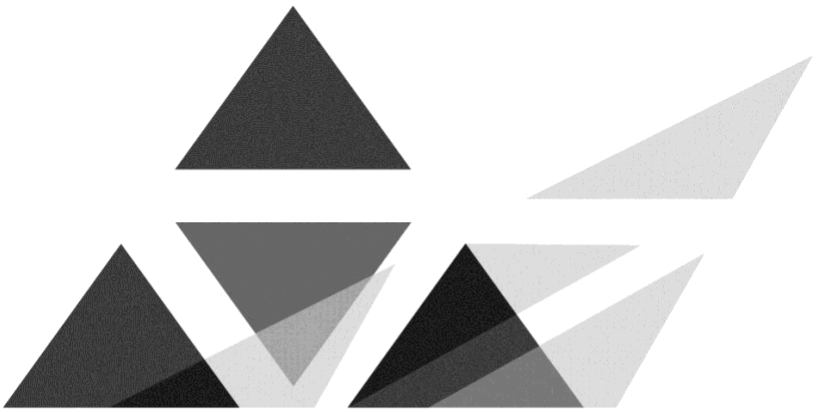

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The Changing Economics of Global Arms Production

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The Changing Economics of Global Arms Production

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Abstract

This paper provides an analysis of the development of international arms production and changing nature of the industry. It begins with an explanation of the basic terms used and the status of data in this field. It then moves on to a description of the international arms market, considering its characteristics and the relation between companies, the state and the military. An analysis of the size and structure of the international arms industry is then provided using the limited data available, followed by a review of the main developments in arms production and the arms industry since the end of the cold war. This includes a review of the driving forces at work, the restructuring that has occurred, the changing composition of the industry and the outcomes of these changes. Finally, an assessment is made of the economic impact of arms production.

Keywords: Arms industry; Arms production; Defence; Post-cold war

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I. Introduction

Arms production has gone through many phases during history. While the use and manufacture of weapons for violent acts has taken place as long as human beings have existed, a more organized form of arms production was born in the context of the military revolution 1560–1660. This was the result of the emergence of modern states with control over their own territories, the emergence of standing armies, and the commercialization of war, arms production and arms sales. A major transformation of arms production took place during the cold war. The main elements in this transformation were rapid technological development, in radar, jet aircraft and ballistic missiles; qualitatively larger investment in research and development (R&D) and production to fund armaments programs; and therefore, also closer state-industry relations. Together with the decision to maintain large permanent military establishments in peace time, these developments gave rise to a large arms industry (outlined in the section 'The international arms industry') with a permanent nature and set of unique characteristics, as described in the section 'The international arms market'.

After the end of the cold war and initiated by a ten-year long decline in military expenditure, particularly in the countries and regions that had been actively involved in the cold war, and with it a decline in demand for weapon systems, the arms industry went through a major restructuring process focused, at least originally, on downsizing and diversification, and subsequently involving a surge of mergers and acquisitions leading to increased concentration of the arms industry. The post-cold war decline in demand lasted only one decade. The arms industry started burgeoning again after 11 September 2001. With the massive increase in US military expenditure in response to the September 11 terrorist attacks on US cities, the restructuring process shifted to the sectors that benefited from the spending increases, especially those producing the capabilities required for the new type of war fighting, such as electronics and information technology. Post-September 11 developments have also reinforced the trends towards outsourcing of military services and the expansion of private military and security companies.

This paper considers the development of arms production and the arms industry in the post-cold war period. This includes a description of the characteristics of the international arms market, a rough illustration of the size and structure of the international arms industry, a survey of the main developments in arms production and the arms industry since the end of the cold war, and an assessment of the economic impact of arms production. The next section deals with some of the definitional and data issues.

II Arms Production and Industry

There exists no generally agreed definition of arms production. Efforts to develop definitions that encompass all facets of this field have proved to be difficult. In a general sense, arms production can be defined as the production of military goods and services. Military goods are usually defined to include not only weapon systems but also all other products that have been developed and produced specifically for military use, but excluding general-purpose items such as food, electricity, ordinary computers, and construction activities. Military services are more problematic to define. Activities such as research and development, testing, and evaluation (RDT&E) of weapon systems, and the marketing, sales, maintenance, servicing, and repairs of such systems, should ideally be included in the definition of arms production, but in practice this is often not the case. These types of activities are often carried out by private companies and are assuming an increasing importance for the armed forces. In addition, there is a broad range of other types of services provided by the private sector to the military sector, which are

not directly linked to weapon systems but rather to military functions. Such services are expanding rapidly as a result of outsourcing of military functions to the private sector. Whether these types of services should be regarded as military services and included in arms production, and if so, which ones, is a matter of contention.

One important difficulty in defining arms production is to decide on the scope of the definition as regards the production process and the supply chain, that is, whether production of subsystems, components and parts should be included. Most often the term ‘arms production’ is used to mean only the production of final weapon systems.

An arms-producing company can be defined in different ways. In this article, it is defined as a company that is engaged in arms production, regardless of the proportion of military sales in the total sales of the company. Few companies produce exclusively for the military market. Most companies have a mixed military and civil production, where most of them have divisions or units that are specialized in military production.

Similarly, the term ‘arms industry’ is sometimes used to refer to the sum of arms-producing companies, while at other times it refers only to the arms-producing parts of these companies. The difference can be great, since arms production can take up a small part of a company’s total sales and employment. In this article the term ‘arms industry’ is used to refer only to the arms-producing activities of companies.

Since the early 1990s, a large private business sector is emerging, which provides military and security services to the military and other government sectors as well as the private sector, in war and conflict zones. These private military and security companies can be divided into private military companies that provide anything from military training and logistics management to armed security and private security companies that provide armed and unarmed security services of personnel and assets. However, in practice, many companies offer both types of services. Some of these activities overlap with the military services of the arms industry, in particular those contracted out, or outsourced, by military establishments.

In general, it should be noted that all these terms are used in a rather fluid way, especially in empirical studies, because of the difficulties of applying any of those definitions properly in the real world and finding the appropriate data.

Data on arms production are not shown separately in the official industrial statistics, since the arms industry is not treated as an industrial sector of its own but cuts across several industrial sectors, such as aircraft and spacecraft, chemicals, motor vehicles, transport equipment, and weapons and ammunition. Therefore, the available data are produced in special projects and are based on different types of surveys of the industry, conducted by governments, industry associations, and research institutes. These are usually national or international aggregations of data reported by individual companies.

Company practices of releasing data on their defence production vary widely. While most publicly traded companies provide rather detailed information in their annual or quarterly reports, others (e.g. privately owned or state-owned) either do not compile separate statistics for military production or keep such data secret. It is often difficult even for the companies themselves to identify separate revenues, profits, and employment in the military business segment of the company because of the fact that most arms-producing companies also produce for the civil market and resources flow between their civil and military production processes.

Data collections for several countries are provided by research organizations. The Stockholm International Peace Research Institute (SIPRI) maintains a database on the major arms-producing and military services companies in the world (until 2020 apart from China for lack of data). Financial and employment data for the 100 companies with the largest arms sales are

published in the online SIPRI Arms Industry Database and in an annual Fact Sheet and described in the SIPRI Yearbooks. These data are based primarily on company annual reports and on information in official documents, military journals, and newspapers.

Aggregate data at the national level of the output and/or employment in arms production used to be provided by a few governments, but this is no longer the case. Some countries have national defence industry associations, which provide such data about their member companies. The problem with these data is that they are usually rough approximations and are calculated in different ways in different countries. Some data refer exclusively to the production of final weapon systems, while others also include the production of parts and maintenance and repairs of military equipment, and some countries include also general-purpose goods and services procured by the armed services. Some estimates include the production by subcontractors and suppliers of parts and raw material to the prime contractors. Data on national arms production provided by the arms industry are difficult to interpret and must be treated with caution.

III. The International Arms Market

During the cold war, the arms market developed some very specific characteristics. In most major arms-producing countries, it became a monopsonistic market in which the national government is the main customer and regulates exports. This means its size, structure, and trade are all determined by government policy. As Dunne states,[1] the general characteristics of the arms market are as follows:

(i) An emphasis on the performance of high technology weaponry rather than on cost.

(ii) The bearing of risks by governments who often finance R&D and, in some cases, provide investment in capital and infrastructure.

(iii) Elaborate rules and regulations on contracts, as a result of the lack of a competitive market and to assure public accountability.

(iv) Close relations between the arms-producing companies, the procurement executive, and the military.

(v) The existence of national monopolies or close to it in other countries than the USA.

These characteristics created a market that tends to favour firms who specialize in arms production, as they know their way around the red tape and have the contacts within the military and the procurement executive. They focus on becoming experts at getting money out of government, rather than being successful in commercial markets. The companies seek involvement in the development programs for technologically advanced weapon systems as the best means of obtaining the subsequent production contracts. This can lead to 'buy ins', where firms understate risk or cost to win initial contracts, making up the losses later. In addition, past programs have seen 'gold plating' where the military continually ask for extras or continuous technological improvements over the contract period. This allows renegotiation of contracts or additional payments, usually to the advantage of the contractor. The granting of large R&D contracts with risk borne by government together with specific types of production contracts with guaranteed cost coverage has created a tendency toward high profitability in spite of low efficiency in production.

As a result of the structure of the market, barriers developed to both entry and exit, which led, to the cold war arms industry showing remarkable stability in terms of its composition of main arms companies. These barriers — market, technological and procedural — mean that not only

[1] Dunne (1995).

has it been difficult for companies to enter into the defence sector to produce weapons systems, or to upgrade from subcontractor status, but also that it is difficult for the defence companies to leave the industry. The emphasis on performance and the large scale of R&D programs are associated with a trend of rising costs of R&D, which in turn has made it increasingly difficult for single companies or even single countries to develop new advanced weapon systems. This created a pressure in the arms industry toward concentration into fewer and larger companies, and toward international collaboration in arms production.

The links between these large arms-producing companies, the state and the military has been described as a military industrial complex (MIC), reflecting the interrelation between the groups with a vested interest in arms production irrespective of rational considerations of national security. In addition, while most manufacturing industries, went multinational, the arms industry remained national and smaller countries, which could not afford the large fixed costs, imported major weapons systems.

With the fall in demand, following the end of the cold war, the ability of even the major countries to maintain a domestic defence industrial base was called into question. Governments had to decide whether to allow mergers and acquisitions which would reduce competition and in particular whether to allow mergers and acquisitions which involved foreign partners. They were also in a situation where the change in the security environment made it harder to justify previous levels of support for the industry and ‘competitive procurement policies’ aimed at value-for-money were introduced in a number of countries. However, although there have been some changes in the size and structure of the global arms industry and in the nature of the military goods and services supplied by the industry, the characteristics of the arms market has by and large maintained its specific characteristics.

IV. The International Arms Industry

The capacity to develop and produce major weapon systems is concentrated in about eight to ten countries and only a handful of countries have a significant defence technological and industrial base. While a number of additional countries have some small-scale manufacturing capability for small arms and light weapons and a few major systems, they depend on imports for their acquisition of arms, at least for major weapon systems.

However, it is very difficult to accurately assess the size and structure of the global arms industry, since there are no official data on total national arms production for most countries. In addition, company collaborations within and across countries as well as mergers and acquisitions add further difficulty and suggests that any analysis on the structure of the arms industry should be divided into national and international. Such assessments must rely on estimates based on various methods.[2] One method is to use the arms sales of the 100 largest arms-producing and military services companies (arms companies for short) in the world and their geographical distribution. Another method is to calculate estimates of national arms production based on data on government arms procurement less arms imports and plus arms exports. This section uses the first method to outline the size and structure of the global arms industry.

The value of the combined arms sales of the top 100 arms companies in 2018 was $420 billion, according to data from SIPRI. While this total does not include China for lack of data, it provides a rough indication of the size and structure of the global arms industry outside China, since these companies account for a major share of global arms production.

Table 1 provides data on the top 100 arms-producing and military services companies in the world (apart from China) in 2018. It shows a strong dominance of US companies. In 2018, 43 US companies accounted for 59% of the combined top 100 arms sales, while Russia as the second largest accounted for 8.6% of total sales. Twenty-seven companies in the rest of Europe, accounted for 24% and the remaining 20 countries in the rest of the world accounted for 8.6%. Interestingly, by 2019 there were no longer any top 100 arms producing companies based in Africa or Latin America after South African arms producer, Denel, dropped out of the top 100 group in 2005 and Brazil's Embraer dropped out in 2019.

However, when recent data for China are included, the picture becomes markedly different. Recent studies drawing on newly available data suggest that Chinese arms companies are among the largest weapons producers in the world.[3] Based on a 2019 SIPRI study, at least 4 of the 11 major arms companies are ranked within the 20 largest in the world.[4] Table 2. shows how these 4 were comparing with the top 20 arms companies in 2017. NORINCO is currently the world's largest specialist in land-based systems and the recent merger of China's two sole shipbuilders (CSIS and CSSC) makes the new China State Shipbuilding Corporation the largest military shipbuilding company in the world. Furthermore, it is highly likely that all 11 arms producing companies in China would be ranked among the SIPRI Top 100.

2 Methodologies described in Brzoska, M. (2019).

3 Béraud-Sudreau, L. and Nouwens, M. (2019) and Tian, N. and Su, F. (2020).

4 Tian and Su (2020).

Table 1. Top 100 arms-producing and military services companies (apart from China)[a] in the world: arms sales[b] and national shares, 2018
Figures are in US dollar, at current prices and exchange-rates.

No. of companies	Country	Arms sales (in $ billions)	Share of total sales (%)
43	USA	246.1	*58.5*
10	Russia	36.2	*8.6*
8	UK	35.1	*8.4*
6	France	23.2	*5.5*
2	Trans-European[c]	15.4	*3.7*
2	Italy	11.7	*2.8*
6	Japan	9.9	*2.4*
3	Israel	8.7	*2.1*
4	Germany	8.4	*2.0*
3	India	5.9	*1.4*
3	Korea, South	5.2	*1.2*
1	Sweden	3.2	*0.8*
2	Turkey	2.8	0.7
1	Ukraine	1.3	*0.3*
1	Poland	1.3	*0.3*
1	Singapore	1.5	*0.4*
1	Spain	1.2	*0.3*
1	Australia	1.1	*0.3*
1	Canada	1.0	*0.2*
1	Switzerland	0.9	*0.2*
100	**Total**	**420.3**	**100.0**

[a] China is not included because of lack of data.

[b] Arms sales include both sales for domestic procurement and export sales.

[c] The companies classified as trans-European are Airbus Group which is based in three countries—France, Germany and Spain—and registered in the Netherlands; and MBDA, which is a joint venture between Airbus Group, BAE (UK) and Leonardo (Italy).

Source: Fleurant, A., Kuimova, A., Lopes Da Silva, D. Tian, N, Wezeman, P.D., Wezeman, S.T. (2019). The SIPRI Top 100 arms-producing and military services companies, 2018. SIPRI Fact Sheet. Stockholm: SIPRI.

Table 2. Top 20 arms-producing and military services companies, 2017.
Figures are in US dollars, at current prices and exchange rates.

Rank	Company	Country	Arms sales (in $ billions)	Share of arms sales in total sales (%)
1	Lockheed Martin	USA	43.9	*88*
2	Boeing	USA	26.9	29
3	Northrop Grumman	USA	22.4	87
4	Raytheon	USA	22.0	87
5	BAE Systems	UK	21.0	95
6	Aviation Industry Corporation of China (AVIC)	China	[20.1]	[34]
7	General Dynamics	USA	19.5	63
8	China North Industries Group (NORINCO)	China	[17.2]	[27]
9	China Electronics Technology Group (CETC)	China	[12.2]	[40]
10	Airbus Group	Trans-European	10.0	15
11	Thales	France	9.0	51
12	Leonardo	Italy	8.8	68
13	Almaz-Antey	Russia	8.6	94
14	United Technologies	USA	7.8	13
15	L-3 Technologies	USA	7.8	79
16	Huntingon Ingalls Industries	USA	6.5	87
17	United Aircraft	Russia	6.5	83
18	United Shipbuilding	Russia	5.0	89
19	China South Industries Group (CSGC)	China	[4.6]	[10]
20	Honeywell International	USA	4.5	11
Top 20			**284.1**	

Source: Tian, N, and Su, F. (2020). Estimating the arms sales of Chinese companies, *SIPRI Insights on Peace and Security, no*. 1 (Jan.). Stockholm: SIPRI.

V. Developments in Arms Production and Industry

Since the end of the cold war, arms production and the arms industry have undergone profound changes in most parts of the world. These changes were driven by five main factors. First, the rapid development in military technology, which pushed up the R&D content in advanced weapon systems and made them increasingly difficult to finance on a national basis; second, a changing relationship between military and civil technology, with civil technology in many areas taking the lead and becoming increasingly important in the production of military equipment; third, changes in the level of demand for military goods and services worldwide; fourth, qualitative changes in demand due to changed military doctrines and ways of warfare; and fifth. government industrial policy.

Rapid developments in military technology is a long-term trend, but it accelerated greatly through the development of new military technologies, as a result of the 'revolution in military affairs' (RMA), involving a range of sophisticated technology, needed for the new concept of network centric warfare. This has had a number of consequences for the arms market and the arms industry, including increased R&D content in advanced weapon systems, making them increasingly difficult to finance on a national basis and thus impacting on the structure of the arms industry, both on the national and the global level.

During the cold war military technology tended to be in advance of civil technology, but gradually developments in civil technology caught up with and superseded military technology in many areas, particularly in electronics and information technology.[5] There became less mention of the 'spin-off' of military technology to the civil sector and more of the 'spin-in' of civil technology into military equipment.

Most recently this has manifested itself in the concept of 'hybrid warfare' defined as:

"the synchronized use of multiple instruments of power tailored to specific vulnerabilities across the full spectrum of societal functions to achieve synergistic effects." [6]

Basically, the expanding scope of security threats in modern society and economies has led to the development of a wider concept of warfare and new capability requirements. This provides new and more extensive roles for the military sector in the economy and society. This combination of conventional ways of warfare with multiple new military tactics, including cyber warfare, has widened the role for the security sector into civil areas, particularly the internet and social media. As such, it has reinforced existing developments in the arms industry. It does rather fit with the tendency to 'threat inflation' that the sector is known for but does also reflect an extension of existing 'economic warfare' tools, that is, actions below military conflict between countries. Recently there have been suggestions that foreign states (Russia) have been meddling in elections in the US and UK, through support for politicians and activities in social media.

The changes this implies for the arms industry are most visible and perhaps most marked in the US but exist also in most other major arms-producing countries. The rapid developments in high technology have created an increased supply of technologies that have military applications and have further created demand to develop new capabilities. Advanced computer

5 Alic, J.A., Branscomb, L.M., Brooks, H., Carter, A.B. and Epstein, G.I. (1992). Gummett, P and Reppy, J. (1998).

6 Understanding Hybrid Warfare MCDC January 2017 (p3) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/647776/dar_mcdc_hybrid_warfare.pdf

chips have allowed the development of a range technologies applications for aircraft, satellites, drones and wireless communications, as have developments in artificial intelligence, leading to the US DOD Maven project aimed at improving the analysis of drone videos. Similarly, developments in robotics have provided possibilities for military systems. Cybersecurity is important in the civil sector against increasing sophisticated attacks and with the development of the concept 'hybrid war' has created demand from the military for technologies for both cyber-attacks and cyber-defences.

The demand for military goods and services have gone through four main phases during the post-cold war period. During the first phase, covering roughly the period 1989-2001, there was initially a continuous and significant decline in world military spending (roughly one-third in real terms) and with it a fall in the demand for military goods and services from the arms industry, and then a bottoming out of the fall towards the end of the period. The fall was greatest in Central and Eastern Europe, primarily because of the sharp reductions in the former Soviet states. The most profound change took place in Russia, which inherited most of the Soviet arms industry after the disintegration of the Soviet Union in 1991.[7] In North America, there was also a significant reduction in military expenditure, while reductions were more moderate in Western Europe.[8]

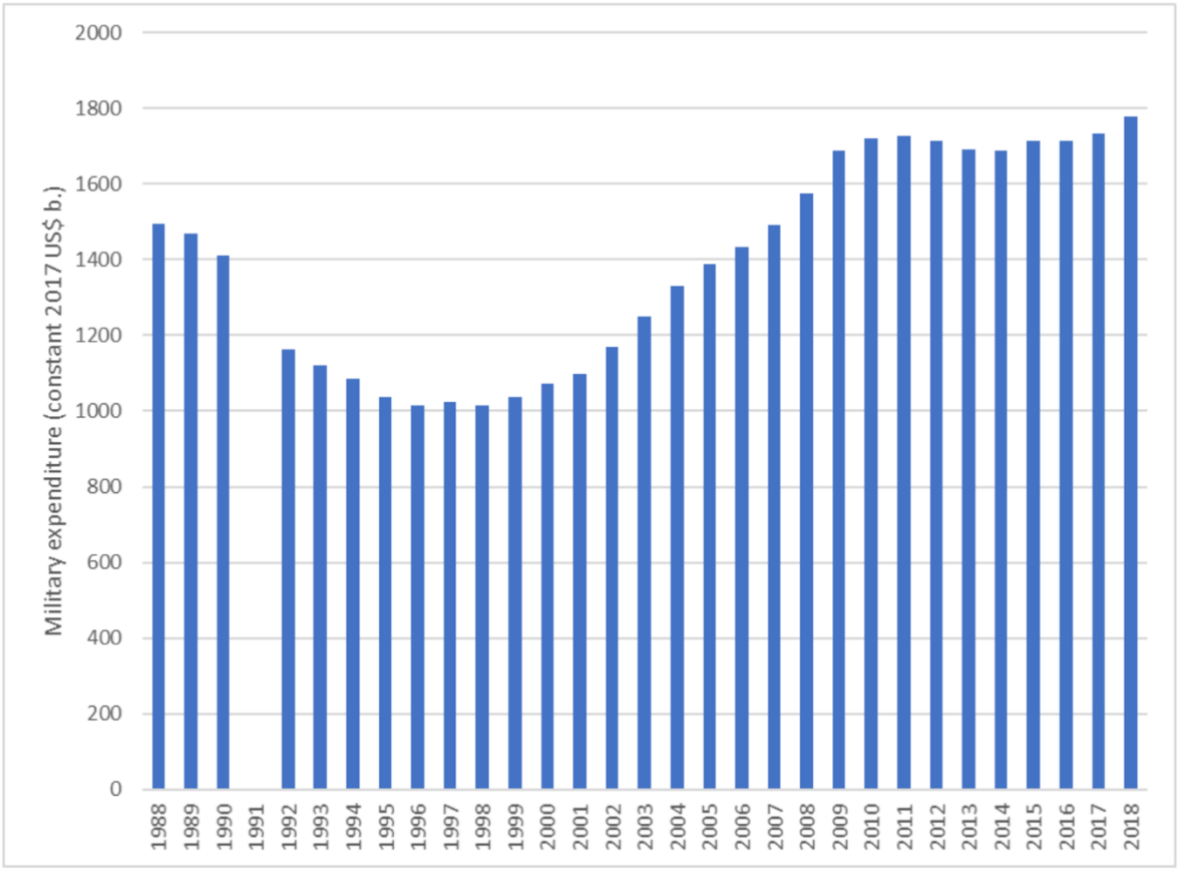
However, beyond the regions that had been directly involved in the East-West rivalry, there was no corresponding decline. On the contrary, military spending continued to increase during this period, particularly in the arms-producing countries in Asia, including in China (by 158%) in real terms, Singapore (126%), Turkey (74%), India (49%), South Korea (42%) and Japan (16%).

The shock generated in 2001 by the 9/11 terrorist attacks in the USA was the beginning of a second phase (2001-2010) of a strong increase in world military spending. In the USA, it resulted in the release of massive supplementary budget allocations under the heading 'Global War on Terrorism' (GWOT), to cover the costs of military operations in Afghanistan and Iraq as well as for homeland security. The US arms industry benefited greatly from this development. In Europe, there was no corresponding increase in demand after 9/11, although the decline in military spending and arms procurement did level off and in some European countries there was a slight increase in military spending. From 2011, with the withdrawal of troops from Afghanistan and Iraq, US and world military spending began to fall, compounded by the impact of falling oil prices on Middle Eastern military expenditures and austerity in Europe.

7 Cooper, J. (2006).

8 Sköns et al. (1998).

Figure 1 World military expenditure, 1988-2018



Since 2016, military spending has been rising again, largely driven by the Trump administrations increasing US spending and putting pressure on NATO allies to follow suit.[9] In 2017, the USA announced a large-scale military modernization program and the 2018 US National Defense Strategy reiterated the need to rebuild US military strength to address the long-term strategic competition from China and Russia.

Throughout these four phases in world military spending, China's military spending has kept a steady increase, roughly in line with its economic growth rate. This amounted to a tripling of Chinese military spending during the 2001-2011 period and another 60% increase up to 2018 and has resulted in an increased demand for indigenously developed and produced advanced weapon systems, while still keeping a low military burden, at only 1.9% of GDP by 2018. Other arms-producing countries that have made significant increases in military spending since the early 2000s include Russia, India and South Korea.

With the end of the cold war and the ensuing changes in the security environment there was a qualitative change in the types of equipment required, as the possibility of mass conflict between superpowers declined. Instead, in some countries the focus shifted to new roles for the armed forces in crisis management and peacekeeping missions in countries in armed conflict in the developing world, which changed both the nature and structure of the required armed forces and the type of weapon systems required. In the United States, the main qualitative shift in demand was from deterrence strategies involving nuclear technologies to a strong emphasis on war-fighting capabilities. This shift accelerated in the post-9/11 period and the military

9 Tian, N. et al. (2018).

operations in Afghanistan and Iraq, which have reinforced the role of advanced information technologies for war fighting (RMA). The use of new technologies in these battlefields also served as demonstration of their utility, which generated further demand. Increasingly remote actions with drones and aircraft have become important, reflecting the availability and improvement of the relevant technologies.

In the face of declining demand for arms during the early post-cold war period, governments developed policies to support the existence of national defence industrial bases, while at the same time guarding against monopolistic tendencies, and to encourage arms exports.

During the early post-cold war period, there was a significant decline in the production of major weapons, as indicated by the decline in arms sales of the top 100 companies, from $175 billion in 1988 to $155 billion in 1998. However, over the entire period since 1990, there has been a significant increase, to $392 billion in 2008 and $420 billion in 2018 (all expressed at current prices and exchange rates) (see figure 2).

In response to the post-cold war decline in demand, countries where the arms industry was largely state-owned undertook privatization processes. In most cases restructuring involved divestitures of existing units or acquisitions of other companies or parts thereof. In many cases, growth through acquisition could be achieved only through cross-border purchases. However, companies' choices were constrained by government policy towards their national defence industrial bases and by the nature of the financial systems within which they operated. During the post-9/11 period, the adjustment process in the US arms industry was linked to the changes in demand produced by the military operations in Afghanistan and Iraq, giving a boost to new military technologies and to the outsourcing of military services, and impacting on both the pattern of acquisitions and on the composition of the US arms industry. Since then, the more recent response to terrorist and hybrid threats have had a similar impact and led to an increasing involvement of civil producers.

Figure 2. Total arms sales of the 100 largest arms-producing and military services companies in the world (apart from China), 2002-2018

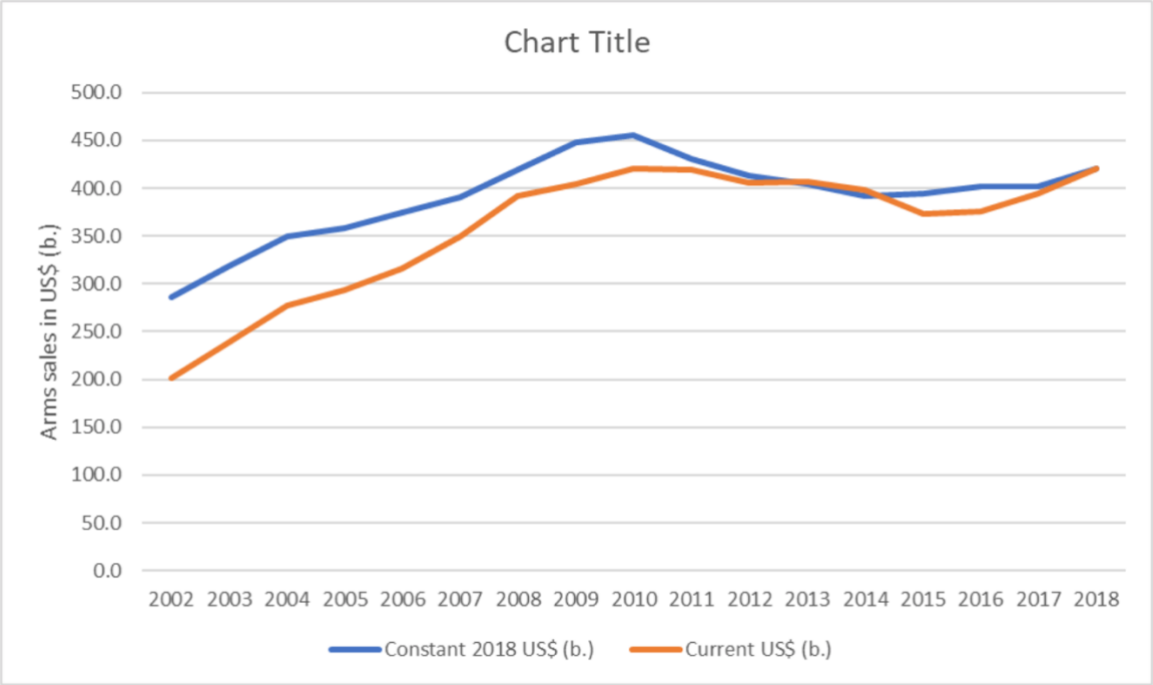


Table 3 Developments in the arms industry during the post-cold war period

Driving forces	Rapid development in military technology
	Changing relations between military and civil technology
	Changes in demand
	Qualitative changes in demand
	Defence industrial policy
Developments in the arms industry	Exiting, diversification and conversion
	Specialization on the military market
	International cooperation, mergers and acquisitions
	Arms export strategies
	Privatization and outsourcing of military services
	Entry of civil companies

During the early post-cold war period, a significant number of companies exited from arms production, in most cases by selling off their arms production units and in a few cases through plant closures or even bankruptcies. Out of the top 100 companies in 1990, by 2003 only 53 had survived as independent arms-producing companies. In principle, the conversion of plants producing military products to producing civil products was also an option to achieve civil diversification, but there were very few examples of a successful conversion strategy in this narrow sense.[10]

10 Dunne and Surry (2006).

By 2018, another 42 companies had exited the group of top 100 companies, some of which due to continued restructuring of the arms industry, but most of these were companies at the lower end of the top 100 list, which had been moved out due to the entry of new companies (primarily based in the USA, Russia, South Korea, Ukraine, Poland and Turkey) with higher arms sales.

The trend towards military specialization was most marked in the United States and the United Kingdom. The diversification efforts of US companies came to an abrupt end following a decision by the US Department of Defense in 1993 to stimulate mergers and acquisitions[11]. This left four major US contractors in 1998—Boeing, Lockheed Martin, Northrop Grumman and Raytheon—which were still in 2018 four of the top five companies in the SIPRI Top 100. Most of the subsequent restructuring has been less apparent, with the major's acquiring smaller defence and civil producers to gain technologies from the high-tech civil side. Since 2017, the US arms industry has experienced a new wave of mergers and acquisitions. Motivated by the new US policy of military modernization to develop a new generation of weapon systems, the technically challenging and diverse nature of the military requirements has pushed companies to add new capabilities to better position themselves against rival companies and win various projects. This has resulted in large-scale mergers among the top 10 US arms producers as well as their acquisitions of IT and other high-tech business units from other defence and civil companies.

In Europe, with its much smaller national markets, the national arms industries were already highly concentrated. The main case of a major merger on the national level in Europe during the early post-cold war period, was the formation of BAE Systems (UK) in 1999 through the acquisition by British Aerospace of the defence division of GEC. Further concentration of the European arms industry would have involved cross-border mergers and raised political issues, particularly as in several European countries, notably France, Italy, Portugal and Spain, there was a degree of state ownership of companies. This made the kind of financially driven merger boom that took place in the USA more difficult in Europe. Nonetheless, the driving forces in Europe were similar and led to an increase in concentration.

In Russia and China, there has also been a consolidation of the arms industry. In Russia, this was a necessity after the disintegration of the Soviet Union and with it the former Soviet arms industry. In China, consolidation has been part of its overall arms industry transformation to meet domestic demand and move away from the reliance on imports from Russia and Ukraine.

In China the aim is to have one major company in each of the arms production sectors. In recent years, this has included a merger of its two major aerospace companies and the 2019 merger of China's two major shipbuilders.

International cooperation has always been common in the arms industry. Companies can use international armaments collaboration, joint ventures and strategic alliances to achieve benefits of size without losing independence. All of these techniques were adopted by arms-producing companies in the post-cold war period, in particular in Europe, where cross-border acquisitions have been difficult to achieve.[12] Joint ventures are partnerships, often in the form of a jointly owned company, where two or more companies share profit, loss and control. They are an option for companies which want to combine without having to merge. During the first decade

11 At a dinner for arms industry executives, that has become known as the 'last supper', the then-Deputy Secretary of Defense, William J. Perry, announced the DOD decision that companies would be eligible to be reimbursed for parts of their costs of mergers and acquisitions, if it could be shown that these would result in future savings and result in reduced costs to the DOD. The policy ended when the DOD decided it had gone far enough and blocked the merger of Lockheed Martin with Northrop Grumman in early 1997.

12 Dunne and Surry (2006).

of the post-cold war period, the formation of joint ventures increased significantly in Europe, with Eurocopter, Astrium, EADS (all of which had merged into Airbus Group by 2014) and MBDA[13] The main transatlantic example from this time is French-US Thales-Raytheon Systems, formed in 2001, and described as the first transatlantic alliance between two global arms-producing companies.

What emerged was a web of cross-border ownership and collaboration relationships between companies, primarily within Europe, but also across the Atlantic and with other countries. In the transatlantic dimension, joint ventures and teaming arrangements for bidding on arms procurement contracts still serve as second best solutions to access each others' markets. At the European level, BAE Systems and Airbus Group form the two poles around which most other European defence and aerospace companies regrouped since the late 1990s. By 2005 this had resulted in a significant degree of European integration, concentrated to the aerospace and electronics sectors with only limited integration in other sectors, such as shipbuilding and land armaments. This situation has more or less prevailed until 2020, with continued fragmented national markets in naval shipbuilding, land armaments, military helicopters and the space industry.[14]

Beyond, the intra-European scene, internationalization in the development and production of major weapons has been even more limited. Throughout the post-cold war period, there have been attempts to develop technological and armaments collaboration in the transatlantic dimension. However, such efforts are confronted with a number of important difficulties, not least regarding the extent of reciprocity between potential partner countries and technology transfer issues.[15] An exception to this is the international collaboration for the F-35 Joint Strike Fighter program, a US project with participation from Australia, Canada and 5 European countries as well as security cooperation partners Israel and Singapore.[16] Participants contribute funding for development costs and most of them will also contribute to the production and acquisition of the around 3,000 aircraft, projected to be built and the production phase includes international joint ventures between US and partner country companies.

Another means of replacing cuts in domestic demand in the early post-cold war period was through efforts to increase arms exports. Companies tried to capture a larger slice of a rapidly declining export market, and governments, mindful of the need to keep costs down by maintaining or increasing the scale of production of domestic arms producers, supported and encouraged the search for orders abroad. This has resulted in some long-term changes in the global arms market. Arms exports became heavily subsidized, both directly and indirectly; government involvement in support of major export contracts increased; and there has been a strong increase in offset arrangements in arms export contracts. An offset is an agreement between a supplier and a buyer that imposes obligations on the seller to compensate the buyer for the costs of the purchase. They can be either direct or indirect. Direct offsets involve the goods and services in the sale, while indirect offsets involve any other goods and services. The most common types of offsets are subcontracting, licensed production or co-production in the importing country, technology transfers to, and capital investment in, the importing country, and counter trade. Arms trade offsets normally amount to more than 100% of the arms deal. This means that the value of the compensation exceeds the full value of the arms sales contract.

[13] Major intra-European examples of cross-border joint ventures include Eurocopter, formed in 1992 to join together French and German helicopter activities; Astrium, formed in 2000 to combine the space activities of France, Germany and the UK, now wholly owned by EADS; and MBDA, formed in 2001 to combine the missile activities of France, Germany, Italy and the UK.
[14] Hartley, K. (2017).
[15] Belin, J. (2017).
[16] Originally 8 partner countries but 7 since 2018 when US Congress decided to block Turkey from receipts of the F-35, due to concerns that Turkey would buy S-400 air defense system from Russia.

Apart from export sales of finished goods, companies were internationalizing their supply chains. The growth of offsets deals encouraged this and gave importing countries the opportunity to develop niche markets, by being part of the supply chain of a major international producer. It is, however, unclear whether the importing countries unambiguously benefited from offsets.[17] These changes led to increased competition among arms producers but failed to prevent the inevitable consolidation within the industry. Since the early 2000s, the international trade in major weapons is increasing again, while offsets still remain an important part of the international arms trade.

Another significant development during the immediate post-cold war period was increased privatization, both of previously state-owned arms-producing companies and of a number of functions previously performed by the armed forces and defence ministries. Outsourcing of military functions to private companies increased dramatically.[18] The private military services industry emerged as a result of a number of factors, including excess supply of military personnel due to downsizing, the changing nature of warfare, and a shift in government policies towards greater acceptance of outsourcing of military functions to the private sector[19] and has estimated annual sales of about $100 billion,[20] While some of the contracts were awarded to traditional arms-producing companies, a large part of these contracts went to private security companies. The industry was given a strong boost during the military operations in Iraq, when the military has made extensive use of private companies for support roles that previously would have been the responsibility of the armed forces. The wars in Afghanistan and Iraq also produced a large market for post-war reconstruction work.

In combination with the rapid growth of the homeland security market in the United States and elsewhere, these developments reinforced two trends: the entry of a new group of civil companies that are increasingly involved in arms production, and an increasing periphery of private security companies with government contracts and homeland security business. The increasing privatization of military services and the new and vast amount of post-conflict reconstruction work was producing a group of influential, profit-chasing companies that have a vested interest in armed conflict, similarly to what arms-producing companies have in the production of weapons and increasing demand for them.[21]

One result of the increased application of information technology and the increased importance of hybrid warfare has been to draw in a new type of companies into the arms industry. Major arms producers have been acquiring civil companies and smaller arms industry companies to acquire technologies and expertise and have expanded supply chains and entered into collaboration, bringing companies into arms production that would earlier have been considered civil producers. More recently, an important development has been major high-tech companies entering into direct collaboration with the military establishment, first to receive huge grants for technological development and second to become major suppliers of software components, software services, IT services and Internet software and services. In the US, the major high-tech companies that have entered the arms industry include Amazon, Apple, Google, Microsoft and Oracle. While they are not among the top 100 companies in the world in terms of arms sales, and their arms sales are difficult to identify and thus measure, they have a significant impact on the security sector. The importance of military work for these

17 Brauer, J. and Dunne, J.P. (Eds) (2004).

18 Wulf, H. (2005) and Holmqvist, C. (2005).

19 Perlo-Freeman, S. and Sköns, E. (2008).

20 Singer, P.W. (2004).

21 Dunne and Surry (2006).

companies was demonstrated in the competition between Amazon, Microsoft and other companies for a $10 billion US military contract for cloud computing, the Joint Enterprise Defense Infrastructure (JEDI), which in 2019 was won by Microsoft but in early 2020 was halted after complaints by Amazon. This close collaboration means high-tech companies that start in the commercial field can turn into arms companies through the dual use of their components and services. It makes it increasingly difficult to draw a clear distinction between commercial and arms production making it more difficult to study the behaviour and dynamics of the industry.

China's arms industry reform has followed a civil-military type of strategy in developing its arms industry. Since the 1990s the industry has benefited from the country's approach to civil-military integration (CMI) whereby 'spin-ins' can be generated from civilian technology to the military.[22] By the mid 2000s China's arms companies were increasing involved in civilian and dual-use sectors and thus blurring the lines between civil and military activities.

There are five main outcomes of the developments in the global arms industry during the post-cold war period: (1) a strong US dominance in global arms production; (2) growth of China Russia and other arms-producing countries; (3) an immense growth in the size of the biggest arms-producing companies; (4) increased involvement by civil high-tech companies in arms production and the arms industry; and (5) an increased concentration in the group of the top 100 companies.

US companies have continued to dominate global arms production since the end of the cold war. In 2018, US companies accounted for 59% of the top 100 companies in the world apart from China. The dominance of US companies is clearly illustrated by the position of US companies in the upper end of the top 100, where all of the 5 largest companies and 12 of the top 20 companies are based in the US. The largest company, Lockheed Martin, with $47.3 billion in arms sales in 2018, accounted for over 10% of total top 100 arms sales ($420 billion) in that year. The United States also has a lead in military technology and is the major military spender in the world, accounting for 36% of world military spending in 2018.[23] At the same time, US dominance has declined somewhat over the past decades. The US share in top 100 company arms sales has decreased from 63% in 2002 and 61 % in 2009. Similarly, the US share in world military expenditure has decreased from 43% in 2002 and 40% in 2009. This decrease is not primarily due to the decline in US military expenditure and arms sales during 2011-2017 but mostly because of the increase in other countries.

China, Russia and other arms-producing countries have increased their arms sales over the past 15 years. Table 4 shows the arms sales of the top 100 companies in the world (apart from China) in 2018 compared with in 2002. It shows how Russia has increased its share from 1.6% of total arms sales in 2002 to 8.6% in 2018. Israel, South Korea and Australia also account for increased shares of total top 100 arms sales. In addition, by 2018, the top 100 includes three countries that were not represented in 2002—Poland, Turkey and Ukraine. Furthermore, if data for Chinese companies had been available, these would also have exhibited a very strong growth over this period.

Table 4 Top 100 arms-producing and military services companies (apart from China), 2002 and 2018

Figures are in US dollars, at current prices and exchange-rates.

[22] Cheung, T. M. (2009)

[23] SIPRI YB, 2019, p194 Table 4.3.

2018				2002			
No. of companies	Country	Arms sales (in $ billions)	Share of total sales (%)	No. of companies	Country	Arms sales (in $ billions)	Share of total sales (%)
43	USA	246.1	*58.5*	43	USA	179.0	*62.6*
10	Russia	36.2	*8.6*	11	UK	29.4	*10.3*
8	UK	35.1	*8.4*	8	France	20.8	*7.3*
6	France	23.2	*5.5*	2	Trans-European[c]	11.4	*4.0*
2	Trans-European[c]	15.4	*3.7*	3	Italy	8.0	*2.8*
2	Italy	11.7	*2.8*	5	Germany	7.2	*2.5*
6	Japan	9.9	*2.4*	6	Japan	6.5	*2.3*
3	Israel	8.7	*2.1*	5	Israel	5.8	*2.0*
4	Germany	8.4	*2.0*	4	Russia	4.5	*1.6*
3	India	5.9	*1.4*	3	India	4.2	*1.5*
3	Korea, South	5.2	*1.2*	1	Sweden	1.8	*0.6*
1	Sweden	3.2	*0.8*	2	South Korea	1.7	*0.6*
2	Turkey	2.8	0.7	1	Singapore	1.5	*0.5*
1	Ukraine	1.3	*0.3*	2	Spain	1.3	*0.4*
1	Poland	1.3	*0.3*	1	Switzerland	0.8	*0.3*
1	Singapore	1.5	*0.4*	1	Australia	0.7	*0.2*
1	Spain	1.2	*0.3*	1	Canada	0.6	*0.2*
1	Australia	1.1	*0.3*	1	South Africa	0.6	*0.2*
1	Canada	1.0	*0.2*	1	Norway	0.4	*0.2*
1	Switzerland	0.9	*0.2*				
100	**Total**	**420.3**	**100.0**	**100**	**Total**	**286.2**	**100.0**

[a] China is not included because of lack of data.

[b] Arms sales include both sales for domestic procurement and export sales.

[c] The companies classified as trans-European are Airbus Group which is based in three countries—France, Germany and Spain—and registered in the Netherlands; and MBDA, which is a joint venture between Airbus Group, BAE (UK) and Leonardo (Italy).

Source: Fleurant, A., Kuimova, A., Lopes Da Silva, D. Tian, N, Wezeman, P.D., Wezeman, S.T. (2019). The SIPRI Top 100 arms-producing and military services companies, 2018. *SIPRI Fact Sheet*, Stockholm: SIPRI (Dec.).

During the first 15 years of the post-cold war period, there was an immense growth in the size of the biggest arms-producing companies. For example, the arms sales of the three largest companies tripled between 1990 and 2005, from a range of $7.5–9 billion to a range of 26.5–28.1 billion. This means that the three largest companies in 2005 each had arms sales of the same magnitude as the entire gross domestic product of countries such as Guatemala and Bulgaria. Since the mid-2000s, the size of company arms sales has increased at a slower rate but is still significant. By 2018, the arms sales of the top 3 companies was in the range of $26.2-47.3 billion and the arms sales of the smallest top 100 company was $800 million.

The increased integration and application of civil technology, in particular IT, into weapon systems has pulled in, and continues to do so, large high-tech companies, such as Amazon, Apple, Google, Microsoft and Oracle into arms production and the arms industry, either as

independent contractors or in collaboration with, or acquired by, major systems integrator companies.

As a result of the merger and acquisition activity during the early post-cold war period, there has been a clear change in the structure of the industry. At the end of the cold war the international arms industry was not very concentrated, with the top 5 companies accounting for 22% of the total arms sales of the SIPRI Top 100. By 2003 their share of the top 100 had increased to 44%. This large increase in the share of the top companies continued further down the list of companies, for the top 10, 15 and 20. In all cases, the big change occurred between 1995 and 2000. Although by 2003 the five largest arms-producing firms accounted for 44% of total top 100 arms sales, this was still a very low degree of concentration compared to other high-technology markets. The market for major weapon systems would probably have become more highly concentrated, like those for civil airliners or pharmaceuticals, if national governments had not inhibited the growth of multinational firms to protect their defence industrial base.[24]

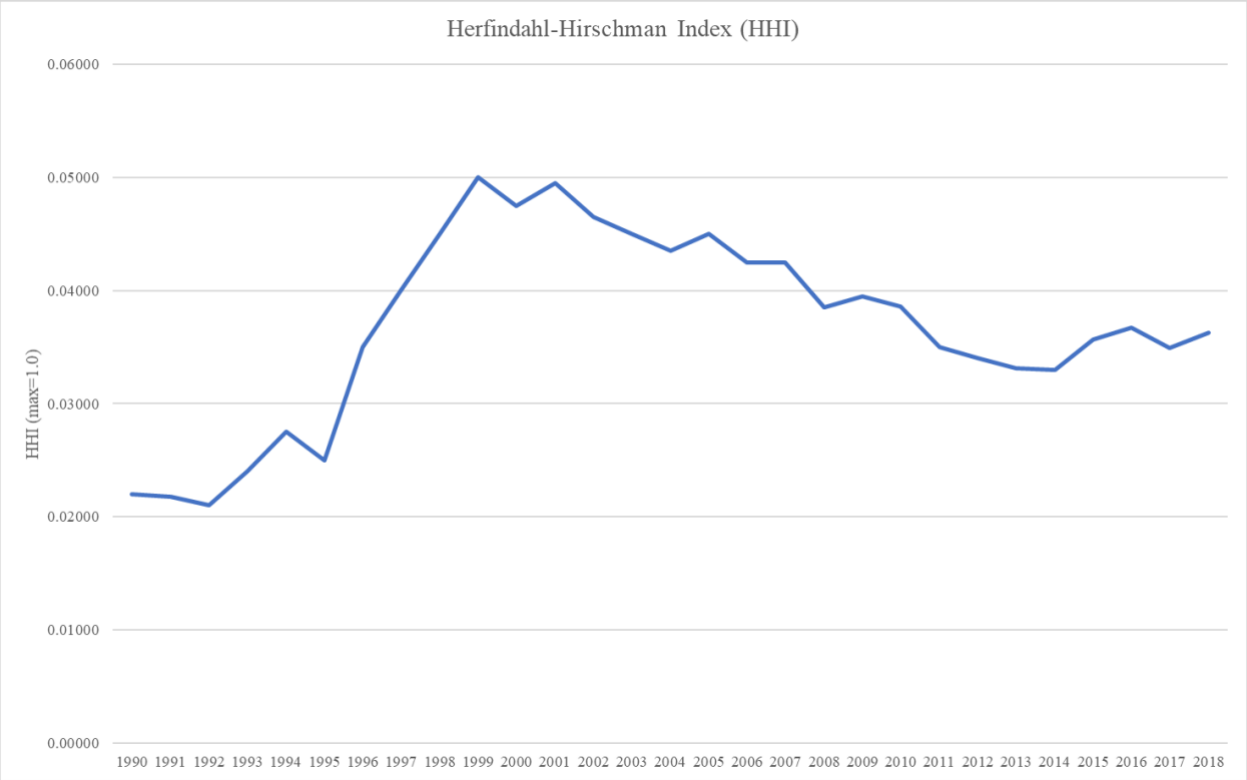
Since the turn of the millennium, there is, however, evidence of a decrease in the concentration of the arms industry. Figure 3 shows the trend in concentration within the top 100 arms companies (apart from China), using the Herfindahl-Hirschman Index (HHI). It shows that there was a sharp increase in concentration during the 1990s and up to 2001, then a falling trend until 2014. While there has been an increase in concentration between 2014 and 2018, overall the concentration index for arms sales has decreased from a 1999 peak of 0.05 to 0.036 in 2018.

It is difficult to measure and interpret the trends in concentration. Rising production costs, the influence of dual-use technologies and civil-military integration have changed the nature of the industry and made it more difficult to measure its size and structure. However, it is clear that the trend until 2001 reflects the strong national concentration process among the largest companies, most of which were based in the US. During this period there was also a national consolidation process in the Russian arms industry and an international military-industrial integration process in Europe.

The decrease in concentration during 2001-2014 is more difficult to understand. Since this period was not characterized by arms industry fragmentation at the national level, the most likely cause is decreased concentration at the global level, including the growth of the arms industry in Russia and in countries other than the established arms producers, such as India, South Korea, Turkey, Ukraine and Poland. There were more countries that could produce major weapon systems and they were increasing their company arms sales. If data from China had been available, the decreasing trend may have been more pronounced.

24 Dunne, J P., Garcia-Alonso, M., Levine, P. and Smith, R. (2007).

Figure 3 Herfindahl–Hirschman Index (HHI) on concentration for top 100 company arms sales,1990-2018



The increasing concentration among the top 100 since 2014 may reflect a stabilization of the entry of new companies both within established and other arms-producing countries, while at the same time renewed concentration at the national level, including in the US arms industry since 2017. While at the national level, arms industries have become more concentrated, globally the concentration is still well below that of the late 1990s.

There is, however, a strong element of continuity in international arms production and industry. While market forces have been allowed to work more freely in the military sector during the post-cold war period, this process is still to a great extent government controlled, particularly for the larger producers. For smaller producer countries maintaining control over their arms industry has become more difficult, not just because of increased foreign ownership and privatization, but also because of greater dependence of smaller companies on the larger systems integrators. This has forced them to adjust their policies to facilitate the integration of their companies into larger international military industrial networks.

VI. The Economic Impact of Arms Production

In a global perspective, the arms industry accounts for a very small proportion of world output and employment. In 1995, global arms production, estimated at $200-205 billion, corresponded to 0.7% of global gross domestic product (GDP). Global employment in arms production, estimated at 10.9 million people in 1995, including indirect employment, corresponded to 0.2% of the world's population and 0.4% of the global labour force in that year.[25]

In 2018 the share of the arms industry in world output is likely to be even smaller. The World Bank estimates that in 2018 world gross domestic product amounted to $85.9 trillion. A

[25] Sköns, E. and Dunne, J.P. (2008).

corresponding 0.7% of GDP as calculated for 1995 would equate to global arms production in 2018 amounting to around $600 billion—an unlikely figure given that total arms sales of the top 100 arms producing companies totalled $420 billion in 2018.

As for employment, the International Labour Organization estimates global employment in 2018 to be 3.3 billion people and the global labour force as 5.7 billion people. To get the same percentage share (i.e. 0.2 and 0.4% of world population and labour force) as found for 1995, the global employment in arms production, including indirect employment, would be 22.8 million people. Another unlikely scenario given that arms production is shifting towards less labour intensive with value added in the form of technological advancements.

Overall it is mostly likely that the arms industry accounts for an even smaller share of world output and employment in 2018 than in 1995. To put this into more perspective, the $420 billion that SIPRI estimates as total arms sales of the top 100 companies is only 1.5 times larger than the sales of Toyota. Despite the small size of the arms industry, it has a high profile and political support and it is often argued that it has significant economic and industrial effects, mainly through its high R&D intensity and the high-tech nature of production of most advanced weapons.

The debate on whether the arms industry has a positive or negative impact is an issue that is linked with the general debate over the economic effects of military spending. A large empirical literature has addressed this issue and, although there is no consensus, is tending to support a negative impact.[26]

A major channel by which the arms industry and by extension military spending is hypothesized to have a positive impact on the economy is through the transfer of technological innovation from the military sector to the civil sector, or technological 'spin-off'. While some argue that military production involves a high level of technology and thus can stimulate the modernization of civilian industries, others suggest the linkages to the civil economy are likely to be small.[27]

Although historically evidence has shown that some military innovations (e.g. transistors) were transferred to the civil sector, now many military equipment stems from highly sophisticated commercial technology. Governments as well as companies are showing increased interest in the integration and application of technology developed for the commercial (civil) market into advanced weapon systems.[28] In China, the push for civil-military integration or 'spin-in' is to have arms producers expand into civil sectors and use non-military resources to support military development. In Europe, there are policy efforts focused on civil-military synergies and the role of dual-use technologies in keeping the defence industry competitive.[29] The combination of findings in the literature and policies undertaken by governments suggest that as in the 1990s and 2000s, there currently remains a lack of real evidence suggesting that the arms industry plays a positive role in innovation, technology transfer or economic development.

26 Dunne and Tian, forthcoming 2020.

27 Schmid, J. (2018).

28 Acosta, M., Coronado, D., Ferrandiz, E., Rosario Marin, M., and Moreno, P. J. (2018).

29 European Commission (2014).

VII. Conclusions

In a fluid geopolitical situation an understanding of the nature and development of the international arms industry is particularly important. The companies involved produce the means of destruction and violence and can have considerable political and economic power, both nationally and internationally. In particular, they can intensify conflict through their influence on the arms trade. This paper has reviewed the changes that have taken place in this industry since the end of the cold war. It is not possible to understand the industry without some knowledge of the cold war industry it came from. The cosy funding environment created particular types of companies with little concern with costs and high fixed R&D costs, who specialised and knew their way around the red tape of procurement executives and were well linked into the military and politics. This meant the when the cold war ended and demand declined there was considerable restructuring and an increase in concentration across the major companies. This changed when defence spending rebounded, with 9/11 and the US wars in Afghanistan and Iraq. It also saw a change in the nature of weapons required with the response to terrorism and the Revolution in Military Affairs. It saw continuing economic development, with civil technologies spilling in to the military sector. It also saw a growing involvement of the private sector in conflicts and post conflict situations. This suggested that arms companies might have an interest in conflict, rather than just fulfilling procurement orders. It also saw a growth in internationalisation of production, but limited by national governments wanting some domestic arms production.

More recently, the industry has gone through a more fallow time, before the recent increases in defence spending. The industry has continued to change and is now responding to the existence of 'hybrid threats' which involve wider parts of society and the economy than normal military areas of activity. The 'hybrid warfare' includes attacks in cyberspace and the use of social media and involvement tin politics. This and the continuing benefits from technological developments in the civil sector have seen the industry change, many in the US to start with. In particular, the increased involvement in IT, social and economic processes of the primes, but also the introduction of major civil technology companies into the security sector. Including Amazon, Apple, Google, Microsoft and Oracle. The role of the defence primes has been maintained and developed through acquisitions to gain new capabilities. One concern with this growth of the reach and control of security sector is the degree to which it represents the sort of threat inflation the sector is known for.

Following an analysis of the SIPRI arms industry database and other information sources, five main outcomes of the developments in the global arms industry during the post-cold war period are identified. First, the continuing US dominance in global arms production, but second the growth in importance of China, Russia and other arms-producing countries. Third there has been immense growth in the size of the biggest arms-producing companies, with fourth, an increased involvement by civil high-tech companies in arms production and the arms industry; and fifth an increased concentration in the group of the top 100 companies.

Identifying the developments in the sector is not easy, given the secrecy that can surround it and so the difficulty of getting comprehensive information. What is clear is that the industry is changing and in ways which may make it more difficult for national governments to control.

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