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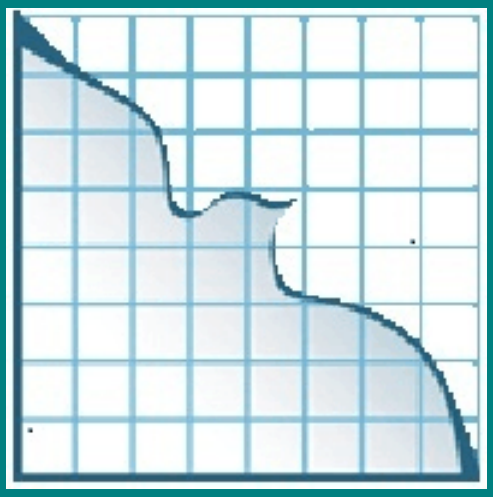

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SIPRI's arms producing and military services companies database

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Abstract

This article describes the history of the Stockholm International Peace Research Institute's (SIPRI) arms producing and military services companies database (AIDB) as well as its purpose, its main strengths and deficiencies, and its data collection and implementation processes. It presents ideas to improve the AIDB discussed at an expert workshop held in Stockholm on 23–24 March 2018 and reports on concrete recommendations that SIPRI wishes to take forward to improve the database. The article's first section provides an overview of the database's history. The second section moves on to AIDB's weaknesses and strengths, its data collection approach, and the sources and methods used. Section three discusses deficiencies of the database. Section four details aspects of the expert workshop and the important takeaways from the two-day meeting. The final section offers possible solution approaches to problems with the database.

SIPRI's arms industry database

Arms producing and military services companies—the arms industry, in short—form the supply side of the military market. An integral component of and active agent in that market, they often are national "heavyweight" or "champion" arms producers such as BAE Systems in the U.K., Lockheed Martin in the U.S., and Thales in France. With established close, enduring ties to their respective ministries of defense, they are influential actors when it comes to lobbying for new arms procurement programs. The primary purpose of SIPRI's arms producing and military services companies database (AIDB) is to follow such companies' yearly evolution by presenting their arms sales, describing and analyzing major industry changes, and, when possible, explaining them and their potential consequences. Making the database publicly available, in the form of an annual listing of the top-100 firms, also enables non-SIPRI experts, researchers, and civil society at large to use the data. AIDB is one of the world's few sources to collect and present companies' arms sales figures systematically and consistently.[1]

From a data collection perspective, the arms industry is difficult to delineate. The potential pool of companies involved in arms production is vast and lack of transparency in reporting as well as the absence of an agreed-upon definition of what is an arms sale present obstacles. Since its creation in 1990, a number of conceptual and practical issues have emerged with the top-100 list, notably its limitations regarding coverage, heuristic value, and relevance to peace research. These were discussed at an expert workshop held at SIPRI's offices, 23–24 March 2018.

The arms industry database, part of SIPRI's four core databases,[2] first published in *SIPRI Yearbook 1990*, was started in part to support the conversion project—the post-cold war conversion from military to civilian production—and also to reveal "a number of important facts about the structure of this industry" (SIPRI, 1990, p. 325).[3] It included figures such as companies' arms sales, total sales, arms sales as a share of total sales and the companies' main sector(s) of activities, employment levels, and profits. These and accompanying analyses were presented annually as *SIPRI Yearbook* chapters until 2002. The effort to collect figures for the supply side of the military market laid the foundations for today's version of AIDB by identifying sources of data and by developing a methodology to estimate companies' arms sales in a rigorously and systematically. Initially, the main purpose was to analyze the post-cold war restructuring of the global arms industry, a goal that is still valid as both the 2000s and the 2010s have seen significant changes in the global arms industry.

By the end of the 1990s, however, a decline in interest in conversion projects led to reduced funding and a publication gap of the top-100 list in the 2003 edition of the *Yearbook*. But as SIPRI had started to redesign the process and methodology to estimate companies' arms sales, the database was updated, and the figures published, as a new arms industry database as from the *Yearbook 2004* onward. (Thus data published in the 2002 and 2004 *Yearbooks* are not directly comparable.) The 2004 edition of the *Yearbook* includes firms from ten countries. Methodological caveats were, and still are, numerous, and figures presented were described as "rough." Comparability and coverage were and remain important problems.

The new version of the AIDB—which is the current version that is updated and published yearly—presents a consistent set of data, following the development of methods to estimate individual companies' arms sales for those that publish problematic figures or those that do not disclose their sales at all. This effort also led to a more diversified collection of sources and increased the pool of potential companies included in the top-100.

Despite improvements, the functionality and uses of AIDB are more limited than those of the other core SIPRI databases. There are enduring issues, for example, the difficulties related to coverage as the arms industry is likely much larger than the top-100 firms, but the resources required to widen the scope of data collection and to augment the current set of companies would be significant. Further, there are gaps in AIDB such as the absence of Chinese firms (discussed below). Additionally, several top-100 companies are privately-held and not required to publish figures related to their military production or services. Frequently, even for companies that do report, the figures presented are questionable or partial.

Several methodological issues arise in using the database. For instance, year-on-year changes in the composition of the top-100 companies tend to occur frequently due to mergers, acquisitions, divestments, bankruptcy, restructuring, and so on. Therefore, the arms sales figures for one company can fluctuate widely over short time frames. The database includes footnotes detailing important variations in arms sales of companies. Another central challenge of the arms industry database is related to the identification of arms sales figures. In the home countries of the top-100 arms companies, national financial authorities may not require that arms companies publish their arms sales figures. There is no agreed-upon definition among the industry and ministries of defense of what is considered an arms and/or military services sale.

SIPRI uses its definition to build arms sales estimates, and it provides figures for incomplete and nonexistent figures when there is enough information to make a rough estimate. For example, some of what SIPRI would consider arms sales often are included in other categories such as intelligence or space, and the military share of these categories needs to be teased out of the sales figures mentioned. Finally, all arms sales are attributed to company headquarters and therefore are linked to the country where the headquarter is located. For large companies with production sites in different countries, the AIDB thus does not reflect where the production occurs. In some cases, when data is available, large subsidiaries are included in the top-100, but do not show up as ranked companies since their revenues already are included in the figures published for the headquarters. This is the case for BAE Inc., for example, which is the U.S. subsidiary of BAE Systems of the U.K. Despite limitations, the AIDB remains one of the only open sources that provide consistent estimates of arms companies' revenues over time. Offering annual snapshots of the largest arms companies in the world, the definitions and methodology behind the data collection and estimations are available online.[4]

This article provides an overview of the history of SIPRI's arms industry and military services companies database (AIDB). It discusses the data collection approach, the sources and methods used, and AIDB's weaknesses and strengths. Further, it reports on an arms industry expert workshop held in March 2018 at SIPRI's offices and on important takeaways from the two-day meeting. Peer-reviewed and edited versions of some of the papers presented at the workshop are published in this special issue of the journal.

Presenting arms companies by country or region offers insights into a country's or region's military posture, notably the need to retain national arms production capabilities and to avoid dependence on foreign sources of supply for weapons acquisition. For instance, AIDB tracks emerging producers' arms sales from countries such as Brazil, India, South Korea, and Turkey. This helps scholars, policymakers, and others to understand that domestic demand, success in export markets, and the need to become self-reliant in arms (e.g., South Korea) can play vital roles in driving arms sales.

Arms industry database, methods, and issues

AIDB provides information on the 100 largest companies ranked by sales of arms and military services in a financial year for the period 2002–16. This includes state-owned enterprises as well as publicly-traded and privately-held companies but excludes manufacturing or maintenance units of the armed services. Companies included are those with activities in the field of military goods and services. While SIPRI publishes details on the top-100 companies' sales, employment levels, and profits, information for about 125 companies are available in its internal database.

Methods

As mentioned, the original purpose of AIDB shaped not only the definition of arms sales but also the methods used for collecting and processing the data. Since the original purpose was to assess the development and structure of the industry, indicators deemed important were total sales, employment, and profitability. While sufficient to gain an industry overview, in practice, the lack of more detailed information is problematic. For example, in several cases, it is challenging to separate

domestic arms sales from arms exports or to disaggregate sales by type of arms sold or military services provided.

Since the database relies on publicly available information, the scope of the data and geographical coverage is limited.[5] Data sources are divided into primary and secondary sources. Primary sources are companies' annual reports and information published on their websites. Secondary sources are news published in the business sections of newspapers, in military journals, and by internet news services specializing in military matters. Press releases, marketing reports, government publications of contract awards, and country surveys also are consulted as ways to triangulate companies' "correct" arms sales figures. For some privately-held companies, which have no legal obligation to provide publicly available annual reports, data are estimates and can be unreliable. In this respect, SIPRI is sometimes contacted by researchers and experts based in different world regions who provide new information or who prepare their own arms sales estimates.

Consistent with the military expenditure database, all data first is collected in local currency and at current prices before conversion into current and constant U.S. dollar values for firms listed in the top-100 list.

Main challenges of the arms industry database

Although the SIPRI top-100 arms industry database provides an invaluable amount of information for policymakers and scholars, there are drawbacks to the database. For example, "[t]he data on arms sales reflect what a company considers to be the defence share of its total sales. In other cases, SIPRI uses the figure for the total sales of a 'defence' division, although the division may also have some unspecified civil sales."[6]

Inconsistency in the way companies report

Unlike SIPRI's arms transfers or military expenditure databases, one of the first problems with the arms industry database, given SIPRI's definition of arms sales, is that there is no consistency in the way companies in the industry report such sales. Figures presented by companies differ substantially both between companies and from SIPRI's definition and thus comparison between companies can become problematic.

Double-counting

Another issue is that looking at companies' arms sales involves some double-counting. As arms companies become more globalized (e.g., globalization via the subsidiaries of large arms producers such as BAE Systems) and weapons are of higher technology, components often are sold between companies so that sales are counted more than once. In a hypothetical example, the sale of an F-35 combat aircraft by Lockheed Martin contains engines from Pratt and Whitney (a subsidiary of United Technologies, the 11th ranked company by arms sales in the 2016 top-100 list) and avionics from BAE Systems. In collecting sales information for these three companies, Pratt and Whitney and BAE Systems will report sales of these items to Lockheed Martin. Lockheed Martin, in turn, will publish the sale of the F-35 aircraft. Thus, when assessing *total* arms sales, the avionics and engines are recorded twice.

What is accurate, however, is the value of the arms sales per company. In counting the total sales of the industry, the data provide an important and correct reflection of the separate sales each company makes.

Not all arms sales are captured

Substantial numbers of sales of arms and military services are missed, and company-specific definitions of what constitutes military goods or services imply a potential underestimate of the figures. Companies like General Electric, Hewlett-Packard, and CACI International mainly focus on military services such as telecommunications and information storage, and the line between arms and non-arms sales can become very blurry.

No information on domestic procurement

In principle, the SIPRI databases should inform each other. Military expenditure, especially the resources dedicated to arms research, development, arms procurement, could serve as an overall indicator of input into the military sector. Arms transfers refer to all the equipment or major weapons that are exported or imported for each country and could also give indications on some arms companies' activities. Thus arms sales, less arms transfers should equal domestic procurement. In practice, however, the database links are tenuous. For example, significant time gaps exist between the time the funding for weapons is funneled into the industry and when it shows as a sale in a company's annual report. This creates uncertainty in establishing direct links between demand and supply. Moreover, the military expenditure and the arms transfers databases have on their own methodologies, and combining them is methodologically challenging. (For a quantitative analysis of the relationship between SIPRI's databases, see the article by Smith and Dunne in this issue of the journal.)

One of the main consequences of the lack of domestic arms procurement data is the inability to assess the role domestic demand plays in the development of an arms industry (see Lopes da Silva, in this issue). Having domestic procurement data allows for an analysis of the determinants of arms imports, the role played by foreign and local markets, and of supplier

dependency ratios. Improvements to the database to include such a measure would open up new research avenues.

Issues related to coverage and changes in the composition of the database

Many have questioned whether SIPRI should expand its top-100 database to include more companies. As it is, the current AIDB is not representative of the entire industry but only of the largest companies. This creates regional biases as smaller arms companies, often located outside the U.S. or Western Europe, are presently excluded.

A more complex issue is the difficulty of following firms' behavior over time. For example, if companies outside the top-100 sales threshold merge and subsequently then meet the threshold they would appear in the top-100 list, using either the old or a new name. For this newly listed company, historical pre-merger information would be missing. Given that the database was created to understand the structure and development of the arms industry, the inability to track companies' actions or changes in the industry is a significant drawback. While relatively easy to address, this would require more resources to implement.

Regional bias and the absence of China in the database

With the emergence of China as not only an economic but also military power, the lack of data on Chinese companies is a serious gap in the database. Given its levels of military spending, relatively high self-dependency, and increasing arms exports, it is safe to assume that if information were available, a number of Chinese arms companies would rank quite high in the SIPRI top-100 list. Companies like the state-owned North Industries Corporation (NORINCO) are known to have sold weapons to countries in Africa (e.g., South Sudan) and any information on arms sales of such companies would greatly improve the arms industry database.

One important consequence of not having Chinese arms companies in AIDB is the possible existence of measurement bias where certain relationships (correlates or causal) may disappear if Chinese sales were included. The data can be seen as having a regional bias away from developing countries and thus relationships found in empirical estimations could be valid only for a group of more industrialized western countries.

Brainstorming about the arms industry database

With these problems in mind, the Arms and Military Expenditure Programme at SIPRI invited experts in the field to present papers and participate in a two-day-long discussion and "brainstorming" workshop in Stockholm held on 23–24 March 2018. (Some of the papers appear in this issue of this journal.)

The workshop led to an open discussion about how the data and their analysis could be improved, on possible ways to present issues related to the industry's supply side, how to better frame the arms industry from a peace research perspective, and ways to increase the database's visibility. Numerous suggestions made are relevant and of interest to SIPRI, highlighting the multidimensionality of arms companies' profiles. Some of the suggested improvements in or changes to AIDB covered ideas that can be implemented quickly (e.g., the display of the data in new ways); others will need longer-term research and modification to the whole arms industry project in order to reform it.

Framing the arms industry data in a more peace research-oriented way

Several short-term, easy-to-implement ideas to improve the database were discussed during the workshop. One suggested a comparison between the arms industry and other industrial sectors' sales revenues (see the paper by Herbert Wulf, in this issue). The goal behind such a comparison is to help counteract militaristic narratives that unduly emphasize the economic importance of these companies when, in fact, their relative importance to national GDP and employment is rather small. This could also help highlight the arms industry's unique, strong relationship with the state where headquarters are based and that it provides, of course, the means to wage war.

Another suggested project that gathered interest and could be implemented relatively quickly was to pay more attention to mergers, acquisitions, and divestments, which—given the original purpose of AIDB—the experts considered an important dimension to include. This would include the need to keep records on companies' genealogy. Related to this idea, was a suggestion to examine arms industry supply chains. Additionally, country case studies were mentioned as relatively straightforward and possible to implement within a short time frame.

The third idea was to reframe or place less emphasis on the ranking of companies in the database. It was found that large arms companies (in their annual reports) often use AIDB to promote themselves, showcasing how well they are doing, and how highly-ranked they are as compared to others. Possible ways to make the data release less about an advertisement for the arms companies and more in line with SIPRI's peace research mission on armament and disarmament are needed.

Identifying long-term, structural changes in the arms industry and finding ways to account for these changes

Other recommendations for changes to AIDB and associated analyses led to an exploration of conceptual and structural

issues. These would take time to implement as this would likely involve new data collection, which also means developing definitions, methods, and new estimates. One approach suggested reconceptualizing the way the arms industry is often depicted, e.g., in terms of a hierarchical structure from large weapons integrators (top of the pyramid) to components producers (lower level of the pyramid). Over time, boundaries between types of activities have become increasingly blurred, and in some cases they may be misleading. Looking at supply chains is one way to investigate how to pinpoint the industry's structure better.

In a similar vein, exploring causes, drivers, and effects of arms industry globalization was deemed a central topic, one on which little open source information exists. Considering the precise nature of its production, the trade controls it is subject to, and the limited number of customers for its products, the arms industry globalization profile differs from civilian sectors in several ways. In the 2000s, a number of reports and articles were published regarding this issue (framed as "transatlantization" at the time), but since then interest in this structural, long-term change appears to have diminished.

Other proposals suggested exploring just how the industry has expanded from a fairly narrow military orientation to broad security concerns—straddling both spheres—and their consequences such as the militarization of public security with greater uses of means of coercion, for instance. While discussed mainly in the Israeli context, this could be investigated broadly. The relationship between arms companies and the government of the country where their headquarters are based also was mentioned as an interesting topic to develop.

Looking for information on Chinese arms companies

As mentioned, AIDB currently does not include information on Chinese companies, an omission highlighted at the workshop. Starting with the 2017 version of AIDB, slated for release in December 2018, special mention will be made of any credible information found on the Chinese arms industry. The objective is to assess if any reliable information is available in Chinese sources based on which estimates can be made.

Some of the ideas discussed, notably investigating supply chains, require significant financial resources (hiring of researchers) which, for database development, have been difficult to acquire. In several cases, such as the military–security nexus, data would be difficult to collect. Nevertheless, the workshop identified several enduring issues with the industry as well as research questions that can be shared with the expert community to possibly help develop a new research agenda on the supply side.

Moving forward

While it is clear that SIPRI's arms industry database is an essential resource in the field of peace and security studies, limitations and flaws exist. As SIPRI looks to improve its databases, the arms industry database is a useful starting point. At the expert workshop, useful discussions were held on topics ranging from the use of the database to its limitations, usability, and possible ways forward. The papers featured in this issue of the journal showcase possible uses of AIDB. They highlight both, strengths and relevance as well as difficulties, limitations, and flaws, and they suggest improvements and, in some cases, significant changes to the database. These range from the inclusion of China as an important part of the database to ideas about calculating domestic arms procurement, issues related to arms industry corruption, and even to a statistical analysis suggesting that AIDB's shortcomings actually may not be as severe as some people believe.

In the end, the fundamental question about what is interesting about the arms industry and why one should care needs to be spelled out and explained with more clarity than before. This is the central starting point for SIPRI to explore new and added dimensions to AIDB, and to highlight its role and influence in the arms market.

Notes

We thank workshop participants for their comments and suggestions as well as an anonymous reviewer who provided helpful comments on a draft of this article.

1. SIPRI's complete database is online and can be accessed at https://www.sipri.org/databases/armsindustry. Another source is *DefenseNews* top-100 list of defense companies. Although the content of this database is similar to SIPRI's AIDB, there are some stark contrasts. While SIPRI uses open sources to construct its database, *DefenseNews* collects data in the form of a surveys sent to companies. These surveys are not made publicly available and thus it is impossible to corroborate the accuracy of the information. In addition, *DefenseNews* uses a different definition of arms sales, one that includes homeland security, which SIPRI does not. Moreover, company comparisons across time are not possible with *DefenseNews*' list since its figures are not provided in constant prices.

2. The other three are the arms transfers database, the military expenditure database, and the multilateral peace operations database.

3. Arms industry data collection supported European countries' efforts to diversify and/or convert arms companies' activities from military to civilian production at a time when military expenditure and funding for weapons procurement declined in large arms producing countries.

4. See https://www.sipri.org/databases/armsindustry/sources-and-methods.

5. Not all countries have arms production capabilities; moreover, the information and coverage of the database is limited due to issues of transparency in countries that do produce arms such as China.

6. Quoted from the definition of the arms industry database on https://www.sipri.org/databases/armsindustry/sources-and-methods#definitions.

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Issues in the quantitative analysis of the SIPRI arms industry database

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Abstract

Although the Stockholm International Peace Research Institute's data on the 100 largest arms (and military services) producing firms is very widely used for various purposes, there is relatively little quantitative statistical analysis of it. This article discusses some of the issues involved in the econometric analysis of the data. This is complicated by the difficulty of modeling the processes of mergers, acquisitions, and divestments which drives entry and exit from the list. Various models are estimated to examine (a) the relationship between arms sales and military expenditure, (b) the evolution of concentration and the size distribution of firms, (c) the cross-section relationship between size and growth of firms, (d) the times-series properties of the arms sales of individual firms, and (e) of arms sales by country of ownership.

Although the Stockholm International Peace Research Institute's (SIPRI) data on the 100 largest arms (and military services) producing firms is very widely used for various purposes, there is relatively little quantitative statistical analysis of this arms industry data. This contrasts with the vast number of econometric studies using the numbers from the SIPRI military expenditure and arms trade databases. This article will discuss some of the issues involved in the econometric analysis of the arms industry data, suggesting topics worth investigating and linking the analysis of the arms industry to more general approaches in industrial economics. In the process it will discuss potential models and provide some exploratory data analysis and preliminary estimates. Hartley (2017) provides a recent review of the economics of the arms industry.

We first discuss the relationship between the data available on military expenditure, the arms trade, and arms sales by firms. This relationship is complicated by differences in definition and valuation and by lack of information about a crucial intervening variable: domestic arms production.[1] We also discuss some definitional issues and practical problems. While there is extensive qualitative work on this topic, quantitative work is complicated by the need to model entry and exit from the list of arms firms as a result of mergers, acquisitions, and divestments.[2]

We then consider some possible research questions. These include the relationship between arms sales and military expenditure, concentration in the arms industry and the size distribution of firms, the patterns of growth by the individual companies over time, and the growth in sales by country of ownership. Finally, we make some concluding comments.

Relationships among the SIPRI databases

SIPRI provides data on military expenditure, the arms trade (imports and exports of arms), and arms sales by the world's top-100 arms companies. In principle, these are all related. In practice, a number of problems arise in linking them, which are reviewed below. The other major data source is *World Military Expenditures and Arms Transfers* (WMEAT), which until 1999 was published by the U.S. Arms Control and Disarmament Agency (ACDA), and subsequently by the U.S. Department of State. It does not include data on arms sales by companies but does include data on the number of people in the armed forces.

Ignore, for now, the practical problems and consider what identities would hold supposing we had perfect data. Military expenditure in a particular country is made up of procurement of domestically produced and imported arms, plus other components of military expenditure such as the salaries of the armed forces.

National arms production equals the amount of domestic procurement by the national government plus the sum of arms exports to other countries. Since exports from country i to j equal imports to j from i, world exports equal world imports. A firm's total arms sales is the sum of what its subsidiaries in each other country sell for domestic procurement in that country, sell to other arms companies as inputs, and sell for export from that country. If Rolls-Royce sells engines to BAE who then sells the aircraft containing the engines, the engines are counted twice, once in Rolls-Royce sales and once in BAE sales. This complicates the interpretation.

We do not observe arms production or sales in a particular country, nor intermediate inputs. In principle, input-output tables allow the measurement of value added, the proportion of

turnover accounted for by intermediate inputs, sales to other companies, and final demand for domestic procurement or exports. But the standard industrial classification used in input-output tables does not have categories that capture total arms production. Not only are exports and imports of weapons components between companies difficult to capture, but also the valuation of international intra-company transactions, such as supply of components between two subsidiaries, is complicated by the transfer pricing policies of the companies, which may reflect tax avoidance or other factors.

In practice, then, the identities do not hold, not even for nonmilitary production. For instance, because of measurement errors world imports are not equal to world exports. The problem is compounded in that the three types of data (military expenditure, arms production, arms trade) come from quite different sources. Military expenditure data ultimately are derived from government budget data, the arms trade data are based on reports of physical transfers, and the arms sales data come from company accounts and measure turnover rather than value added. There are different valuation procedures (current or constant prices, which currency is used, etc.) and different definitions of what constitutes "military" among the three types of data. Since the data are given in U.S. dollars, movements in exchange rates against the dollar can make a large difference.

Definitions of the arms industry

A major difficulty is that arms is not a category in any of the standard lists, such as the Harmonized Commodity Description and Coding System of the World Customs Organization, the UN Standard International Trade Classification, SITC, or the International Standard Industrial Classification, ISIC. In ISIC Revision 4 there are categories—Weapons and Ammunition (ISIC2520; in Rev. 3 it was 2927), Military Fighting Vehicles (ISIC3040), and Defense Activities (ISIC8422)—which cover the operation of the military. But both military and civilian items are included in many of the relevant categories, such as aerospace and electronic equipment.

For military expenditure SIPRI uses government definitions. Although NATO tries to establish common reporting categories, in practice there is considerable flexibility in what governments report. Definitional changes, such as the removal of paramilitary forces from the NATO definition, agreed in 2004, cause structural breaks, particularly since different countries revised their definitions at different dates. Sometimes the figure may be a budgeted number rather than actual outlays. The degree of disaggregation of the total differs, and although for NATO countries one can also get data on procurement expenditure on equipment, there are questions about its reliability and whether definitions are consistent

This article discusses some of the issues involved in the econometric analysis of arms industry data. Various models are estimated to examine (a) the relationship between arms sales and military expenditure, (b) the evolution of concentration and the size distribution of firms, (c) the cross-section relationship between size and growth of firms, (d) the times-series properties of the sales of individual firms, and (e) of arms sales by country of ownership.

across countries. There are also inevitable currency conversion issues. Smith (2017) discusses the measurement of military expenditure.

For arms transfers SIPRI construct a volume measure of transfers of major weapons systems valued using trend indicators. WMEAT has a wider definition and refers to the value of the goods and services actually delivered, although the price actually paid can be difficult to determine. Some studies have examined the use of the ratio of the WMEAT to SIPRI measures to provide an implicit price index, e.g., Smith and Tasiran (2010). Most export licensing systems are designed to approve or prohibit particular transfers and are not designed to capture data on the volume and value of trade. Other reported data might relate to orders, deliveries, or payments and these can differ substantially because some orders are cancelled and some deliveries are never paid for. Given how complicated international arms transfers are, with offsets, countertrade, aid, concessionary finance, servicing, and training, it is often difficult to know how to define an appropriate price or interpret the reported numbers for the value of a contract.

For the list of the largest 100 arms producing firms, SIPRI uses data that come largely from company accounts. What is counted as arms production probably differs considerably between firms.[3]

Firms differ in the amount of information they provide on where the sales are made and where the production takes place. Although the arms industry is less multinational than many other industries, it is still globalized, particularly through components. Whereas military expenditure and arms transfers have global coverage, the arms company data is missing data on Chinese firms that are now an increasing proportion of the market. As noted, looking at total arms sales by companies involves some double-counting since they sell military components to each other.

Domestic production

The biggest gap in the data is that there is virtually no direct data on domestic production of arms. In principle, countries should have estimates of the size of their defense industrial bases for procurement planning purposes. However, in many

cases the defense ministry may not know where the production is coming from. It may procure from a domestic firm that assembles the weapons from components sourced from all over the world and if those components are dual use, they will not be counted in arms imports figures. Often the arguments about the defense industrial base are political. Firms emphasize how many jobs a military contract will generate when lobbying for it. This adds more noise into the figures. Countries also differ in whether they define their defense industrial base on the basis of ownership by nationals or the national location of production, irrespective of ownership. One could try to estimate domestic production, for NATO countries where spending on equipment is available, as being procurement of defense equipment plus exports minus imports. But the measurement errors are likely to be large, because of definitional and valuation differences, although there may be statistical ways to reduce the noise in the series. A theoretical model of the defense industrial base which links the elements discussed above is provided in Dunne, *et al*. (2007).

The data analyzed

The analysis that follows uses the arms industry database spreadsheet as retrieved from SIPRI's website. Within it, each sheet is for a year and gives in column A, the rank for that year; B, the rank in the previous year; C, company name; D, notes; E, country; F, arms sales; G, arms sales in constant prices; H, total sales; I, arms sales as a percent of total sales; J, total profit; and K, total employment. There is a separate spreadsheet setting out total sales over all top-100 companies for each year, at current and constant prices.

Companies are ranked according to the value of their arms sales at the end of their financial year. Figures for subsidiary companies, where available, are given together with the name of the parent company, although subsidiaries are not included in the ranking. Company names and structures are listed as they were at the end of the financial year. The notes list information about subsequent changes, e.g., when Lockheed Martin acquired helicopter producer Sikorsky from United Technologies in 2015, and explanations of major revisions. When there is a lot of uncertainty attached to an estimate this is also noted. The notes are more detailed for more recent years. In the past SIPRI gave data for the sectors that the companies operated in, but this is no longer given. Allocating companies to sectors can be difficult for many of the companies which are highly diversified conglomerates. There has been a major growth in military service companies over the years (Dunne and Smith, 2016).

Table 1: Arms sales and military expenditures

Dependent variable: D(LAS) sample, 2003–2016

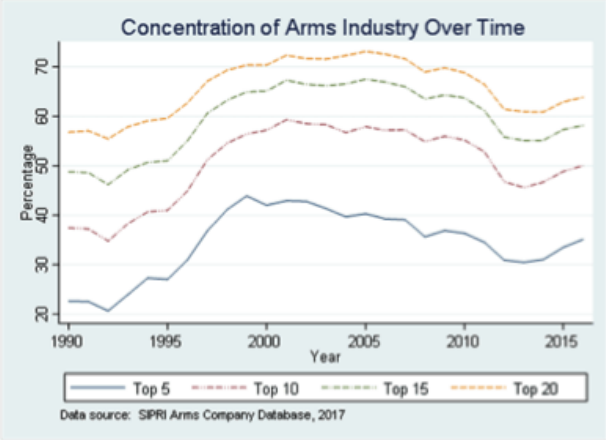
Variable	*Coefficient*	*Std. error*
C	-0.474416	0.155104
D(LMELC)	1.555025	0.143426
Z(–1)	0.349445	0.116098
R-squared	0.917374	
Adj. R-squared	0.902351	
S.E. of regression	0.015956	

The relationships of arms sales to military expenditure

There is clearly scope for more work on the empirical relationship among the three types of variables: military expenditure for individual countries, arms exports and imports, and the sales by countries' arms firms. On the demand side, high military expenditure may suck in imports (see Smith and Tasiran, 2010) or may boost sales of the national arms firms, and this might help them to export. The latter link, through the sales of domestic arms firms, does not seem to have been investigated. Some arms firms like Airbus are not national, but their sales could be allocated to the owning nations. However, there would be jumps in sales by a country's firms when there was a cross-national takeover.

As a crude example of this sort of analysis, consider the ratio between world arms sales and world military expenditure, both in constant 2015 U.S. dollars, over the period 2002–16. This ratio averages about 25 percent. As noted already, military expenditure includes things other than expenditure on arms, including wages for the military, and the total sales of the arms companies involves some double-counting. Over the period, real military expenditure grew about 45 percent and real arms sales 38 percent. Since the arms sales figures exclude China we used world military expenditure less China. The estimated error correction model made the change in log arms sales, D(LAS), a function of the change in log military expenditure less China, D(LMELC), and the lagged difference between log military expenditure less China and log arms sales: Z=LMELC–LAS. The results are given in Table 1.

The short-run elasticity of arms sales to military expenditure is 1.56, the long-run elasticity is constrained to be one (the *t*-value testing the hypothesis of a unit coefficient was 1.1), and the speed of adjustment is 35 percent a year. The fit is quite good: an average error of 1.6 percent, and 92 percent of the growth in arms sales explained by military expenditure.



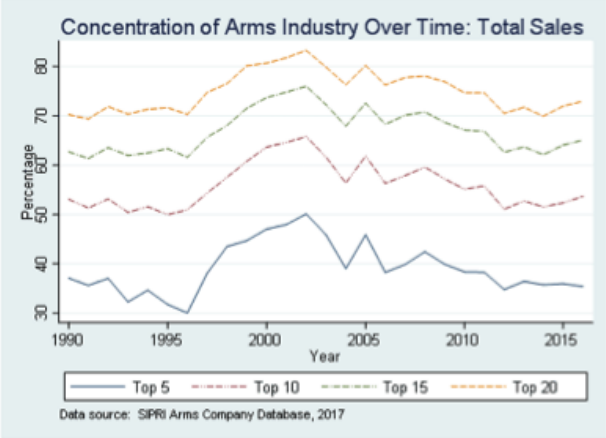


Figure 1: Concentration ratios for the SIPRI top-100 arms firms. *Top panel*: Arms sales only. *Bottom panel*: All sales, including arms sales.

Using world military expenditure including China gave a very similar fit, with an R-squared of 0.913. Given that the two series are apparently independently constructed, the similarity between them is quite striking. This is, of course, a very short time series and structural changes may cause the relationship to change. Similar equations could be estimated for the total arms sales of the companies located in individual countries to examine the relationship with military expenditure and exports of that country.

Concentration and the size distribution of firms

An example of the quantitative analysis of the SIPRI arms industry data is Dunne and Smith (2016), which examines the evolution of concentration in the global arms industry over the period 1990–2013. The market share of the top-5 firms, C5, went up from 22 percent in 1990 to a peak of 43 percent in 1999 before declining to 35 percent by 2011. Using revised data, the 5-firm concentration ratio was 45 percent in 2002, falling to a low of 33 percent in 2014, then rising to 37 percent in 2016. The top panel in Figure 1 shows the concentration of arms sales for differing numbers of firms, which show a similar pattern to C5, albeit on different vertical scales. The global arms industry is less concentrated than comparable civilian industries. In fact, the size distribution of *arms* sales by these firms is less concentrated (top panel) than the *total* sales of the same companies as shown in the bottom panel of Figure 1.

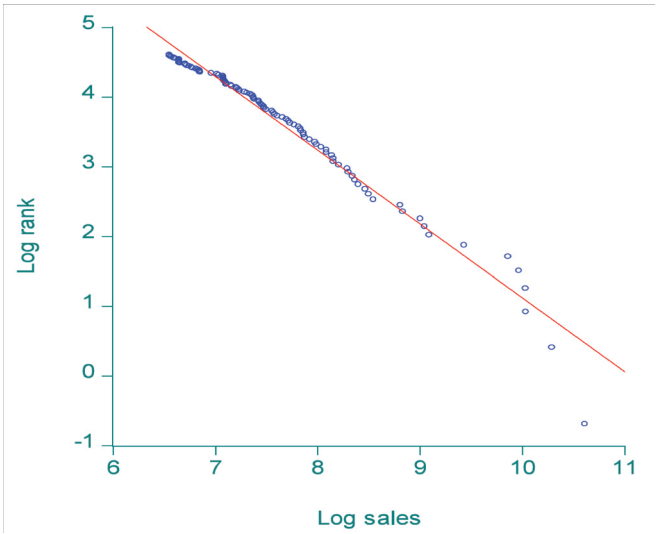


Figure 2: Plot of log rank against log sales for SIPRI top-100 arms firms, 2016.

Real arms sales peaked in 2010, then fell until 2015, rising again in 2016. There is some negative relationship between sales and concentration—falling sales prompt concentration—but it is not close. Dunne and Smith (2016) concluded: "What is clear is that there are economic forces pushing for increased competition, but the final outcome will be determined by political forces, and transparency and governance will become increasingly important issues."

An alternative way to examine the size distribution of firms is to see whether the industry follows the usual power law. This involves a plot of the log rank against log arms sales. This shows how sales decline with firm rank. Power laws or Pareto Distributions occur in many phenomena such as the size of wars, cities, businesses, income, or wealth. The graph for 2016 is given in Figure 2.

Relative to the graphs shown in Dunne and Smith (2016), there are larger positive errors, i.e., more firms larger than one would expect, for values of log size between 9 and 10. For values of log size above 10, there is the same pattern of negative errors that they noted. Sales tend to be lower at the

Table 2: Pareto regression of log rank minus a half on log size

Dependent variable: Log (rank – ½)
Sample 1 100

Variable	*Coefficient*	*t-statistic*
C	11.68888	82.62594
Log sales	–1.056655	–57.52369
R-squared	0.971235	
Adj. R-squared	0.970942	
S.E. of regression	0.167848	
Durbin-Watson stat.	0.368271	

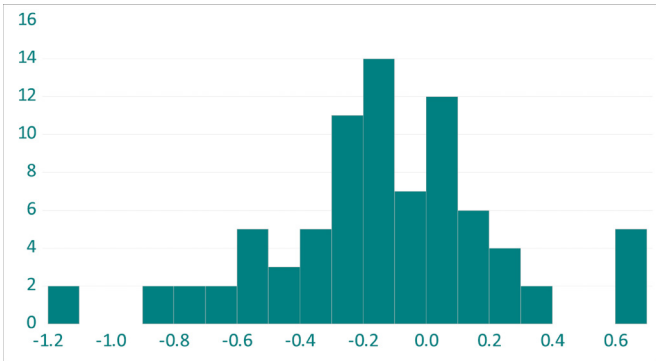


Figure 3: Distribution of continuing company growth rates (change in logarithm), 2011–6.

very top relative to what would be predicted. This pattern is also present in power law graphs for all firms, but is more marked for arms firms.

This distribution can be summarized using a Power Law regression. The relationship between rank, R, and size, S, can be written: $R=AX^{-b}$. A special case is Zipf's law, where b=1, coming from linguist Zipf's observation that the frequency of any word is in proportion to its rank in the frequency table. So the most frequent occurs twice as often as the second most frequent, and so on. This does seem to work well for the distribution of firm size, but there is a downward bias on estimation, which has been dealt with by using the half correction and estimating a regression of log (Rank – ½) on a constant and log size.

If b=|1| then the distribution fits the Zipf. If b>|1| there is a tendency for concentration to larger firms and if b<|1| there is a tendency for concentration to smaller firms. For nondefense firms the size distribution tends to follow the distribution with an exponent of about |1.06|. Dunne and Smith (2016) found that there was a clear change in the coefficient value from above one to below it, with the transition taking place in the early 2000s. Then, in the late 2000s, it rises again and is close to 1 by 2011. It has continued rising toward more concentration and is |1.06| in 2016, as shown in Table 2.

Growth by company

Using cross-section information, one can regress the growth of firms over a period on the logarithm of initial size and other characteristics, such as nationality or the sectors they operate in. Gibrat's law says that growth is independent of initial size and whether this holds is an interesting question. As a crude example consider growth over the five year period 2011–16. Matching companies, in some cases with different names, gave a sample of 82 firms. The length of the period over which one measures the growth rate will determine the size of the sample. Because firms enter and exit the top-100, the longer the period the fewer continuing firms there will be.[4] The simple histogram for the change in the logarithm of current sales is shown in Figure 3.

The hypothesis that the distribution is normal is not rejected on a skewness-kurtosis test (skewness= –0.16; kurtosis=3.72; Jarque-Bera=2.11; p-value=0.35). Both the mean and median decline by 14 percent, but the range is massive (–1.17 to 0.70) and, at 0.37, the standard deviation is well over twice the mean. Starting from 12 country dummies, there seemed to be little difference between countries, except that Russian firms and firms from non-Japanese Asian countries grew faster than the others. The growth by Russian firms is partly the result of the creation of holding companies, such as United Aircraft, many of whose constituents were not in the top-100 before.

Neither the share of arms in total sales[5] nor log arms sales in 2011 were significant. This suggests that Gibrat's Law, that growth is independent of size, holds. However, there seemed to be a nonlinearity in log initial size and when its square was added to an equation, also including dummies for other Asian and Russian companies, it was significant, giving a U-shaped relationship with a minimum at arms sales of USD5.7 billion, which was around rank 13. Firms bigger and smaller than that size grew significantly faster, but there is a lot of noise in the relationship. Adding the squared term increased the adjusted R-squared from 0.19 to 0.26. The equation does not fit well, explaining a small proportion of the variation in growth. There are two outliers close to the minimum which have the largest negative growth rates, less than minus one. These are two U.S. firms, Science Applications International Corp., ranked 12 in 2011, which divested Leidos, and Oshkosh, ranked 17 in 2011, which suffered from a decline in demand for armored vehicles

with the reduction of U.S. troops in Iraq and Afghanistan. However, when dummy variables were added for these two firms, log initial size and its square remain significant, both jointly and individually. Adding the two dummies increases the adjusted R-squared to 0.38 and reduces the *t*-statistics of log initial size from –2.89 to –2.53 and of its square from 2.81 to 2.48; both still significant.[6] The implied minimum, at USD5.4 billion, is very similar. It would be interesting to see if the U-shape relation held in earlier years as well.

Table 3: Sales and ranks for 15 large arms companies, 2002 and 2016

Company	*Country*	*Sales*	*Rank*	*Sales*	*Rank*
Lookheed Martin Corp.	US	18,870	3	40,830	1
Boeing	US	23,560	1	29,510	2
Raytheon	US	12,020	5	22,910	3
BAE Systems	UK	14,070	4	22,790	4
Northrop Grumman	US	21,000	2	21,400	5
General Dynamics	US	9,820	6	19,230	6
Airbus/EADS	Europe	5,630	9	12,520	7
L-3 Communications	US	3,020	12	8,890	8
Leonardo/Finmeccanica	Italy	3,720	11	8,500	9
Thales	France	6,840	7	8,170	10
United Technologies	US	5,640	8	6,870	11
Textron	US	1,390	23	4,760	15
Rolls-Royce	UK	2,850	14	4,450	16
Leidos/Science Applications	US	3,000	13	4,300	17
Mitsubishi Heavy Industries	Japan	2,780	15	3,670	21

Time series for firms

The quantitative time-series analysis of the development of individual firms over time is problematic because of the prevalence of mergers, acquisitions, and divestments. This is a general problem in industrial economics and not particular to arms firms. There is an extensive qualitative literature on the corporate strategies of the large arms firms. This covers issues like the evolution of individual companies, the extent to which they specialize in military sales, the process of merger, acquisition, and divestment, the extent of internationalization, and the relative importance of demand side, government, and supply side, corporate, forces in the evolution of market structure. These all pose interesting questions, but quantitative work is complicated by modeling the processes of mergers and acquisition and entry and exit from the list, which make it difficult to identify continuous entities. There is also the problem that firms change their names, e.g., Finmeccanica was renamed Leonardo in April 2016.

SIPRI note that the same 12 companies have occupied the first 10 ranks during the past 15 years so one can do time-series analysis for those companies. Table 3 gives the data for the top 11 in 2016 and some others that also had high rankings in 2002. The ones that are excluded are as follows. Number 12 in 2016 was Huntington Ingalls Industries, from the U.S., a shipbuilder formed in 2011 as a spin-off from Northrop Grumman. Number 13 in 2016, United Aircraft Corp., Russia, did not appear on the 2002 list. It was created in 2006 by merging various Russian firms. Number 14 in 2016, Bechtel Corp., U.S., a construction company, was not on the 2002 list. Number 18 in 2016, Harris Corp., U.S., electronic systems, was number 37 in 2002. Number 19 in 2016, United Shipbuilding Corp., Russia, established in 2007, was not on the 2002 list. Number 20 in 2016, Booz Allen Hamilton, U.S., a government services company, was number 47 in 2002.

If one looks at plots of the logarithm of arms sales for the 15 large companies, the variance over all 15 firms is fairly constant. The largest drops by individual firms were when Leidos was formed as a spin-off from Science Applications International Corp. in 2013, and the big fall in United Technology sales from 2014 to 2016 with its divestment of Sikorsky. There is clearly an element of sample selection bias in choosing to focus on companies that had high rankings in both years, but the stability at the top contrasts with the turbulence of the histogram of growth over the whole sample.

The average of the 105 correlations between these firms is 0.68. There are 19 pairwise correlations over 0.9 and only 4 negative correlations. The four negative correlations all involve Northrop Grumman, perhaps because of the effect of the spin-off of Huntington Ingalls in 2011. Northrop Grumman's correlation with Rolls-Royce was –0.10, with Lockheed –0.10, with Textron –0.05, and with United Technologies –0.03. Northrop has the lowest average correlation, at 0.22, and the next lowest is 0.50 for Leidos, the SAIC spin-off. Airbus has the highest average correlation, at 0.81. Principal components, PCs, were used to examine the commonality between the performance of the firms. The first PC explains 73 percent of the variance. It weights the firms roughly equally, with loadings between 0.2988 and 0.2149, except for Northrop which gets a weight of 0.0884, reflecting its low correlations.

The first two PCs explain 87 percent of the variance. The second PC weights heavily negatively on Lockheed, Mitsubishi, Rolls-Royce, and Textron and positively on Northrop and Leidos. It seems to be distinguishing between two types of companies but it is not obvious on what basis, beyond distinguishing Northrop and Leidos which have low correlations with the others. The third PC raises the cumulative proportion explained to 92 percent, but does not have an obvious interpretation.

To examine how the logarithm of the arms sales of each firm responded to the total log arms sales, 15 error correction equations were estimated. These were similar to that used above for the arms sales to military expenditure relationship. This model proved to have too many parameters for the 14 observations available, although the fit was quite high with 4 firms with adjusted R^2 over 0.9, and another 6 with over 0.8. Boeing with an adjusted R^2 at 0.47 and Northrop at 0.49 were the lowest. The average short-run effect was 1.2 and the long-run effect, calculated from the averages of the short-run coefficients, was 0.98. The average speed of adjustment was 0.43. Although the averages look plausible, the individual estimates often do not and there was a large dispersion around the averages. For L-3, the adjustment coefficient was negative and there were 4 firms with a short-run elasticity greater than 2. There was no obvious common restricted form that looked likely to work better.

There is an element of judgment in how one links the firms. For instance Electronic Data Systems (EDS) and HP could have been (but was not) treated as continuous, as the latter had no arms sales prior to their acquisition of the former. This process of merger, acquisition, and divestment is continuing. In February 2018, General Dynamics announced it was acquiring the IT and cybersecurity group CSRA for USD9.6 billion. This would make GD+CSRA the second-largest defense IT company on 2018 revenues of about USD10 billion, after Leidos, with just over USD10 billion (and followed by Booz Allen, with around USD6 billion). This process is always political as indicated by the controversy around the proposed alliance of Fincantieri of Italy and Naval of France to create a European "champion" in military shipbuilding.

Other questions that could be analyzed with SIPRI's time series for firms constructed from the arms industry database include the balance between military and other sales, and much greater use and comparison could be made with other sources such as the *Defense News*' top-100 list.

Table 4: Arms sales by country, ordered by 2002 rank

Country	*No. of firms (2016)*	*Sales (USD millions)*	*% of total*	*No. of firms (2002)*	*Sales (USD mn)*	*% of total*	*Real % growth, 2010–6*
US	38	217,150	57.9	42	128,050	63.7	25
UK	8	36,110	9.6	11	23,590	11.7	13
France	6	18,570	5.0	8	13,320	6.6	3
Trans-European	2	15,780	4.2	2	7,280	3.6	60
South Korea	7	8,370	2.3	2	1,030	0.5	501
Russia	10	26,580	7.1	4	2,250	1.1	774
Japan	5	8,220	2.2	6	5,590	2.8	9
Germany	3	5,980	1.6	5	4,560	2.3	–3
Italy	2	10,100	2.7	3	4,900	2.4	53
India	4	6,160	1.6	3	2,080	1.0	119
Israel	3	7,830	2.1	5	3,540	1.8	64
Other Europe	5	6,210	1.7	5	2,390	1.2	92
Total (USD bn)		375			201		38

Growth by country

The analysis thus far has been for individual arms companies, but one can look at individual countries to gain some idea of the changing geographical distribution of arms production. Table 4 gives the number of firms in the top-100 list and total arms sales in 2002 and 2016 by country of ownership of the firm as given by SIPRI. Also included are the two trans-European firms, Airbus/EADS and MBDA, although many of the national firms like BAE Systems and Leonardo are effectively multinational. BAE's U.S. subsidiary had arms sales of USD9.3 billion, almost half its total arms sales of USD22.8 billion. Real growth for the top-100, calculated using a price index which is 1 in 2016 and 0.74 in 2002, was 38 percent. The U.S. grew slightly slower, at 25 percent, so its share of the total fell, from 64 percent to 58 percent. Russian, South Korean, and Indian sales all more than doubled. In real terms, German sales dropped while trans-European sales grew, mainly because of Airbus. The Italian growth between 2002 and 2016 is largely the result of the expansion of Leonardo/Finmeccanica (although, in 2016, had rather smaller arms sales than it had in 2010–11).

Conclusion

Given the vast amount of econometric work using SIPRI's military expenditure and arms transfer data it is surprising that there is not more quantitative work using the arms industry data. It may be that political scientists, who are interested in arms, think primarily in terms of nation states rather than firms while economists, who do think in terms of firms, are not particularly interested in arms. The data are provided as tables for each year giving the company name, rank, and data. This means that it is less convenient to get time series but the amount of work involved is not that great, as the examples above illustrate. A more serious problem for the quantitative analysis of the firm data on arm sales is how one deals with mergers and acquisitions, which reduce the number of companies, and divestments, which increase the number. Both introduce discontinuities over time. There is considerable qualitative analysis of this process, but it is not obvious how to code and model these transitions. This is less of a problem with cross-section studies that look at a moment in time but is a severe problem for time-series analysis.

Overall, our conclusion is that SIPRI's database is a valuable asset and that there is considerable scope for more formal quantitative modeling of the evolution of the structure of the arms industry, although there are some issues that need to be confronted in conducting a quantitative analysis. In particular, one needs methods of handling the implications of mergers, acquisitions, and divestments for the data. We have certainly found the data valuable and used it in a number of papers, including Smith (2013a,b) as well as Dunne and Smith (2016) and we are sure that there is scope for much greater use.

Notes

This is a revision of a paper prepared at the SIPRI Expert Workshop, 22 March 2018. We are grateful to Sam Perlo-Freeman for considerable help and to Ensar and Filiz Yesilyurt, workshop participants, and an anonymous reviewer for useful comments on earlier versions.

1. At a March 2018 workshop held at SIPRI's offices, Michael Broszka discussed various methods of combining data to get rough estimates of arms production.

2. It was suggested at the workshop that SIPRI could make more readily available the information it had on entry and exit.

3. In the description of Sources and Methods SIPRI say: "The SIPRI definition of arms sales serves as a guideline; in practice it is difficult to apply. Nor is there any good alternative, since no generally agreed standard definition exists. In some cases, the data on arms sales reflects only what a company considers to be the defence share of its total sales. In other cases, SIPRI uses the figure for the total sales of a 'defence' division, although the division may also have some unspecified civil sales. When the company does not report a sales figure for a defence division or similar entity, arms sales are sometimes estimated by SIPRI. Such estimates are based on data on contract awards, information on the company's current arms production and military services programmes, and figures provided by company officials in media or other reports. For all these reasons, the comparability of the company arms sales figures given in the Top 100 is limited."

4. We have used the publicly available dataset to allow replication. SIPRI's full dataset includes companies below the top-100 and it would be helpful if SIPRI could make this more readily available. There is also a potential problem of sample selection bias as initially large firms which grow slowly drop out of the sample and initially small firms that grow fast enter.

5. This was missing for a few companies and set at 50 percent in those cases.

6. The variance of growth rates is much larger for the smaller companies but the *t*-statistics are even larger if heteroskedasticity-robust standard errors are used.

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Filling arms production data gaps: South America as a case in point

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Abstract

In this article I argue that the data collection methods and procedures behind the Stockholm International Peace Research Institute's (SIPRI) global arms trade database can also be used to approximate domestic purchases of local production of major conventional arms. The total output of domestic arms industries would then be the sum of what is domestically retained (procured) plus arms exports, if any. The feasibility of this idea is tested by presenting new data on domestic arms production for five South American countries (Argentina, Brazil, Chile, Colombia, and Venezuela) between 1960 and 2015. The results show the critical role government purchases play in maintaining domestic arms industries.

One of the main research challenges in defense and peace economics concerns data availability. For example, states may choose not to disclose information on arms production or trade as this might hinder deterrence and impair their strategic position. This assumes that states do have full information, but the lack of specialized local bureaucracies in maintaining national statistics may in fact contribute to poor data to begin with. Despite its crucial importance, the literature has only occasionally discussed issues of data availability and accuracy.[1]

While challenging, there are important efforts to amend the opacity in military affairs and associated data. In particular, the Stockholm International Peace Research Institute (SIPRI) stands out as the leading institution providing data on arms industries, trade, and military expenditure. Regarded by many as the most authoritative source of information for defense and peace economics research, its data are widely used in the literature. Although providing data at very high standards of quality, SIPRI's work still has significant gaps. In this article, I discuss one, if perhaps not the main, shortcoming of SIPRI's databases, namely the lack of data on domestic arms production and procurement. I argue that collecting or imputing such data is feasible by using the same measurement methodology SIPRI currently applies to build its arms trade database—the Trend Indicator Value (TIV). Plausible estimates of overall national arms industrial output can then be achieved. To illustrate feasibility, I present a new dataset of arms production for Argentina, Brazil, Chile, Colombia, and Venezuela, 1960 to 2015.[2]

This article is organized as follows. In the first section, I discuss SIPRI's arms industry and arms trade databases, their uses in the literature, and their limits. A review of the main empirical attempts to amend the absence of domestic procurement data is also provided. In a second section, I make a case that, using SIPRI's arms transfer methodology, it is possible to gather data on domestic arms purchases potentially going back to 1950, the starting year of SIPRI's database. The third section presents and discusses the dataset on South America's arms production, stressing its contributions and limitations.

SIPRI's data on arms industry and trade: Contributions and limitations

SIPRI's arms trade database records all transfers of major conventional weapons from 1950 to the most recent full calendar year. Extant studies on arms production and arms transfers much rely on SIPRI's records.[3] Likewise, SIPRI's arms industry database has proven to be a valuable resource. The institute provides annual data on the top-100 largest arms producing and military services firms, recording market shares, profits, total sales, and levels of employment.[4] The arms industry database has been used, for example, to track the process of firm consolidation taking place since the late 1980s.[5]

Although highly valuable, SIPRI's data have some critical gaps. In particular, none of the databases provide figures for domestic arms procurement. By accounting for international transfers only, the arms transfers database possibly misses a significant part of the industry's output. Similarly, the top-100 arms industry database provides no information about where production takes place, so that the locally produced and purchased share is not known. Domestic procurement data, were it available, could allow for a more accurate assessment of the determinants of arms imports, the role played by foreign markets, and supplier dependency.[6]

This data gap, however, must be contextualized. When created, in 1989, the arms industry database aimed at understanding how the changing international environment would affect arms companies and their relationship with the state. Addressing issues of domestic arms procurement or import dependence was beyond its initial scope. SIPRI certainly excelled at this principal task; notwithstanding, as research agendas shift and more data become available, other dimensions of the arms industry must be explored.

Empirical efforts have tried to amend or bypass these data limitations. Bove and Cavatorta (2012) estimate the share of domestic procurement in military expenditure by equaling it to domestic arms production plus arms imports minus arms exports. Smith and Tasiran (2010) adopt a random coefficient approach to account for the effects of unobserved domestic production capability on arms imports propensity. Yesilyurt, *et al*. (2014) seek to remedy the same shortcoming by using the International Standard Industrial Classification (ISIC) code 2927 for armaments and ammunition as a database for arms industry output. Nonetheless, the figures provided by ISIC suffer from various weaknesses such as the limited number of weapon types included. Moreover, the regular revision of ISIC data classification to reflect technological and industrial changes compromises data consistency for long-term analysis. These concerns are worsened in that the category of weapons and ammunition does not cover all arms production, excluding platforms for example. Considering the lack of long-span data on arms production, Yesilyurt, *et al*. (2014) provide a relatively short panel data covering 15 countries between 1997 and 2002.

The case for domestic procurement data

Domestic procurement data are in nearly ubiquitous demand in the literature. By providing it, SIPRI would further assist researchers to improve their empirical investigations and thus increase our understanding of the arms industry. However, this is no easy task as it may demand new measurement methods, data sources, and human resources. Albeit challenging, the task is not impossible, and considering the potential benefits, it is certainly worthwhile.

SIPRI's arms industry database, in its current form, has some limitations that may hamper efforts to account for domestic procurement or national arms production output. The data collection process for this database relies mainly on firm's annual reports. Publicly available information on financial and employment data on the arms industry worldwide is limited, and the quantity and quality of the information provided vary widely. For purposes of consistency, SIPRI focuses on a minimum common denominator, forgoing any additional information that is not available across reports. Consequently, the arms industry top-100 list does not specify, for example, where the production takes place as data are not provided consistently among firms. Without this information, it is not possible to build national output time-series.

This article argues that collecting or imputing domestic arms production data worldwide is feasible by using the same measurement methodology the Stockholm International Peace Research Institute (SIPRI) currently applies to build its global arms trade database—the Trend Indicator Value (TIV). Plausible estimates of overall national arms industrial output can then be achieved. To illustrate the feasibility, the article presents a new dataset of arms production for Argentina, Brazil, Chile, Colombia, and Venezuela covering the years 1960 to 2015.

Another shortcoming of the arms industry database is its regional bias. By sorting the database based on sheer performance measures, it excludes smaller and incipient arms industries often located in developing countries. Hence, the arms industry database is useful insofar as it addresses production in economically developed areas, such as Western Europe and North America. As discussed later on, a revival in arms production in South America has taken place over the past decade or so; however, due to the criteria of SIPRI's arms industry database, this revival is largely ignored even though several prominent arms companies have conducted businesses in that region, such as BAE Systems and Saab for example. This bias is unfortunate as the study of the determinants of arms production in developing countries is an important strand in the literature.[7]

The arms trade database itself may provide a feasible and efficient solution to this data conundrum. SIPRI uses a standard measurement unit to track international arms transfers, the Trend Indicator Value (TIV). TIVs are based on the known unit production costs of a core set of weapons. They represent the transfer of military resources rather than of financial values. Weapons for which the production costs are unknown are compared with core weapons based on size and performance characteristics. Intended as a standard unit to allow for the measurement of arms flow trends to countries and regions over time, these TIVs could also be used to record domestic procurement as some of the primary sources used by SIPRI to collect data for arms transfers also contain records of domestic purchases. Examples includes *Jane's All the World's Aircraft*, *Jane's All World's Fighting Ships*, and *Conway's All the World's Aircraft*. These publications offer annually updated military inventories, including locally produced equipment. Once identified, this equipment knowledge could be converted into TIVs, thus giving a measure of local arms transfer. By tracking domestic procurement, an estimate of total arms

production can be achieved, adding domestic purchases to exports. The use of the same measurement method to account for domestic purchases is an efficient way to expand SIPRI's databases, fills a critical data gap, and compensates for the regional bias of the arms industry database. This is not to say an expansion is effortless; however, it is an efficient solution as it would employ a method already in use. In the following section, I present new data on arms production in South America using the method discussed above.

Arms production in South America

Scholarly work on arms production in South America divides into two waves. The first analyzed the performance of arms industries during the 1970s and 1980s, addressing mainly the cases of Argentina, Brazil, and Chile. Due to the significant size it achieved by the 1980s, Brazil's arms industry was the most widely studied.[8] This strand of the literature also proposed a number of hypothesis regarding the subsequent failure of these industries. In the Brazilian case, for instance, the steep fall in arms exports following the end of the Iran–Iraq war of the 1980s is identified as one of the main reasons for the subsequent industry's crisis and demise. On this matter, there is broad a consensus in the literature. Lock (1986, p. 81), for example, asserts that as exports were Brazil's main arms production driver, eventual domestic financial constraints did not permit the continuance of large domestic procurement.

During the 1990s, military spending in the region was severely curtailed. As regional arms industries were dismantled—several arms firms went bankrupt or else were privatized—academic interest faded away. Interest was renewed when, by the mid-2000s, a worldwide commodity boom lifted economic conditions and budget constraints in South America and allowed governments to allocate more funds to military projects and investments. The recent wave of scholarly work has mainly focused on the political drivers behind this revival.[9]

The bulk of the literature on domestic arms production in South America adopted a qualitative methodological framework. Statistical tools have only seldom been employed. While contributing substantially to our current understanding of the industries, this approach has disregarded quantitative data collection. Its primary focus was placed on policy analysis and decisionmaking processes. Consequently, data on domestic arms production in South America are scattered in the literature. Maldifassi and Abetti (1994) provide estimates of domestic purchases for Argentina, Brazil, and Chile between 1969 and 1988 based on a "minimum cost per soldier" calculation. While clever, the estimates nevertheless are imprecise as their base value relies on an assumption.[10] More accurate data on domestic arms procurement and arms industry output for South America could provide evidence to corroborate or to refute hypotheses put forward in the literature. For instance, several studies of Brazil's arms industry attribute the crisis of the sector to a loss of foreign markets. But without an assessment of the role played by the domestic market vis-à-vis arms exports, such conclusion might be an extrapolation.

To fill the data gap and illustrate the feasibility of expanding SIPRI's database, I present data on domestic procurement for Argentina, Brazil, Chile, Colombia, and Venezuela between 1960 and 2015. Data were collected from numerous editions of specialized publications in military inventories such as the aforementioned works by *Jane's* and *Conway's*. Moreover, SIPRI granted access to its internal database in which some domestic acquisitions are also listed.[11]

The process of building the database follows a two-step routine: identification and valuation. For example, Argentina's Espora class frigates (Meko 140 A16) were built at the Río Santiago Shipyard (Astilleros y Fábricas Navales del Estado, or AFNE) under a license contract with Blohm and Voss signed on 1 August 1979. All frigates were acquired by the Argentine Navy and registered as domestic procurement. Records of the acquisitions were found in the 2016 edition of *Jane's All World's Fighting Ships*. After identification, purchases are transformed into SIPRI Trend Indicator Values (TIVs). Argentina's 1986 acquisition of the *Rosales* frigate, for instance, records a TIV of 226.32. By using TIVs to track domestic procurement, an estimate of total arms production can be achieved, adding domestic purchases to exports. Regarding export values, equipment not locally produced or assembled was excluded.

Tables 1 and 2 provide summary measures of the resulting overall dataset. The descriptive statistics indicate interesting aspects of the industry so far unnoticed in the literature. First, the data suggest that the domestic market plays a crucial role in maintaining arms industries in South America: The vast majority of the trade was conducted locally for purposes of domestic arms procurement. While substantial empirical evidence on the importance of exporting arms exists, far less attention has been given to the role played by domestic procurement, a shortcoming that may now be rectified.[12] Consider the Argentinean case whose arms exports are small, as observed in the literature,[13] so that the state is the predominant recipient of Argentina's arms industrial output. The domestic market played a similarly overwhelming role in Chile. The importance of foreign markets is higher in Brazil's case but not as much as one would expect. Foreign clients were the main recipient of arms for most of the 1980s, true, but the

Table 1: Descriptive statistics (Argentina, Brazil, Chile, Colombia, and Venezuela, 1960– 2015)

	Argentina	*Brazil*	*Chile*	*Colombia*	*Venezuela*	*Mean*
Arms production	79.3	254.6	18	6.2	2.6	72.1
Domestic Procurement	78.6	197.6	17.2	6.2	2.3	60.4
Arms exports	0.74	57	0.9	0	0.3	11.8
Arms imports	362.8	474.7	348.7	178.7	379.5	348.9
Military expenditure	6,394.8	11,208.4	2,340.7	3,202.9	10,629.1	6,755.2
GDP	0.28	1.32	0.12	0.17	0.26	0.43

Notes: Arms production, exports, imports and domestic procurement are in millions of TIV dollars at 2015 constant prices. Military expenditure is in millions of 2015 constant dollars, GDP is in trillions of 2015 constant dollars. Unweighted mean. *Sources*: Arms exports, imports, and military expenditure (SIPRI); GDP (World Bank). Arms production and domestic procurement, author's calculations.

Table 2: Pearson's *R* correlation matrix

	Arms prod.	*Domestic proc.*	*Arms exports*	*Arms imports*	*Military exp.*	*GDP*
Arms production	1					
Domestic procurement	0.97	1				
Arms exports	0.64	0.45	1			
Arms imports	0.27	0.28	0.10	1		
Military expenditure	0.35	0.33	0.25	0.35	1	
GDP	0.56	0.50	0.52	0.17	0.73	1

Table 3: Argentina's Espora class (Meko 140 A16)

Name	*(1)*	*(2)*	*(3)*
Espora	1980	1982	1985
Rosales	1981	1983	1986
Spiro	1982	1983	1987
Parker	1982	1984	1990
Robinson	1983	1985	2000
Gomez Roca	1983	1986	2004

Notes: (1) "Laid down" means that the keel has ben laid and marks the beginning of production; (2) "Launched" refers to the moment the ship is actually put in the water; (3) "Commissioned" refers to the time of delivery, i.e., the official acquisition date. .*Source*: *Jane's All the World's Fighting Ships* (2016).

industry was borne out of a *local* demand shock. This corroborates Kapstein (1991) who stated that contrary to the contention of some analysts at the time, Brazil's arms industry was not established as an export sector from its inception. Instead, its primary goal was to meet the domestic requirements of Brazil's own military forces. Domestic procurement data were also found for Colombia and Venezuela. In their cases, however, no significant revisions of what is currently known about them arise.

As mentioned, in adding exports to domestic procurement one arrives at a total arms production output figure. These data then shed light on the overall size of the arms industry in South America. In Table 1, the figures for total arms production are significantly higher than those for exports alone—72.1 versus 11.8—indicating that assessments of South America's arms industry based solely on exports, particularly for Argentina, Brazil, and Chile, underestimate its actual size. If this divergence between old and new data were to be found for other countries as well then estimates of arms production would significantly increase.

Table 2 correlates total arms production, exports, imports, domestic procurement, military expenditure, and GDP to each other. Arms production has a remarkably high correlation with domestic procurement (r=0.97), and arms exports comes in second place (r=0.64). Interestingly, domestic procurement has a positive correlation with arms imports, possibly suggesting that the industry's output was not sufficient to result in substitution between these two variables. The finding of a positive association between arms production and imports in developing countries is in line with previous empirical studies.[14] The correlation between arms production and military expenditure (r=0.35) varies among countries. In Argentina, military spending is closely correlated to arms production. But in Brazil arms industry output fell despite growing military spending.

Expanding SIPRI's dataset in this way does not add any new methodological problems as the TIV method already is in place and widely accepted. That said, an expansion would certainly reproduce some of the current shortcomings, mainly the disregard for changes in the production costs of a same equipment. To reuse an example, Argentina's Espora class frigates (Meko 140 A16) were commissioned between 1985 and 2004 (Table 3, Column 3). The construction of the last two frigates, *Robinson* and *Gomez Roca*, were to be canceled. However, in 1997 the government decided to resume production plans. During this time span, production costs have

certainly changed, and most likely risen.[15] Yet, there is no methodological artifice to include such alteration into TIVs. Trend Indicator Values do change according to the generation of the equipment—newer generations of the same equipment type have higher TIVs—but there are no corrections for production costs of the same weapon in different periods. In our example, the same TIV is assigned to all six frigates. By disregarding changes in production costs for the same weapon, TIVs are underestimated when applying SIPRI's measurement methodology. (In essence, TIVs are minimum estimates of production costs.) Developing a production cost change rate for the same weapon system might amend this deficiency. Of course, collecting data for such estimates might prove challenging, perhaps even infeasible, if done on a large scale.

Conclusion

Over the years, SIPRI has contributed hugely to the betterment of defense and peace economics research by providing data on the global arms industry and its trade at very high standards. Nevertheless, data gaps remain of which the lack of domestic arms production and domestic procurement data is one example. Without these, a complete assessment of the industry is precluded and important questions, such as the determinants and relative importance of arms production, arms imports, and arms export markets, cannot be fully addressed.

SIPRI's arms trade database could potentially be enlarged to record procurement of locally produced equipment. The Trend Indicator Value (TIV) method can be used to track both international and domestic transfers, thus allowing for a better account of arms industry output. The use of TIVs is an efficient solution as no new methodology would be needed. To illustrate the potential benefit, this article discussed the preparation of a new dataset for domestic arms procurement for Argentina, Brazil, Chile, Colombia, and Venezuela covering 1960–2015. Although more refined methods of statistical estimation are still needed, the initial descriptive statistics alone suggest very large domestic markets for domestic arms production.

Future development of this research could disaggregate domestic procurement by weapon categories to learn whether certain types of equipment are oriented to the internal market. Likewise, using domestic procurement figures in inferential statistical models may further our understanding of the determinants of arms production. For such a task, making headway in data collection is imperative.

Notes

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1. Data availability: The issue is highlighted in Brzoska (1982), Smith and Tasiran (2005, 2010), and Yesilyurt, *et al*. (2014) and extensively discussed in Kolodziej (1979), Fei (1979), and Brzoska (1982). Regarding military expenditure data, a recent example is Colgan (2011).

2. Widely used in the literature: Some examples of empirical studies using SIPRI's data are Bitzinger (2003), Smith and Tasiran (2005), Villa and Viggiano (2012), Akerman and Seim (2014), and Kollias, *et al*. (2017).

3. On arms production and transfers, see, e.g., Brzoska (1999, 2004), Sanjian (1999), Kinsella (2000), Smith and Tasiran (2005, 2010), and Battaglino (2013a).

4. Consistent information can be found for about 125 companies, but only the top-100 are reported and published.

5. See Sköns and Wulf 1(994); Bitzinger (1994, 2003). Dunne (2009) draws heavily on SIPRI's database in his account of arms industry restructuring after the cold war. Another example is Hartley and Sandler's (2003) account of the changes defense firms have been subjected to in the 1990s.

6. On imports, see Smith and Tasiran (2005, 2010). Regarding the role played by foreign markets, see Bitzinger (1994), Sköns and Wulf (1994), and Dunne (2009). Studies on supplier dependency include Smith, Humm, and Fontanel (1985), Kinsella (1998), and Neuman (2006).

7. Seminal studies include Peleg (1980) and Neuman (1984).

8. See Lock (1986), Kapstein (1991), Conca (1997), Costa (1998), and Franko (2014).

9. See, e.g., Perlo-Freeman (2004), Battaglino (2011, 2013b), Franko (2014), and Gouvea (2015).

10. Maldifassi and Abetti (1994) calculate domestic arms production levels based on a Dollars Per Soldier (DPS) metric, computed as the ratio of (defense budget–defense imports) to the number of military personnel. For the 20-year period covered by their study, the minimum DPS value then was assumed to represent the minimum possible expenditure per soldier that would allow the armed forces to operate. The authors assume that when DPS was at its lowest point, defense spending was devoted to arms imports, minimum operational expenses, military personnel salaries, and infrastructure maintenance, with no domestic arms purchases.

11. No claim is made that the database is fully complete. Certainly, there are local purchases for which reliable records were not found. Still, it is likely that the bulk of domestic procurement is accounted for and that remaining purchases are minimal as there are no indications whatsoever that major contracts were signed for which I have no data. For example, Brazil acquired a small number of radars (2, if not 1) in the early 2000s for which no reliable data were found regarding the amount. Thus, this purchase is excluded. Such cases are not of sufficient weight (expense) to change the main results, such as

the role and heft of the domestic market.

12. Notable exceptions include Molas-Gallart (1998), Hall, Markowski, and Thomson (1998), and Markowski and Hall (1998).

13. For example, Moraes (2011).

14. See, e.g., Kinsella (2000).

15. Kirkpatrick (1995, 2004) discusses the upward trend in arms production costs.

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Analysis of SIPRI's arms production data: Some suggestions for expansion

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Abstract

This article proposes that the Stockholm International Peace Research Institute's top-100 dataset of the world's largest arms producers and military service providers be expanded to permit comparison of the value of arms/service sales not only in absolute terms across countries and time but also relative to countries' industrial output. Specifically, the article suggests setting the sum of the arms/service sales of a country's top-100 members in SIPRI's list in relation to that country's output in its machinery and equipment sector. Illustrating the suggestion with data for 2015 finds that countries such as Israel, Russia, the U.K., and the U.S. have a far greater percentage of its machinery and equipment sector vested in arms production than do countries such as France, Germany, or Japan. The article also suggests comparing a country's top-arms producers to its top non-arms producers, that is, comparing country's arms-makers listed in SIPRI's top-100 list with, for example, companies in the *Fortune Global 500* list. The article concludes with a discussion of methodological issues.

The Stockholm International Peace Research Institute (SIPRI) first published a list of the world's one hundred largest arms producing and military service companies, by sales volume, in 1990 (SIPRI, 1990). The idea was to use the tool of company lists, common in many sectors of the economy, for the arms industry with the intention to reveal "a number of important facts about the structure of this industry" (SIPRI, 1990, p. 325). This primary purpose has not changed since. At the time, it was not possible to collect reliable data on socialist countries. Thus, SIPRI's first top-100 list included corporations of 15 countries, drawn mainly from the OECD and a few from what was then referred to as the Third World. In 2016, the last year for which data on the top-100 companies was available, the total number of countries in the list was 22, with 40 percent of the companies located in the United States alone. Lack of data on Chinese companies was and remains a serious drawback, an information gap that should be closed whenever possible. Gauged by China's efforts in modernizing its armed forces and by anecdotal information about Chinese arms producing conglomerates, it is safe to assume that if even reasonably exact data were available, a number of Chinese companies would have to be included in the top-100 list.

The main information contained in SIPRI's arms industry data collection concerns companies' arms sales, that is, revenue, and their associated rankings. (Technically, this is arms and military service sales but, for the sake of brevity, is shortened here to "arms" sales.) This is complemented by arms sales as a percentage of a company's total sales—indicating companies' revenue dependence on arms sales—as well as by information on companies' employment and profit levels.[1] Among the best-known of SIPRI's research products, the list probably is also the best available global collection.

As the list is published annually, an analysis of temporal trends and geographic distribution of the major arms producing companies is possible. The suggestion made in this article is not to change this centerpiece of information but to add other indicators. As has been pointed out in numerous publications, a comprehensible database on arms production is not available. Data on arms production volume is scarce, usually addressing firms or occasionally countries (e.g., arms procurement in NATO countries as a proxy for arms production). Beyond the SIPRI list, no global statistics exist, neither as industry statistics (since arms production is not a recognized branch in international statistics) nor as econometric data (input-output tables) or as UN statistics.

My proposal for a modest expansion of the SIPRI database relates to non-arms economic and industrial indicators so as to assess the size of a country's arms sector relative to its non-arms sector. This is analogous to what SIPRI already does in regard to countries' military expenditure data, namely recording it in absolute terms as well as relative to central government spending and relative to GDP. Comparing arms sales with non-arms economic and industrial indicators can illustrate if the arms industry in a given country is a key industry or plays a less important role. In this vein, I suggest two indicators: First, the arms sales ratio to industrial output of the machinery and equipment sector and, second, the rank of the SIPRI top-100 companies within the *Fortune Global 500* companies (and in the top company list of certain countries).

Table 1: Share of arms (and military service) sales to output in machinery and equipment, 2015

	(1)	*(2)*	*(3)*
Israel	7,710	4,955	156
Russia	27,100	26,876	101
UK	40,700	72,511	56
USA	213,530	466,288	46
France	18,740	83,350	22
Ukraine	870	4,020	22
India	5,570	44,267	13
Sweden	2,640	28,768	9
Turkey	1,890	21,696	9
Italy	10,800	144,503	7
South Korea	6,390	89,427	7
Singapore	1,660	22,854	7
Australia	890	13,221	7
Poland	1,190	19,461	6
Switzerland	1,690	34,176	5
Norway	730	17,892	4
Japan	7,290	272,331	3
Spain	740	27,600	3
Germany	5,600	307,737	2
Brazil	810	44,136	2
Canada	760	36,330	2

Notes: Column (1)—arms sales of SIPRI top-100 companies (in millions of USD)*; (2) output of the machinery and equipment sector (in millions of USD)**; (3) share of arms sales to output (%).
Sources: * SIPRI (2015); ** UNIDO (2017). UNIDO statistics refer to the output of industrial establishments and cover sectors such as mining, manufacturing, electricity, gas, steam, and air-conditioning.

Arms sales ratio to industrial output

While SIPRI's top-100 list is informative in its own right, adding comparative indicators can help reveal the relative importance of a given country's arms production sector within industry and to the economy at large. A comparison to the machinery and equipment sector would seem especially appropriate as this sector develops and produces technically significant products, comparable to technical requirements in arms production.

For the year 2015, Table 1 compares SIPRI's top-100 list with output for machinery and equipment by country. Column 1 shows the sum total of companies' arms sales in each country and compares this to the respective countries' industrial output in column 2. For example, in the United States, arms sales of companies in SIPRI's top-100 list totaled USD213.5 billion. This compares to USD466.3 billion of industrial output that year, or almost half as shown in column 3. Even though its manufacturing and equipment sector is the largest in the world, the arms sales of just the biggest of the U.S. arms companies occupy a very large part of the U.S. industrial sector, namely 46 percent. In the case of United Kingdom, the size of its largest arms companies is even more important—at 56 percent—in comparison to its machinery and equipment sector. In contrast, Japan's largest arms producers account for only three percent of its machinery and equipment sector. Similarly, in Germany the percentage is only two percent.

This article proposes that SIPRI's top-100 list of the world's largest arms producers be expanded to permit comparison of the value of arms sales not only in absolute terms but also relative to industrial output and to a country's GDP.

A methodological remark is in order here. The comparison of arms sales of companies to the output of an entire sector is, of course, problematic since sales and sectoral output are different types of indicators. To generate profits, the value of sales, i.e., revenues, must cover all required inputs into the production of arms products while sectoral output is based on the concept of value added only (that is, over and above input costs). This becomes clear by looking at the case of Israel which, in Table 1, shows a share of 156 percent. Moreover, the tabular comparison suggests that arms production is part of the machinery and equipment sector. However, this is not always the case. Particularly in Israel, military service contracts play a big role in the sales of the defense sector which, according to SIPRI's definition, are part of "arms" sales. Further, SIPRI's list does not include *all* of a countries' arms manufacturing activity but only that portion that results in a top-100 listing. As such, the percentages given in column 3 are lower-bound minima. Despite these methodological cautions, the purpose here—of indicating the arms sector's minimum relative economic importance—would seem valid. Alternative comparisons could be made, for instance, to a country's motor vehicles or any other industry.

Table 1 is sorted by column 3, that is, in order of how important is the arms sector to an economy. This ranges from 156 percent in Israel, to 56 in the U.K. and 46 in the U.S. to Germany, Brazil, and Canada at the bottom of the table with only two or three percent. Accordingly, the arms sector is of great importance relative to the machinery and equipment sector in Israel, the U.K., and the U.S. and of comparatively little importance in Germany, Brazil, and Canada.

Table 2: Top-10 SIPRI arms producers in the *Fortune Global 500* list, 2015

Company	*FG500 rank*	*SIPRI rank*	*Total sales (USD mn)*	*Arms sales (USD mn)*	*% arms sales*
Walmart	1	—	482,130	—	—
Boeing	85	2	96,114	27,960	29
Airbus Group	106	7	71,476	12,860	18
United Technologies	149	8	61,047	9,500	16
Lockheed Martin	237	1	46,132	36,440	79
General Dynamics	386	6	31,469	19,240	61
BAE Systems	468	3	25,647	25,510	99
Northrop Grumman	494	5	23,256	20,060	86
Wuhan Iron & Steel	500	—	23,720	—	—
Raytheon	—	4	23,247	21,780	94
Finmeccanica	—	9	14,412	9,300	65
L-3 Communications	—	10	10,406	8,770	93

Sources: SIPRI (2015); *Fortune Global 500* https://de.wikipedia.org/wiki/Fortune_Global_500#2015

Ranking of arms and non-arms producing companies

The "blueprint" idea for SIPRI's original listing of the world's largest arms producing companies came from existing annual rankings of corporations such as the *Fortune 500* list. Why, then, not also directly compare SIPRI's list with *Fortune*'s global or other country-specific lists? Assume for instance that SIPRI wishes to analyze Russia's arms producing sector in a given year in more detail. It could use an all-Russia industrial ranking list as a way to assess the role the arms producing companies play within Russia.

Fortune does not differentiate between arms and non-arms production in a given company, simply using total sales as the indicator for inclusion in its list. For 2015, only seven arms-producing companies appear in the *Fortune Global 500* list (see Table 2), and four of them only because of their high total sales. The other three—Lockheed Martin, Boeing, and BAE Systems—would qualify by arms sales alone, however. The smallest of the *Fortune Global 500*, China's Wuhan Iron & Steel, has total sales slightly larger than Raytheon, which ranks fourth in SIPRI top-100 list for 2015. Put differently, SIPRI's largest arms producing companies are small relative to other big corporations. The largest company in the *Fortune Global 500* list (Walmart) is ten times bigger by sales than is the largest arms-producing company in SIPRI's list (Lockheed Martin).

Using company lists for specific countries, or regions, one could make similar, more detailed analyses. For example, in the European Union BAE Systems, the largest European arms-maker, appears only at rank 125. No other arms-producing company ranks among the top-150 European companies. Unsurprisingly, Japanese arms producing firms are not in the same league as the big technology companies in the country. In Russia, the largest arms company, United Aircraft Corporation, is listed at rank 25. None of SIPRI's top Indian arms companies ranks among the top-50 companies in that country.[2]

As a general result, for most countries it can be stated that in quantitative terms arms producing firms do not play an overwhelmingly important role. Often the sector is marginal compared to the rest of the economy. However, in a few cases, like Israel, the U.K., and the U.S., the arms industry is a relatively important producing sector.

Conclusion

As mentioned, in making comparisons certain methodological constraints need to be observed (and readers should be made aware of the methodological limitation). I point to four such constraints.

First, I have chosen UNIDO statistics for the output of the machinery and equipment sector. There are, of course, other industry statistics available. It is essential to choose a dataset that allows comparisons to the SIPRI top-100 type of data. The arms industry should be classified as belonging to the machinery and equipment sector. However, as noted, in Israel the arms industry is, according to SIPRI statistics, bigger than the entire machinery and equipment sectors as defined by UNIDO.

Second, sales (revenue) and output (value-added) are not the same thing. It is necessary to study the methodology used in detail and possibly opt for other, more appropriate indicators. Third, the cutoff point for SIPRI's top-100 arms producing companies results in a high concentration for U.S.-based companies. If the list were expanded to the, say, top-150 or top-200 companies, the ratio of arms sales to machinery and equipment output (in Table 1) would probably be more informative. Since SIPRI collects data on many more than the top-100 companies, it would be worthwhile to consider

expanding the table beyond the top-100 firms (without necessarily publishing this expanded list regularly). And fourth, using companies' arms sales as representing arms production of the whole of a country is, of course, misleading. Companies listed among SIPRI's top-100 do not necessarily comprise the whole of a country's arms production sector. The fluctuations in SIPRI's list (especially at the bottom of the list) are considerable and this may distort the overall picture. If, for example, two arms companies merge they might, due to the merger, make it into SIPRI's list and, as a result, other companies, possibly from other countries, might fall out of the list. This is not a specific problem regarding the arms industry but is a general methodological problem for all company ranking lists.

Despite methodological difficulties (which are commonplace in economic and econometric studies), it is suggested here to expand the SIPRI database and, especially, its analysis of its top-100 list by two additional indicators: First, comparing the arms sales of the major arms producers with other (non-military) industrial and economic indicators and, second, ranking the SIPRI top-100 companies with other global, regional, or country company lists. This modest expansion allows for a broader analysis of the economic importance of the arms industry.

Notes

For comments I thank participants at the SIPRI arms industry workshop held in March 2018 in Stockholm and an anonymous reviewer.

1. SIPRI's list is available at https://www.sipri.org/databases/armsindustry.

2. EU: See https://en.wikipedia.org/wiki/List_of_largest_European_companies_by_revenue. Russia: See https://en.wikipedia.org/wiki/List_of_companies_of_Russia#Largest_firms.

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Arms industry data: Knowns and unknowns

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Abstract

This article surveys the past, present, and possible future nature and features of the global defense, arms, and security industry and associated data collection issues. It concludes with remarks on the economics of data, the public goods nature of data, and the incentive–reward system in the data market.

The focus on knowns and unknowns can be expressed in three questions. First, what is known; second, what is not known; and third, what do we need to know for a better understanding of arms industries? The short answer to all three questions is quite a lot. There is a lot which we know; a lot which we do not know; and a lot which we need to know. The approach to these questions involves consideration of the defense economics problem reflected in rising costs and the economics of arms markets. Arms industries need to be defined and data requirements in an ideal world are reviewed. The future of the defense firm is assessed and the conclusion deals with "where next?" for data requirements.

The defense economics problem

The defense economics problem takes the form of rising unit equipment costs in real terms leading to intergenerational cost escalation. In the United Kingdom, examples of annual real unit cost escalation over the period 1955 to 2010 has ranged from some 2 percent for frigates, to 6 percent for aircraft carriers and tanks to 7 percent for combat aircraft. More examples of rising unit costs are shown in Table 1. Here, unit airframe costs in real terms doubled or more than doubled between generations of aircraft.[1]

Rising unit costs of equipment affect the arms industry and armed forces. For industry, there are fewer new types of equipment and smaller production runs for each type. For example, in the mid-1950s, the U.K.'s Royal Air Force (RAF) operated about 1,000 fighter aircraft but by 2018, the numbers had declined to 160 Typhoon aircraft. Rising costs for both development and production means that some nations can no longer afford to buy modern combat aircraft. For example, New Zealand has abandoned a fighter aircraft capability for its air force.

Rising costs provide greater incentives for nations to import arms, especially from the United States, but will also lead to increased role specialization in military alliances even as the extent of such specialization will be limited by the acceptance of trust between alliance members (e.g., in a conflict, will other members "turn-up"?). In addition, rising costs will provide greater incentives for defense policymakers to substitute among cost, time, and performance in weapons acquisition. For example, there might be a greater willingness to sacrifice ambitious performance targets to achieve cost and delivery targets. And, governments will always promise acquisition reforms to control cost growth (although usually such reforms will fail and represent a triumph of hope over experience).

The economics of arms markets

Arms markets comprise buyers and sellers, where governments

Table 1: Rising unit costs

Aircraft type	*Airframe unit costs (£s, 2017 prices)*
Gladiator (1937)	142,629
Spitfire (1939)	230,969
Meteor (1945)	507,150
Hunter (1955)	1,224,000
Lightning (1960)	4,345,000
Typhoon (2003)	34,208,000

Notes: (1) Costs are for airframes only comprising fuselage, wings, and tail but excluding engines, guns, undercarriage, radio, and avionics. (2) Dates refer to date of contract. Gladiator was a biplane; Spitfire was a monoplane; Meteor was a first generation jet fighter. Between the Lightning and Typhoon, the U.S. Phantom and U.K. Tornado fighter were in service but no cost data were available, hence the massive rise in unit costs between the Lightning and Typhoon which reflect missing observations for these generations of aircraft. (3) Unit costs for bomber/strike aircraft are not shown in this Table.

are buyers and arms firms and industries are suppliers. Governments dominate these markets. Governments are major buyers or the only buyer (monopsony buyer). Government can use its buying power to determine the arms industry's size, ownership, structure, entry and exit conditions, conduct, and performance. Often, the supply side or arms industry is characterized by domestic monopoly, duopoly, or oligopoly, especially for high technology weapons (e.g., combat aircraft, helicopters, missiles, nuclear submarines). There are both entry and exit barriers and firms are either privately-owned or state-owned. Privately-owned firms are subject to different incentives, motivated by profitability, rivalry, and "policing" by capital markets reflected in "hard" budget constraints. In contrast, state-owned arms-makers might be protected from competition, are not exposed to the pressures of private capital markets, and operate with "soft" budget constraints.

While rising costs and arms markets are major issues, others are important as well, and examples include industry structure, with its typical prime contractor and complex supply chains, and the constant drive for new technologies leading to new types of military strategies and new kinds of warfare. Compared with civilian markets, where technical change is often associated with falling prices, such changes in military markets lead to higher quality and costlier equipment (i.e., more advanced rather than cheaper equipment).

Questions on arms industries

Why are we interested in arms industries and what are the key data questions? Arms industries use scarce resources with alternative uses. As a result, we need to know the size of these industries which forms a major data requirement. We also need to know the alternative uses of arms industry resources. How transferable are its resources, which forms another data requirement. The conversion question also needs to be addressed, in both directions. In disarmament, how quickly and easily are resources transferable from military to civilian uses and in rearmament, how quickly can arms industries be reconstituted? Identifying the questions is easier than obtaining answers. For example, difficulties arise in identifying and measuring resource transferability and the speed of the adjustment process. At a more basic level, governments frequently introduce defense industrial policies without data and information on the size and structure of their national defense industrial base.

Definitions

Arms industries have been the subject of various definitions, and international comparisons need to be based on some common definition. A starting point defines arms industry as all firms involved in the design, development, production, and sale of arms where these are defined as lethal equipment. But such a simple definition is not without its problems.

This article surveys the past, present, and possible future nature and features of the global defense, arms, and security industry and associated data collection issues. It concludes with remarks on the economics of data, the public goods nature of data, and the incentive–reward system in the data market.

Debates about arms industries often focus solely on their major prime contractors (e.g., the SIPRI top-100 arms producers). This is misleading since there is an extensive supply chain providing inputs for the prime contractors. For example, military aerospace prime contractors purchase major inputs from firms supplying avionics, engines, landing gear, and materials for constructing aircraft. In turn, each major supplier has a supply chain of firms providing inputs for avionics, engines, landing gear, and so on. As a result, supply chains are complex; they differ between air, land, and sea systems; they might be international; and published data are generally not available on defense industry supply chains. The presence and complexity of supply chains raises further definitional problems in identifying the limits of arms industries. At which level in the supply chain do we determine the extent of arms industries (e.g., levels three, four, etc?). In some cases, firms might not be aware that they are involved in supplying to arms firms. For example, firms supplying ball bearings and track might not be aware that these products might be inputs for tanks. But collecting data on arms industry supply chains is time-consuming and costly.

There are further problems in defining arms industries. Should the definition include nonlethal equipment? Defense ministries usually make substantial purchases of nonlethal goods and services. Examples include construction and accommodation, computers, vehicles, and services such as accountancy and financial advice, training and transport. In some nations, defense ministries are making greater use of military outsourcing than in others.

The definition used as a starting point excludes post-production activities. These include repair, maintenance, modifications, up-dates, and disposal. Increasingly, with financial pressures on defense budgets, some of these activities are being outsourced to private contractors (e.g., maintenance, training). As a result, private firms are replacing activities traditionally undertaken "in-house" by the armed forces. Disposal forms another industrial sector ranging from simple to complex and costly activities. The simple end of the disposal industry embraces the sale of surplus military equipment, or its

destruction and sale as scrap metal. The more complex end involves the disposal of nuclear systems (e.g., nuclear bombs, submarines, etc) and the decontamination of nuclear sites which can be exceedingly costly.

Technical progress also affects the definition of arms industries. Technical change can lead to the new entry of firms and the creation of new industries. For example, the aircraft industry did not exist in 1900, nor did firms such as BAE Systems, Boeing, and Lockheed Martin. Similarly, missiles, space systems, and the nuclear weapons industry developed after the second world war created new markets, new firms, and new industries.

Data requirements in an ideal world

Ideally, full and complete understanding of arms industries requires data on their size, structure, conduct, performance, and ownership. All of these variables are influenced by national governments, and a corresponding data collection approach is based on the structure-conduct-performance model in industrial economics, a standard economic method of analyzing any industry.

Industry size

Industry size can be measured by sales and employment. Again, problems arise where international comparisons use different definitions of arms industries. For example, some employment data are based on direct employment only while others include indirect employment among suppliers even as the latter might be based on different definitions of supply chains. Furthermore, supply chains are complex and differ between air, land, sea, and nuclear systems. Moreover, published data are generally unavailable on arms industry supply chains.

There are different data sources on industry size. Often, governments fail to provide and publish official statistics on their national defense industry. In some cases, the official statistics are limited to a few clearly-defined defense industry groups such as the annual sales of weapons, ammunition, and fighting vehicles. Data on other defense-dependent industry groups such as aerospace and shipbuilding include civil as well as military sales.

Some industry trade associations also provide sales and employment data for their industry (e.g., aerospace, electronics, shipbuilding). But trade associations use various definitions of an industry and their employment data might include all sources of employment, including induced employment reflecting jobs created by the spending of defense industry workers (e.g., in local shops and restaurants). Industry trade associations might also be aiming to maximize the size of their industry by maximizing its sales and employment numbers.

Industry structure

Industry structure focuses on the number of arms firms in the industry and their size (both absolute and relative size). Industries might be competitive, comprising large numbers of relatively small firms, or monopolistic, comprising a single seller of a product or service. Or they might be oligopolistic, comprising a small number of relatively large firms. Each industry structure has different efficiency outcomes, ranging from a socially desirable competitive outcome to a socially undesirable monopoly with arms industries revealing examples of each type of structure.

Governments determine arms industry structure through procurement policy and contract awards, through preferential purchasing (e.g., buy U.S. or buy French), through allowing or banning mergers, and by allowing or preventing foreign competition for national arms contracts. For example, between 1958 and 1960, the U.K. government used its powers over contract awards to restructure the aircraft industry and reducing it from a large number of aircraft and engine firms to five major groups.[2]

Structure embraces entry and exit conditions for the arms industry which are also determined by national governments. For example, governments support their "national champions" by protecting them from rivalry, especially from foreign competition. Or, government can prevent exit by "bailing-out" arms firms where intervention might involve the state-ownership of a private firm, subsidy payments, or a generous contract award (e.g., a new cost-plus arms contract).

The arms industry structure has some distinctive features. Arms industries are decreasing-cost industries reflecting economies of scale and learning. Typically, arms firms are large firms forming national monopolies, duopolies, and oligopolies with examples of each structure in each sector of air, land, and sea systems for each nation. For example, for combat aircraft, European nations are characterized by national monopolies compared with a national oligopoly in the U.S. Similarly, for nuclear submarines, there are monopoly suppliers in each of France and the U.K. compared with a domestic duopoly in the United States. U.S. firms dominate the arms industry, especially for aerospace equipment (aircraft, helicopters, missiles, space systems).[3]

Arms industry ownership reflects a mix of private and state ownership. Private ownership is typical in the U.S., the U.K., Germany, and Sweden whereas state ownership is prevalent in China, Greece, India, Italy, Russia, and Spain.

The arms industry has not been static. There has been

considerable industrial restructuring reflecting changes in the demand for arms and technical progress. For example, the rearmament prior to the second world war resulted in new entrants and larger firms while the end of the cold war-era led to mergers and exits from the industry. Technical progress has also led to new entrants. The emergence and development of the aircraft and aerospace industry over the period 1900 to 2018 created a new industry which eventually developed into the aerospace industry embracing helicopters, missiles, unmanned aerial vehicles (UAVs), and space systems.

Industry conduct

Conduct is about the form of competition used in the arms industry. Competition ranges between price and nonprice competition. Nonprice competition is varied and embraces advertising and marketing, R&D policy, offsets for arms exports, national procurement policy, and lobbying for arms contracts where there are opportunities for bribery and corruption. Of course, bribery and corruption are not confined to the arms business and occur in other industries (e.g., public procurement and sports such as athletics, cricket, cycling, football, and tennis).

Arms markets embracing both buyers and sellers are subject to change with new markets emerging. Examples include new markets for UAVs, cyber systems, and for military outsourcing (e.g., private firms providing military training and managing military facilities such as firing ranges and accommodation).

Differences in pricing arise between military and civilian markets with implications for the transferability of resources between these markets. Prices in arms markets might be cost-based or cost-plus where firms recover all their costs regardless of cost levels and are guaranteed a certain level of profits. In contrast, prices in civilian markets are demand-sensitive responding to market pressures where firms might incur losses. The entrepreneurship required in civil markets creates an entry barrier for arms firms seeking to transfer resources from military to civil markets. Also, arms firms' resources might not be easily and quickly transferred from military to civilian uses: Resource transfer can be costly.

Industry performance

Various indicators can be used to measure the performance of arms firms and industries. Possibilities include prices, profits, productivity, and exports. Other indicators include the progress of projects against contract schedules reflected in cost overruns and schedule slippages. Further performance indicators embrace comparisons of arms industries with other civil industries such as motor cars, computers, and pharmaceuticals. These comparisons allow an assessment of the alternative use value of resources used in arms industries: What are the alternative uses of resources?

While there is no shortage of performance indicators, there is the perennial problem of finding actual published data. In some cases, data can be obtained from project case studies. For example, some governments publish data which allows comparisons between costs, prices, time-scales, delays, and exports for similar major arms projects. Such data can be obtained for the U.S. F-35, European Typhoon, French Rafale, and Swedish Gripen combat aircraft.

The challenge of comparing arms industries with civil industries requires the choice of an appropriate civil industry comparator which publishes similar data. Productivity comparisons are an obvious performance indicator derived from data on sales and employment. But productivity figures require further choices between labor or value-added productivity. Value-added productivity is preferred since it based on a firm's value-added rather than its gross sales or turnover which includes purchases of inputs from suppliers.

In measuring and assessing performance, further distinctions can be made between firms and industries. Industries comprise groups of firms producing similar products while firms are the basic component of an industry. Typically, official government statistics identify industries and present industry performance data. In contrast, firm-level performance data are obtained from a company's annual report or accounts which vary between firms and nations.

Exceptions

There are some major exceptions to the traditional view of arms markets which often views arms industries as dominated by a small number of large firms. The media and anti-arms groups like to focus on the behavior of a few large arms firms (e.g., BAE, Lockheed Martin) where the interest is on their profitability and performance on major arms contracts. In fact, numerically, arms industries are dominated by small firms: They comprise large numbers of small firms as represented in supply chains. There are also examples where small firms are the appropriate economic size for the production of some arms. An obvious example is small arms which are usually produced by small firms.

Further exceptions to the traditional view arise in those cases where arms are produced by terror groups. For example, the 9/11 attacks in the U.S. were an example of a terrorist group creating a private air force using airliners as "flying bombs". Other examples arise where terror groups convert civil vehicles and trucks into armored fighting vehicles and rubber dinghies into fast patrol boats. The ultimate example is where

suicide bombers become the equivalent of precision guided weapons.

Private arms markets provide a role for arms dealers. These agents facilitate trade in arms by bringing together buyers and sellers and arranging market transactions. Some of these markets and transactions might be illegal (illegal arms markets) with further opportunities for bribery and corruption. Also, mercenary forces might be among the buyers in private arms markets. Typically, mercenary forces are buyers of small arms (ammunition, rifles, light artillery). They might also buy used helicopters, and they will improvise to create armored fighting vehicles and vehicle transport.

Market failures

Market failure analysis allows an assessment of how well arms markets are working. Usually, left to themselves private markets fail to work properly in the sense of failing to fully and accurately respond to consumer preferences. Market failures arise from imperfections on both the buying and selling side of markets (e.g., monopolies, entry barriers) and from beneficial and harmful externalities (e.g., defense and peace as public goods, pollution). In principle, state intervention can be used to correct for failures and aim to improve the operation of markets. However, identifying market failures is only the start of the analysis. The causes of market failure have to be identified, the costs of any proffered corrections have to be estimated, and choices made between various policy solutions (e.g., tax/subsidy policy, various forms of regulation, state ownership).

A competitive market with large numbers of buyers and sellers together with free entry and exit is used as the ideal-type model for assessing market failure. Failures on the demand side of arms markets arise from government. Government is a dominant or single buyer. It controls information on demand requirements, and it controls entry and exit. Consumers are unable to register accurately their demands and willingness to pay for defense (defense is a public good). Failures on the supply-side arise from monopoly, oligopoly, and entry barriers. There are, for example, high entry costs required for the costly R&D for modern high technology weapons (e.g., combat aircraft, missiles, space systems). There might also be barriers to exit with government funding major arms firms threatened with bankruptcy so that they remain in the industry. Overall, there is a presumption that arms markets are failing to work properly with opportunities for state intervention to improve their operation. However, care is needed since state intervention might have adverse and perverse effects (making the situation worse) and an overall assessment is needed to ensure that intervention is, on balance, worthwhile.

Alternatives exist to the traditional structure-conduct-performance model. Markets can be analyzed as contestable or modified to allow for the Austrian School's view where markets are never at rest and never reach equilibrium. Instead, in a world of uncertainty, markets are constantly changing and in continuous disequilibrium. More fundamentally, the traditional approach has been modified by the introduction of game theory which recognizes the role of interdependence between small numbers of sellers and between a single government buyer and a few sellers. For example, in oligopolistic industries, the actions of small numbers of firms will be based on the expected reactions of their rivals (e.g., to price changes). Similarly, where there are few suppliers and competition is used to award large arms contracts, there is always the possibility that a losing firm will acquire the winner!

The future of the arms firm

Do arms or defense firms have a future and what might they look like in the year 2050? Predicting the future is hazardous and likely to be wrong. However, some general principles can be suggested.

Arms firms will survive so long as threats exist to nation states or are perceived to exist. But the future arms firm will be as different as today's arms firms are from those of 1945 or 1900. For example, BAE Systems did not exist in 1945. Nor did space travel exist in 1945. And, in 1900, aircraft and aircraft firms did not exist. There are likely to be new entrants as well as exits. In the future, electronics firms might emerge as prime contractors and traditional "metal bashers" such as tank firms might depart the arms industry.

The future arms firm might be larger and less dependent on government (e.g., through diversification into civil markets). Government will also have to review the profitability of defense business if arms firms are to be induced to remain in the business. This will require a review of the profitability of noncompetitive defense contracts. These raise efficiency and equity issues. Noncompetitive contracts for monopoly suppliers need to provide efficiency incentives acting as hard budget constraints, avoiding the inefficiencies associated with cost-plus contracts. At the same time, there are equity issues requiring a fair and appropriate reward for monopoly suppliers.[4]

The future will also be dominated by the continued rising unit costs of arms with impacts on the armed forces and arms industries. Rising costs have led to forecasts of a future comprising a single-tank army, a single-ship navy, and a single Starship Enterprise for the air force. For arms industries, there will be fewer but more complex types of new equipment with

smaller production runs for each type.

There will be continued technical change requiring changes in both armed forces and arms industries—but both groups might resist change. Also, technical change can be evolutionary or revolutionary, with revolutionary change requiring greater adjustments by the armed forces and arms firms. The introduction of tanks, the jet engine, and atomic weapons were past examples of revolutionary technical change. The future will present further examples of revolutionary technical change but, currently, these are unknown and unknowable. Even so, arms firms will survive since they have a unique expertise, namely, their expertise in the weapons business.

Governments, arms firms, and arms industries face a further future challenge in the form of how to retain arms industry capacity during troughs in development and production work. Possible solutions are not costless and include technology demonstrators, mid-life updates, and mothballing. Cheap technology demonstrators enable arms firms to retain technologies and R&D staff for next-generation equipment. Mid-life updates also provide work allowing arms firms to retain both R&D and production workers. Mothballing appears an attractive solution to retaining capacity, especially plant and equipment (e.g., jigs and tools for F-22 aircraft), an approach often used in civil industries (e.g., steel plants, coal mines). However, mothballing not only involves costs in policing and maintaining idle capacity but, more importantly, costs in retaining skilled labor. Retaining research scientists and technologists requires that they be offered challenging and meaningful tasks and similarly for skilled production workers. Without "real" work, skilled research and production staffs will quit for alternative employment.

Developments in the security industry provide a further challenge for arms industries. The security industry embracing internal or homeland security involving surveillance in public places (e.g., underground trains, water supplies), cyber security, and border control issues has led to an expansion of what was previously viewed as a more narrowly-drawn defense/arms industry. Although security companies do not produce lethal products, the business prospects in the security area has led arms firms to move into this area. These developments have occurred alongside the introduction of electronics/optics, information technology, and robotics, all of which might have dramatic effects on the future arms firms.

Data requirements: the knowns

Surprisingly, most governments do not provide basic data on their arms industries. Until recently, the U.K. was an exception with its Ministry of Defence (MoD) providing defense industry employment data distinguishing between direct and indirect employment and regional employment data dependent on U.K. defense spending and defense exports. However, in 2009, it decided to discontinue publishing such statistics, mainly because the "data did not directly support MoD policy-making and operations."[5] There were also concerns about the accuracy of some of the employment data and the mistaken impression that decisions about contracts were made on a regional basis.

Elsewhere, the U.K. official statistics only identify two specialist defense industries, namely, weapons and ammunition and fighting vehicles. Official U.K. statistics are available for other defense-dependent industries, including aerospace and shipbuilding, but these report total annual output comprising both military and civil output.

Industry trade associations are a further data source. For example, the U.K.'s Aerospace, Defence, Security and Space Association publishes annual data on total aerospace sales but again such totals comprise both military and civil sales. Similarly, the U.S.'s Aerospace Industry Association publishes good quality data with some defense data. Other data sources include annual company reports, but these differ in the quality of coverage and often present only total sales data comprising military and civil sales. BAE Systems is an exception. It is a defense-specialist firm providing sales and employment data for each of its various defense divisions. Some further sources of data emerge as by-products of other studies. For example, the 2017 U.K. Shipbuilding Strategy provided an overview of the U.K. warship industry identifying its major firms and new entrants. Similarly, data on project case studies provides useful information for analysis of comparative performance. For example, the U.K. and the U.S. regularly publish official data on the performance of major arms projects and their contractors, showing their total costs and cost overruns, delays, and performance failures. Examples include data on such projects as the Typhoon combat aircraft, the U.K. aircraft carriers, the collaborative A400M airlifter, and the US F-35 combat aircraft.[6]

Overall, on data availability, there are substantial knowns although considerable searching is required and in many cases, approximations have to be accepted with scope for imagination and ingenuity. National data might have to be constructed from industry trade association sources. For Europe, data are available from the European Commission, the European Defence Agency, and the Aerospace and Defence Industries Association of Europe. The Stockholm International Peace Research Institute provides data on large arms firms and some performance indicators are available (e.g., from project case studies). On industry structure, most arms firms are large firms in national monopoly industries with the exception of the U.S.

where the typical structure ranges from duopoly to oligopoly for high technology weapons. Comparative firm and industry performance is more easily addressed since there are published data on a variety of civil firms and industries. But what of the unknowns?

Conclusion: Where next?

There is no shortage of future requirements for arms industry data. SIPRI's annual list of the top-100 arms producers has made an invaluable and original contribution to our knowledge and understanding of arms industries. But much remains to be done. The top-100 list could be expanded to, say, the world's top-150 arms firms. There are gaps to be addressed, namely, the need for accurate data on arms firms in China, North Korea, and Iran. Defense industry supply chains and small arms firms need to be recognized.[7]

The lack of data is related to the political nature of arms markets. Governments have influence on arms industries and on their size, structure, conduct, performance, and ownership. However, despite their influence, they are often reluctant to provide data on their national defense industrial base (e.g., on arms exports).

Compiling a list of data gaps is the easy part. Data additions can be costly and are not costless: Someone has to fund data searches. This raises a more general issue about the economics of data and the incentive–reward system in the data market. Published data are a public good where there is nonexcludability and nonrivalry in consumption. Nor do universities provide an appropriate incentive–reward system to scholars who specialize in data collection. Instead, the rewards for university scholarship are based on academic publications in top-rated journals where the focus is on highly abstract models and theories. As a result, the collection and widespread publication of data on arms industries is unlikely to be encouraged by universities. The public goods nature of data collection and publication on arms industries means that it is unlikely to be funded by private firms. Thus, data collection efforts require funding by state agencies or by charitable institutions (e.g., with a focus on peace research).[8]

Notes

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1. Examples of cost escalation: See Davies, *et al*. (2011).
2. U.K. aircraft industry restructuring: Hartley (2017).
3. Decreasing-cost industry: Hartley (2017, chapter 3).
4. Review of noncompetitive defense contracts: Hartley (2019).
5. MoD (2009, p. 21).
6. U.K. Shipbuilding Strategy: See MoD (2017).
7. SIPRI also has contributed valuable data on military expenditure. Together with its data on arms firms, it has helped researchers to gain a greater understanding of the military-industrial complex.
8. The author and Jean Belin (Bordeaux University) are preparing an edited volume which will address some of the data gaps and issues raised in this article. It will be titled *The Economics of the Global Defence Industry* and is to be published by Taylor and Francis as part of its Defence and Peace Economics Series (London, forthcoming 2019 or 2020).

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Arms, corruption, and the state: Understanding the role of arms trade corruption in power politics

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Abstract

This article discusses patterns of corruption in the arms business around the world. It finds corruption to be widespread, almost ubiquitous in some sectors such as submarines, and affecting developed democracies as recipients as much as other countries. Anti-corruption efforts face severe challenges in proving corruption in highly complex financial cases involving multiple jurisdictions. However, they also face obstruction from exporter governments who are reluctant to prosecute their national defense industry champions so that even where investigations bear fruit, companies tend to receive light treatment. The article argues that corruption in the arms trade is not merely and simply a matter of individual and corporate greed, but is, on the seller's side, also an element of defense industrial policy as countries seek to maintain advanced technological capabilities in the face of limited domestic demand, widespread international competition, and a buyer's market. For recipients in buyer, and sometimes also seller, countries, an underemphasized aspect is the role of arms trade corruption as a means of securing political finance by senior politicians involved in decisionmaking. Thus, the practice occupies a systemic role in political competition, complicating efforts to tackle it.

That the international arms trade is particularly susceptible to corruption has long been recognized. Factors such as the high value and complexity of deals, and the level of secrecy shrouding the arms business all help provide means, motive, and opportunity to politicians, bureaucrats, and military officers to profit from arms deals, and for arms exporting companies to seek to swing deals in their favor.[1]

This article argues that corruption in the arms business is not merely and simply a matter of opportunity for personal enrichment, but is closely connected to the pursuit and practice of political power at both the buyer's and seller's ends, and to the national security interests of exporting states. This makes corruption in the arms business a tough "nut to crack" in the sense that the vested interests in preserving corruption are systemic and are tied to long-standing institutions of state power and politics rather than just the greed of individuals.

The analysis is based on the work conducted over the past two years by the World Peace Foundation's (WPF) program on Global Arms and Corruption, in particular its *Compendium of Arms Trade Corruption*, a collection of currently 29 cases of corruption in the arms trade and the broader military sector. The article presents a summary of the results of this work, discusses some of the lessons learned about the scope and nature of arms trade corruption, and then explores more deeply the underlying political economic factors driving arms trade corruption.

The next section briefly presents the *Compendium* as it stands and discusses pending cases that may be included in the near future. It also discusses patterns of corruption in the global arms trade as revealed by the *Compendium* and the broader work of WPF's Global Arms and Corruption project. The section thereafter discusses corruption in the arms trade from the seller's perspective in the context of a crowded international arms market where exporters (sellers) are willing to turn a blind eye to corruption as a means of maintaining a defense industrial base in their home country. This is followed by a section that considers the relation between arms trade corruption and domestic political power plays in both buyer and seller countries and how such corruption is often closely linked to political finance. The last section concludes.[2]

Patterns of corruption in the arms trade

The arms trade is widely recognized as one of the most corrupt areas of legal international trade worldwide. In 2005, anti-corruption researcher Joe Roeber estimated, based on a review of U.S. corruption complaints, that 40 percent of corruption in international trade was arms trade-related. Andrew Feinstein in *The Shadow World* describes a pattern of systematic corruption in the arms trade, with numerous examples. More recently, Transparency International's (TI)

Government Defence Anti-Corruption Index shows that, due to a lack of transparency and accountability in their budgeting and procurement processes and their operational practices, most of the world's leading arms importers have High to Critical ratings for the vulnerability of their military sector to corruption. It should be noted that corruption in the military sector goes well beyond arms procurement. Senior commanders appropriate salaries of nonexistent "ghost" soldiers, divert arms and equipment through illegal sales, sell promotions, award fake supply contracts to businesses run by friends and family, and much more. These are common problems in many militaries. In war contexts such as Afghanistan and Nigeria, this can have a devastating effect on military effectiveness, contribute to human rights abuses, and have a prolonging effect on conflict.[3]

Several key factors are frequently presented as reasons why the arms trade, and the military sector more broadly, are particularly susceptible to corruption. First is the degree of secrecy that frequently surrounds defense and security matters in general and major arms deals in particular. The military budget is often the least transparent area of the state budget. Parliament and civil society often have limited access to information and frequently are discouraged or prevented from holding the government to account on defense matters. Even in western democracies that are typically more transparent, the details of major procurement tenders may be restricted due to national security and/or commercial confidentiality issues. In some countries the military have *de jure* or *de facto* immunity, or near-immunity, from corruption investigations, leaving authorities unable to conduct meaningful investigations.

Second, and more specific to the arms trade, is the huge value of individual deals for major weapons systems such as combat aircraft, warships, and submarines. Often once-in-a-generation purchases, they represent a large potential win for exporters and an enormous potential bounty for corrupt officials or politicians on the importer side even when only a small percentage in "commissions" (that is, bribes) is in play. This gives a powerful motivation for corruption on both the buyer and seller side as explored in later sections below.

Third, major arms deals are often highly complex and technical affairs with only a handful of people on the buyer's end understanding or even knowing the details of a tender, making procurement requirements vulnerable to manipulation if key individuals are bribed. Moreover, major arms deals are highly customized: A variety of subsystems and weaponry are included as part of the deal, along with long-term maintenance, training, and offsets packages, the latter involving investments, subcontracting, and countertrade with the buyer country on the part of the seller company. This means that there is no clear price for a given weapon system so that commission payments can readily be hidden in the overall price of the package.

This article argues that corruption in the global arms trade is not simply a matter of individual and/or corporate greed, but is, on the seller's side, an element of defense industrial policy as countries seek to maintain advanced technological capabilities in the face of limited domestic demand, widespread international competition, and a buyer's market. For recipients in buyer, and sometimes also seller, countries, an underemphasized aspect is the role of arms trade corruption as a means of securing political finance by senior politicians involved in decisionmaking. Thus, the practice occupies a systemic role in political competition, complicating efforts to tackle it.

Finally, offsets specifically are themselves a major source of corruption. Typically open to even less scrutiny than the underlying arms deals, due to commercial confidentiality, the investments and contracts resulting from offset packages can offer a major boon to businesses in the buyer country, and to their shareholders, allowing decisionmakers to direct offsets toward items that will benefit themselves or their friends and family. While offsets occur in other areas of government procurement, they are most prominent in the arms trade, largely due to the national security exemptions in the WTO Agreement on Government Procurement of 1994, and other international trade agreements, which otherwise prohibit offsets.[4]

In its *Compendium*, WPF has so far collected 29 cases of arms trade and broader military corruption. These are set out in a standard format providing key details of each deal such as buyer, seller, equipment sold, price, and the amount involved in the corruption allegations, along with a narrative description of the deal, the corruption, and the investigations that have taken place. The work is being expanded. The cases do not constitute a systematic or representative sample, but through the research WPF has conducted into these and other cases it is possible to gain some further insights into the nature, scope, and political driving forces that lie behind arms trade corruption.

The scale and scope of arms trade corruption

To no one's surprise, WPF finds that there is indeed plenty of corruption in the arms trade. The 29 cases in the *Compendium* represent to some degree the proverbial tip of the iceberg and additional cases have been found in country studies of Indonesia, Russia, and India. Moreover, the *Compendium* covers only those cases that have been the subject of serious investigations where significant evidence of corruption has emerged (although convictions have not always followed).

In some sectors, the prevalence of cases suggests that corruption may be routine. The sale of submarines, chiefly by France and Germany (the U.K. and the U.S. produce only nuclear-powered submarines and do not export them), is the subject of no less than 8 cases in a fairly small universe of contracts for these major platforms. Major combat aircraft sales from Europe also appear to be a sector where a high proportion of deals have been the subject of serious corruption cases, in particular where BAE Systems has been involved, through its established network of agents and financial shell companies.

The systematic, routine nature of bribery in some sectors is illustrated with an anecdote from Jean Guisnel's book, *Armes de corruption massive*. Guisnel describes a raid in 2008 at the offices of the French naval manufacturer DCNS, the company involved in the French submarine sales in question (as well as surface ships). The raid found a notebook from the company's former finance director in which he describes the processes by which DCNS vessels were marketed. He remarks that between 1991 and 2002, DCNS sold 60 billion francs-worth of vessels (EUR9.15 billion), of which 8 to 10 percent—thus around 732 million to 915 million euros—were paid in Frais Commerciaux Exceptionelles (or FCE, that is, Exceptional Commercial Expenses). These payments went to agents and lobbyists who redistributed them to their ultimate beneficiaries. FCE was the term given to commission payments, in other words bribes, that until France's accession to the OECD Convention on Corruption in 1999 were not only legal but tax-deductible. Moreover, in some of the cases from the 1990s assembled in the *Compendium*, the payment of such commissions was charged to the French state arms export agency, SOFRIMA, so normal and routine was the practice.[5]

Of course, the direct involvement of state agencies could no longer continue after the signing of the OECD convention, so since then French companies have had to use their own networks to pay commissions, where they have done so. There is no indication that the practice of paying commissions/bribes by European arms sellers has ceased as a result of the Convention. Of the cases in the *Compendium*, 14 involve sales by European countries after the Convention entered into force, and in most cases after national implementing legislation had also come into force.

It is also clear that corruption can occur in arms sales to developed, high-income democracies with strong institutions as well as to developing countries or those with weaker institutions. The *Compendium* includes cases where Austria, Belgium, Greece, Portugal, and the United States are the recipient countries. The Fat Leonard scandal in the U.S., where dozens of senior U.S. military officers were bribed by Malaysian defense contractor Francis Glenn to direct port and maintenance work for U.S. vessels toward his shipyards, is the most recent major example of such corruption in western countries and has seen the first-ever criminal conviction of a serving U.S. Admiral. (See "The 'Fat Leonard' Scandal" in WPF, 2017. This, and the other cases mentioned in the text can be accessed by following the *Compendium* link in endnote 2.)

Strong institutions, while not on their own sufficient to guard against bribery in arms procurement, do make a difference, however. Where such institutions and controls are absent, corruption in arms procurement can go well beyond mere bribery to encompass outright embezzlement of state funds, often through the medium of fake contracts issued for goods and services that are never, or only very partially, delivered. The ongoing Nigerian Armsgate scandal is a case in point (see "Armsgate" in WPF, 2017), where former President Goodluck Jonathan's National Security Advisor Lt. Col. Sambo Dasuki was given unchecked control over billions of U.S. dollars worth of budget and off-budget procurement funds and used them, along with a wide network of cronies in the military, government, politics, and business, to steal billions of U.S. dollars of funds. Between 2007 and 2015, as much as USD15 billion may have been looted, according to the Nigerian Economic and Financial Crimes Commission, most of it during Dasuki's tenure from 2012–2015. And this in a country whose annual official defense budget runs to about USD2 billion only. By comparison, the Fat Leonard scandal involves perhaps tens of millions of dollars, for a country with a defense budget of over USD600 billion.

Numerous cases of embezzlement and fake contracts have been uncovered also in Indonesia and Russia, although not on the same scale as in Nigeria. In one case in Russia a contract was given—in return for bribes to various officials—for the repair of the Russian Navy Cruiser, the *St. Petersburg*. Even though the vessel did not actually need repairs, funds went to a shell company which had mimicked the name of a real naval maintenance and repair company. The fake company did not carry out any work and, moreover, overcharged for the work it was hypothetically supposed to do.[6]

The limits of anti-corruption efforts

Apart from the fact of corruption itself, a second pattern that clearly emerges from WPF's work is how difficult it is to prove corruption cases in the arms business (and probably in many other domains as well) and how rare it is for serious penalties to be imposed on those engaged in corrupt activities. Part of this concerns the extremely complex nature of bribery cases, where those paying and receiving bribes do all they can to obscure the financial trails, e.g., through the use of intermediaries and shell companies. While it may be possible

to demonstrate that a company has paid a fee to an agent that cannot be explained by any legitimate service performed, it is much harder or entirely impossible to establish the ultimate beneficiary of the payments or demonstrate a *quid pro quo* connected to an underlying arms deal. Many corruption cases span numerous jurisdictions: The buyer's, the seller's, the country where agents are based, the location of financial intermediaries and shell corporations, and so forth. A successful prosecution may therefore require complex inter-jurisdictional cooperation. The *Compendium* abounds with cases of investigations that ultimately failed to lead to convictions (or that remain ongoing, seemingly bogged down), or where convictions are overturned on appeal due to a technicality, or where convictions are secured only on minor charges with more serious charges dropped.

Typical is the case of BAE System's go-to arms agent in central Europe, Austrian Count Alfons Mensdorff-Pouilly, who was alleged to have been involved in the payment of bribes to Czech and Hungarian politicians in connection with these countries' purchase of the Gripen combat aircraft (see "Gripen Deals with the Czech Republic and Hungary" in WPF, 2017). An Austrian judge acquitted him of corruption charges, but emphasized that this was not the same as a clean bill of health on the Count's dealings—"the whole thing stinks," commented the judge. But proof of who were the ultimate beneficiaries of Mensdorff-Pouilly's disbursements was lacking. Meanwhile, the Count was charged by the U.K.'s Serious Fraud Office (SFO) in connection with these deals but the charges were dropped in 2010 as part of a plea deal with BAE Systems. BAE received a paltry "false accounting" fine of GBP30 million in connection with a corruption case involving Tanzania, while all other charges in relation to deals with South Africa, the Czech Republic, Hungary, and Romania, were dropped in spite of the existence of ample evidence of wrong-doing.

The BAE Systems deal illustrates another reason why arms trade corruption frequently goes unpunished, or very lightly punished, namely, the political protection that those involved often enjoy in both recipient and supplier countries. On the recipient side, whether an investigation is started at all will frequently depend on the nature of the government and on the political position of those under suspicion. Where those receiving bribes retain political power, or are allied to those who hold power, they are unlikely to face investigation and may be in a position to actively obstruct or halt investigations such as when then-President Zuma of South Africa disbanded the Scorpions, an elite anti-corruption investigatory force that was pursuing the massive bribery that took place in an South African arms deal of 1999 (see "The South African Arms Deal" in WPF, 2017). In India, one sees a pattern of new governments being keen to investigate corrupt deals signed by their predecessors from the opposite side of the political divide while ignoring those of their own.[7]

On the supplier side, arms-producing countries are reluctant to punish companies that form a core part of their defense industrial base. The most extreme example of this is the U.K.'s cancellation of the Serious Fraud Office's investigation into BAE's Al-Yamamah arms deals with Saudi Arabia in the face of Saudi pressure (see "The Al Yamamah Deals" in WPF, 2017). But even in the U.S., which is much more willing to prosecute cases of bribery of foreign officials under the Foreign Corrupt Practices Act (FCPA), the worst any company is likely to face is a Deferred Prosecution Agreement, or DPA, accompanied by a fine and a "dressing down". The fines can be large—BAE Systems was fined USD400 million for its failure to declare payments and its violation of the FCPA and the U.S.'s International Traffic in Arms Regulations (ITAR) in relation to Saudi, South African, Czech, and Hungarian deals—but even so this is a small fine as compared to the vast profits made by the company from their Saudi sales alone over the decades. By contrast, as noted, the U.K.'s SFO entered into a "sweetheart" deal with BAE, whereby the company paid only GBP30 million in 2010 and, moreover, was guaranteed immunity for any corrupt dealings up to that point.

For individuals involved in corruption on the seller's side prosecution is rarer still. The only case we have found in which anyone went to prison for paying bribes to foreign officials in relation to an arms deal, or for collaboration in such activities, is that of two mid-level German executives of the company Ferrostaal, for bribes in connection with submarine sales to Greece and Portugal (see "Greek Submarine Scandal" and "The Portuguese Submarine Deal" in WPF, 2017). Two much higher-level Italian executives—the former CEOs of Italian arms giant Finmeccanica (now Leonardo) and of its helicopter-making subsidiary AgustaWestland—were convicted and sentenced to jail in 2014 for bribery in relation to the sale of VVIP helicopters to India. Yet, following numerous appeals, both were ultimately acquitted (see "India VVIP Helicopter Deal" in WPF, 2017).

In contrast, in at least some cases recipient countries have sentenced bribe-takers to prison. In the Greek submarine case, a former Minister of Defense, among others, received a prison term. In the Portuguese case for which the German executives were jailed, however, no prosecutions have been successful.

There are some tentative signs that enforcement efforts are increasing. Rolls Royce, for example, was subject to a record GBP600 million fine in 2016 as part of a settlement with the U.K.'s SFO for a range of corruption cases spanning the globe in both its military and civil business (see "Rolls Royce Jet

Engine Sales to India" in WPF, 2017). Nonetheless, this was once again a Deferred Prosecution Agreement, which is supposed to be for companies that volunteer information resulting from internal investigations. Rolls Royce did cooperate with the SFO but only after the latter had already uncovered ample evidence of wrong-doing. The message to other companies is that "so long as you cooperate after you are caught, you will get a DPA." This hardly provides a strong deterrent to corruption.

The German and Italian cases do illustrate some effort by national prosecutors to hold companies accountable for their actions. (Ferrostaal paid a substantial fine in relation to the affair). Meanwhile in France, investigations are continuing into several older corruption cases and prosecutors have begun investigations into the much more recent sale of submarines to Brazil in 2014. This is in contrast to the more common pattern where corruption is only investigated, if at all, many years after the event.

It is possible, then, that European arms producing companies are beginning to take their obligations under the OECD convention, and the national laws implementing it, at least semi-seriously. However, one current case in the U.K. may prove to be an important test of this proposition: For deals stretching back to the 1970s, the SFO has been investigating allegations of corruption in contracts with the Saudi Arabia National Guard by the company GPT Project Management, a U.K. subsidiary of Airbus, for the supply and support of communications equipment. The corruption allegations, relating in particular to the most recent contract signed in 2010, arose from information provided by an ex-Ministry of Defense (MoD) whistle blower in Saudi Arabia who was then working for GPT as part of a joint company–MoD team implementing the project. Several GPT employees have been arrested and questioned in connection with the case. Reports suggest that the SFO is nearing the point where charges could be brought but is awaiting permission to proceed from the top U.K. law officer, the Attorney General (see "GPT and the Saudi National Guard" in WPF, 2017). The question is, will the U.K. government once again, as in the Al-Yamamah case, prioritize the arms trade with Saudi Arabia over the rule of law and halt the investigation (or leave it hanging without outcome), or will it allow prosecutions to take place in spite of the potential consequences for business with the U.K. arms industry's number one foreign customer?

Corruption as industrial policy

In understanding why corruption in the arms trade is so prevalent, it is important to consider the political-economic structure of the global arms trade that makes exporters so willing to pay bribes to secure deals and governments willing to go easy on companies that do so, or even to actively collaborate in such activities.

The arms industry is much less concentrated than comparable industries with similar levels of technology and capital requirement.[8] While the market for major civilian aircraft is dominated by just two players, Boeing and Airbus, the market for major combat aircraft includes Boeing, Lockheed Martin, Northrop Grumman, United Aircraft Corporation (Russia), AVIC (China), Airbus (trans-European), BAE Systems (UK), Dassault (France), Mitsubishi Heavy Industries (Japan), and Saab (Sweden). In this, and other sectors, middle-sized players are seeking to keep autonomous technological and production capabilities going that would not be viable in a fully competitive market if price and quality, rather than the national base of manufacture, were the only issues. But the desire on the part of countries to develop and maintain autonomous arms production capabilities as a means of preserving some strategic autonomy and security of supply appears to be almost universal. Even those countries that cannot realistically aspire to producing a wide range of advanced major armaments—such as smaller European producers, or the likes of Australia, Singapore, Indonesia, and Canada—still seek to maintain some sort of arms industry, whether based on licensed production, specialization in particular types of system, fitting into the supply chains of major producers, or some combination thereof.[9]

For the major European producers, "national champions" such as BAE Systems (UK), Dassault, Thales, and Naval Group (France), Leonardo (Italy), ThyssenKrupp (Germany), Saab (Sweden), and the French-German Airbus Group exercise significant influence over government policy as a result of their position at the heart of their countries' defense industrial base and are monopoly domestic suppliers either in a particular domain of weapons systems or, in the case of BAE, Leonardo, and Saab, in multiple domains. This influence is exercised via a "revolving door" arrangement between government (especially the defense and sometimes trade ministries) and industry, secondments from industry to government, representation on policy committees, and frequent high-level access of corporations to top government officials and politicians. One author quotes a Swedish defense procurement agency official likening the relation of the Swedish government to Saab to that of "a parent and child." Presidents, prime ministers, and even royalty will often make lobbying for arms sales a major priority of overseas visits.[10]

For most producer countries, domestic demand is insufficient to maintain viable capabilities, especially the most advanced, and therefore export dependence is high. This is true

of all the major West European producers as well as of Russia. Up until the mid-2010s, indeed, the Russian arms industry was almost entirely export-dependent. (Today, increasing levels of domestic demand are complementing export sales.) Much is often made of the role of exports in reducing unit costs due to scale and learning effects in the production of major systems. While learning effects are undoubtedly highly significant for major systems with relatively short production runs, the extent to which exports reduce the cost to national governments is uncertain as this will depend on whether the government will recoup these gains from the exporting company. In the U.K., for example, BAE Systems enjoys sole source contracts for over 90 percent of its sales to the U.K. government. In such contracts, a standard profit rate is applied over costs and does not take into account potential future exports. Thus, the U.K. government essentially pays the costs of research and development plus a profit margin up-front, allowing BAE to enjoy profits from export sales and the benefits of reduced unit costs from longer production runs.[11]

However, the key question for governments concerns not so much unit costs as whether national champions will be able to maintain their technological and production capabilities for the most advanced systems at all. Even countries like the U.K. and France renew major platforms such as aircraft and ships only every few decades, so long gaps between these domestic orders are common. Without exports, production lines would have to be closed down or mothballed, key employees would leave, and thus key know-how and capabilities could be lost and become difficult to reconstitute. For companies, exports represent major profit opportunities, but for governments they also represent the means of ensuring the continued capability of their defense industrial base to develop and produce new weapons systems and preventing a growing dependence on imports.

The problem for exporters is that major deals for systems such as combat aircraft, submarines, major surface combatants, and the like are rare, with most countries making such purchases once or twice in a generation. Moreover, for the majority of countries that do not face urgent conventional military threats, the purchase of an entirely new advanced system is often a luxury rather than a necessity: Like someone deciding on buying a car, keeping the current one going for a couple more years or buying a good used car are viable alternatives.

For example, over the period 2008 to 2017, a total of 64 deals were agreed worldwide (including some selected but not definitively ordered) for exports of 1,739 major combat aircraft. However, 25 of these 64 deals were by the U.S., and 21 by Russia, leaving six other countries—China, France, Italy, South Korea, Sweden, and the U.K.—fighting over the remaining 18 deals for 465 planes. (Plus Germany, which also produces Eurofighter Typhoons but which did not win any deals during this period). In the naval sphere, a total of 72 submarines were ordered by 16 countries from just 5 suppliers: Germany (32), France (17), China (11), Russia (9), and South Korea (3). For major surface warships, 95 were ordered from 11 suppliers: China (20), France (16), South Korea (13), Italy (9), Netherlands (8), the U.S. (8), Germany (7), Russia (6), Turkey (4), the U.K. (3), and Spain (1). In other words, the deals are few and far between, and the workloads they generate for the producers of these complex systems are limited.[12]

Corruption is not so much an aberrant feature of arms deals but actually a facet of defense industrial policy.

Thus, the international arms trade tends to be a buyer's market even when international tensions are fairly high. Numerous sellers are competing for a limited number of deals, where buyers have other options. Failure to make one of the handful of sales opportunities coming up over a period of a few years may threaten the viability of national capabilities. The incentive for exporters to do whatever it takes to win these crucial orders, up to and including bribery, is therefore great as is the incentive for their national governments to turn a blind eye to such practices, or at the very least to go easy on them when discovered. Corruption is, in this sense, not so much an aberrant feature of arms deals, but actually a facet of defense industrial policy.

Does the U.S. bribe less? (And if so, why?)

A large proportion of the cases WPF has examined involve major European arms producers as exporters. Russian arms sales, too, have in a number of cases been the subject of corruption allegations, although investigations have only ever come from the buyer's end. There is no indication that Russian authorities have opened any investigation into such deals.

In contrast, while some cases involving U.S. arms exports have emerged and been prosecuted by the Department of Justice and/or the Securities and Exchange Commission, these have been relatively minor and few in number in comparison to the huge size of U.S. arms exports—excepting, that is, cases such as BAE, and another involving Brazilian company Embraer, where foreign-based companies have been prosecuted by U.S. authorities on the basis of their possession of U.S. subsidiaries and listing on U.S. stock exchanges, thus making them subject to U.S. reporting requirements.

It is possible that U.S. companies have become more adept at disguising corrupt payments and avoiding detection, but it

seems likely that the infrequency of cases reflects a lesser tendency for U.S. arms exporters to engage in significant bribery. (This does not exclude that some cases may remain undetected, in addition to those that have been investigated). There are a number of reasons why this might be the case, some of which relate to the defense industrial considerations discussed above and to the U.S.'s unique place in the global arms trade and in international security more broadly.

First, in the FCPA, the U.S. has long-standing legislation against bribery of foreign officials. Moreover, anti-corruption legislation is stronger than in Europe, with ITAR requiring companies to report all commissions, fees, and political contributions made in connection with foreign arms sales. While almost all exporters report zero such payments, the requirement makes it easier to establish malfeasance, in that it is necessary only to establish that an unreported payment was made rather than to prove corrupt intent or to identify the ultimate beneficiaries of the payment.[13]

Second, the U.S. has extremely strong political and security ties with many of its major customers such as Japan, South Korea, Saudi Arabia, and Australia, and these countries are inclined to turn to the U.S. as their principal arms supplier as a way of maintaining this relationship and effectively seeking to purchase continued U.S. security guarantees along with the weaponry. For some of these countries, interoperability with U.S. forces and indeed with their own existing U.S. equipment may be another motivation. (Saudi Arabia appears to have no such concerns, buying a hybrid air force from several different suppliers.) Thus, the U.S. government does much of the work involved, especially in relation to government-to-government Foreign Military Sales agreements, greatly reducing the need for companies to employ dubious independent marketing strategies.

Third, the U.S. domestic market is by far the largest arms market in the world and an enormous and essentially guaranteed source of profit for the major U.S. arms manufacturers. Not that these companies do not also seek whatever export opportunities may come their way, but the lesser degree of export dependence of U.S. companies means that the U.S. government has less incentive to turn a blind eye to bribery as a means of preserving its defense industrial base. Indeed, this lower export dependence may be one of the reasons why the U.S. is willing to maintain stronger legislation and investigatory practices against arms trade corruption. Moreover, U.S. companies seem to devote the bulk of their lobbying and influence-peddling activities to the much larger domestic market, where unlimited campaign contributions to legislators are entirely legal. Thus, a risk-benefit analysis of breaking the law through foreign bribery may be much less appealing.[14]

Corruption as a political tool

Politics is an expensive business as election campaigns become ever more costly. Where strict limits to election spending exist, as in France for example, candidates may well seek off-budget sources of funding. A high profile recent case is that of the current French investigation into former President Nicholas Sarkozy, who, it is alleged, received up to EUR50 million in payments from former Libyan dictator Moammar Gaddafi. Aside from regular election expenses, the costs of political success can include internal party competition, building up local party structures (cultivating loyalty and support), and sometimes more nefarious activities such as vote buying, paying local "enforcers", maintaining a patronage network that rewards loyal supporters, and so forth. All of this requires a substantial political budget for leading politicians, some of which may be obtained through legal channels but some of which may require alternative, illicit sources of funding.[15]

The arms trade is a highly political business, being tightly connected to national security. Governments are the prime customers, and decisions on major acquisitions tend to involve leading political figures as well as procurement officials and military officers. At both the buyer's and seller's ends, senior politicians may play a decisive role. Arms deals, therefore, can provide a perfect opportunity for politicians to fund their political budget. Hence, arms trade corruption frequently has a political motivation, beyond personal enrichment. The *Compendium* includes numerous cases where bribes paid in connection with arms sales have gone to finance political parties or individual candidates' election campaigns. In many cases, bribes are very widely distributed, not just to the prime decisionmakers but also to those who could potentially act as "spoilers" and need their cut and to those who form part of top politicians' patronage networks.[16]

Offsets

One of the clearest symptoms of the perennial buyer's market in the arms trade is the prevalence of offsets, a nearly universal feature in major arms deals. Offset agreements require exporters to make investments and counterpurchases in the importing country to offset the foreign currency cost of the deal. Offsets can be direct, such as local production of some or all of the equipment, subcontracting, and technology transfer, or indirect, where investments and counterpurchases may be in sectors unrelated to the deal or in the arms industry in general. Offsets are largely unknown in other industries (indeed prohibited by the WTO convention on government procurement, for those who are signatories). But in

international arms deals, buyers are able to demand them, and sellers—even the U.S.—have little choice but to accede to these requests if they are to compete.[17]

Offsets create a fertile channel for corruption in arms deals and are particularly well-suited to political corruption as they can be an effective means for politicians to reward supporters without offering direct bribes. Because offsets imply a discretionary opportunity for the selling firm or the buying government to pick and choose partners in the buying state, they create lobbying incentives for potential partners. Allotting offset investments can serve as a mode of patronage, that is, rewarding political supporters and their aligned business interests. Offset arrangements, even those for indirect offsets, are typically highly opaque, with details of individual contracts rarely made public unless it is in the interests of one party to do so. Thus, it is much harder for the public and regulatory authorities to scrutinize just who is benefitting from offset investments and contracts. One example of how this can operate is in an South African arms deal, where then-Defense Minister Joe Modise bought shares in a company, Conlog, which shortly afterward received offset investments and contracts from BAE Systems as part of the deal.[18]

Offsets may provide an attractive channel for corruption in arms deals in general (political or otherwise) as they add an extra layer of obscurity and deniability to the process. A large commission payment to an agent who provides no obvious service to justify the payment is inherently suspicious. But an offsets package, negotiated without transparency, and where many of the specific offset investments are not made public, may not give rise to clear grounds for suspicion, such as large payments of a dubious nature. Thus, decisionmakers might steer offset negotiations toward subcontracting that they know they or their allies will benefit from, while the exporting company can maintain plausible deniability. Even if the corrupt nature of the transaction is discovered, it may be hard to demonstrate that the exporting company has been culpable, for example through lack of due diligence.[19]

In at least nine *Compendium* cases in WPF (2017) offsets have been identified as a vehicle of corruption. This likely only scratches the surface, given the difficulties in cataloguing offset arrangements and identifying who may have benefitted from them.

Retrocommissions

A specific example of corruption opportunities is the phenomenon of so-called retrocommissions associated with several French arms sales. In particular, in the case of sales of submarines to Pakistan and of frigates to Saudi Arabia, a portion of these commissions was funneled back to fund the 1995 presidential election campaign of then-Prime Minister Edouard Balladur (see "l'Affaire Karachi" in WPF, 2017). The key agent for some of these deals, French-Lebanese arms broker Ziad Takieddine, is also involved in the current Sarkozy investigation. He claims to have personally delivered suitcases full of Gaddafi money to Sarkozy. The corruption scandal that brought down former German Chancellor Helmet Kohl also involved retrocommissions on arms sales, mostly used to fund intra-party political competition to support Kohl's faction within the Christian Democrat Party (see "The CDU Party Funding Scandal" in WPF, 2017).[20]

Regarding arms trade-related corruption, the law enforcement and national security functions of government may be working at cross-purposes to each other, one seeing it as a criminal investigation, the other as a matter of fundamental national defense interests.

Conclusions

Understanding the systemic nature of arms trade corruption is crucial to understanding why and how it operates and to our prognosis and prescriptions for reform. On the exporter side, the role of arms export deals as a means of maintaining defense industrial capabilities in medium or even medium-large producers gives a powerful incentive to turn a blind eye toward the means deployed to achieve them, including corruption, and to protect companies from the legal consequences of such actions. The law enforcement and national security functions of government may therefore be working at cross-purposes to each other, one seeing it as a criminal investigation, the other as a matter of fundamental defense interests.

On the side of the bribe recipients—in the buyer, and sometimes also the seller country—if the motivations for seeking kickbacks in connection with arms deals is political as well as personal (although the latter is undoubtedly a factor in many cases), then the driving forces behind arms trade corruption may be deeply embedded in the structure of political power and competition in a country rather than merely and simply being a function of the individual greed of particular leaders and decisionmakers. A "new broom" may come in with a genuine desire to reduce corruption but will be subject to the same political imperatives to obtain reliable sources of political finance as any predecessor. The tendency to pursue corruption scandals by previous administrations while turning a blind eye to, or actively collaborating in, corruption in one's own party is therefore likely to be a strong one.

The prognosis is not completely without hope. In several countries, including the U.S. and the U.K., a strong consensus appears to be emerging across the political spectrum on the

need to strengthen financial transparency and to combat corruption, money laundering, and other financial crimes (including transparency on the beneficial ownership of companies and foundations) to make it harder for corrupt dealings to hide behind anonymous shell companies. One of the reasons for this is that vulnerabilities in the financial system can be exploited in numerous ways: to facilitate corrupt arms and other deals, certainly, but also for money laundering in support of terror and organized crime, and by oligarchs and sanctioned regimes and individuals to launder corrupt gains and evade sanctions.

While new measures may make arms trade corruption easier to detect, they do not deal with the problem of political will to prosecute companies and individuals who engage in it. Repeated exposure may help, but to seriously tackle arms trade corruption would require addressing the underlying political and defense policy forces that drive it.

Notes

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1. Long recognized: See, e.g., Roeber (2005).

2. Compendium: See WPF (2017). The *Compendium of Arms Trade Corruption* (http://sites.tufts.edu/corruptarmsdeals) was first published online in May 2017. New entries have continued to be added up to April 2018 and existing entries continue to be updated as new information becomes available about the cases. The *Compendium*, and its component entries, is nonetheless referred to throughout this article as WPF (2017), based on the original date of publication.

3. U.S. corruption complaints: Roeber (2005). Pattern of systematic corruption: Feinstein (2011). High to Critical ratings: TI (2015). In war contexts: See, e.g., Chayes (2015).

4. On arms offsets, see Brauer and Dunne (2004; 2011). Collins (1996, p. 5) writes: "Much of the existing discussion of procurement offsets relates to the exceptions found in many national and international legal systems in favour of defence procurement, the sector in which offsets remain the most popular and where prohibitions in international and national laws do not apply."

5. Systemic, routine nature: Guisnel (2011). Previous names of DCNS include DCN and Direction des Constructions Navales.

6. Russian cruiser: Beliakova and Perlo-Freeman (2018).

7. Zuma: The charges, dropped just before he assumed the presidency, were reinstated soon after Zuma left office.

8. Dunne and Smith (2016). Some other recent works that give a good overview of the structure of the contemporary arms industry include Bitzinger (2009a, 2009b) and Tan (2010).

9. Brauer (2000) concluded that "countries that can produce arms (potential) do produce arms (actual)." For a relatively recent overview of the modern global arms industry, and the place of different nations within the international arms production hierarchy, see Bitzinger (2009a, 2009b).

10. One author: Åkerström (2016, p. 195). Presidents, prime ministers, and royalty: See, for example, Tony Blair's promotion of U.K. arms sales to South Africa (Plaut, 2007), Prince Charles' promotion of U.K. arms sales to Saudi Arabia (Norton-Taylor, 2014), and Donald Trump's promotion of U.S. arms sales to numerous customers (Hartung, 2018). See also Feinstein (2011), Guisnel (2011).

11. Export dependence is high: Overseas sales no longer are a supplemental form of income; they are increasingly critical to the health and survival of the defense industrial base. Reducing unit costs: E.g., Chalmers, *et al*. (2002) estimated an annual saving to the U.K. MOD of GBP160 million per year as a result of unit cost savings from exports. In such contracts: There is a small "commercial exploitation levy" applied by the government to exports, but this recoups only a tiny proportion of R&D costs, amounting to an average of GBP9.5 million over the years 2012/13 to 2014/15 (see Perlo-Freeman, 2016).

12. All information taken from SIPRI's Arms Transfers Database. Second-hand sales were excluded, unless substantially modernized before delivery, as these do not generate new work. Major surface combatants include frigates, corvettes, and amphibious assault and landing ships. No contracts for aircraft carriers or destroyers were signed during this period, although a few were in the preceding decade.

13. On this, see, e.g. Pelak (2017).

14. Lesser degree of export dependence: U.S. spending on procurement as part of national defense spending consistently exceeds USD100 billion while military R&D spending consistently exceeds USD50 billion (Office of Management and Budget, 2018). The vast majority of this is spent on the U.S. defense industry, as is a significant portion of the Operations and Maintenance budget. By contrast, U.S. arms exports do not exceed USD30 billion per year (Perlo-Freeman, 2018).

15. Sarkozy: Arfi and Laske (2018). Political budget: de Waal (2015).

16. Numerous cases: Such cases are discussed in detail in Liang and Perlo-Freeman (2018).

17. Prohibited: See Art. XVI, Agreement on Government Procurement, available at www.wto.org. For background, see https://www.wto.org/english/tratop_e/gproc_e/gpa_overview_e.htm.

18. See "The South African Arms Deal" in WPF (2017).

19. For a discussion of some of these issues, see for example Fluka, Muravska, and Pyman (2012) and Weissman (2014).

20. Suitcases: Arfi and Laske (2018).

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HERBERT WULF on possible improvements in SIPRI's arms production database

KEITH HARTLEY on knowns and unknown in arms industry and trade data

SAM PERLO-FREEMAN on corruption in the global arms trade