column (3) we use an indicator for countries

12. Note that, to facilitate the interpretation of our coefficients, a positive Δ ln oil price$_t$ implies a reduction of oil prices, thus an increase in the local oil dependence. Note also that this strategy is not entirely immune from other potential sources of endogeneity in this shock, and Bazzi and Blattman (2014) discuss the possible caveats.

with no oilfield discovery between time t and $t-10$ and an indicator for countries with a giant oilfield discovery (with size in top quartile) between time t and $t-3$, respectively; in Column (4) we use an indicator for countries with a share of the global cumulative oil discoveries below the median at time t and an indicator for countries with a share of the global cumulative oil discoveries above the 99th percentile at time t, respectively. To avoid opening the door to subjective coding, Table A3 replicates models in Table 4 using indicators for countries with no oilfield discovery between time t and $t-s$ with $s = 6$, 7, 8, and 9 and indicators for countries with giant oilfield discovery between time t and $t-s$ with $s = 4$, 5, and 6. Our results hold up well to this series of specification checks and the size of the coefficients is almost unaltered, which increases the confidence in our results.

Second, as errors for countries belonging to the same cluster may be correlated, it is common to report standard errors that account for clustering of units. In our models errors are likely to be correlated by country pair, given the complex economic and political dependency structure that arises due to the connections between dyad members (Aronow et al. 2015). In fact, dyadic clustering could arise in many ways with these data, if for example, a country enters into an alliance, thereby changing the military alliance indicators, or if the political affinity changes (Aronow et al. 2015). It is also customary to allow for clustering by country pair in a gravity model context (Helpman et al. 2008). Yet, as it is sometimes difficult to justify why we use clustering in some dimensions but not others (Abadie et al. 2017), in Table 5, Columns (1) and (2), we re-estimate our baseline models with robust standard errors clustered at exporter level. Our results remain statistically significant at conventional levels.

Third, we ask whether our results are driven by specific outliers. Top arms exporters in the period under consideration are the two global powers, United States and Russia, while two countries, Saudi Arabia and Iran, are top oil producers and the major importers of weapons. We exclude them in Table 5, Columns (3) and (4), and, by and large, the results carry over, thus suggesting that they do not rely on outliers. In fact, the size of the coefficients is now larger than in models with the full sample.

Fourth although our hypotheses speak to the issue of oil dependence, it could be easily extended to strategic natural resources, more generally. Gas is an obvious candidate, and we reproduce the baseline models but use gas in lieu of oil. The results are shown in Columns (5) and (6) of Table 5. The coefficient on the interaction term is overall similar to the ones presented above for the case of oil, while net gas import is similar in magnitude but not statistically significant. This last result suggests that global dependence on gas is more crucial than a direct gas-for-weapons relation.

Fifth, oil-rich economies often import goods and services in exchange for the oil that they export. An important question is whether weapons are different from other manufactured goods that embody a similar level of

Table 5. Additional Robustness Checks

	Arms transfers$_{ijt}$					
	Clustering by exporter		Excluding USA, RUS, SAU, IRN		Using gas *in lieu* of oil	
	(1)	(2)	(3)	(4)	(5)	(6)
Net oil import$_{ijt}$	1.615**	1.602**	3.084*	3.002*		
	(0.762)	(0.748)	(1.823)	(1.787)		
Oil dependent$_{it}$ * Oil rich$_{jt}$		0.454**		0.815***		
		(0.177)		(0.208)		
Net gas import$_{ijt}$					1.722	1.504
					(1.247)	(1.254)
Gas dependent$_{it}$ * Gas rich$_{jt}$						0.736***
						(0.249)
Military alliance	0.812**	0.808***	0.231	0.220	0.669**	0.734***
	(0.277)	(0.281)	(0.336)	(0.327)	(0.326)	(0.328)
Political affinity	2.245***	2.232***	1.463***	1.381***	2.164***	2.238***
	(0.597)	(0.581)	(0.413)	(0.403)	(0.329)	(0.324)
Gravity controls	Yes	Yes	Yes	Yes	Yes	Yes
(*it*)- and (*jt*)-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Clusters	81	81	8907	8907	8919	8919
Observations	63,129	63,129	43,879	43,879	63,129	63,129

Notes: Robust standard errors in parentheses are clustered at the exporter level in Columns (1) and (2) and at country-pair level in Columns (3)–(6). The dependent variable, Arms transfers$_{ijt}$, measures the volume of major weapons transfers from country *i* to country *j* at time *t*. Net oil import$_{ijt}$ measures the net oil import (import–export) of country *i* from country *j* at time *t*. Oil dependent$_{it}$ is a dummy variable that takes value equal to 1 if country *i* is a net oil importer in the global system at time *t*. Oil rich$_{jt}$ is a dummy variable that takes value equal to 1 if country *j* has a new oil discovery at time *t*. In Columns (3)–(4) we exclude the major arms' exporters (United States and Russia) and the richest oil countries (Saudi Arabia and Iran). In Columns (5) and (6), we re-estimate our main specifications by using gas *in lieu* of oil. Gravity controls include distance, common colony, common currency, common ethnicity, common language, common religion, and RTAs.
*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

technology. Therefore, in Table 6, we run a number of placebo regressions by replacing arms transfers with "machinery and transport equipment" (SITC code 7), that is, machines with comparable levels of sophistication as weapons but without clear military attributes. Our results show that none of the coefficients of local and global oil dependence are significantly different from zero across the various sectors. The results are interesting because they suggest that arms are indeed a special commodity with economic and strategic implications that extend well beyond those of conventional non-military items.[13]

13. We thank an anonymous reviewer for suggesting these placebo regressions. Note that we use all divisions with the exception of 79 "Other transport equipment", as this might include dual-use items—that is, equipment that can be used for both civil and military applications such as aircrafts and satellites.

Table 6. Placebo Regressions: Using Exports of Machinery with Comparable Levels of Sophistication to Weapons as Outcome Variable

	Machinery exports$_{ijt}$							
	Sector 71		Sector 72		Sector 73		Sector 74	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Net oil import$_{ijt}$	−0.177	−0.181	−0.098	−0.113	−0.261	−0.286	0.149	0.147
	(0.176)	(0.174)	(0.163)	(0.161)	(0.203)	(0.202)	(0.135)	(0.136)
Oil dependent$_{it}$ * Oil rich$_{jt}$		−0.053		−0.174		−0.185		−0.026
		(0.108)		(0.109)		(0.121)		(0.079)
All country-pair's characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(*it*)- and (*jt*)-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clusters	8705	8705	8588	8588	7451	7451	8422	8422
Observations	65,019	65,019	65,170	65,170	59,808	59,808	65,061	65,061
	Sector 75		Sector 76		Sector 77		Sector 78	
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Net oil import$_{ijt}$	−0.309	−0.334	0.198	0.160	−0.186	−0.194	−0.095	−0.094
	(0.333)	(0.323)	(0.194)	(0.186)	(0.187)	(0.185)	(0.193)	(0.192)
Oil dependent$_{it}$ * Oil rich$_{jt}$		−0.217**		−0.209		−0.091		0.019
		(0.104)		(0.151)		(0.111)		(0.131)
All country-pair's characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(*it*)- and (*jt*)-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clusters	8278	8278	8695	8695	8678	8678	8540	8540
Observations	63,573	63,573	64,973	64,973	64,877	64,877	65,114	65,114

Notes: Robust standard errors in parentheses are clustered at country-pair level. The dependent variable, Machinery exports$_{ijt}$, measures the exports of power-generating machinery and equipments (71), machinery specialized for particular industries (72), metalworking machinery (73), general industrial machinery and equipment (74), office and automatic data-processing machines (75), telecommunications and sound-recording apparatus (76), electrical machinery, apparatus, and appliances (77), road vehicles (78) in Columns (1)–(2), (3)–(4), (5)–(6), (7)–(8), (9)–(10), (11)–(12), (13)–(14), and (15)–(16), respectively. Net oil import$_{ijt}$ measures the net oil import (import–export) of country *i* from country *j* at time *t*. Oil dependent$_{it}$ is a dummy variable that takes value equal to 1 if country *i* is a global oil importer at time *t*. Oil rich$_{jt}$ is a dummy variable that takes value equal to 1 if country *j* has a new oil discovery at time *t*. Country-pair's characteristics include military alliance and political affinity. Gravity controls include distance, common colony, common currency, common ethnicity, common language, common religion, and RTAs.

*$p<0.10$, **$p<0.05$, ***$p<0.01$.

Sixth, the decisions on whether to transfer weapons or not and on how much to trade might not be completely independent, thus leading to selection bias; a common way to correct for this issue is to estimate a sample selection model (see e.g., Egger et al. 2011). We therefore rely on a Heckman (1979) model which, in the first stage, explains whether two countries trade or not using a Probit model and, in the second stage, uses an OLS to explain the quantity of arms flows, conditional on the first stage. Because of space limitations, the results are reported in Table A4. We find that global and local oil dependence are statistically significant in the selection equations, and that local oil dependence explains also the volume of the arms trade after controlling for selection whereas global oil dependence is not significant. There are however several caveats associated with this procedure, and these last results should be interpreted with caution.[14]

5. Conclusions

One of the most debated issues in the study of international economics revolves around the question of whether and to what extent the economic ties between nations affect or are affected by the "flag", that is, the nature and quality of their diplomatic relations. The arms trade is a very sensitive issue as it reveals national interests beyond simple economic considerations; as such, the volume of bilateral arms transfers can be used as a barometer of political relations between the supplier and the recipient states. The empirical literature on the arms trade is remarkably scarce and the aim of this article is to advance the relevance of energy dependence, and in particular of oil, in explaining the volume of arms transfers between countries. We claim that instances of political violence can cause disruptions in the global supply of oil and increasing oil prices. Oil-dependent economies have therefore incentives to provide security by selling or giving away arms to oil-rich countries to lower their risks of political turmoils and instabilities. This indirect military support should in turn ensure that countries maintain crude oil production within a target range. By the same token, countries with proven as well as a potential for oil production are more likely to receive weapons by oil-dependent economies. We argue for the existence of both a bilateral or local oil dependence as well as a global oil dependence. The former indicates

14. Selection models require identifying assumptions and the Heckman model is appropriate only when at least one additional explanatory factor influences the selection but not the outcome equation. To identify the parameters in both stages, we follow Helpman et al. (2008) and choose either common religion (Models 1 and 2) or common language (Models 3 and 4) as the excluded variable. Yet, choosing the right variable to omit from the outcome equation—one that is only correlated to the decision to transfer weapons rather than to the actual level of arms flows—is very difficult. As a consequence, the results are sensitive to the validity and correct specification of the two equations. Moreover, as Santos Silva and Tenreyro (2006) point out, the validity of the estimator hinges critically also on the assumption of homoskedasticity, which is unrealistic when we use trade data.

that arms import is positively tied to the quantities of oil exported to the arms supplier. Speculatively, arms export to a specific country is affected by the degree of dependence on its supply of oil. The latter indicates that global dependence on oil is a motivated factor for the arms trade and increases the volume of arms transfers between countries, even in absence of a direct bilateral oil-for-weapons exchange.

To test these hypotheses, we assemble an extensive panel of oil wealth and oil trade data, including stock variables such as the size of reserves and recent discoveries to prove plausibly exogenous sources of variation; we also include flow variables, in particular the bilateral and global balance of trade in oil of each country, to measure the potential damage of regional instabilities to its oil supply. Our hypotheses about the impact of oil dependence on the arms trade are strongly borne out by the empirical results. Overall, the evidence seems to point consistently toward the conclusion that the arms trade can be associated to attempts to securing and maintaining access to oil and stabilizing prices.

Our research has important implications for scholarship and policy. First, oil profits can allow some nations to acquire advanced weapons systems or develop important security programs. Agreements to exchange oil for weapons technology or systems, especially to energy-starved countries, give oil-rich countries useful leverage that can be employed to advance military expansion and acquire capabilities and influence. Our research shows how the oil trade is an important determinant of arms transfers and military expenditures, more generally. In fact, according to the SIPRI Military Expenditure Database, following recent declines in national oil revenues, due to low oil prices, only 2 of the 15 countries with the largest falls in military spending in 2016 were not oil exporters.[15] We shed new light on the economic dimension of the arms trade and contribute to the large literature on the demand for military spending. En route, we investigate the extent to which the classical impediments or facilitating factors included in the gravity models of trade affect the volume of the arms transfers. Second, the acquisitions of weapons often represent long-term investments that require a commitment of decades. Moreover, the replacements of air defense systems or naval ship building activities often require years to negotiate, design, develop, and build. Thus, oil revenues can be used to obtain long-term purchase agreements for weapons and, at the same time, reinforce bilateral ties between states. As such, oil might play an even larger role in influencing economic and political decisions than is generally acknowledged. Because of the limited number of empirical works on the arms trade and the fact that securing future energy supplies remains a major challenge, there is certainly an interesting agenda for future research in this area.

15. https://sipri.org/research/armament-and-disarmament/arms-transfers-and-military-spending/military-expenditure.

Conflict of interest statement. None declared.

Appendix A

Table A1. Variable Definitions and Sources

Variable	Definition	Source
Arms transfers$_{ijt}$	Trend-indicator value (TIV) of major weapons transfers from country *i* to country *j* at time *t* in 10 million US$	Stockholm International Peace Research Institute (SIPRI) Arms Transfers Database (http://www.sipri.org/databases/armstransfers)
Net oil import$_{ijt}$	Volume of net oil import (import–export) of country *i* from country *j* at time *t* in 10 million metric tons	Feenstra etal. (2005)
New oil discoveries$_{jt}$	Volume of new oil discoveries in country *j* at time *t* in thousand million barrels	Cotet and Tsui (2013)
Oil reserves$_{jt}$	Volume of oil reserves in country *j* at time *t* in thousand million barrels	Cotet and Tsui (2013)
Oil dependent$_{it}$	Dummy for global oil importer countries	Authors' own
Oil rich$_{jt}$	Dummy for countries with a new oil discovery at time *t*	Authors' own
GDP	Real GDP in 10 million US$	Expanded trade and GDP data—Gleditsch (2002) (http://private www.essex.ac.uk/~ksg/exptradegdp.html)
Democracy	Regime authority spectrum on a 21-point scale ranging from −10 to +10 (Polity 2 indicator)	The Polity IV Project—Marshall and Jaggers (2013) (http://www.systemicpeace.org)
NATO	Dummy for countries belonging to the North Atlantic Treaty Organization (NATO)	Authors' own
Warsaw pact	Dummy for countries belonging to the Warsaw pact	Authors' own
Military burden	Military spending as a percentage of Real GDP	The Correlates of War (COW) Project (http://www.correlatesofwar.org/)
Soldiers *per capita*	Number of soldiers *per capita* (as a percentage of population)	COW
War	Dummy for countries with a war	Cotet and Tsui (2013)
Neighboring wars	Number of neighboring countries with a war	Authors' own
Arms embargo	Dummy for countries with arms embargo from either UN or EU	SIPRI Arms Embargoes Database (http://www.sipri.org/databases/embargoes)
Military alliance	Dummy for pairs of countries with a formal military alliance	COW
Political affinity	Affinity of Nations score ranging from −1 (least similar interests) to +1 (most similar interests)	United Nations General Assembly Voting Data—Voeten and Merdzanovic (2009) (https://dataverse.harvard.edu/dataverse/harvard?q=affinity)

(continued)

Table A1. Continued

Variable	Definition	Source
Distance	Capital-to-capital distance between countries in a pair (in 10 million km)	CEPII distance database (http://www.cepii.fr/CEPII/fr/bdd_modele/presentation.asp? id=6)
Common colony	Dummy for pairs of countries with common colonizer	CEPII distance database
Common currency	Dummy for pairs of countries with common currency	CEPII distance database
Common ethnicity	Dummy for pairs of countries with the same language spoken by at least 9% of the population	CEPII distance database
Common language	Dummy for pairs of countries sharing a common official or primary language	CEPII distance database
Common religion	Percentage in which both countries share religions	CEPII distance database
RTAs	Dummy for pairs of countries with regional trade agreements in force	CEPII distance database

Table A2. Summary Statistics

Variable		Mean	Standard deviation	Min.	Max.	Observations
Arms transfers$_{ijt}$	Overall	8.14E−07	7.69E−06	0	0.000445	N=66,037
	Between		2.96E−06	0	0.0001211	n=8919
	Within		5.29E−06	−0.0000983	0.0003806	T-bar = 7.40408
Net oil import$_{ijt}$	Overall	0.0028298	0.047657	−1.975061	1.776768	N=66,037
	Between		0.026982	−0.7229579	0.6972872	n=8919
	Within		0.0294296	−1.249273	1.082311	T-bar = 7.40408
New oil discovery$_{jt}$	Overall	0.2607624	1.166614	0	26.06	N=53,104
	Between		0.7135286	0	26.06	n=7141
	Within		1.023653	−9.389858	24.38469	T-bar = 7.43649
Oil reserves$_{jt}$	Overall	14.42523	37.83175	0	269.2931	N=53104
	Between		32.12553	0	268.0759	n=7141
	Within		3.124776	−21.70162	38.02587	T-bar = 7.43649
Oil dependent$_{it}$	Overall	0.6960038	0.4599845	0	1	N=66,037
	Between		0.4468527	0	1	n=8919
	Within		0.2621927	−0.2706629	1.657542	T-bar = 7.40408
Oil rich$_{jt}$	Overall	0.616094	0.4863391	0	1	N=66,037
	Between		0.4665396	0	1	n=8919
	Within		0.2348566	−0.356879	1.516094	T-bar = 7.40408
Country i*'s characteristics*						
GDP	Overall	0.0660101	0.1399601	0.0003061	1.080727	N=66,037
	Between		0.0961951	0.0003061	1.055819	n=8919
	Within		0.046305	−0.3761831	0.6000276	T-bar = 7.40408
Democracy	Overall	4.145049	7.633289	−10	10	N=65,971
	Between		7.563904	−10	10	n=8894
	Within		2.994871	−12.2994	19.2627	T-bar = 7.41747
NATO	Overall	0.2881566	0.4529078	0	1	N=66,037
	Between		0.3628751	0	1	n=8919
	Within		0.1047493	−0.6530198	1.249695	T-bar = 7.40408
Warsaw pact	Overall	0.0468677	0.211357	0	1	N=66,037
	Between		0.1554131	0	1	n=8919
	Within		0.1133512	−0.8975768	0.9357566	T-bar = 7.40408
Military burden	Overall	38.75193	47.23373	1.955919	439.1977	N=65,810
	Between		41.61042	2.387705	439.1977	n=8886
	Within		26.69683	−164.8069	320.3836	T-bar = 7.40603

(continued)

Table A2. Continued

Variable		Mean	Standard deviation	Min.	Max.	Observations
Soldiers *per capita*	Overall	0.0101501	0.0097293	0.0007721	0.0592347	$N=65,878$
	Between		0.0098963	0.0008129	0.0592347	$n=8913$
	Within		0.0029402	−0.0095188	0.0306763	T-bar = 7.39123
Country j's characteristics						
GDP	Overall	0.0300009	0.0901078	0.0000366	1.080727	$N=66,037$
	Between		0.0782683	0.0000366	0.9897429	$n=8919$
	Within		0.0246673	−0.4800269	0.4569758	T-bar = 7.40408
Democracy	Overall	0.9815015	7.783907	−10	10	$N=65,627$
	Between		7.166009	−10	10	$n=8893$
	Within		3.327537	−16.206	15.11483	T-bar = 7.37962
NATO	Overall	0.1396944	0.3466723	0	1	$N=66,037$
	Between		0.290054	0	1	$n=8919$
	Within		0.0592084	−0.7353056	1.048785	T-bar = 7.40408
Warsaw pact	Overall	0.0087981	0.0933853	0	1	$N=66,037$
	Between		0.0757552	0	1	$n=8919$
	Within		0.0528084	−0.9245352	0.897687	T-bar = 7.40408
Military burden	Overall	30.12046	49.15098	0	1122.41	$N=65,388$
	Between		38.61121	0	1122.41	$n=8853$
	Within		35.16985	−327.9368	1054.419	T-bar = 7.38597
Soldiers *per capita*	Overall	0.0081499	0.0084986	0	0.076889	$N=66,005$
	Between		0.0082349	0	0.076889	$n=8913$
	Within		0.0029744	−0.0232502	0.0505131	T-bar = 7.40548
War	Overall	0.2285879	0.4199263	0	1	$N=66,014$
	Between		0.3630391	0	1	$n=8919$
	Within		0.2478524	−0.7369294	1.201561	T-bar = 7.4015
Neighboring wars	Overall	0.7794115	1.034563	0	7	$N=66,037$
	Between		0.9453883	0	7	$n=8919$
	Within		0.503142	−2.287255	3.946078	T-bar = 7.40408
Arms embargo	Overall	0.0334358	0.179773	0	1	$N=66,037$
	Between		0.1968729	0	1	$n=8919$
	Within		0.1083636	−0.8832309	1.005658	T-bar = 7.40408
Country-pair's characteristics						
Military alliance	Overall	0.0893287	0.2852198	0	1	$N=66,037$
	Between		0.2241216	0	1	$n=8919$
	Within		0.0750288	−0.8551157	1.050867	T-bar = 7.40408
Political affinity	Overall	0.6794393	0.3708258	−1	1	$N=66,037$
	Between		0.2877884	−0.8271789	1	$n=8919$
	Within		0.1995143	−0.8619195	1.970751	T-bar = 7.40408
Distance	Overall	0.0007285	0.0004481	5.96E−06	0.0019951	$N=66,037$
	Between		0.0004415	5.96E−06	0.0019951	$n=8919$
	Within		2.44E−19	0.0007285	0.0007285	T-bar = 7.40408
Common colony	Overall	0.029862	0.1702079	0	1	$N=66,037$
	Between		0.2274352	0	1	$n=8919$
	Within		0	0.029862	0.029862	T-bar = 7.40408
Common currency	Overall	0.0027712	0.0525693	0	1	$N=66,037$
	Between		0.0505179	0	1	$n=8919$
	Within		0.0354742	−0.7750066	0.9757441	T-bar = 7.40408
Common ethnicity	Overall	0.1429199	0.3499938	0	1	$N=66,037$
	Between		0.3405333	0	1	$n=8919$
	Within		0	0.1429199	0.1429199	T-bar = 7.40408
Common language	Overall	0.1071066	0.3092511	0	1	$N=66,037$
	Between		0.3149798	0	1	$n=8919$
	Within		0	0.1071066	0.1071066	T-bar = 7.40408
Common religion	Overall	0.1566662	0.2512904	0	0.992012	$N=66,037$
	Between		0.253095	0	0.992012	$n=8919$
	Within		0	0.1566662	0.1566662	T-bar = 7.40408
RTAs	Overall	0.060133	0.2377348	0	1	$N=66037$
	Between		0.1556189	0	1	$n=8919$
	Within		0.1291106	−0.8963888	1.021671	T-bar = 7.40408

Table A3. Sensitivity Analysis: Using Different Definitions of Oil Dependent$_{it}$ and Oil Rich$_{jt}$

	Arms tranfers$_{ijt}$							
		Oil rich$_{jt}$ = 1 if			Oil dependent$_{it}$ = 1 if			
	Baseline (1)	Any giant in [$t-4$, t] (2)	Any giant in [$t-5$, t] (3)	Any giant in [$t-6$, t] (4)	No discov in [$t-9$, t] (5)	No discov in [$t-8$, t] (6)	No discov in [$t-7$, t] (7)	No discov in [$t-6$, t] (8)
Avg. Net oil import$_{ij}$ * Δ ln oil price$_t$	1.248**	1.184**	1.178**	1.183**	1.242**	1.243**	1.262**	1.197**
	(0.491)	(0.485)	(0.487)	(0.487)	(0.492)	(0.494)	(0.499)	(0.485)
Oil dependent$_{it}$ * Oil rich$_{jt}$ (2nd def.)	0.449**	0.496**	0.488**	0.433**	0.442**	0.447**	0.440**	0.398*
	(0.227)	(0.226)	(0.229)	(0.228)	(0.227)	(0.228)	(0.234)	(0.239)
All country-pair's characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(*it*)- and (*jt*)-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clusters	8919	8919	8919	8919	8919	8919	8919	8919
Observations	63,129	63,129	63,129	63,129	63,129	63,129	63,129	63,129

Notes: Robust standard errors in parentheses are clustered at country-pair level. The dependent variable, Arms transfers, measures the volume of major weapons transfers from country *i* to country *j* at time *t*. Avg. Net oil import$_{ij}$ measures the average value of net oil import of country *i* from country *j* over the whole sample period (1962–1999). Δ ln oil price$_t$ measures the ln-change in international oil prices between $t-1$ and *t* so as an increase in Δ ln oil price$_t$ implies a reduction in international oil prices over time. Therefore, the interaction term Avg. Net oil import$_{ij}$ * Δ ln oil price$_t$ captures how variations in international oil prices affect the net oil import of country *i* from country *j* over time (i.e., country *i*'s local oil dependence from country *j* at time *t*). Oil dependent$_{it}$ is a dummy variable that takes value equal to 1 if country *i* has no oilfield discovery between time $t-s$ and *t*. Oil rich$_{ij}$ is a dummy variable that takes value equal to 1 if country *j* has any giant oilfield discovery (with size in top quartile) between time $t-s$ and *t*. Country-pair's characteristics include military alliance and political affinity. Gravity controls include distance, common colony, common currency, common ethnicity, common language, common religion, and RTAs.

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table A4. Heckman Selection Model: Two-Step Estimates

	Arms transfers$_{ijt}$			
	(1)	(2)	(3)	(4)
Outcome equation				
Net oil import$_{ijt}$	0.000028***	0.000027***	0.000029***	0.000027***
	(0.000003)	(0.000003)	(0.000003)	(0.000003)
Oil dependent$_{it}$ * Oil rich$_{jt}$		0.000002		0.000002
		(0.000002)		(0.000001)
Military alliance	−0.000002	−0.000000	−0.000000	0.000000
	(0.000002)	(0.000002)	(0.000002)	(0.000001)
Political affinity	0.000010***	0.000010***	0.000011***	0.000011***
	(0.000001)	(0.000001)	(0.000001)	(0.000001)
Common religion			−0.000009***	−0.000009***
			(0.000001)	(0.000001)
Common language	0.000003**	0.000004***		
	(0.000001)	(0.000001)		
Selection equation				
Net oil import$_{ijt}$	0.378082***	0.271010**	0.378082***	0.271010**
	(0.135296)	(0.136011)	(0.135296)	(0.136011)
Oil dependent$_{it}$ * Oil rich$_{jt}$		0.154948***		0.154948***
		(0.036572)		(0.036572)
Military alliance	0.479222***	0.469871***	0.479222***	0.469871***
	(0.029376)	(0.029429)	(0.029376)	(0.029429)
Political affinity	0.146970***	0.142814***	0.146970***	0.142814***
	(0.027377)	(0.027439)	(0.027377)	(0.027439)
Common religion	−0.138524***	−0.122744***	−0.138524***	−0.122744***
	(0.034405)	(0.034617)	(0.034405)	(0.034617)
Common language	0.135111***	0.151488***	0.135111***	0.151488***
	(0.036345)	(0.036505)	(0.036345)	(0.036505)
Inverse Mills' ratio	−0.000004	0.000003	−0.000000	0.000002
	(0.000005)	(0.000004)	(0.000004)	(0.000004)
Other gravity controls	Yes	Yes	Yes	Yes
Year-fixed effects	Yes	Yes	Yes	Yes
Excluded instrument	Common religion		Common language	
Observations	64,531	64,531	64,531	64,531

Notes: Robust standard errors in parentheses are clustered at country-pair level. The dependent variable, Arms transfers$_{ijt}$, measures the volume of major weapons transfers from country *i* to country *j* at time *t*. Net oil import$_{ijt}$ measures the net oil import (import–export) of country *i* from country *j* at time *t*. Oil dependent$_{it}$ is a dummy variable that takes value equal to 1 if country *i* is net oil importer in the global system at time *t*. Oil rich$_{jt}$ is a dummy variable that takes value equal to 1 if country *j* has a new oil discovery at time *t*. In the selection equation, the dependent variable is a dummy equal to 1 if Arms transfers$_{ijt}$ is positive, and zero otherwise. The excluded instrument (i.e., the variable excluded from the outcome equation) is common religion in Columns (1)–(2) and common language in Columns (3)–(4), respectively. The other gravity controls include distance, common colony, common currency, common ethnicity, and RTAs.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

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