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## Arms production, national defense spending and arms trade: Examining supply and demand

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# Arms Production, National Defense Spending and Arms Trade: Examining Supply and Demand

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## Arms Production, National Defense Spending and Arms Trade: Examining Supply and Demand\*

### Abstract

Scholars have estimated demand functions for national defense spending and investigated international arms trade for a long time. The relationship between supply and demand for military goods has, however, only been examined on aggregate level or in formal models yet. I investigate how the supply of military goods by arms-producing companies and the demand for military goods by both the national government and foreign governments are related by using a panel of up to 195 arms-producing companies in 21 countries for the period 2002-2016. The results show that if the demand for national defense spending increases by 1%, the arms sales by a country's largest arms-producing companies increase by up to 1.2%. If exports of major conventional weapons increase by 1%, sales increase by up to 0.2%. Arms imports do not affect domestic arms sales because imported and domestically produced arms are complements, and countries mainly import those arms they do not produce themselves. Country-specific estimation results suggest that differences among countries in geopolitical conditions and international relations determine whether a country's arms industry serves economic rather than security purposes.

JEL Code: L64, F14, H56, C23

Keywords: Arms industry, arms trade, defense spending, panel data

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# 1. Introduction

Scholars have estimated demand functions for national defense spending (Dunne and Perlo-Freeman 2003a, 2003b, Collier and Hoeffler 2007, Albalade et al. 2012, Blum 2019a, 2019b, George and Sandler 2018, Blum and Potrafke 2019) and examined determinants of international arms trade (Smith and Tasiran 2005, Comola 2012, Akerman and Seim 2014, Kinne 2016, Brender 2018, Thurner et al. 2018) for a long time. The effect of arms trade on national defense spending has been investigated, too (Pamp and Thurner 2017, Pamp et al. 2018). Both national defense spending and arms trade express the demand for military goods by the national government and foreign governments while the supply of military goods is provided by the arms industry.<sup>1</sup> The market for military goods with arms-producing companies on the supply side and domestic and foreign governments on the demand side has, however, only been considered in formal models yet (Glismann and Horn 1992, Levine et al. 1994, Levine and Smith 1997, Dunne et al. 2007).<sup>2</sup> This paper is original in establishing the link between supply and demand for military goods and estimates the effect of national defense spending and arms transfers on the sales of military goods by arms-producing companies.

The empirical analysis applies three databases from the Stockholm International Peace Research Institute (SIPRI): the ‘SIRPI Arms Industry Database’ containing the sales of arms and military services by the worlds’ top 100 arms-producing and military services companies, the ‘SIPRI Arms Transfers Database’ containing trend indicator values (TIV) for the exports and imports of major conventional weapons and the ‘SIPRI Military Expenditure Database’ containing data on national defense spending. These three databases have not been linked to each other yet. Smith and Dunne (2018), however, provide a parsimonious model describing world arms sales as a function of world defense spending; they find an arms sales elasticity of

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<sup>1</sup> Military goods include military equipment (both arms and other equipment) and military services.

<sup>2</sup> Scholars often have regarded arms exports as the supply of arms in the international arms market. This view, however, considers the country level only and ignores the company level (e.g., Smith et al. 1985).

defense spending of 1.5. The authors conclude that “it is surprising that there is not more quantitative work using arms industry data” and encourage scholars to investigate the economics of arms at the firm level (Smith and Dunne 2018).

I examine how a country’s demand for defense spending and the foreign demand for military goods from that country relate to the sales of military goods by its arms-producing industry. The sample includes up to 195 arms-producing and military services companies in 21 countries for the period 2002-2016. Arms orders for the own armed forces and arms exports determine the sales of military goods by arms-producing companies. In industrialized countries, arms orders are placed well in advance (especially larger procurement projects have long lead times) and exports previously need to be approved by the government. Companies thus produce ‘on demand’ rather than stockpiling arms, and company sales describe the outcome of orders by the domestic government and by foreign governments. This chronological order between orders and production of military goods makes reverse causality in this supply-demand model less likely. I use panel data models with fixed effects and in first differences. The fixed effects results indicate that if national defense spending increases by 1%, arms sales by a country’s largest arms-producing and military services companies increase by up to 1.2%. If exports of major conventional weapons increase by 1%, arms sales for these companies increase by up to 0.2%. Estimation results in first differences are similar for national defense spending, however, estimates for exports of major conventional weapons are considerably smaller. Arms imports are not shown to affect domestic arms sales, because countries mainly import arms they do not produce themselves. Imported and domestically produced arms are, thus, complements rather than substitutes. Country-specific estimation results suggest differences among countries in how the arms industry serves security or economic purposes. These differences are likely to be based on geopolitical conditions and international relations: the results suggest that, for instance, the United States’ arms-producing companies primarily serve security purposes, while arms-producing companies in Germany primarily serve the export market.

## 2. Supply and demand for military goods

Supply and demand for military goods describe an imperfect market with few suppliers and few customers. The arms industry in most industrialized countries has an oligopolistic structure: the capital (including human capital) intensity in production, the high cost for military R&D, and strong confidentiality standards in procurement projects—which impair the diffusion of know-how and enhance long-term dependencies from arms suppliers in terms of training, maintenance and possible reorders—give rise to a market structure in which a few large arms manufacturers develop and produce arms and, thus, dominate the market for military goods (Glismann and Horn 1992, Levine et al. 1994). Military arms are highly differentiated products and companies, thus, operate under monopolistic competition. The demand side in industrialized countries is described by a monopsony in which the domestic government is the only domestic customer and even decides on arms exports to other countries (Glismann and Horn 1992). In an open economy model, the output of arms by domestic suppliers in equilibrium equals domestic arms demand, i.e. the demand for a country’s own armed forces, plus arms exports less arms imports:

$$\textit{Domestic arms supply} = \textit{Domestic arms demand} + \textit{Arms exports} - \textit{Arms imports} \quad (1)$$

Equation (1) can be approached with data provided by the Stockholm International Peace Research Institute (SIPRI). SIPRI provides data on the sales of military goods by the world’s top 100 arms-producing companies, data on national defense spending and data on exports and imports of major conventional weapons (data is described in section 3 in detail). Sales of military goods can thus be described as a function of national defense spending and international arms transfers. Reverse causality between the sales of military goods and national defense spending or arms transfers in such a supply-demand equation is unlikely because defense budgets in industrialized countries are commonly adopted before the beginning of a fiscal year (and include orders which have been placed well in advance or even long-term

procurement projects with long lead times) and arms exports undergo thorough approval processes in advance.<sup>3</sup> Arms-producing companies thus produce arms ‘on demand’ contingent to domestic orders and approved exports rather than stockpiling arms. National defense budgets and approved arms exports determine the output of military goods by arms-producing companies. Defense spending and arms exports are, in turn, also the outcome of demand functions, which describe, for example, increased defense spending during wartime or increased arms exports when an ally is involved in an armed conflict. Regarding arms imports, it is important to examine whether imported arms and domestically produced arms are complements or substitutes.

Equation (1) allows to derive hypotheses on how supply and demand for military goods are related. Countries have built up domestic arms industries to provide their armed forces with military goods. Despite the increasing role of arms trade and joint procurement projects among allies, it is reasonable to assume that governments still source arms from their domestic arms-producing companies if possible to ensure security of supply, which is particularly important during wartime. These companies are often even partly or fully owned by the national government and have privileged status with respect to take-overs and foreign ownership to ensure control over domestic arms production. Variation in national defense spending over time is often driven by equipment spending—even though national defense spending is not limited to cost elements related to the arms industry such as procurement and maintenance but also includes large cost elements like personnel cost.<sup>4</sup> The first hypothesis to be examined is:

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<sup>3</sup> Reverse causality might, however, arise if governments absorb cost-overruns for large-scale procurement projects.

<sup>4</sup> NATO figures show that the increase in national defense spending for NATO countries after NATO member states have committed themselves to the two percent spending target in 2014 disproportionately increased equipment expenditure compared to personnel expenditure (see “Defence Expenditure of NATO Countries (2011-2018).” NATO Press Release (2018)091).



**Hypothesis 1:** *If national defense spending increases, the sales of arms and military services by a country's largest arms-producing and military services companies increase.*

Military arms include small arms, major conventional weapons and weapons of mass destruction. Transfers of small arms are difficult to track and small arms not exclusively serve military purposes. Transfers of weapons of mass destruction are strongly monitored and internationally heavily regulated. Exports of major conventional weapons are, however, likely to be positively related to the sales of military goods by domestic arms-producing companies. A country's largest arms-producing and military services companies which belong to the world's top 100 defense companies are likely to contribute disproportionately more to the production of major conventional weapons and disproportionately less to the production of small arms and weapons of mass destruction. Arms exports also include used major conventional weapons, though arms-producing companies are only involved in the production of new and the modernization of used arms. Export deals of used weapons, however, only represented 12% of the export deals of all major conventional weapons between 2002 and 2016 (2% were export deals of used but modernized major conventional weapons and 86% were export deals of new major conventional weapons). The second hypothesis to be examined is:

**Hypothesis 2:** *If exports of major conventional weapons increase, the sales of arms and military services by a country's largest arms-producing and military services companies increase.*

National defense spending includes—among other cost buckets—both domestically produced arms on the left-hand side of equation (1) and imported arms on the right-hand side of equation (1); arms imports therefore have a negative sign in equation (1). A negative relationship between the sales of military goods by domestic arms-producing companies and arms imports

would imply a ‘make or buy’ decision by the government, i.e. that a government decides whether it buys a military good from a domestic arms-producing company or whether it imports such a good from abroad. In an environment of monopolistic competition with differentiated goods, however, domestically produced and imported military goods are likely not to be substitutes. Arms for military purposes are differentiated because of both product properties and origin: with regards to security of supply, domestically produced arms differ from imported arms because imported arms imply a strategic dependency from other countries. A country therefore seeks to be self-reliant in the production of military goods fundamental for national defense and restricts arms imports to those arms it does not produce itself (Glismann and Horn 1992). The Berry Amendment, for example, requires the United States Department of Defense to prefer procurement of domestically produced military goods.<sup>5,6</sup> Countries therefore need to import only those military goods which are not produced by domestic arms-producing companies. Domestically produced arms and imported arms are, thus, complements rather than substitutes. Because of the complementarity between domestically produced and imported arms, increases in arms imports might even coincide with increases in arms sales by domestic arms-producing companies without any explicit causal link—for example, during large procurement activities. The complementarity might also give rise to reverse causality if components for domestically produced arms are sourced from foreign suppliers. The third hypothesis to be examined is:

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<sup>5</sup> See Grasso, V.B. 2014. “The Berry Amendment: Requiring Defense Procurement to Come from Domestic Sources.” Congressional Research Service (RL31236).

<sup>6</sup> In 2017, Donald Trump took measures to enforce source restrictions by means of the Buy American Act and the Berry Amendment (see Gregg, A. 2017. “Pentagon moves to shut foreign firms out of its supply chain.” The Washington Post. Available at: [https://www.washingtonpost.com/business/capitalbusiness/pentagon-moves-to-shut-foreign-firms-out-of-its-supply-chain/2017/07/06/37bc7498-60f6-11e7-8adc-fea80e32bf47\\_story.html?noredirect=on&utm\\_term=.443c0ac4e1c8](https://www.washingtonpost.com/business/capitalbusiness/pentagon-moves-to-shut-foreign-firms-out-of-its-supply-chain/2017/07/06/37bc7498-60f6-11e7-8adc-fea80e32bf47_story.html?noredirect=on&utm_term=.443c0ac4e1c8), accessed January 9, 2019).

**Hypothesis 3:** *If imports of major conventional weapons increase, the sales of arms and military services by a country's largest arms-producing and military services companies do not decrease. Imports are rather unrelated or even positively related to sales.*

Scholars have described the trade-off between security considerations and economic returns in the context of arms trade (Levine et al. 1994, Thurner et al. 2018). This trade-off also applies to the importance governments attribute to the cost for defense spending and the returns from arms trade. A country's geopolitical role and its position within the international community are, among others, likely to determine the extent to which the arms industry serves security or economic purposes: the United States, for example, act as a world power and have quite often been engaged in military activities within the last decades to pursue national interest or the interest of the Western world. This role is likely to support a strong domestic arms industry which provides the armed forces with military goods and guarantees security of supply. Germany, in contrast, has been much more reserved in engaging in international conflicts and continuously decreased defense spending after the Cold War. The strong German defense industry, however, exports arms to numerous countries around the world. The examples for the United States and Germany support the conjectures stated by Levine et al. (1994) that "there might be a Stackelberg leader, the US, who has world-wide security concerns, and a number of 'small' followers (Britain and France) who are purely motivated by the economic return." The fourth and last hypothesis to be examined is:

**Hypothesis 4:** *Countries differ in whether and to what extent national defense spending and arms transfers explain the sales of arms and military services by a country's largest arms-producing and military services companies.*

### 3. Data and descriptive statistics

Data on arms sales, national defense spending and arms trade is provided by means of different SIPRI databases. The ‘SIRPI Arms Industry Database’ contains information on the sales of arms and military services of the top 100 arms-producing and military services companies of each year in OECD countries and developing countries (no data is available for Chinese firms). Military goods are supposed to explicitly serve military purposes and military services include—among others—IT, maintenance, repair, logistics, training, intelligence and armed security services. The sales of military goods include “both sales for domestic procurement and sales for exports.”<sup>7</sup> The database covers the period 2002-2016 and indicates the country of each company. Sales figures are reported in million constant (2016) US dollars and reflect each company’s financial year.<sup>8</sup> As companies drop out or enter the list of the top 100 companies over the years, the number of countries for which data is available from 2002 through 2016 is less than 100. The database is subject to noteworthy shortcomings which have not been improved yet: e.g., the definition of military goods and the information provided on arms sales is not standardized among companies, arms sales might be double-counted because of intra-industry trade in intermediate products and components, Chinese companies are not covered at all and information on merger and acquisition activities and divestments of companies are only selectively available for 2015 and 2016. Since quality and consistency of sales data are the better, the larger the companies considered are, the top 100 companies describe the most reliable data available. The companies included are, however, not representative for the entire arms industry.<sup>9</sup>

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<sup>7</sup> See <https://www.sipri.org/databases/armsindustry/sources-and-methods>, accessed December 3, 2018.

<sup>8</sup> Data is collected in local currency and converted into constant (2016) US dollars using average exchange rates. Domestic sales of military goods are, however, more likely to be conducted in local currency whereas international sales are conducted in US dollars. As the data does not reflect a company’s domestic and international sales share and timing of these sales within a year, sales figures cannot to be interpreted exactly if intra-annual exchange rate fluctuations are high.

<sup>9</sup> See Fleurbaey and Tian (2018) and Smith and Dunne (2018) for a discussion of the SIPRI Arms Industry Database.

The ‘SIPRI Arms Transfers Database’ includes trend indicator values (TIV) for a country’s exports and imports of major conventional weapons such as aircrafts, ships, tanks, or missiles. The TIV are supposed to describe “actual deliveries of major conventional weapons” per year in units which are comparable among countries and show trends in arms trade. The TIV constructed by SIPRI are therefore “based on the known unit production costs of a core set of weapons and is intended to represent the transfer of military resources rather than the financial value of the transfer.”<sup>10</sup> Trend indicator values are expressed in millions. Used weapons are valued with 40% and used but modernized weapons are valued with two thirds of a weapon’s initial value.

The ‘SIPRI Military Expenditure Database’ provides data on national defense spending for a given calendar year. National defense spending is defined in million constant (2016) US dollars, i.e. in absolute terms. Defense spending in absolute terms better reflects the demand for security the arms industry must meet than defense spending as a share of GDP, which is the measure commonly applied when demand functions for national defense spending are estimated (see Dunne and Perlo-Freeman 2003a, 2003b, Blum 2019a, 2019b). Using defense spending in absolute terms is consistent with data on arms sales and TIV for arms trade, which are both also expressed in absolute terms.

The ‘SIRPI Arms Industry Database’ also considers large foreign subsidiaries of international defense corporations which as an independent company would rank among the top 100.<sup>11</sup> Subsidiaries are specified by the country in which they are located. Since sales figures of subsidiaries are included in the sales figures of the parent company, including both subsidiaries and parent companies into one panel would result in double-counting.<sup>12</sup> I therefore

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<sup>10</sup> See <https://www.sipri.org/databases/armstransfers/sources-and-methods>, accessed December 3, 2018.

<sup>11</sup> E.g., subsidiaries of BAE Systems (United Kingdom) like BAE Systems Inc. (United States) and BAE Systems Australia, or other subsidiaries of international corporations such as Airbus and Thales.

<sup>12</sup> It is not possible to subtract subsidiary figures from parent company figures, because time series of both subsidiary and parent in most of the cases do not have the same length and would result in inconsistent time series of the parent companies.

employ three panel data sets: i) a balanced panel of arms-producing and military services companies, ii) an unbalanced panel of arms-producing and military services companies and iii) an unbalanced panel of large subsidiaries of arms-producing companies. The first two panels include the large international corporations but exclude subsidiaries as further elements of national arms production; the third panel, in turn, does not consider any independent company. Given the data availability for national defense spending and arms transfers, the balanced company panel contains 44 companies in nine countries during the period 2002-2016.<sup>13</sup> These nine countries include the strongest arms industries like the United States, the United Kingdom, France and Germany and six of the top ten arms exporting countries. The unbalanced company panel (which the balanced company panel is a subset of) contains 195 companies in 21 countries and the unbalanced subsidiary panel contains 74 subsidiaries in 12 countries. Companies in the balanced company panel belonged to the top 100 arms-producing and military services companies from 2002 through 2016 while companies and subsidiaries in the unbalanced panels belonged to these top 100 according to their sales in at least one of the years from 2002 to 2016. Table A1 in Appendix 1 shows a list of countries with the number of companies by country included in each panel as well as country ranks in national defense spending, exports of major conventional weapons and imports of major conventional weapons as of 2016.

Tables A2 and A3 in Appendix I show summary statistics and correlations of arms sales, national defense spending and arms exports and imports for each of the three panels. Summary statistics and correlations for the sales of arms and military services are based on company-level data, thus including more observations than summary statistics and correlations for country-level data like national defense spending, exports and imports. The unconditional correlations of the sales of arms and military services with national defense spending and with exports of major conventional weapons are positive and of similar size: more than 30% in the

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<sup>13</sup> In three cases, company names have been unified in the dataset after name changes: the Israeli aerospace company Israel Aircraft Industries changed name to Israel Aerospace Industries in 2006, EADS changed name to Airbus Group in 2014 and to Airbus SE in 2017 and Finmeccanica changed name to Leonardo in 2016.

balanced company panel and more than 20% in the unbalanced company panel. The correlation of imports with the sales of arms and military services is positive but only 5% in the unbalanced company panel. The high unconditional correlation between national defense spending and the exports of major conventional weapons of more than 60% in each of the three panels reflects that countries with high levels of national defense spending are also strong in arms exports, and vice versa.

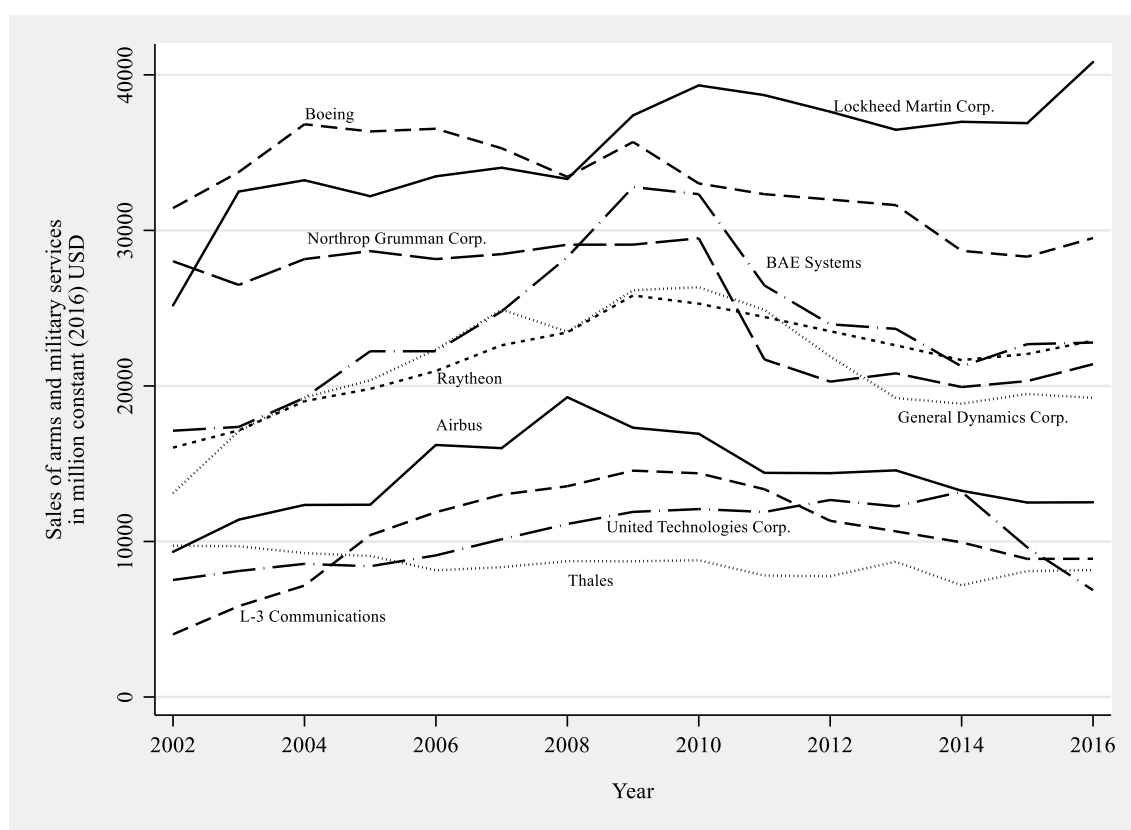


FIGURE 1: ARMS SALES BY THE TOP 10 ARMS-PRODUCING AND MILITARY SERVICES COMPANIES

Figure 1 shows the sales of arms and military services by the ten largest arms-producing companies from the balanced company panel (i.e. with time series available from 2002 through 2016). Seven of these companies are in the United States, one in France, one in the United Kingdom and another one—Airbus—is trans-European.<sup>14</sup> The sales of arms and military

<sup>14</sup> The “main engineering and production facilities” of Airbus Defence and Space—the division for equipment and services in the fields of aerospace and defense—are in France, Germany, Spain and the United Kingdom. For the further analysis, Airbus sales are allocated to France and Germany with a share of 40% each and to Spain and the United Kingdom with a share of 10% each, reflecting the employee shares of Airbus SE in these four countries (see: Airbus SE. 2017. “Annual Report 2017.” Available at <https://www.airbus.com/investors/financial-results-and-annual-reports.html#annualreports>). Almost all employees of MBDA—the second trans-European company

services differ among companies over time: sales figures of Boeing, United Technologies and Thales hardly varied over time while sales figures of Lockheed Martin, BAE Systems and Northrop Grumman have been rather volatile during the observation period. A considerable share of these ten companies, however, experienced peaks in sales during the late 2000s while sales decreased in the early 2010s; this development is concurrent with national defense spending in the United States, the United Kingdom and France. Figures 2 and 3 show how time series of national defense spending and exports of major conventional weapons are related to the total arms sales by the largest arms-producing companies in the United States (Figure 2) and in France, Germany, Israel and the United Kingdom (Figure 3; axes are removed and figures are not sized to scale to enhance readability). Companies do not drop out during the observation period because Figures 2 and 3 contain companies of the balanced company panel only; time series for total sales within one country thus describe the same set of companies from 2002 to 2016. For the United States and the United Kingdom, the similarity in time series for the sales of arms and military services and national defense spending is much more pronounced than for arms sales and the exports of major conventional weapons. For France and Germany, however, the sales of arms and military services and the exports of major conventional weapons show a pronounced similarity rather than arms sales and national defense spending do. The sales of arms and military services by Israeli companies have been rather constant since the late 2000s; national defense spending remarkably dropped in 2016 while the exports of major conventional weapons increased after 2014, thus allowing to hold arms sales at rather constant levels. The time series drawn for the five illustrated countries support the hypotheses stated in

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in the sample—work in France (45%), the United Kingdom (31%), Italy (12%) and Germany (12%). For the further analysis, MBDA sales are allocated to these four countries according to the employee shares (see: MBDA. 2016. “Corporate and Social Responsibility Report 2016.” Available at [https://www.mbda-systems.com/wp-content/uploads/2015/04/csr\\_report\\_2016.pdf](https://www.mbda-systems.com/wp-content/uploads/2015/04/csr_report_2016.pdf)). Comparison of prorated sales data and sales data available for MBDA subsidiaries in France and Italy supports the approach of prorating sales figures according to employee shares.



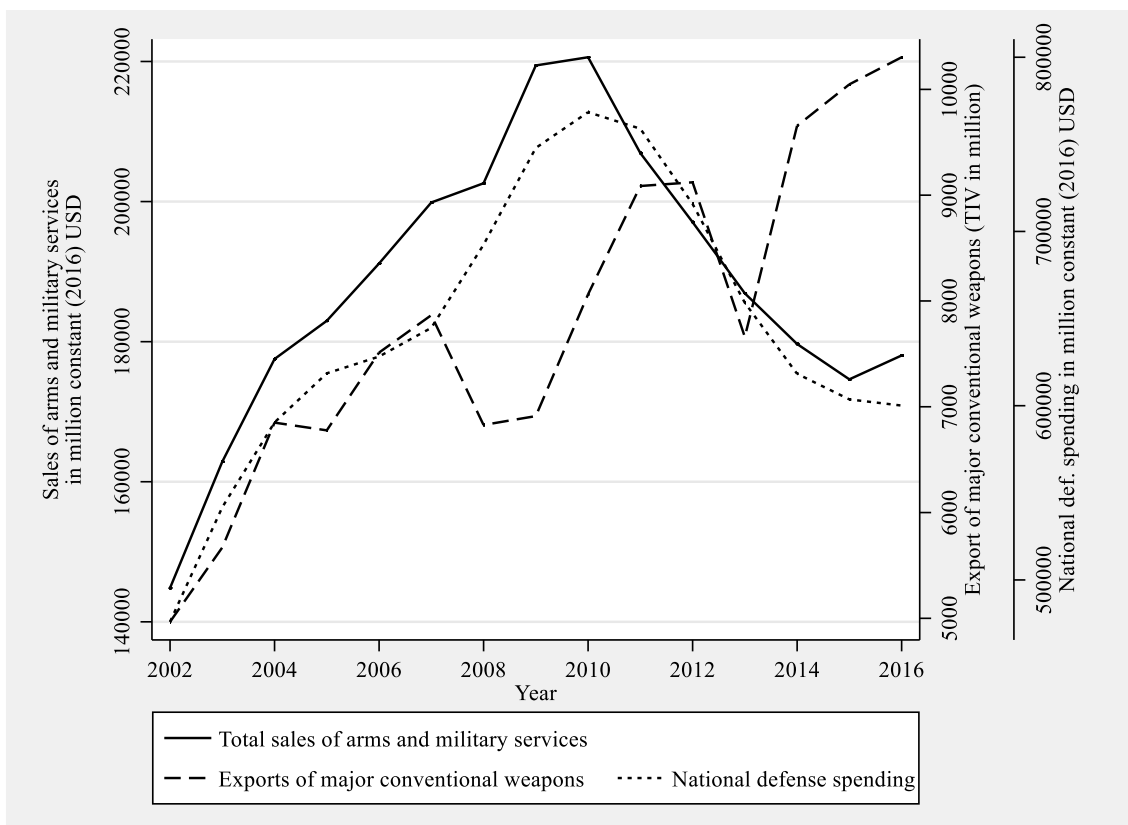


FIGURE 2: UNITED STATES TOP COMPANIES' ARMS SALES, NATIONAL DEFENSE SPENDING AND EXPORTS OF MAJOR CONVENTIONAL WEAPONS

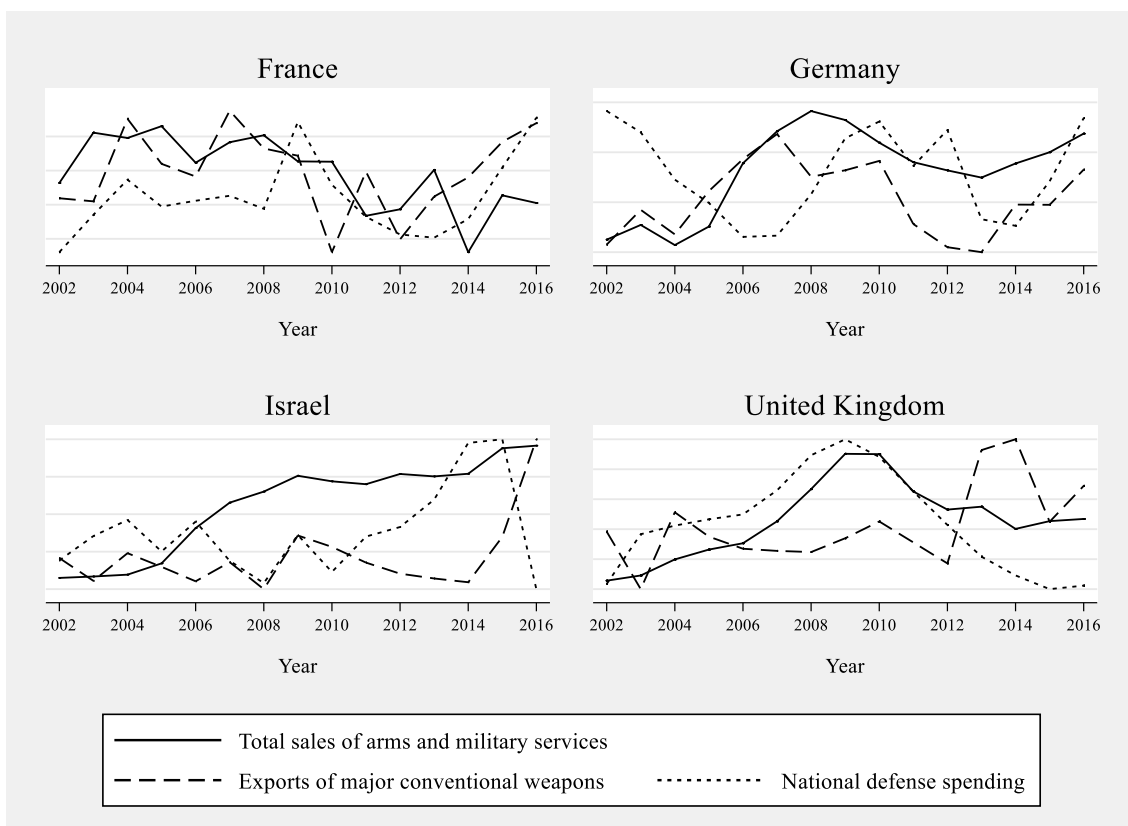


FIGURE 3: TOP COMPANIES' ARMS SALES, NATIONAL DEFENSE SPENDING AND EXPORTS OF MAJOR CONVENTIONAL WEAPONS

section 2 that national defense spending and arms exports are positively correlated with the sales by arms-producing companies and that country-specific differences exist.

#### 4. Empirical strategy

The baseline panel data model to estimate how national defense spending and arms transfers affect the sales of military goods by arms-producing companies has the following form:

$$\ln(\text{Sales of arms and military services})_{ijt} = \beta_1 \ln(\text{National defense spending})_{jt} + \beta_2 \ln(\text{Arms exports})_{jt} + \beta_3 \ln(\text{Arms imports})_{jt} + \alpha_{ij} + u_{ijt} \quad (2)$$

The dependent variable *Sales of arms and military services*<sub>ijt</sub> describes the sales of arms and military services by company *i* in country *j* in year *t*. The considered companies belonged to the worlds' top 100 arms-producing and military services companies in at least one of the years during the observation period (*t* = 2002,..., 2016). The number of companies *i* and countries *j* (in which these *i* companies are located) differs among the three assembled panels (see section 3). The variable *National defense spending*<sub>jt</sub> describes national defense spending in country *j* in year *t*. The variables *Arms exports*<sub>jt</sub> and *Arms imports*<sub>jt</sub> describe trend indicator values for the exports and the imports of major conventional weapons from and to country *j* in year *t*. Both dependent and explanatory variables are expressed in their natural logarithms, which allows to interpret estimated coefficients as elasticities. The coefficient  $\alpha_{ij}$  describes company fixed effects to account for unobserved characteristics of individual companies. The empirical model thus exploits the within-variation of the variables for companies and countries and allows to investigate how trends in the sales by individual arms-producing companies are influenced by trends in national defense spending and arms transfers. The within-interpretation is, moreover, favorable because—due to differences in how the figures are collected for different companies and countries—SIPRI data for company sales and national defense spending is more reliable

over time than across companies and countries. The standard error  $u_{ijt}$  is clustered at the company level and robust to serial correlation and heteroskedasticity (Huber/White/sandwich standard errors – see Huber 1967 and White 1980).

Time series of the sales of arms and military services and the explanatory variables might be non-stationary for the period 2002-2016 and give rise to spurious estimation results. Temporary trends might exist in national defense spending for individual countries and in the total sales of arms and military services by arms-producing companies (see Figures 2 and 3). I therefore also estimate the model in first differences (i.e. log-differences), thus eliminating company fixed effects  $\alpha_{ij}$ , to alleviate possible problems resulting from non-stationary time series. The panel model in first differences looks as follows:

$$\begin{aligned} \Delta \ln(\text{Sales of arms and military services})_{ijt} = & \delta_1 \Delta \ln(\text{National defense spending})_{jt} + \\ & \delta_2 \Delta \ln(\text{Arms exports})_{jt} + \delta_3 \Delta \ln(\text{Arms imports})_{jt} + \varepsilon_{ijt} \end{aligned} \quad (3)$$

Standard errors  $\varepsilon_{ijt}$  are again clustered at the company level and robust to serial correlation and heteroscedasticity. The fixed effects and the first differences log-log panel data models are both estimated with ordinary least squares. The estimated coefficients  $\delta_1$ ,  $\delta_2$ , and  $\delta_3$  are interpreted like the coefficients of the panel fixed effects model. Hypotheses 1 to 3 imply that the estimated coefficients yield  $\beta_1 > 0$ ,  $\beta_2 > 0$  and  $\beta_3 \geq 0$  for the fixed effects model and  $\delta_1 > 0$ ,  $\delta_2 > 0$  and  $\delta_3 \geq 0$  for the first differences model.

Since—as discussed in section 2— companies produce arms ‘on demand’ contingent to defense budgets which are adopted before the beginning of the fiscal year (and include orders which have been placed well in advance or even long-term procurement projects with long lead times) and arms exports which have been approved in advance, reverse causality is less likely in this empirical supply-demand model. Omitted variable bias cannot be ruled out though factors influencing the sales of arms and military services both directly and indirectly through

the channels of defense spending and arms trade are unlikely to exist on a large scale and to substantially bias the results. In any event, I include further control variables on the country-level in a robustness test.

## **5. Empirical results**

### **5.1 Baseline results**

Table 1 shows the baseline estimation results for the fixed effects and the first differences model.<sup>15</sup> The 44 and the 195 companies of the balanced and the unbalanced company panel reported in Table 1 indicate six companies more than included in the panels, because sales figures for the two trans-European companies Airbus and MBDA have been allocated to individual countries according to employee shares (see footnote 14). The results for the fixed effects model indicate that if national defense spending increases by 1%, the sales by domestic arms-producing and military services companies increase by 1.1% for the balanced company panel and by 1.2% for the unbalanced company panel. The estimates of the first differences model are similar in size and statistically significant at the 1% level, too. An elasticity above one is plausible following the assumption stated in section 2 that increases in national defense spending in the short run influence equipment expenditure more than they influence personnel expenditure. If total national defense spending increases by 1%, equipment spending is therefore likely to increase by more than 1%. If exports of major conventional weapons increase by 1%, the sales by domestic arms-producing and military services companies increase by almost 0.2% for the balanced company panel and by almost 0.1% for the unbalanced company panel; both estimates are statistically significant at the 1% level. Estimation results in first differences are considerably smaller (0.05% and 0.03%), but statistically significant at the 1% level, too. Imports of major conventional weapons do not turn out to be statistically significant

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<sup>15</sup> The number of observations and the number of companies and subsidiaries in the unbalanced panels is reduced in the first differences model because of the first differenced time series.

for both the balanced and the unbalanced company panel neither in the fixed effects model nor in the first differences model. The empirical results of both empirical models for the two company panels, i.e. that  $\beta_1 > 0$ ,  $\beta_2 > 0$ ,  $\beta_3 \geq 0$  and  $\delta_1 > 0$ ,  $\delta_2 > 0$ ,  $\delta_3 \geq 0$ , support hypotheses 1 to 3.

**TABLE 1: BASELINE ESTIMATION RESULTS**

<b>Fixed effects model</b>	(1)	(2)	(3)
	Balanced Company Panel	Unbalanced Company Panel	Unbalanced Subsidiary Panel
Sales of arms and military services <sup>a</sup>			
National defense spending <sup>a</sup>	1.087*** (0.234)	1.208*** (0.137)	0.908** (0.417)
Exports of major conventional weapons <sup>a</sup>	0.194*** (0.048)	0.089*** (0.024)	-0.004 (0.064)
Imports of major conventional weapons <sup>a</sup>	0.014 (0.015)	0.016 (0.011)	-0.034* (0.019)
Company Fixed Effects	yes	yes	yes
Observations	660	1,460	252
Companies (for column (3): Subsidiaries)	44	195	74
R <sup>2</sup> Overall	0.106	0.045	0.447
R <sup>2</sup> Within	0.203	0.234	0.094
R <sup>2</sup> Between	0.108	0.057	0.391
<b>First differences model</b>	(1)	(2)	(3)
	Balanced Company Panel	Unbalanced Company Panel	Unbalanced Subsidiary Panel
Sales of arms and military services <sup>a</sup>			
National defense spending <sup>a</sup>	0.977*** (0.155)	1.202*** (0.123)	1.064** (0.491)
Exports of major conventional weapons <sup>a</sup>	0.051*** (0.015)	0.027*** (0.010)	-0.025 (0.051)
Imports of major conventional weapons <sup>a</sup>	0.008 (0.008)	0.002 (0.007)	-0.029* (0.015)
Observations	616	1,238	170
Companies (for column (3): Subsidiaries)	44	162	44
R <sup>2</sup>	0.117	0.117	0.061

Notes: Standard errors in parentheses. \*, \*\*, and \*\*\* indicate significance at the 10, 5, and 1% significance level, respectively. All regressions apply standard errors clustered at the country level. <sup>a</sup> denotes variables which are expressed in their natural logarithms.

Results are different in column (3) which shows results for the unbalanced subsidiary panel. If national defense spending increases by 1%, the sales by subsidiaries located in this country increase by 0.9% according to the fixed effects model; the first differences estimate for national defense spending is slightly larger. Compared to columns (1) and (2), the coefficients are statistically significant only at the 5% level because, in terms of national defense, countries might rely less on arms produced by foreign subsidiaries than on arms produced by domestic companies. Exports of major conventional weapons do not turn out to be statistically significant neither in the fixed effects model nor in the first difference model, because foreign companies might place their subsidiaries in countries which domestically absorb large shares of the

subsidiaries' production rather than producing military goods for export (e.g., the BAE subsidiary in the United States). Arms-producing companies are often blamed to circumvent arms export bans (e.g., to conflict countries or autocracies) by using foreign subsidiaries or licensed arms production abroad. The results on export effects for the unbalanced subsidiary panel, however, at least do not indicate that these are large-scale practices. Imports are negative and statistically significant at the 10% level for both empirical models because a government's rationale not to import military goods which are also domestically produced (see Hypothesis 3) is likely to be reduced for military goods provided by a foreign company's subsidiary. The results for the unbalanced subsidiary panel need to be interpreted with due caution because—as the number of observations and the number of subsidiaries indicate—the average time series for subsidiaries are quite short.

## **5.2 Robustness tests**

I examine the robustness of the empirical results in several ways. Given the market structure for military goods, national defense spending and arms exports describe the two channels national arms production flows into. It cannot, however, be ruled out that other factors at the country level contribute to both the sales by arms-producing and military services companies and to national defense spending or arms exports. I therefore include five control variables at the country level to reduce possible omitted variables bias: a war dummy for involvement in an internal or interstate war, a proxy variable for internal stability and domestic conflict probability, the natural logarithm of GDP in constant (2010) US dollars to capture business cycle effects and to account for the presumably positive relationship between defense spending and economic growth (see Alptekin and Levine 2012), an index for trade globalization accounting for the trade in goods and services and for trade partners diversification and a

continuous democracy measure describing political institutions.<sup>16</sup> Including these control variables does not change the inferences from the baseline results (see Table A4 in Appendix II). Estimates of the added control variables are only rarely significant because these country-level variables explain arms sales mainly via the channels of defense spending and arms trade rather than directly influencing arms sales. In column (2) of the fixed effects model, the war dummy is negative and statistically significant at the 5% level. This result might indicate that after controlling for defense spending arms sales are lower during wartime when defense spending is commonly high, i.e. that the effect of national defense spending might otherwise overestimate arms sales in periods of armed conflict. War does, however, not turn out to be statistically significant neither in the other fixed effects nor in the first differences models. Internal threat does not turn out to be statistically significant in the unbalanced company panel, which is the only panel with within-country variation for this variable. GDP has positive but only rarely significant estimates in the fixed effects and the first differences model for the company panels and shows that economic development positively influences arms sales by arms-producing companies. Trade globalization is statistically significant in column (3) only and indicates that trade integration is positively related to the amount of military goods produced by subsidiaries of foreign firms. The continuous democracy measure is statistically significant only in column (2) for the fixed effects model.<sup>17</sup>

Arms sales figures of one year might not exclusively contain sales volumes of military goods delivered in the respective year. It is likely that sales figures also include advance payments, especially for major orders which might be paid in several installments rather than

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<sup>16</sup> Data for armed conflicts is taken from the ‘UCDP/PRIO Armed Conflict Dataset’ by Gleditsch et al. (2002). Data for the proxy variable for internal stability and domestic conflict probability is taken from the ‘Major Episodes of Political Violence (MEPV) and Conflict Regions, 1946-2016’ dataset. Data for GDP is taken from the World Development Indicators of the World Bank. The index for trade globalization is a subset of the KOF Globalization Index (Dreher 2006, Gygli et al. 2019, see Potrafke 2015 for a survey). The continuous democracy index (CSVMDI) is based on machine learning techniques and provided by Gruendler and Krieger (2016, 2018).

<sup>17</sup> Controlling for government ideology (see Comola 2012 and Brender 2018) using data from the Database of Political Institutions does not change the inferences either, however, the number of observations is reduced for governments which cannot be categorized by means of leftwing-rightwing patterns (results not reported).

upon delivery. National defense spending may reflect such payment smoothing, however, export TIV for major conventional weapons reflect actual deliveries irrespective of the actual payment flow. I therefore estimate the model including lead values for the exports of major conventional weapons to allow for less contemporaneity in the payments for sold arms (i.e. the sales by arms-producing companies) and their actual delivery. Lead values for the exports of major conventional weapons are thus supposed to capture effects of advance payments. Inferences from the baseline results in Table 1 do not change when lead values of up to three years for the exports of major conventional weapons are added to the regression (see Table A5 in Appendix II). An increase in approved exports of major conventional weapons in the subsequent year ( $t+1$ ) is significantly positively related to an increase in the arms sales by arms-producing companies according to both fixed effects and first differences results. Further lead values for the exports of major conventional weapons are only rarely statistically significant.<sup>18</sup>

It is a worthwhile endeavor to more specifically delimit elements of domestic and foreign demand which determine the sales of military goods. First, NATO provides data on national defense spending and on the equipment spending share of total defense spending, which allows to construct figures for military equipment spending of NATO countries in million constant (2015) US dollars.<sup>19</sup> Equipment spending (as a subset of overall defense spending) might more accurately approximate the domestic demand arms-producing companies have to meet. The fixed effects estimates for military equipment spending of NATO countries are less than half the size compared to the coefficients for overall defense spending (see Table A6 in Appendix II). The first differences estimates for military equipment spending are also considerably smaller and statistically significant only at the 5% level for the balanced and at the 10% level for the unbalanced company panel. It is reasonable that coefficients for overall

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<sup>18</sup> The number of observations decreases from column to column because the latest year is dropped from the sample for each additional lead value of the export variable. The number of companies and subsidiaries is reduced by those companies and subsidiaries for which no further lead values are available.

<sup>19</sup> NATO reports do not include military expenditure in constant US dollars for years prior to 2010. I therefore deflated military expenditure in current US dollars by using the US GDP deflator from the World Bank.



defense spending are larger because—as mentioned earlier—increases in overall defense spending often imply that equipment spending increases disproportionately. Imports are now statistically highly significant according to fixed effects estimation results in columns (1) and (2) and have a positive sign. This result is in line with hypothesis 3 that arms sales by a country's largest arms-producing companies do not decrease if arms imports increase. The positive sign for imports even confirms that imported and domestically produced arms are complements rather than substitutes: increasing arms imports might coincide with increasing national arms production because of, for example, larger procurement activities, and imported components for domestically produced arms might give rise to reverse causality which further explains the positive sign for arms imports. Equipment spending does not turn out to be statistically significant for subsidiaries in column (3)—neither for the fixed effects nor for the first differences model.

Second, SIPRI provides data on arms transfers at the level of individual deals which allows to distinguish between new, used and used but modernized major conventional weapons. Excluding exports of used major conventional weapons from the estimation might more accurately approximate the foreign demand companies face because arms-producing companies are involved in the production and new arms or the modernization of used arms only. As described in section 2, aggregated data for the exports of new and used but modernized weapons is similar to the data for the exports of all weapons: only 12% of the tracked arms export deals of all major conventional weapons between 2002 and 2016 have been exports of used weapons (2% were export deals of used but modernized weapons and 86% were export deals of new weapons) and used and used but modernized weapons, moreover, only receive 40% and 66% of a new weapon's trend indicator value. I do not distinguish between new and used imported weapons, because procurement projects for the armed forces can include both new and used imported weapons and both are able to substitute domestically produced weapons. The results for approved exports of new and used but modernized major conventional weapons confirm the

previous inferences from Table 1 regarding the effect of arms exports on companies' sales of military goods (see Table A7 in Appendix II).<sup>20</sup>

## 6. Country-specific results

Differences in country-specific results might indicate the extent to which an arms industry serves security or economic purposes. Figures 2 and 3 showed that in the United States and the United Kingdom, sales figures follow national defense spending rather than exports of major conventional weapons; for Germany, however, sales figures seem to follow the exports of major conventional weapons rather than national defense spending. I estimate country-specific coefficients for the explanatory variables to examine this heterogeneity among countries. Figure 4 illustrates coefficient estimates and their 95% confidence intervals according to the fixed effects and the first differences model for the balanced panel. Results for countries with at least three companies in the panel are shown, which includes those countries where the majority of the top 100 arms-producing and military services companies is located. National defense spending is significantly and positively related to the sales by arms-producing and military services companies in Israel, the United Kingdom and the United States (in Israel according to the fixed effects model only); this result reflects the baseline estimation results. For France, Germany and Italy, however, national defense spending does not turn out to be statistically significant. Arms exports surprisingly do not turn out to be statistically significant for France, one of the world's largest arms-producing and arms-exporting country. In Germany, Israel, Italy and the United Kingdom, in turn, exports of major conventional weapons are significantly positively related to the sales by arms-producing and military services companies (in Israel and Italy according to the fixed effects model only). Arms exports from the United States do not turn out to be significantly correlated with the sales by US arms-producing and military services

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<sup>20</sup> As a further robustness test, all three panels are estimated excluding the trans-European companies Airbus (former EADS) and MBDA, for which sales figures have been allocated according to the employee share in individual countries. Inferences from the baseline results do not change (results not reported).

companies. Imports of major conventional weapons do not turn out to be statistically significant according to both the fixed effects and the first differences model for any of the six countries.

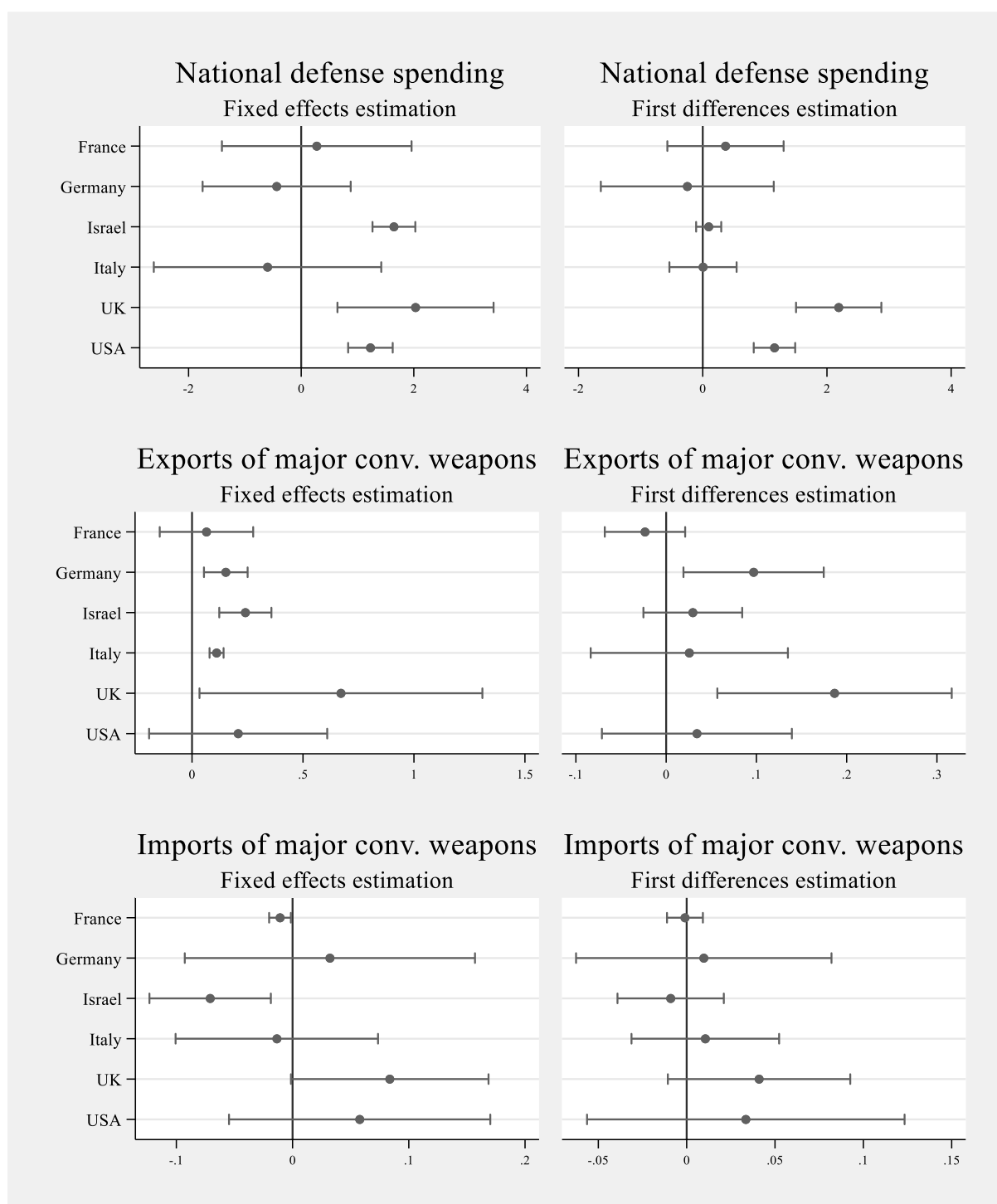


FIGURE 4: COUNTRY-SPECIFIC COEFFICIENTS AND 95% CONFIDENCE INTERVALS FROM FIXED EFFECTS AND FIRST DIFFERENCES ESTIMATION FOR THE BALANCED PANEL

Figure 5 illustrates country-specific results of the fixed effects and the first differences model for the unbalanced company panel, thus including more countries. The results confirm the

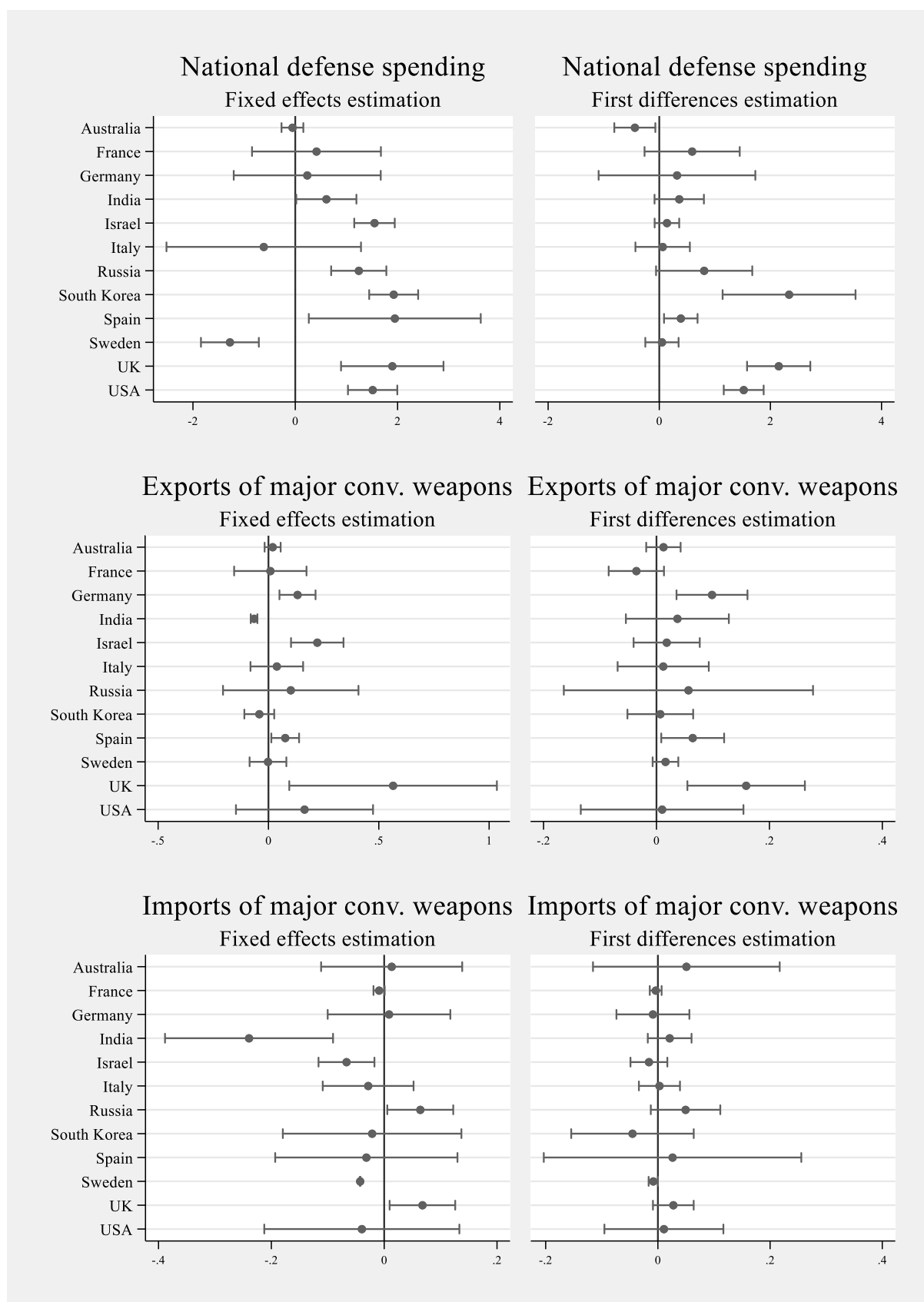


FIGURE 5: COUNTRY-SPECIFIC COEFFICIENTS AND 95% CONFIDENCE INTERVALS FROM FIXED EFFECTS AND FIRST DIFFERENCES ESTIMATION FOR THE UNBALANCED PANEL

inferences for the six countries shown in Figure 4. National defense spending in India, Russia, South Korea and Spain is significantly and positively related to the sales by arms-producing and military services companies in these countries according to fixed effects results (according to the results in first differences, this holds for South Korea and Spain only). Exports of major conventional weapons are significantly and positively related to the sales by arms-producing and military services companies in Spain.

The results support hypothesis 4 and suggest differences among countries in the extent to which the arms industry serves security or economic purposes. Arms-producing companies in the United States serve the superpower's security concerns and develop and produce arms primarily for the country's own armed forces. Arms exports by the United States are likely to be solely an externality of the strong domestic demand for military goods. The same holds for strong military powers like India, Israel, Russia and South Korea as well as for Spain and the United Kingdom. In Israel, Spain and the United Kingdom, however, arms exports significantly determine the sales of military goods by domestic arms-producing companies, too. In Germany, a country with low levels of defense spending, arms exports and the economic returns they generate primarily determine the sales of military goods by German defense companies; national defense spending only seems to subordinately contribute to the sales of military goods. The lack of statistical significance of national defense spending for the sales of military goods reflects that countries like Germany and France have—among other countries—often been criticized by the United States for free-riding on the United States' defense burden within NATO. In times of low levels of defense spending and, thus, low domestic demand for arms, an orientation towards arms exports might ensure the survival of the domestic arms industry and its innovative capacity. Arms exports thus might work like a subsidy the government does not need to pay for, safeguard jobs and ensure that defense capacities can later be increased if necessary. Considering the tremendous R&D cost for new weapon systems and high cost of manufacturing, arms exports are often necessary to realize economies of scale and to reduce

procurement cost, thus making national security even affordable. Export-oriented arms industries like Germany, however, might be less effective in meeting the requirements of the own armed forces when it comes to domestic orders.

Table 2 shows estimation results when the large share of US-companies and subsidiaries located in the United States is excluded from the three panels. Compared to the baseline estimation results of the fixed effects model, national defense spending does no longer turn out to be statistically significant in columns (1) and (3), however, inferences for the unbalanced company panel in column (2) are unchanged. Inferences regarding the estimation results of the first differences model are—apart from smaller estimates for national defense spending—unchanged for any of the three panels.

TABLE 2: ESTIMATION RESULTS EXCLUDING COMPANIES AND SUBSIDIARIES IN THE UNITED STATES

<b>Fixed effects model</b>	(1)	(2)	(3)
	Balanced Company Panel	Unbalanced Company Panel	Unbalanced Subsidiary Panel
Sales of arms and military services <sup>a</sup>			
National defense spending <sup>a</sup>	0.364 (0.514)	0.929*** (0.210)	0.128 (0.325)
Exports of major conventional weapons <sup>a</sup>	0.157*** (0.036)	0.076*** (0.022)	-0.015 (0.050)
Imports of major conventional weapons <sup>a</sup>	0.010 (0.015)	0.019 (0.012)	-0.011 (0.014)
Company Fixed Effects	yes	yes	yes
Observations	405	838	186
Companies (for column (3): Subsidiaries)	27	110	58
R <sup>2</sup> Overall	0.045	0.068	0.132
R <sup>2</sup> Within	0.054	0.150	0.003
R <sup>2</sup> Between	0.045	0.066	0.149
<b>First differences model</b>	(1)	(2)	(3)
	Balanced Company Panel	Unbalanced Company Panel	Unbalanced Subsidiary Panel
Sales of arms and military services <sup>a</sup>			
National defense spending <sup>a</sup>	0.619** (0.241)	0.798*** (0.153)	0.675** (0.316)
Exports of major conventional weapons <sup>a</sup>	0.048*** (0.016)	0.028*** (0.010)	-0.024 (0.052)
Imports of major conventional weapons <sup>a</sup>	0.008 (0.008)	0.005 (0.007)	-0.027* (0.016)
Observations	378	710	120
Companies (for column (3): Subsidiaries)	27	88	35
R <sup>2</sup>	0.039	0.057	0.035

Notes: Standard errors in parentheses. \*, \*\*, and \*\*\* indicate significance at the 10, 5, and 1% significance level, respectively. All regressions apply standard errors clustered at the country level. <sup>a</sup> denotes variables which are expressed in their natural logarithms.

## 7. Conclusion

This paper presented new empirical evidence on how supply and demand in the market for military goods are related. I examined how national defense spending and arms transfers relate to the sales of military goods by arms-producing companies. The sample included data for up to 195 arms-producing and military services companies in 21 countries for the period 2002-2016. The results of the fixed effects model indicated that if national defense spending increases by 1%, the arms sales by a country's largest arms-producing and military services companies increase by up to 1.2%. If exports of major conventional weapons increase by 1%, arms sales by these companies increase by up to 0.2%. Estimation results in first differences were similar for national defense spending, however, the elasticity of companies' arms sales with regards to the exports of major conventional weapons was considerably smaller. Arms imports were not shown to affect domestic arms sales, because countries mainly import arms they do not produce themselves. Imported arms and arms produced by domestic arms manufacturers are, thus, complements rather than substitutes.

Country-specific estimation results suggest differences among countries in the extent to which an arms industry serves security or economic purposes. The differences allow to draw inferences regarding the structure of a country's arms industry. In the United States and Russia, the arms industry's purpose is to provide the own armed forces and to guarantee self-reliance in the production of military goods to maintain the role as independent world powers. In Germany, a NATO ally surrounded by closely aligned partners and under the security umbrella of the United States, the arms industry primary served economic purposes during the observation period. The insights into supply and demand for military goods are derived from a positive analysis and do not describe a normative claim or policy recommendations. The findings contribute to the literature on the arms industry and have implications for scholars investigating into arms trade and defense spending: differences among arms industries, for example, reflect the long-lasting debate on burden sharing within NATO.

Future research should examine the supply side of the market for military goods in more detail. Arms exports have shown to imply positive externalities and serve as substitutes for defense spending: democracies decrease national defense spending in response to increases in their arms exports to other democracies (Pamp and Thurner 2017, Pamp et al. 2018). Investigating the extent to which arms-producing companies benefit or suffer from this shift from defense spending to arms exports is a worthwhile endeavor. Another related question is whether governments even balance out domestic arms orders and arms exports to smooth national arms production. Governments might, for instance, approve arms exports in times of decreased defense spending—meaning the relationship between defense spending and arms exports was reversed—to ensure the survival of the domestic arms industry.



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## Appendix I

TABLE A1: LIST OF COUNTRIES, NUMBER OF COMPANIES AND SUBSIDIARIES AND COUNTRY RANKS IN DEFENSE SPENDING, EXPORTS AND IMPORTS

Country	Number of companies		Number of subsidiaries	Rank: National defense spending (2016)	Rank: Exports of major conventional weapons (2016)	Rank: Imports of major conventional weapons (2016)
	Balanced company panel	Unbalanced company panel	Unbalanced subsidiary panel			
Australia	-	4	3	12	20	8
Brazil	-	1	-	13	22	44
Canada	-	1	2	14	19	34
Finland	-	1	-	47	26	37
France	5	14	9	5	4	62
Germany	5	8	5	9	3	59
India	-	4	-	6	30	1
Israel	3	6	-	16	6	15
Italy	3	5	14	11	8	13
Japan	-	4	-	8	-	23
Netherlands	-	-	1	25	12	47
Norway	-	1	-	30	18	42
Poland	-	2	-	24	43	49
Russia	-	20	9	3	2	41
South Korea	-	10	2	10	9	7
Spain	1	5	1	17	11	54
Sweden	1	3	3	33	14	55
Switzerland	1	2	-	37	15	57
Turkey	-	2	-	15	13	22
Ukraine	-	1	-	46	10	-
United Kingdom	8	16	9	7	7	30
United States	17	85	16	1	1	16
<b>Total # of companies</b>	<b>44</b>	<b>195</b>	<b>74</b>			
<b>Total # of countries</b>	<b>9</b>	<b>21</b>	<b>12</b>			

TABLE A2: SUMMARY STATISTICS

	Observations	Mean	Std. Dev.	Min	p25	p75	Max
<b>Balanced Company Panel</b>							
Sales of arms and military services	660	6,291	8,871	328	1,345	6,125	40,830
National defense spending	135	96,069	197,148	4,220	14,783	52,739	768,466
Exports of major conventional weapons	135	1,676	2,333	16	422	1,697	10,304
Imports of major conventional weapons	135	290	286	1	74	451	1,196
<b>Unbalanced Company Panel</b>							
Sales of arms and military services	1,460	3,683	6,480	328	835	2,945	40,830
National defense spending	333	83,444	179,179	3,063	15,030	51,763	768,466
Exports of major conventional weapons	333	1,513	2368	2	175	1,474	10,304
Imports of major conventional weapons	333	444	604	1	99	563	5,322
<b>Unbalanced Subsidiary Panel</b>							
Sales of arms and military services	252	2,281	3,060	395	757	2,543	22,261
National defense spending	89	139,987	231,175	4,882	26,383	55,922	768,466
Exports of major conventional weapons	89	2,536	3,053	14	512	4,967	10,304
Imports of major conventional weapons	89	410	374	2	104	572	1,574

Note: Sales of arms and military services and national defense spending are in million constant (2016) US dollars. Exports and imports of major conventional weapons are trend indicator values (TIV) in million.

TABLE A3: CORRELATIONS

	Sales of arms and military services <sup>a</sup>	National defense spending <sup>a</sup>	Exports of major conventional weapons <sup>a</sup>	Imports of major conventional weapons <sup>a</sup>
<b>Balanced Company Panel</b>				
Sales of arms and military services <sup>a</sup>	1.000			
National defense spending <sup>a</sup>	0.326	1.000		
Exports of major conventional weapons <sup>a</sup>	0.302	0.839	1.000	
Imports of major conventional weapons <sup>a</sup>	0.193	0.494	0.292	1.000
Observations	660	135	135	135
<b>Unbalanced Company Panel</b>				
Sales of arms and military services <sup>a</sup>	1.000			
National defense spending <sup>a</sup>	0.209	1.000		
Exports of major conventional weapons <sup>a</sup>	0.223	0.619	1.000	
Imports of major conventional weapons <sup>a</sup>	0.051	0.357	-0.180	1.000
Observations	1,460	333	333	333
<b>Unbalanced Subsidiary Panel</b>				
Sales of arms and military services <sup>a</sup>	1.000			
National defense spending <sup>a</sup>	0.667	1.000		
Exports of major conventional weapons <sup>a</sup>	0.457	0.743	1.000	
Imports of major conventional weapons <sup>a</sup>	0.243	0.292	-0.166	1.000
Observations	252	89	89	89

<sup>a</sup> denotes variables which are expressed in their natural logarithms.

## Appendix II

TABLE A4: ROBUSTNESS TEST – ESTIMATION RESULTS WITH ADDITIONAL CONTROL VARIABLES AT THE COUNTRY-LEVEL

<b>Fixed effects model</b>	(1)	(2)	(3)
	Balanced Company Panel	Unbalanced Company Panel	Unbalanced Subsidiary Panel
Sales of arms and military services <sup>a</sup>			
National defense spending <sup>a</sup>	0.933*** (0.212)	1.108*** (0.133)	0.973** (0.401)
Exports of major conventional weapons <sup>a</sup>	0.120*** (0.040)	0.069*** (0.018)	0.016 (0.053)
Imports of major conventional weapons <sup>a</sup>	0.024 (0.016)	0.014 (0.011)	-0.042* (0.023)
War	-0.094 (0.104)	-0.130** (0.066)	0.042 (0.059)
Internal threat	-	-0.040 (0.037)	-
GDP <sup>a</sup>	0.558* (0.316)	0.198 (0.254)	-0.195 (0.811)
Trade globalization	0.008 (0.007)	0.007 (0.005)	0.029*** (0.009)
Continuous democracy measure (CSVMDI)	2.477 (1.874)	1.574** (0.735)	-0.307 (1.551)
Company Fixed Effects	yes	yes	yes
Observations	660	1,460	252
Companies (for column (3): Subsidiaries)	44	195	74
R <sup>2</sup> Overall	0.109	0.0497	0.419
R <sup>2</sup> Within	0.264	0.259	0.155
R <sup>2</sup> Between	0.110	0.0641	0.360

<b>First differences model</b>	(1)	(2)	(3)
	Balanced Company Panel	Unbalanced Company Panel	Unbalanced Subsidiary Panel
Sales of arms and military services <sup>a</sup>			
National defense spending <sup>a</sup>	0.943*** (0.167)	1.078*** (0.140)	1.083** (0.482)
Exports of major conventional weapons <sup>a</sup>	0.046*** (0.017)	0.021** (0.010)	-0.022 (0.051)
Imports of major conventional weapons <sup>a</sup>	0.008 (0.008)	0.000 (0.006)	-0.028 (0.017)
War	0.008 (0.011)	0.011 (0.010)	0.012 (0.020)
Internal threat	-	-0.030 (0.038)	-
GDP <sup>a</sup>	0.399 (0.340)	0.518** (0.208)	-0.176 (0.860)
Trade globalization	0.000 (0.003)	-0.003 (0.002)	0.011* (0.006)
Continuous democracy measure (CSVMDI)	0.265 (0.557)	0.232 (0.259)	-0.855 (1.301)
Observations	616	1,238	170
Companies (for column (3): Subsidiaries)	44	162	44
R <sup>2</sup>	0.125	0.129	0.076

Notes: Standard errors in parentheses. \*, \*\*, and \*\*\* indicate significance at the 10, 5, and 1% significance level, respectively.

All regressions apply standard errors clustered at the country level. <sup>a</sup> denotes variables which are expressed in their natural logarithms.

TABLE A5: ROBUSTNESS TEST – ESTIMATION RESULTS INCLUDING LEADS FOR THE EXPORTS OF MAJOR CONVENTIONAL WEAPONS

<b>Fixed effects model</b>									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Balanced Company Panel	Balanced Company Panel	Balanced Company Panel	Unbalanced Company Panel	Unbalanced Company Panel	Unbalanced Company Panel	Unbalanced Subsidiary Panel	Unbalanced Subsidiary Panel	Unbalanced Subsidiary Panel
Sales of arms and military services <sup>a</sup>									
National defense spending <sup>a</sup>	1.138*** (0.230)	1.215*** (0.226)	1.240*** (0.229)	1.266*** (0.144)	1.246*** (0.156)	1.249*** (0.162)	1.252** (0.474)	1.322** (0.533)	1.054* (0.590)
Exports of major conventional weapons <sup>a</sup>	0.136*** (0.040)	0.135*** (0.038)	0.133*** (0.040)	0.069*** (0.022)	0.090*** (0.024)	0.112*** (0.027)	0.019 (0.067)	0.097 (0.078)	0.054 (0.161)
Imports of major conventional weapons <sup>a</sup>	0.004 (0.015)	0.001 (0.016)	-0.004 (0.018)	0.008 (0.011)	0.011 (0.012)	0.004 (0.013)	-0.061** (0.026)	-0.056** (0.023)	-0.043 (0.026)
Exports of major conventional weapons <sup>a</sup> (t+1)	0.126*** (0.039)	0.112*** (0.034)	0.123*** (0.035)	0.069*** (0.021)	0.059*** (0.020)	0.088*** (0.025)	0.133 (0.122)	0.129 (0.138)	0.274* (0.154)
Exports of major conventional weapons <sup>a</sup> (t+2)		0.039 (0.031)	0.014 (0.026)		0.031 (0.022)	-0.003 (0.021)		0.036 (0.106)	0.006 (0.104)
Exports of major conventional weapons <sup>a</sup> (t+3)			0.055 (0.044)			0.052* (0.028)			0.007 (0.173)
Company Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	616	572	528	1,238	1,061	911	170	125	94
Companies (for columns (7) - (9): Subsidiaries)	44	44	44	162	142	128	44	31	21
R <sup>2</sup> Overall	0.108	0.109	0.107	0.047	0.045	0.051	0.455	0.485	0.462
R <sup>2</sup> Within	0.239	0.272	0.305	0.259	0.274	0.303	0.173	0.201	0.209
R <sup>2</sup> Between	0.109	0.110	0.108	0.058	0.029	0.044	0.316	0.417	0.372
<b>First differences model</b>									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Balanced Company Panel	Balanced Company Panel	Balanced Company Panel	Unbalanced Company Panel	Unbalanced Company Panel	Unbalanced Company Panel	Unbalanced Subsidiary Panel	Unbalanced Subsidiary Panel	Unbalanced Subsidiary Panel
Sales of arms and military services <sup>a</sup>									
National defense spending <sup>a</sup>	1.045*** (0.159)	1.043*** (0.161)	1.016*** (0.159)	1.224*** (0.131)	1.248*** (0.137)	1.164*** (0.134)	1.346** (0.574)	1.538* (0.758)	1.278 (0.762)
Exports of major conventional weapons <sup>a</sup>	0.069*** (0.015)	0.071*** (0.016)	0.089*** (0.019)	0.035** (0.015)	0.034** (0.015)	0.058*** (0.019)	0.026 (0.052)	0.034 (0.064)	0.089 (0.123)
Imports of major conventional weapons <sup>a</sup>	0.007 (0.009)	0.004 (0.009)	-0.001 (0.011)	0.002 (0.007)	0.002 (0.007)	-0.001 (0.008)	-0.039* (0.023)	-0.035* (0.020)	-0.027 (0.023)
Exports of major conventional weapons <sup>a</sup> (t+1)	0.063*** (0.017)	0.070*** (0.019)	0.088*** (0.023)	0.032** (0.013)	0.043*** (0.014)	0.058*** (0.018)	0.123 (0.081)	0.137 (0.118)	0.278* (0.133)
Exports of major conventional weapons <sup>a</sup> (t+2)		0.009 (0.015)	0.025 (0.020)		0.026 (0.017)	0.025 (0.016)		0.028 (0.050)	0.119 (0.088)
Exports of major conventional weapons <sup>a</sup> (t+3)			0.034* (0.019)			0.047*** (0.016)			0.180 (0.121)
Observations	572	528	484	1,061	911	779	125	94	73
Companies (for columns (7) - (9): Subsidiaries)	44	44	44	142	128	111	31	21	17
R <sup>2</sup>	0.144	0.152	0.161	0.128	0.148	0.155	0.111	0.131	0.164

Notes: Standard errors in parentheses. \*, \*\*, and \*\*\* indicate significance at the 10, 5, and 1% significance level, respectively. All regressions apply standard errors clustered at the country level.

<sup>a</sup> denotes variables which are expressed in their natural logarithms.

TABLE A6: ROBUSTNESS TEST – ESTIMATION RESULTS FOR THE EQUIPMENT SPENDING OF NATO COUNTRIES

<b>Fixed effects model</b>			
	(1) Balanced Company Panel	(2) Unbalanced Company Panel	(3) Unbalanced Subsidiary Panel
Sales of arms and military services <sup>a</sup>			
<i>Equipment</i> spending <sup>a</sup>	0.380*** (0.111)	0.413*** (0.084)	0.180 (0.284)
Exports of major conventional weapons <sup>a</sup>	0.220*** (0.050)	0.174*** (0.037)	0.078 (0.099)
Imports of major conventional weapons <sup>a</sup>	0.042** (0.019)	0.041*** (0.014)	-0.000 (0.024)
Company Fixed Effects	yes	yes	yes
Observations	585	1,162	197
Companies (for column (3): Subsidiaries)	39	139	57
R <sup>2</sup> Overall	0.043	0.013	0.398
R <sup>2</sup> Within	0.155	0.127	0.018
R <sup>2</sup> Between	0.041	0.008	0.353
<b>First differences model</b>			
	(1) Balanced Company Panel	(2) Unbalanced Company Panel	(3) Unbalanced Subsidiary Panel
Sales of arms and military services <sup>a</sup>			
<i>Equipment</i> spending <sup>a</sup>	0.094** (0.038)	0.093* (0.051)	-0.098 (0.162)
Exports of major conventional weapons <sup>a</sup>	0.057*** (0.017)	0.060*** (0.015)	-0.023 (0.055)
Imports of major conventional weapons <sup>a</sup>	0.014 (0.009)	0.010 (0.006)	-0.023 (0.015)
Observations	546	1,006	138
Companies (for column (3): Subsidiaries)	39	124	36
R <sup>2</sup>	0.030	0.018	0.016

Notes: Standard errors in parentheses. \*, \*\*, and \*\*\* indicate significance at the 10, 5, and 1% significance level, respectively. All regressions apply standard errors clustered at the country level. <sup>a</sup> denotes variables which are expressed in their natural logarithms.

TABLE A7: ROBUSTNESS TEST – ESTIMATION RESULTS FOR THE EXPORTS OF NEW AND USED BUT MODERNIZED MAJOR CONVENTIONAL WEAPONS

<b>Fixed effects model</b>			
	(1) Balanced Company Panel	(2) Unbalanced Company Panel	(3) Unbalanced Subsidiary Panel
Sales of arms and military services <sup>a</sup>			
National defense spending <sup>a</sup>	1.064*** (0.232)	1.194*** (0.137)	0.913** (0.416)
Exports of <i>new</i> and <i>modernized</i> major conventional weapons <sup>a</sup>	0.201*** (0.048)	0.100*** (0.026)	-0.011 (0.066)
Imports of major conventional weapons <sup>a</sup>	0.019 (0.016)	0.018 (0.011)	-0.035* (0.018)
Company Fixed Effects	yes	yes	yes
Observations	660	1,453	252
Companies (for column (3): Subsidiaries)	44	191	74
R <sup>2</sup> Overall	0.107	0.045	0.448
R <sup>2</sup> Within	0.215	0.239	0.094
R <sup>2</sup> Between	0.109	0.056	0.391
<b>First differences model</b>			
	(1) Balanced Company Panel	(2) Unbalanced Company Panel	(3) Unbalanced Subsidiary Panel
Sales of arms and military services <sup>a</sup>			
National defense spending <sup>a</sup>	0.976*** (0.154)	1.231*** (0.123)	1.071** (0.491)
Exports of <i>new</i> and <i>modernized</i> major conventional weapons <sup>a</sup>	0.048*** (0.014)	0.027*** (0.010)	-0.038 (0.049)
Imports of major conventional weapons <sup>a</sup>	0.008 (0.008)	0.002 (0.007)	-0.029* (0.015)
Observations	616	1,232	170
Companies (for column (3): Subsidiaries)	44	162	44
R <sup>2</sup>	0.116	0.118	0.063

Notes: Standard errors in parentheses. \*, \*\*, and \*\*\* indicate significance at the 10, 5, and 1% significance level, respectively.  
All regressions apply standard errors clustered at the country level. <sup>a</sup> denotes variables which are expressed in their natural logarithms.