Department for International Trade

Department for Business, Energy & Industrial Strategy

Analysis

Estimating the level of UK defence exports on a deliveries basis

Final Research Report

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This is a report of research carried out by Cambridge Econometrics, on behalf of the Department for International Trade and the Department for Business, Energy & Industrial Strategy.

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Contents

Tables

Figures

Executive Summary

A previous feasibility study established two key short-term options for estimating UK defence export deliveries

- The aim of this report, funded jointly by the Department for International Trade (DIT) and the Department for Business, Energy and Industrial Strategy (BEIS), is to produce an estimate of the value of UK defence exports on a delivery basis.

Official estimates of UK defence export deliveries are no longer maintained

- Previous efforts by UK government departments to estimate UK defence export deliveries have been identified as far back as 1994. However, such measures were discontinued, partly driven by changes to tariff code classifications in 2005 that limited the continued application of established methods to estimate UK defence export deliveries.
- In 2018, Cambridge Econometrics (CE) renewed efforts to estimate UK defence export deliveries in a feasibility study funded by BEIS. For the study, CE identified a range of options to estimate UK defence export deliveries. Two short-term options were identified in particular:
    - one based on commodity code classifications in the HM Revenue and Customs (HMRC) Overseas Trade Statistics (OTS), referred to in this report as the 'OTS approach';
    - another based on UK defence export orders data published by the Defence and Security Exports (DSE) of DIT, referred to as the 'DSE approach'.

The DSE approach maps export orders to deliveries

- Export orders do not necessarily materialise into actual export sales or deliveries. Under the **DSE approach** therefore, DSE export orders data (covering both goods and services) are distributed across subsequent delivery years, based on information on arms orders and their deliveries from the Arms Transfer Database (SIPRI ATD), developed by the Stockholm International Peace Research Institute.

The OTS approach attempts to identify the proportion of goods exports for defence use

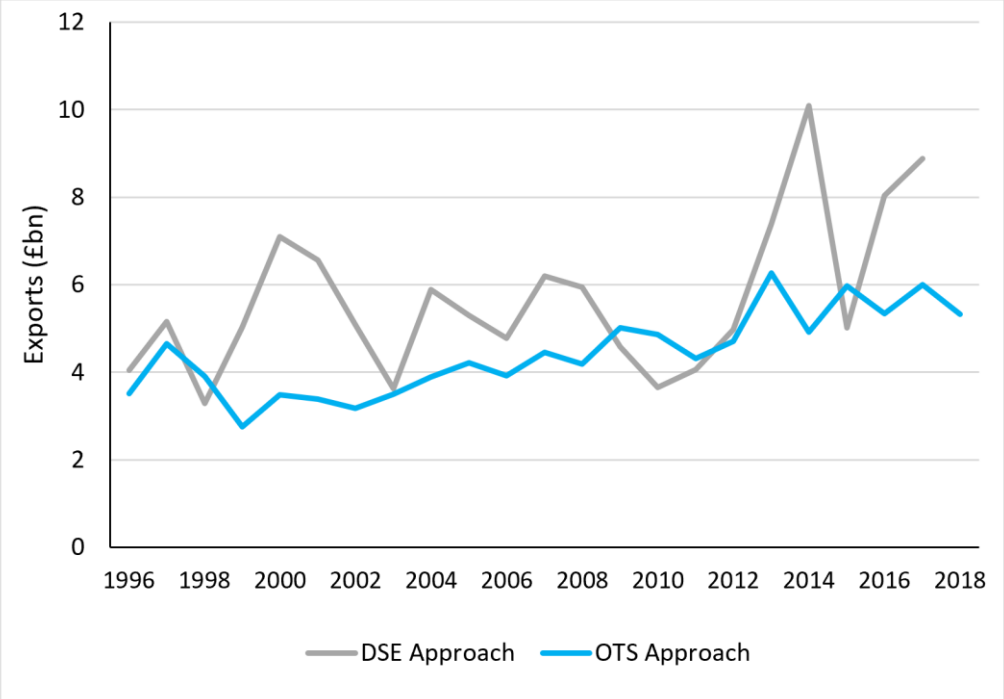
- The **OTS approach** relies on identifying exports of goods that are 'defence-related'. 'Defence-related' covers products that are exported for both defence and non-defence use; for example, aircraft. Assumptions are then developed for each commodity code on the proportion of the defence-related exports that are for defence use only. The adopted approach relies on a number of very strong assumptions, extrapolations from historical 'other than civil use' (o/t civil) shares available in data pre-2006, and ONS Prodcom data on UK sales of defence products. The two approaches produce estimates of UK defence export deliveries in the region of £6bn-£9bn in 2017, in nominal terms.

Both approaches suggest robust growth of UK defence export deliveries in recent years

- The OTS approach estimates that UK defence export deliveries of goods increased from £4.7bn in 1997 to £5.3bn in 2018 in nominal terms, with annual growth rates averaging 3.3% over that period. Annual growth rates over 2011-18 averaged 2.7%. Export deliveries of Aircraft & Parts dominate UK defence goods export deliveries, comprising around 75% of the estimated value in 2018.

- The DSE approach produces an estimate of defence exports of £8.9bn in 2017, an increase from £5.2bn in 1997. The average growth rate of defence exports over that period was 9.1% pa. There is a notable decline in defence exports following the 2007/08 financial crisis, from £6.2bn in 2007 to £3.7bn in 2010. Since 2010 however, defence exports have been increasing rapidly, reaching £8.9bn in 2017. There is also a relatively large (£37.8bn) accumulation of undelivered orders over the 1995-2017 period, predominantly driven by orders in 2014-2017.
- For most years, using the DSE approach produces higher estimates than the OTS approach. The differences in the estimates from the two approaches and the volatility of the time series can be attributed to methodological differences. Provided that the defence share in the OTS approach is roughly accurate, in theory the OTS-based estimate should always be lower in any given year, as it omits exports of services and accounts for the cancellations of orders.

Estimates of UK export deliveries based on the OTS and DSE approaches



Sources: CE calculations based on HMRC OTS, ONS Prodcom, ONS Supply and Use Tables, and SIPRI ATD database.

Of the two approaches, the DSE approach provides more reliable estimates. It produces an estimate of UK defence exports of goods and services of £8.9bn in 2017

- Both approaches to estimating UK defence export deliveries are imperfect, and subject to uncertainties. Of the two, the DSE approach is considered more credible for estimating defence export deliveries in the short-term. Relative to the OTS approach, the assumptions are considered to be less restrictive, and there are identified areas for further refinement of the estimates. The DSE approach also accounts for exports of both defence

goods services, unlike the OTS approach which only covers exports of defence goods.

The OTS approach covers goods only and is constrained by a lack of up-to-date datasets that can inform content for defence-use

- While arguably based on more robust (administrative) data compared to the DSE approach, the key limitation of the OTS approach is the lack of reliable and up-to-date data on defence-content share in defence-related exports. The estimates are highly sensitive to the method used to obtain defence shares. The historical defence shares are extrapolated over years, and therefore, the method is unable to fully reflect the variation of the defence-content over time, becoming less reliable for the most recent years.
- The DSE approach arguably improves for estimates of deliveries in recent years (compared to earlier years), given the longer historical time series of orders that can be mapped to delivery years.
- The primary uncertainties of the DSE approach relate to the accuracy of SIPRI delivery schedules and the coverage of the database, as well as the representativeness of Trend Indicator Values (TIV)[1] as a proxy for the value of exports.

Without new data, the OTS approach cannot be taken further

- There are limited options for how the OTS approach can be improved given the methodology involved and the available data. Some of the assumptions underpinning the estimates could potentially be validated or challenged from assessing the characteristics of firms engaged in production of defence products using linked microdata.

Export orders microdata could help verify the assumptions underpinning the DSE estimate

- There is scope to develop further the DSE-based estimates through exploring the order-level transactions in the DSE data. In the first instance, comparing order-level transactions in SIPRI and DSE can verify or challenge whether the orders by year, destination country and product align. The microdata can also validate whether the TIV values across products are roughly aligned to order values across products.
- One longer term option that is worth exploring further is the feasibility of adding questions to the DSE export orders questionnaire to capture directly the value of defence export deliveries (in addition to existing data collected on defence export orders). If such information were available in the DSE dataset, then this could lessen (or even eliminate) the dependency on the SIPRI dataset for delivery estimation. Moreover, in the short-term, DSE data on export deliveries would provide an opportunity to test the validity of the SIPRI data.

Estimating UK defence exports by destination country is possible, but is subject to huge uncertainty

- The feasibility of estimating UK defence export deliveries of goods by destination country is severely constrained by the number of suppressions in the OTS data for UK exports of defence-related goods by partner country. Furthermore, there is limited scope to apply defence shares given the lack of data on goods for defence use at the bilateral trade level.
- The method considered to provide the best approximation of UK defence exports of goods by destination country is to apply destination country

[1] The definition of TIV is provided in Chapter 2.

shares obtained from SIPRI data to the estimate of total UK defence exports using the OTS approach.

Estimates of UK defence exports by export partner are considered unreliable

- The assumptions underpinning UK defence exports by destination country relate to the coverage of the OTS data and the SIPRI data being aligned; the mapping of commodity codes to SIPRI categories being broadly representative; and that the country distribution of UK defence exports averaged over time is representative for individual years. Even though this is considered the most reasonable method given the available data, we have strong reservations about the reliability of the estimates; the estimates are based on a large number of strong assumptions, and there is very little information that can help validate or challenge those assumptions. In addition, this approach produces (imperfect) estimates of goods exports only, as the OTS dataset does not capture services.

Developing robust estimates for other G7 countries is considered unfeasible given the quality of existing data

There is insufficient data to derive reliable estimates for other G7 countries

- While it is in principle feasible to derive estimates of export deliveries for other G7 countries, our assessment is that this is not recommended based on the available data. Suppressions and lack of consistency in the coverage of trade data across the G7 countries at the commodity-code level mean that the scope for cross-country comparisons of defence-related exports is limited. The limited data to inform the content for defence use further compounds the uncertainty. Where data are identified for other G7 countries to inform defence shares, they are often time-invariant (reducing the feasibility of assessing trends over time), unrealistic (in the case of the US) or unconvincing (in the case of using export licenses for Germany). The recommendation is not to conduct cross-country comparisons of defence exports based on the available data for other G7 countries.

1 Introduction

1.1 Background

Previous attempts to produce estimates of UK defence exports were discontinued

The issue of estimating defence-focused export statistics is not new. Identified archive documents indicate that statistics on exports and imports of defence equipment were published as early as 1994[2]. Subsequent efforts to estimate defence exports have made use of industry association statistics, HM Customs and Excise (now HM Revenue and Customs (HMRC)) data, and export orders data. However, these statistics have since been discontinued.

In addition, changes to tariff code classifications around 2005 meant that trade data that previously distinguished between commodities 'for civil use' and 'for other than civil use' were discontinued. Other possible options were considered to estimate defence exports – such as using Customs Procedure Codes (CPCs) – but these were all assessed to have considerable limitations[3]. In many cases, the data are sensitive or subject to suppression, and cannot be shared in the public domain.

At present, there are no official data available on defence export deliveries. This means that the analysis of defence export statistics relies on either (1) exports orders data, which can have long lags in delivery or even be cancelled; or (2) export licence data, which do not equate to sales.

The work for this project is based on a feasibility assessment conducted by Cambridge Econometrics in 2018

In 2018, Cambridge Econometrics (CE) explored the feasibility of estimating the value of defence exports[4]. The starting point was to reconsider the method used to estimate defence exports based on industry association statistics, export orders and HMRC trade in goods data. However, this approach was deemed unsuitable given that the industry association no longer collects the same data that it had produced previously. In addition, CE's judgement was that too many restrictive and strong assumptions are required to reconcile defence export orders and trade in goods data.

Consequently, the 2018 study identified two main options as most feasible to take forward in the short term:

- The **DSE approach** focuses on mapping export orders data published by the Defence and Security Exports of the Department for International Trade (DIT DSE) to a delivery schedule, based on information from the Stockholm International Peace Research Institute (SIPRI). SIPRI data include information on both the year of order and year(s) of delivery of the defence product. The DIT DSE data cover contract values, and therefore include services.
- The **OTS approach** identifies defence-related goods within HMRC Overseas Trade Statistics (OTS) data. This consists of two components; identifying the list of relevant products (via classification codes) and identifying the defence content of each product. The OTS data do not cover services trade.

[2] See DASA (1994).

[3] For example, the use of CPCs would only identify trade for military use with non-EU partners only.

[4] Cambridge Econometrics (2018).

It should be noted that any estimates developed using these two options are not directly comparable; trade data obtained from customs data only cover goods, whereas exports data from DIT DSE cover both goods and services.

1.2 Objectives

This project, commissioned by the Department for International Trade (DIT) and the Department for Business, Energy and Industrial Strategy (BEIS), and building on the work undertaken for the feasibility study, looks to further the understanding of what can be achieved in the short-term with regard to estimating defence export deliveries. More specifically, this project consists of the following requirements:

1. Time series estimates of UK defence export deliveries going as far back in time as possible
2. Time series estimates of UK defence export deliveries by destination/recipient country
3. Estimates of defence export deliveries for other G7 economies for international comparisons
4. Recommendations for any further improvements on data sources, methods or assumptions for estimating UK defence exports on a deliveries basis.

Requirements 2 and 3 mark additional avenues of interest. At the outset, it is recognised that there are gaps and challenges associated with the available data in these areas:

- For customs export delivery data, exports by destination country for defence-related goods are often suppressed
- Uncertainty around data availability for the other G7 countries and, in addition, the availability of sources to inform the share of defence-related goods for defence use.

1.3 Structure of the report

Chapter 2 of the report outlines the results of developing the DSE approach from the feasibility study further. In particular, we outline the calculated delivery schedules based on SIPRI data, as well as sensitivity analysis based on key uncertainties associated with the approach, such as estimating the value of undelivered units, and the monetary values of each deal. We form an assessment of the approach given the analysis, as well as key recommendations.

Chapter 3 of the report outlines the results of developing the OTS approach further. Building on the assessment of different options for estimating the share of goods exports that are for defence use, we present our assessment of the method we consider to be suitable to develop a rough approximation of defence exports. We also outline the assumptions underpinning the method, as well as a comparison with other methods to estimate defence-related goods for defence use. We then provide a summary of the validity of the approach to estimating UK defence export deliveries.

Chapter 4 of the report provides a more detailed comparison between the estimate of UK defence exports based on the two approaches. The chapter provides a couple of detailed case studies of instances where there are large discrepancies, and in doing so, assesses the relative strengths and weaknesses of the two options.

Chapter 5 outlines the work to estimate UK defence exports for defence use by destination. It outlines the key challenges associated with suppression and data unavailability, as well as the options for estimating UK defence exports by destination country using alternative data sources (such as SIPRI).

Chapter 6 summarises our exploration of defence exports for the other G7 economies.

Chapter 7 offers concluding remarks.

2 Estimating UK defence exports of goods and services using the DSE approach

Key points

- The DSE approach to estimating defence export deliveries involves transforming DSE defence export orders data into deliveries by year using a delivery schedule calculated from the SIPRI Arms Transfer Database (SIPRI ATD).
- The DSE approach estimates UK defence export deliveries to total £8.9bn in 2017, up from £5.2bn in 1997. This estimate includes exports of both defence goods and defence services. There is considerable year-on-year volatility; this is unsurprising, given the nature of defence orders and deliveries.
- According to the delivery schedule, for most years, less than 1% of the value of all orders is delivered in the same year the order was made, suggesting that using export orders data in isolation as a measure of export deliveries may be misleading. Linked to this, a large proportion of orders received in 2016 and 2017 are undelivered. A similarly high proportion of orders in 2011 are undelivered, which is due to technical issues associated with UK sales of air refuelling systems to the US.
- The delivery schedule is fairly erratic across order years, highlighting the difficulty associated with applying a 'typical' lag to all order years in the DSE data.
- The key strengths of the method are: (1) that it circumvents the need to estimate and apply defence shares of multipurpose items, which is currently very difficult with available data; and (2) that by using DSE data, the estimate also includes services exports.
- The accuracy of the estimate is contingent on a few uncertainties. The approach cannot account for order cancellations. Additionally, the DSE approach assumes that the SIPRI-based delivery schedule is representative of the DSE export orders data (even though the SIPRI data coverage is likely to be lower). Furthermore, the delivery schedule is based on a measure estimated from input costs, rather than the monetary value of the order.
- Further work outside of the scope of this study could verify the impact of some of these uncertainties. It is possible to cross-examine the coverage and representativeness of SIPRI data with DSE orders data at the firm level, by matching individual orders in the microdata to orders in the SIPRI database.

2.1 Introduction

One option to estimate defence exports is to use UK defence and security export (orders) figures published by DIT DSE and to map these orders onto deliveries using a delivery schedule (the DSE approach). This approach was applied to the order period 1988-2017, using the publicly available data on UK export orders published by DSE. The delivery schedule is estimated using the SIPRI

ATD. This database contains trade registers of UK trade in defence, and a tool for quantifying defence trade volumes: Trend Indicator Values (TIV).

Section 2.2 presents and discusses the findings. This includes the estimated delivery schedule and the corresponding export delivery estimate using the publicly available DSE data. Section 2.3 highlights the assumptions required to produce the measure and provides an indication of the type of violations which could cause bias or inaccuracy. Sensitivity analyses are also performed where relevant and possible. Section 2.4 offers our assessment as well as overall recommendations for the application of this approach.

2.2 Presentation of findings

Delivery schedules

Figure 2-1 outlines the estimated delivery schedule of orders received between 2006 and 2017 in matrix form. The proportions presented in the delivery schedule are calculated on the basis of Trend Indicator Values (TIV) from the SIPRI ATD. The columns represent the order years and the rows indicate the delivery years and the proportion delivered (e.g. 38% of orders in 2006 were delivered in 2007). The sum across all delivery years and *Undelivered*[5] is always 100%.

What is TIV?

Trend Indicator Values (TIV) refers to an internally consistent 'common unit' of conventional weapons used by SIPRI to examine global trade patterns in defence exports.

The common unit is based on known unit production costs of a core set of weapons. The set of known production costs is then interpolated by size, performance characteristics and the sophistication of the electrical components.

TIV, therefore, tells us how much military products are being physically moved from one country to another, with the quantity being evaluated based on costs and resource characteristics.

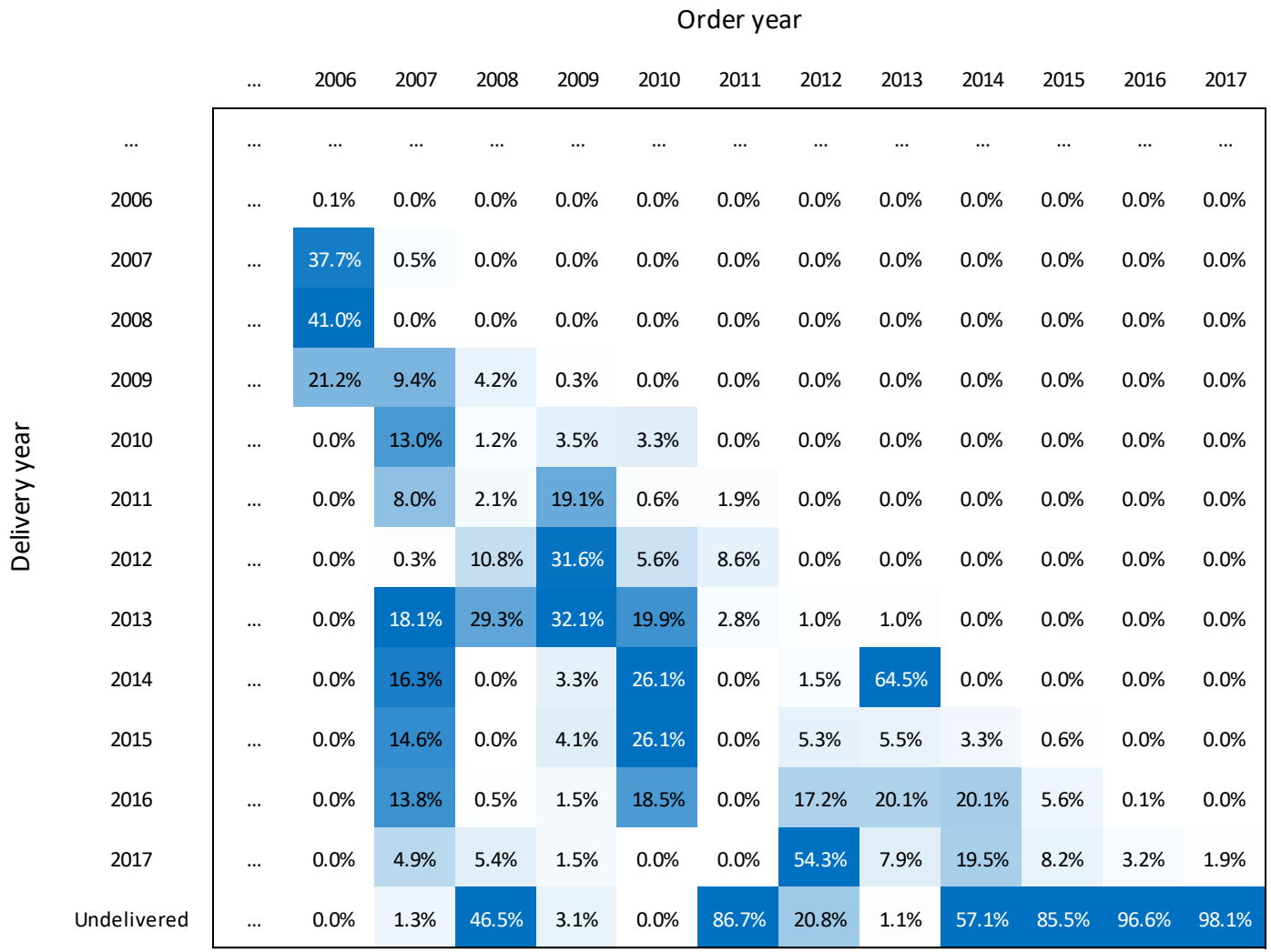
TIV is not a measure of the financial value of the sale and thus cannot be directly compared to other trade statistics (which are expressed as monetary values). Specifically, TIV is not 'externally valid' in the sense that comparisons between TIV and export value cannot be made.

TIV is, however, 'internally valid', in the sense that relative flows of defence items can be compared across products and years within the dataset.

The time period presented in Figure 2-1 is partial for illustration purposes. The full delivery matrix over the 1988-2017 period is available and is presented in an accompanying workbook.

[5] Undelivered items in this context means undelivered to date. In future vintages of the SIPRI ATD (updated annually), the volume of undelivered items will fall as new deliveries are made.

Figure 2-1: Orders to deliveries converter matrix (2006-2017)



Sources: Cambridge Econometrics (CE) calculations based on SIPRI ATD.

A relatively large proportion of orders is undelivered in recent years

One feature of the delivery schedule that we observe is the steady increase in the proportion of undelivered orders between 2013 to 2017. This is consistent with prior expectations about the lumpiness of the defence export market. It also fits the observation that defence exports are very rarely delivered in the same year. For most years, the proportion of orders that are delivered in the same year (as the order) is less than 1%.

We also observe a large portion of undelivered orders in 2011 – and to a lesser extent 2008. The large portion of undelivered items which were ordered in 2011 are attributed to a very large order of air refuelling systems for the US air force[6] [7] [8]. Some of these systems were expected to be delivered in 2018 but were delayed due to technical difficulties[9]. The undelivered item which was ordered in 2008 is reportedly the Super Vita fast-attack craft (FAC), which was ordered by the Greek navy.

The delivery schedule does not exhibit a consistent pattern over time

Another general observation is that the delivery schedule is inconsistent across years with regard to the length of the delay (that is, it is difficult to construct and apply a 'typical' delivery schedule based on existing orders – at least, for total UK defence orders). This suggests that applying a fixed lag (e.g. assume that 40% of orders are delivered in year t+1) is inappropriate. This finding therefore rules out econometric techniques which are commonly used to account for lags between economic variables in time series. Specifically, such techniques depend on patterns in the lag structure. The apparent absence of such patterns imply that empirical evidence is necessary to perform the transformation.

Orders received prior to 1988

As mentioned in Section 2.1, the delivery matrix was estimated for the period 1988-2017, matching the start-year of the export orders data published by DSE. This allows all orders included in the DSE dataset to be mapped to a set of delivery years. It does not, however, incorporate any orders received before 1988 as this is beyond the scope of the DSE dataset. For this reason, it is not possible to produce a credible estimate of defence export deliveries in the early years of that time period (e.g. 1990) because a large proportion of deliveries are likely to have been ordered before 1988.

Crucially, SIPRI data extend back to 1950 so it is feasible to analyse the volume of orders received prior to 1988 in terms of TIV (even if we cannot obtain the monetary values of those orders from DSE export orders data). Therefore, in addition to the calculation of the delivery schedule, further analysis of the SIPRI dataset relating to patterns of defence orders before and after 1988 was completed. This task had three key aims:

1. to better understand the impact and importance of pre-1988 orders on the final delivery estimate;
2. to form a view on a credible start year for the export delivery time series;
3. to adjust the estimate of export deliveries in order to better account for pre-1988 orders.

[6] UK Defence Journal (2018).

[7] Defense News (2018a).

[8] Boeing (2018).

[9] Defense News (2018b).

With regard to the first aim, we know that deliveries made before or around 1988 are likely to be underestimated using this approach due to the nature of lags between orders and deliveries. It is, however, possible to improve our understanding of this issue by quantifying orders and deliveries around the 1988 cut-off year. Specifically, we may be able to produce an estimate of the share of deliveries which were ordered before the cut-off year – and consequently are missing from the DSE dataset. This estimate would show the extent to which the figure is underestimated for any given delivery year.

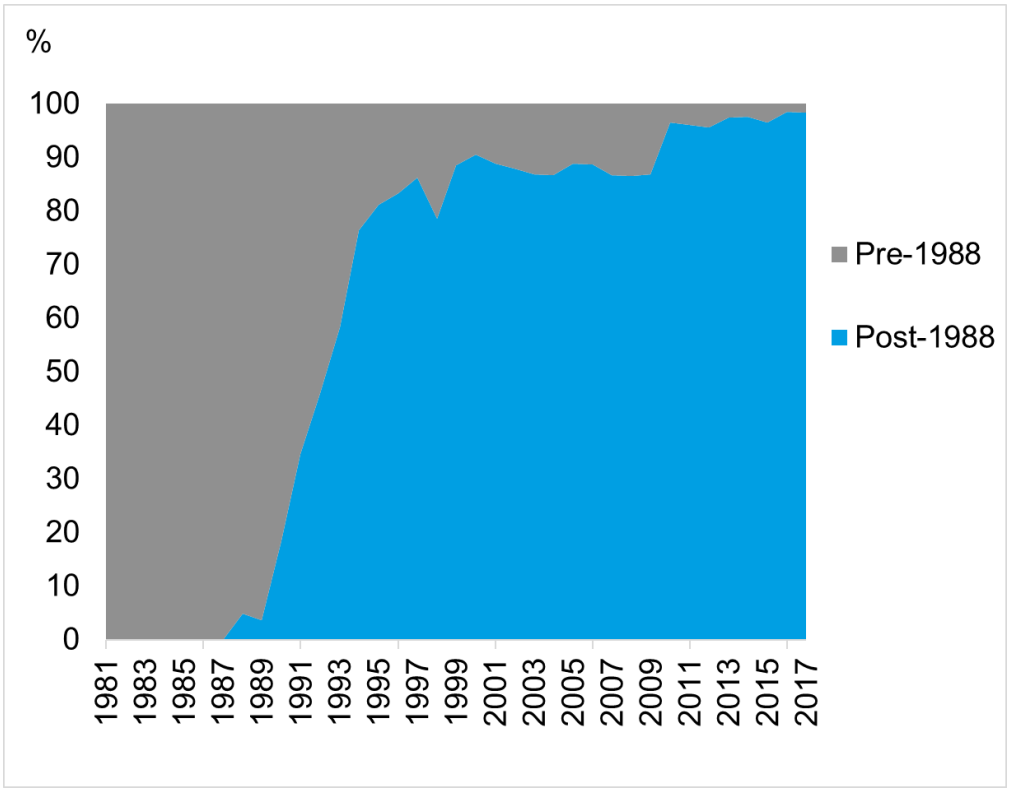
Figure 2-2 presents the percentage of orders received before and after 1988 for all delivery years in the period 1981-2017. For all delivery years prior to 1988, the proportion of orders received post-1988 (inclusive) is zero. This is true by definition, as the delivery year cannot predate the order year.

The proportion of deliveries over 1988-2017 which were ordered after 1988 – and thus included in the DSE dataset – increases rapidly between 1990 and 1995 from 18% to 81%. This is because the likelihood of an order being delivered increases over time. Specifically, the majority of (UK) defence orders in terms of TIV (79.6%) are delivered in the first seven years.

We also observe a temporary drop in the proportion of deliveries ordered after 1988 in the 1998 delivery year. In 1997, 86% of export deliveries were ordered after 1988 (inclusive); in 1998 this falls to 79%. This is consistent with the estimate of defence deliveries presented in Table 2-2 (described below), which observed a fall in export deliveries in the same year.

The proportion of orders received after 1988 increases further in later delivery years, reaching 98% in 2014. From 2010 onwards, the proportion of orders received before 1988 is negligible.

Figure 2-2: Percentage of orders received pre-1988 and post-1988 (inclusive) by delivery year (1981-2017)



Sources: CE calculations based on SIPRI ATD.

UK defence export deliveries can be reliably estimated from 1995 onwards

In light of the findings presented above, 1995 was considered to be a credible start year for the final delivery estimate. From 1995 onwards, at least 79% of all deliveries were reportedly ordered in the DSE dataset time horizon (1988-2017).

Moreover, the proportions calculated and presented in Figure 2-2 can be used to adjust the results to account for variation in the share of pre-1988 orders. In particular, the greater the share of orders received before 1988, the more we are likely to be underestimating defence deliveries. To account for this, we apply an adjustment factor. For each delivery year, the factor will equal the TIV value of all orders, divided by post-1988 orders. Where 100% of orders are received in the 1988-2017 period, the adjustment factor will equal 1.0 (i.e. no adjustment).

Estimated export deliveries

UK defence export deliveries are estimated at £8.9bn in 2017

An estimate of defence export deliveries is yielded by applying the matrix in Figure 2-1 and the adjustment factor (to account for pre-1988 orders) in Table 2-1 to DSE orders data. The result of this operation is presented in Table 2-2. In 2017, the value of UK defence export deliveries is estimated at £8.9bn, up slightly from £8.0bn in 2016.

Table 2-1: Proportion of deliveries that were ordered before 1988 (%) and adjustment factor to account for pre-1988 orders, by delivery year

Delivery year	Proportion of orders received before 1988 (%)	Adjustment factor
1995	19	1.23
1996	17	1.20
1997	14	1.16
1998	21	1.27
1999	12	1.13
2000	10	1.11
2001	11	1.13
2002	12	1.14
2003	13	1.15
2004	13	1.15
2005	11	1.13
2006	11	1.13
2007	13	1.15
2008	13	1.16
2009	13	1.15
2010	3	1.04
2011	4	1.04
2012	4	1.05
2013	3	1.03
2014	2	1.02
2015	3	1.04
2016	1	1.01
2017	2	1.02

Sources: CE calculations based on: SIPRI ATD, DIT DSE export orders data.

We observe three notable peaks in defence export deliveries over 1995-2017

In Table 2-2, we observe three notable peaks in defence export deliveries. The largest and most recent peak occurs in 2014 (£10.1bn). This peak appears to have been partly driven by the delivery of several frigates to Indonesia (ordered in 2013) and combat/training aircraft ordered by India in 2010. The second peak observed in the data occurs in 2007 (£6.2bn) and is largely driven by orders of fighter aircraft (India), SAM missiles (Chile) and air refuelling systems (United States). The third peak occurs in 2000 (£7.1bn). Significant orders include: Super Lynx-100 ASW helicopters to South Korea, Hawk-200 aircraft to Indonesia and Challenger 2 tanks to Oman.

In addition to the peaks highlighted above, a general upwards trend is observed in estimated UK defence export deliveries, with nominal growth averaging around 9% pa between 1997 and 2017.

Table 2-2: Defence export deliveries (1995-2017, orders from 1988 onwards only)

	Deliveries incl. pre-1988 adjustment (£bn)
1995	4.7
1996	4.0
1997	5.2
1998	3.3
1999	5.0
2000	7.1
2001	6.6
2002	5.1
2003	3.6
2004	5.9
2005	5.3
2006	4.8
2007	6.2
2008	5.9
2009	4.6
2010	3.7
2011	4.1
2012	5.0
2013	7.4
2014	10.1
2015	5.0
2016	8.0
2017	8.9

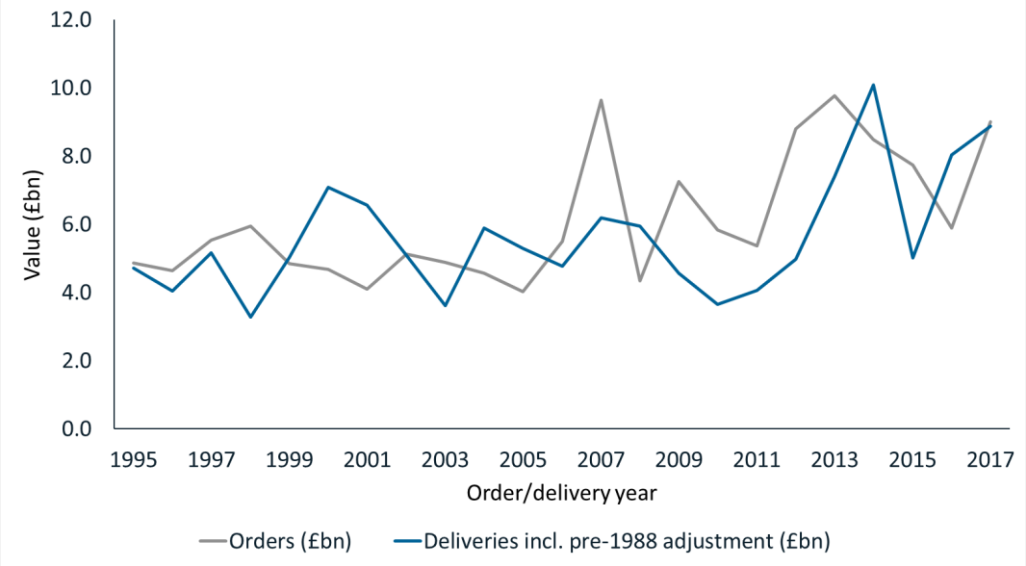
Notes: The figures presented include orders in the DSE dataset from 1988 onwards, which are adjusted using SIPRI data (1950-2017).
Sources: CE calculations based on: SIPRI ATD, DIT DSE export orders data.

Figure 2-3 compares the results for estimated defence export deliveries (with adjustment) to the original orders data. For certain periods of the data, we observe a noticeable lag between orders and deliveries. Defence orders experience a period of accelerated growth between 2008 and 2013, peaking at £10bn. Defence deliveries, on the other hand, decline in the three years between 2007 and 2010, and then experience a delayed uptick between 2010 to 2014 also peaking at around £10bn.

Lag patterns are often unpredictable

However, due to the wide variation in delivery schedules across years, patterns are often unpredictable. The sharp increase in orders over 2005-2007 is not mirrored by export deliveries. This is because the spike in orders received in 2007 is delivered gradually over 2009-2017. As a result, there is no equivalent peak in the defence deliveries time series.

Figure 2-3: Defence export deliveries and orders (£bn)



Sources: CE calculations based on: SIPRI ATD, DIT DSE.

The differences between orders and deliveries are driven by three main transformations

In interpreting the differences between the orders and deliveries (including the pre-1988 adjustment), it is important to understand what the drivers of the variation are and how these drivers take shape. Namely, the difference between the estimate of deliveries and orders stems from three transformations:

1. a reduction in exports to account for defence orders received over 1988-2017 which are not yet delivered;
2. an increase in defence exports to account for orders received before 1988, but that are delivered over 1988-2017;
3. a lag between exports which are ordered and delivered in the 1988-2017 period.

A large proportion of recent export orders is categorised as being undelivered

The impact of the first transformation is demonstrated in Figure 2-4, which presents the difference between DSE defence orders including and excluding orders of undelivered items. Especially in recent years (i.e. 2014-2017), a large proportion of export orders are categorised as being undelivered and therefore do not contribute to the measure of export deliveries. At the beginning of the series however, all defence orders are delivered.

Over the period 1988-2017, total undelivered export orders amounted to £37.8bn from a total of £168.1bn.

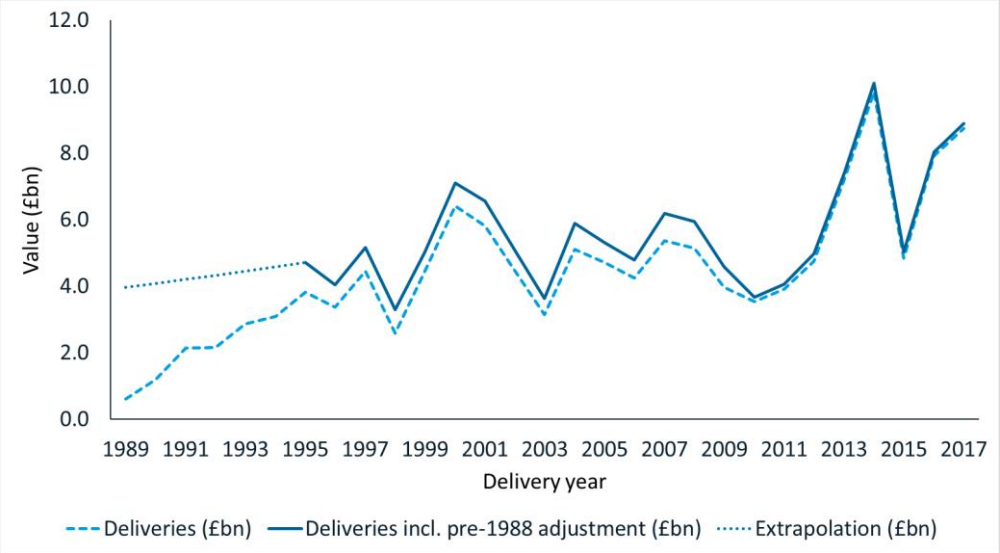
The impact of the second transformation (i.e. an increase in defence exports to account for orders received before 1988) is partly demonstrated by Figure 2-5. The figure shows estimated defence export deliveries before and after the adjustment process. It is not, however, possible to produce a credible estimate of adjusted defence export deliveries prior to 1995. Therefore, for the purpose of the figure, the adjusted estimate is extrapolated back to 1988 using long-term

trends to provide a comparison for earlier years. In later years, the effect of the deliveries adjustment is minimal because the share of orders which fall before 1988 is small.

Figure 2-4: Defence orders versus orders excl. undelivered items

Notes: Prior to 2002, Orders and Orders excl. undelivered are equivalent.
Sources: CE calculations based on: SIPRI ATD, DIT DSE.

Figure 2-5: Defence deliveries versus deliveries incl. pre-1988 adjustment (1988-2017)



Sources: CE calculations based on: SIPRI ATD, DIT DSE.

Over 1995-2017, total adjusted export deliveries was £129.4bn; slightly less than total export orders (£140.9bn)

For the period 1995-2017, the total adjusted export deliveries (£129.4bn) exceeded the unadjusted measure (£117.8bn) but was still slightly less than total export orders over 1995-2017 (£140.9bn). This is due to the increasing trend in UK defence exports observed over the period which means that defence orders in recent years are typically higher than defence orders in past years. This affects the proportion of undelivered items because orders in recent years are more commonly undelivered.

The third transformation (the lag) does not impact the total value of exports and thus does not cause a wedge between the delivery and order totals. It simply reallocates the value of orders to different (delivery) years based on the length

of the lag. Figure 2-3 shows the result of all three transformations, from defence orders (including undelivered items, excluding pre-1988 orders) to an estimate of deliveries (with adjustment).

2.3 Assumptions and sensitivity analysis associated with the estimate

SIPRI data are not assumed to be exhaustive

The most fundamental assumption is that the collated data in the SIPRI ATD are representative of the orders underpinning the DSE data. According to the latest DSE Methodology Note[10], the Defence and Security Exports dataset covers 94% of total UK defence exports in value[11]. The SIPRI dataset will likely be a smaller subset of total defence exports in terms of coverage. This is because the estimates of orders and deliveries are derived from public sources such as defence publications, White Papers and data shared with the UN Register of Conventional Arms. Without access to order-level survey data (which are unavailable to us), it is almost certain that some of the orders recorded in the DSE dataset will not be included in SIPRI.

However, SIPRI data are assumed to be representative of the orders in the DSE dataset

This issue of SIPRI data not being exhaustive is not necessarily severe. The SIPRI data are only used to transpose the DSE dataset which will contain the value of defence exports captured by the DSE survey data. Provided that the typical timing of deliveries is well represented, this will not be problematic.

However, if the subset of orders and deliveries which are recorded in the SIPRI dataset is unrepresentative of the DSE data, then this could lead to errors in the delivery schedule and inaccuracy in the final estimate.

It is also possible that short-term bias could emerge from a lack of representativeness. In practice however, violations to the assumption of representativeness of the SIPRI data would more likely result in temporal inaccuracy rather than systematic bias. For example, the assumption of representativeness appears to be violated for 2013 orders. Table 2-3 shows all recorded orders from 2013 in TIV tables and trade registers in SIPRI. For orders placed in 2013, the delivery of frigates in 2014 appears to be over-represented, accounting for over 60% of all 2013 orders in TIV terms.

[10] DIT DSE (2018).

[11] This is based on assumptions made regarding the concentration of defence exports among certain key players in the market and knowledge about their participation in the survey. While the source of this statistic is credible, there are considerable challenges in approximating the 'true' value of defence exports which is necessary to calculate an approximate coverage percentage.

Table 2-3: Reported orders of all weapon designations in 2013

Buyer	Description	Numbers delivered	Delivery year	TIV delivery values
Saudi Arabia	Guided bomb	2400	2015	48
Indonesia	Frigate	3	2014	588.75
South Korea	ASW helicopter	8	2016	111.2
Saudi Arabia	ASM	50	2017	70
Saudi Arabia	ASM	50	2016	70
Brazil	Gas turbine	3	2013	1.8
Chile	Gas turbine	1	2013	0.6
Pakistan	Gas turbine	1	2013	0.6
Mozambique	APC	40	2013	4
Mozambique	APC	25	2013	2
Rwanda	APC	1	2013	0.1
Brazil	MP aircraft radar	1	2017	2
Brazil	MP aircraft radar	1	2016	2
Brazil	MP aircraft radar	1	2015	2

Sources: CE calculations based on SIPRI ATD.

The result is a short-term spike in deliveries in 2014, followed by a dip in 2015. If the trade register – and resultantly, the delivery schedule – had drawn from an exhaustive list of trades, it is likely that the proportion delivered in 2014 would have been lower and that deliveries in other years (e.g. 2015) would have been higher. Crucially, this is an issue of temporal distribution rather than bias, provided that the original DSE dataset is reliable.

Undelivered orders are accounted for, but this does not fully resolve the issue of cancellations

As discussed above, an advantage of the approach is that it factors out undelivered orders. However, this only addresses the issue of orders which have been confirmed but not yet produced/delivered. It does not address the issue of orders which are cancelled altogether and will never be delivered.

This issue will lead to bias in the estimate as it implicitly assumes that all orders in the DSE dataset will be delivered at some point in the future. The severity of this issue depends on the proportion of sale value which gets cancelled. Anecdotal evidence suggests the proportion is low[12].

At present, a certain share of UK undelivered orders date back to orders received before 1988. It could be assumed that after a certain duration of time (e.g. 15 years) undelivered items can be thought of as cancelled. However, the proportion of such items is very small (<0.1%) and so would have little impact on estimates of export deliveries. Furthermore, it is unlikely that this would adequately capture cancelled orders.

Moreover, caution should be taken when applying SIPRI data to estimate cancellations. Minor violations to the assumptions listed in this chapter would

[12] This evidence comes from discussions with key stakeholders at DIT DSE.

probably be tolerable because, under the current method, SIPRI data are not used to markedly change the total export revenue reported in the DSE dataset.

At present, SIPRI data are used to perform two transformations: (1) reallocate export orders revenue to later delivery years and (2) allocate export orders as being 'undelivered'. In the case of the former, there is no risk that incongruence between SIPRI and DSE would cause a persistent over-estimation (or under-estimation) of defence deliveries because the transformation does not impact the total, solely the distribution. In the case of the latter (undelivered items), the transformation does impact the total for defence deliveries, but only significantly affects defence orders in the most recent years (2014 onwards). This means that it is possible for short-run over-estimation (or under-estimation) to occur, but that the problem would not grow over time. This is because the share of persistently undelivered items is exceptionally small.

If SIPRI data were used to estimate the share of cancellations in DSE orders, then this would allow violations to the assumptions listed above to affect total export flows in the final measure. Persistently adjusting total trade flows – rather than just the distribution over time – according to estimated cancellations would risk systematic and potentially deteriorating mis-estimation of exports.

The sample of companies in the DSE questionnaire changes over time

The use of the export orders data as a time series dataset should also be caveated. DSE data on export orders are derived from a survey of known UK defence companies. The list of companies which take part in the survey is revised on a year-by-year basis, to ensure that the maximum number of defence exporters are included[13]. An uncertainty associated with this is that the evolution of the sample composition over time could result in the tendency to underestimate defence orders received in earlier years. This would occur if a smaller proportion of defence exporters were included in the survey in earlier years, thereby capturing a smaller portion of total defence exports.

Sale values in the comments section were not used due to concerns over reliability

Closer inspection and application of the SIPRI data raised serious questions regarding the reliability of sale values in the comments section of the trade registers. This data entry reflects any additional data that SIPRI was able to gather on the deal. Being such, it is uncertain how the sale value was calculated and whether this is done consistently across different orders. This issue is pertinent because defence trade can come in a variety of forms; for instance, payment-in-kind (e.g. petroleum supply). Moreover, the gains from incorporating sale-values are limited as the evidence is only available for a small share of total sales.

The approach instead assumes that relative prices are well reflected by TIV

As a result, TIV were adopted as a consistent measure of proportional trade volumes. The impact of TIV units on the total estimated trade volume is negligible, because only the proportions of TIV are taken (and used in the delivery schedule). Table 2-4 illustrates a case where TIV underestimate total exports but would not affect the proportional schedule. However, adopting TIV can lead to distortions to the relative prices of defence products, and, in doing so, possibly generate inaccuracy in the weights used in the calculations.

[13]DIT DSE (2018).

Table 2-4: TIV assumptions – Example 1 (Constant relative prices)

	Sale value	TIV	% of total (Sale value)	% of total (TIV)
Product A	100	20	29	29
Product B	150	30	43	43
Product C	100	20	29	29
Total	**350**	**70**	**100**	**100**

Sources: CE invented example.

Table 2-5: TIV assumptions – Example 2 (Diverse relative prices)

	Sale value	TIV	% of total (Sale value)	% of total (TIV)
Product A	100	25	29	31
Product B	150	25	43	31
Product C	100	30	29	38
Total	**350**	**80**	**100**	**100**

Sources: CE invented example.

Example 2 in Table 2-5 presents an illustrative case where such distortions occur. Violations to the assumption of representative relative prices would generate measurement error, but would not result in systematic underestimation (or overestimation) of the estimate of total defence export deliveries[14].

Estimating undelivered orders requires additional assumptions

For orders with undelivered units, additional assumptions are required to estimate the delivery schedule[15]. In these instances, an entry exists in the trade register but not in the TIV tables. This means that the TIV (i.e. the statistical weight) of the trade is not recorded and needs to be estimated using previous observations of the same item.

Table 2-6 outlines the set of weapon designations which appears as wholly[16] undelivered items. For most weapon designations, there are previous instances of UK trade deals involving the exact same weapon designation, which can be used to estimate a unit value. For all weapon designations for which there have been many trade deals, the TIV unit value does not change.

[14] An exception to this would be if undelivered items had a higher likelihood of being allocated (higher/lower) relative prices because this would distort the proportion of export value which is removed from the deliveries measure. In this case, the measure would be biased but consistent (i.e. the bias would tend to zero as the number of years included increases).

[15] This section does not address sensitivities associated with undelivered orders for which there is no indication of quantity sold. In such instances, it is difficult to gauge the impact on the estimate because the quantity sold has no evident upper limit.

[16] This excludes partially delivered items, for which a TIV unit value is included.

Table 2-6: Undelivered items and instances of trade deals involving the same item

Weapon designation (Weapon type)	Prior UK deals involving weapon designation	Prior worldwide deals involving weapon designation	Prior worldwide deals involving weapon type
Air refuel system (Air refuel system)	Yes	Yes	Yes
AW-159 Wildcat (Anti-submarine warfare helicopter)	Yes	Yes	Yes
Brimstone (Air-to-surface missile)	No	No	Yes
BVT-90 (Offshore patrol vessel)	Yes	Yes	Yes
CAMM (Surface-to-air missile)	No	No	Yes
Hawk-100 (Trainer/combat aircraft)	Yes	Yes	Yes
Meteor (Beyond-visual-range-air-to-air-missile)	Yes	Yes	Yes
MT-30 (Gas turbine)	Yes	Yes	Yes
Ocean (Amphibious assault landing ship)	No	No	Yes
Paveway (Guided bomb)	Yes	Yes	Yes
PV-90 (Offshore patrol vessel)	Yes	Yes	Yes
Raven ES-05 (Combat aircraft radar)	No	No	Yes
Seaspray (Multi-platform aircraft radar)	Yes	Yes	Yes
Storm Shadow/SCALP (Air-to-surface missile)	Yes	Yes	Yes
Super Lynx-100 (Anti-submarine warfare helicopter)	Yes	Yes	Yes
Super Vita (Fast-attack craft)	Yes	Yes	Yes
Thales ROTSS (Armoured personnel carrier turret)	No	Yes	Yes
Trent-700 (Turbofan)	Yes	Yes	Yes
Typhoon Block-20 (Fighter/ground attack aircraft)	Yes	Yes	Yes

Sources: CE calculations based on: SIPRI ATD.

Where there are no instances of UK trade deals of a given weapon designation, we expanded the search to all worldwide trade deals. Where there are still no recorded instances of trade, we estimate the TIV unit using the distribution of TIV units in the parent category (weapon type).

Testing assumptions further with orders-level data

In the future, it may be possible to test the assumptions presented in this chapter by comparing the orders included in the SIPRI dataset to those provided in the DSE microdata. Table 2-7 and Table 2-8 provide a stylised example of the kind of sample composition analysis which could provide insight into biases in the delivery matrix.

Suppose the monetary value of small components is far higher as a proportion of the total in DSE data (20% in example) than that of SIPRI (as estimated by TIV). Such a result might suggest that the lag is overestimated in the delivery schedule, because components are underrepresented in the SIPRI dataset.

Table 2-7: Stylised example of sample composition analysis

	Typical lag	Monetary value (DSE)	Share of total (DSE)	TIV (SIPRI)	Share of total (SIPRI)
Small parts	1 year	£2bn	20%	50	5%
Large aircraft	5 years	£7bn	70%	800	80%
Large ships	10 years	£1bn	10%	150	15%

Notes: This example is entirely illustrative and has no empirical basis.
Sources: CE invented example.

Table 2-8: Stylised example of relative price analysis

	SIPRI (TIV)	DSE (£m)	SIPRI (numeraire)	DSE (numeraire)
Typhoon Block-20	57.5	90	4.83	1.80
PV-90 OPV	33.25	70	2.79	1.40
Super Lynx-100	11.9	50	1.00	1.00
Hawk-100	10	40	0.84	0.80
MP aircraft radar	2	3	0.17	0.06

Notes: The TIV values for the items were taken from the SIPRI data. Otherwise, this example is entirely illustrative and has no empirical basis.
Sources: CE calculation based on: CE invented example figures; SIPRI ATD (TIV values).

Recommendation: Examine the relative prices of items in SIPRI and DSE

It may also be possible to test the assumption that relative prices are well-reflected by TIV values in SIPRI. One possible approach to testing relative prices in both datasets would be to create a numeraire using a commonly traded UK export (e.g. Super Lynx-100 helicopter). This would involve collecting the unit prices of all available items and dividing through by the selected numeraire item. Table 2-8 provides an example of this approach to relative price analysis.

As demonstrated by the example, creating a numeraire would provide a comparable metric for contrasting relative prices between the two datasets. Namely, it would show how many of each item could be exchanged for the price of one Super Lynx-100. In the (illustrative) example, relative prices of typhoon jets and helicopters differ considerably.

2.4 Concluding remarks and recommendations

This chapter has presented the results of the analysis of UK defence exports using DSE and SIPRI data (1988-2017).

An estimate of UK defence export deliveries is feasible – £8.9bn in 2017

A core result of the analysis is that it is feasible to produce a credible estimate of defence export deliveries using DSE data and a delivery schedule calculated using the SIPRI ATD. The analysis estimated that the value of UK defence export deliveries was £8.9bn in 2017. Exports have increased over time, with growth averaging around 9% pa between 1997 and 2017.

Most orders are delivered with a lag and some are undelivered for years

The analysis also reveals that a relatively large (22%) proportion of orders (£37.8bn out of £168.1bn) received over 1995-2017 remains undelivered. A sizeable share of undelivered orders relates to orders from recent years (i.e. since 2014), reflecting the fact that defence orders are typically delivered over several years. Even for delivered items, the length of the lag is often long, in some cases spanning five or more years. This finding confirms our prior expectations regarding the nature of defence exports.

Detailed empirical evidence is required to produce an estimate

Another key finding is that the delivery schedule does not appear to exhibit a consistent pattern over time. This reinforced our understanding that detailed empirical evidence is required to perform the mapping, and that ad-hoc assumptions regarding the lag structure are insufficient.

The nature of the lags also implied that the analysis should be complemented by supplementary analysis of pre-1988 defence orders. Doing so serves two key purposes: (1) it determines a start year from which it is possible to credibly estimate defence deliveries; and (2) it permits the adjustment of the estimate to account for pre-1988 orders.

Trend-indicator values were assessed to be the most consistent measure of proportional trade flows, as there are questions regarding the reliability of sale values in SIPRI (which are only available as supplementary comments in the trade registers and on an irregular basis). The shortfall of this approach is that it introduces the possibility of relative price distortions between different products in a given order year. If the relative 'price' (TIV-units) between ships and engines, for instance, is considerably different to the actual sale value, then this could lead to inaccuracy in the statistical weight. It would not, however, lead to bias in the final measure of total defence exports.

Validation using export orders microdata

Acquiring additional detail from DSE can provide avenues for developing this approach to estimating UK defence export deliveries. The DSE defence export survey is carried out annually and requests a range of details from key UK firms, including:

- the nature and characteristics of the product or service exported;
- the value of the contract (if above £10,000);
- the contract signature date, and delivery date;
- the customer country and organisation (e.g. India; Navy);
- the quantity sold; and,
- the end user (if different from customer).

Further analysis depends on the availability of detailed microdata on orders

According to discussions with key stakeholders at DSE, there is often missing detail in the responses due to the fact that the survey is voluntary. The delivery year, for instance, is seldom provided and, in some cases, the respondent will simply provide an aggregate figure for the value of all orders received. Nonetheless, a relatively rich dataset is still available usually containing detail on product/service description, destination country, order date and order value.

Recommendation: Match orders between SIPRI data and DSE

Under this premise, the first recommended use of the DSE microdata would be to attempt to match recorded orders in the survey results with orders registered in the SIPRI dataset.

This would involve, firstly, matching individual recorded orders by destination country, order year and product/service type. By populating a set of unique matched values, this serves as a verification exercise for the evidence contained in SIPRI. Secondly, after initially matching the datasets using the three variable characteristics, it is possible to relax one of the criteria (e.g. order year) to identify errors. For example, suppose an order of Hawk jets are ordered from India in 2011 (according to DSE) but the order year is reported as 2010 in the SIPRI data. In such an instance, it may be advisable to amend the SIPRI data such that it is more closely in line with survey results. The appropriateness of such adjustments depends on the reliability of (relaxed) match. Where there is further evidence on the trade (e.g. units sold), this could be used to build a case that the order is indeed the same and should be reported in the same year.

Recommendation: Examine differences in coverage and representativeness

Another helpful line of inquiry would be to investigate differences in the sample composition between SIPRI and DSE. The DSE dataset is able to survey defence exporters directly and therefore is likely to have a far better coverage of defence exports than SIPRI. As mentioned in Section 2.3, coverage differences are acceptable provided that the sample included is representative in terms of order-delivery lag. It may be possible to test this assumption by comparing the items included in both datasets to see if there is any reason why SIPRI might fail to represent the delivery schedule of DSE orders.

3 Estimating UK defence exports of goods using the OTS approach

Key points

- Based on the OTS approach, estimated UK defence goods exports amounted to £5.3bn in 2018. Approximately 75% of exports in that year could be attributed to exports of aircraft and parts.
- The OTS approach is based on HMRC OTS, which collect data on goods crossing the border; services are not included. The current product classification in OTS does not identify products for defence use.
- While there is no universal definition of what constitutes defence exports, this study is based on commodity codes identified as defence or defence-related in a previous Defence Analytical Services Agency (DASA) study. Exports according to these commodity codes, however, are not for defence use only, and 'defence shares' need to be estimated to obtain a defence exports measure.
- For aircraft and parts, which account for around 80% of defence-related exports on average over 1996-2018, the defence shares are obtained as ratios of exports in discontinued commodity codes for 'civil' and 'other than civil' use. These historical defence shares are extrapolated to more recent years based on year-on-year changes to the shares of aircraft and parts sales for military use.
- For other goods, a lack of appropriate data means that either direct extrapolations from historical 'other than civil' shares or assumption-based shares are adopted.
- The estimates based on the OTS approach rely on a set of very strong assumptions and are deemed unreliable. The historical 'other than civil' OTS codes included exports of non-defence goods, which results in an upward bias of the defence shares.
- The extrapolations of the historical 'other than civil' shares are uncertain because the data supporting the extrapolations do not distinguish between domestic sales and sales for exports. It is unlikely that the trend in domestic military sales is representative of the trend in military sales for exports.
- OTS statistics also do not capture trade in defence services, contributing to the overall uncertainty about the reliability of the total exports figure.
- Due to a lack of data, there is limited scope for improving these estimates. The method is not recommended for future attempts to estimate defence exports on a delivery basis.

3.1 Introduction

The OTS approach to estimating UK defence exports uses as the main source of data the OTS published by HMRC that detail trade by country, commodity, and year. Even though the product classification is very detailed (with approximately 9,500 product categories), the end-use of each product is not identified. Therefore, to estimate UK defence export deliveries, there is a requirement to identify a subset of products that are considered to be defence-related and, within each product category, the proportion of the category that is exported for defence use.

Section 3.2 outlines the key products that are identified to be defence-related according to the product classification of the database. Section 3.3 presents the estimate of UK defence export deliveries using the approach considered most sensible. Section 3.4 outlines the assumptions associated with the method, as well as sensitivity analysis of different assumptions underpinning the method. Section 3.5 offers concluding remarks and recommendations going forward.

3.2 Identifying defence-related goods

Relevant defence-related commodity codes have been identified in previous studies

There are several examples of existing studies that have used commodity codes in order to determine UK defence exports. A methodological review conducted by UK Defence Statistics (UKDS) Review Team in 2005[17], aimed at establishing a 'methodology for the identification and reporting of military goods exports and imports' (p. 3), outlined specific commodity codes according to two criteria:

- commodity codes used for military trade, and
- dual-use commodity codes

With respect to the former, 100% of the trade in those goods was classed as for defence use. In the latter set of commodity codes, a mixture of methods were considered to estimate the proportion of the dual-use commodity that was for defence use[18].

An account of efforts[19] to refine the estimation of defence exports was published by the DASA in 2007 to estimate the defence-related export statistics for the Annual Report on Strategic Export Controls (ARSEC). The methodology for this has been reviewed and summarised in previous reports prepared by CE and will not be repeated here. A summary of previous efforts is outlined in the introduction of this report.

It is important to consider, however, that compared to the 2005 methodological review, the DASA account (Bennett, 2007) provides an updated set of commodity codes considered for military use, and marks an evolution of the list considered in previous research outputs. Part of this is to do with classification changes in commodity codes (i.e. commodity codes available in 2005 were no longer available in 2007).

For the purpose of this project, CE has taken the full list of commodity codes from all three lists – commodity codes defined as military, dual-use, or used in the ARSEC publications. With duplicate codes removed and after replacement of subsumed codes with codes in use, the list of commodity codes considered for this project is outlined in Table 3-1[20].

[17] UKDS Review Team (2005).

[18] Methods considered to partial out the defence component include: apportionment using available military, civil shares; apportionment using microdata on Customs Procedures Codes or the VAT registration number; Known Military Trader lists, or using the data of dual-use commodities as they are.

[19] Bennett (2007).

[20] For some of these commodity codes, the data are currently suppressed.

Table 3-1: Full list of OTS (CN8) commodity codes considered defence-related

OTS Commodity code	Description
36010000	Propellant powders
36020000	Prepared explosives o/t propellant powders, incl. Gelatinous
36030010	Safety fuses; detonating fuses
36030090	Detonators & percussion caps
36049000	Pyrotechnic articles o/t articles for signalling/entertainment
40113000	New pneumatic tyres, of rubber, of a kind used for aircraft
84071000	Spark-ignition reciprocating or rotary internal combustion piston engine, for aircraft
84091000	Parts suitable for use solely or principally with internal combustion piston engine for aircraft, n.e.s.
84111100	Turbojets of a thrust <= 25 kN
84111210	Turbojets of a thrust > 25 kN but <= 44 kN
84111230	Turbojets of a thrust > 44 kN but <= 132 kN
84111280	Turbojets of a thrust > 132 kN
84112100	Turbopropellers of a power <= 1.100 kW
84112220	Turbopropellers of a power > 1.100 kW but <= 3.730 kW
84112280	Turbopropellers of a power > 3.730 kW
84119100	Parts of turbojets or turbopropellers, n.e.s.
84121000	Reaction engines other than turbojets
85261000	Radar apparatus
87100000	Tanks and other armoured fighting vehicles, motorised, whether or not fitted with weapons, and parts of such vehicles, n.e.s.
88010010	Gliders, without motor and not capable of being fitted with a motor, and hang gliders; balloons and dirigibles (excl. party balloons)
88010090	Kites and other non-powered aircraft (excl. gliders, hang gliders, balloons and children's kites)
88021100	Helicopters of an unladen weight <= 2.000 kg
88021200	Helicopters: of an unladen weight exceeding 2000kg
88022000	Aeroplanes and other aircraft, of an unladen weight not exceeding 2000kg
88023000	Aeroplanes and other aircraft, of an unladen weight exceeding 2000kg but not exceeding 15000kg
88024000	Aeroplanes and other aircraft, of an unladen weight exceeding 15000kg
88031000	Propellers and rotors and parts thereof
88032000	Under-carriages and parts thereof
88033000	Other parts of aeroplanes or helicopters
88039090	Parts of aircraft, n.e.s. (excl. of spacecraft, incl. satellites, and suborbital and spacecraft launch vehicles)
88051010	Aircraft launching gear and parts thereof, n.e.s. (excl. motor winches for launching gliders)
88051090	Deck-arrestor or similar gear for aircraft and parts thereof, n.e.s.
88052100	Air combat simulators and parts thereof
88052900	Ground flying trainers and parts thereof, n.e.s. (excl. air combat simulators and parts thereof)
89061000	Warships
90131000	Telescopic sights for fitting to arms; periscopes; telescopes designed to form parts of machines, appliances, instruments or apparatus of chapter 90 or Section 16, chapters 84 and 85
90139010	Parts & accessories for liquid crystal devices
90139090	Other pts & acc o/t liquid crystal devices

OTS Commodity code	Description
93011000	Artillery weapons 'e.g. guns, howitzers and mortars'
93012000	Rocket launchers; flame-throwers; grenade launchers; torpedo tubes and similar projectors
93019000	Military weapons, incl. sub-machine guns (excl. artillery weapons, rocket launchers, flame-throwers, grenade launchers, torpedo tubes and similar projectors, revolvers and pistols of heading 9302 and cutting and t...
93020000	Revolvers and pistols, other than those of heading 9303 or 9304
93051000	Parts and accessories of articles of headings 9301 to 9304: of revolvers or pistols
93059100	Parts and accessories of articles of headings 9301 to 9304: other: of military weapons of heading 9301
93063010	Other cartridges and parts thereof: for revolvers and pistols of heading 9302 and for submachine guns of heading 9301
93063030	Other cartridges and parts thereof: for military weapons
93069010	Other [munitions and ammunition] for military purposes
93070000	Swords, cutlasses, bayonets, lances and similar arms and parts thereof and scabbards and sheaths therefore.

Sources: DASA, UKDS publications.

The commodity classification has changed over time

For many of the products, the codes reflect the latest year for which data were considered (2018). For previous years, data for the same product may be reported under a different commodity code, because trade data in previous years were based on different vintages of the classification system (Combined Nomenclature). For these commodity codes, it is necessary to conduct data-filling methods via extrapolation to develop a time series for each commodity code across different vintages of the classification system.

There is no single agreed definition of the defence sector

In addition, while previous publications provide some indication of the relevant products constituting 'defence' for the UK, the coverage is by no means definitive. Given the absence of an internationally agreed definition of the defence sector, there remains a question over which combination of products best represent defence exports. For example, products such as:

- 93062100 (Cartridges for smooth-barrelled shotguns);
- 93062900 (Parts of cartridges for smooth-barrelled shotguns; lead shot for air rifles and pistols);
- 93063090 (Cartridges and parts thereof, n.e.s.)

are included in some publications that outline arms trade (see Pavesi, 2016), but not in the DASA or UKDS publications. Thus, while the focus of the work has been on commodity codes that have previously been considered within the UK as defence or defence-related, how exhaustive or comprehensive these are in their coverage of the UK defence sector depends on how the defence sector is defined. Furthermore, these estimates based on customs trade data cover goods only, and do not capture services.

3.3 Estimates of UK defence exports using the OTS approach

Publicly available data on defence exports are sparse

The amount of publicly available data to inform the share of exports for defence use is limited. All estimated defence shares across the various sources were identified to require strong assumptions. More details of the analysis underpinning this can be found in Appendix B; in which we describe the range

of assumptions that could be adopted, as well as the types of data sources considered.

Nevertheless, out of the options explored, we assessed what we consider would be most sensible based on the following principles:

- It is best to use as timely data as possible, given the potential volatility of the share of each product for defence use in a single year;
- it is best to use reported and observed values as far as possible;
- reliable defence use shares are most important for the defence-related goods which account for the highest share of UK defence-related exports.

Based on these considerations, an estimate of UK defence exports has been developed using OTS trade data and estimates of defence content of exports; the latter obtained using a combination of historical 'other than civil' (o/t civil) ratios based on discontinued OTS commodity codes and ratios obtained using the UK Prodcom manufacturing survey. The calculation procedure and assumptions are outlined in more detail in Section 3.4.

Estimates of UK defence-related exports

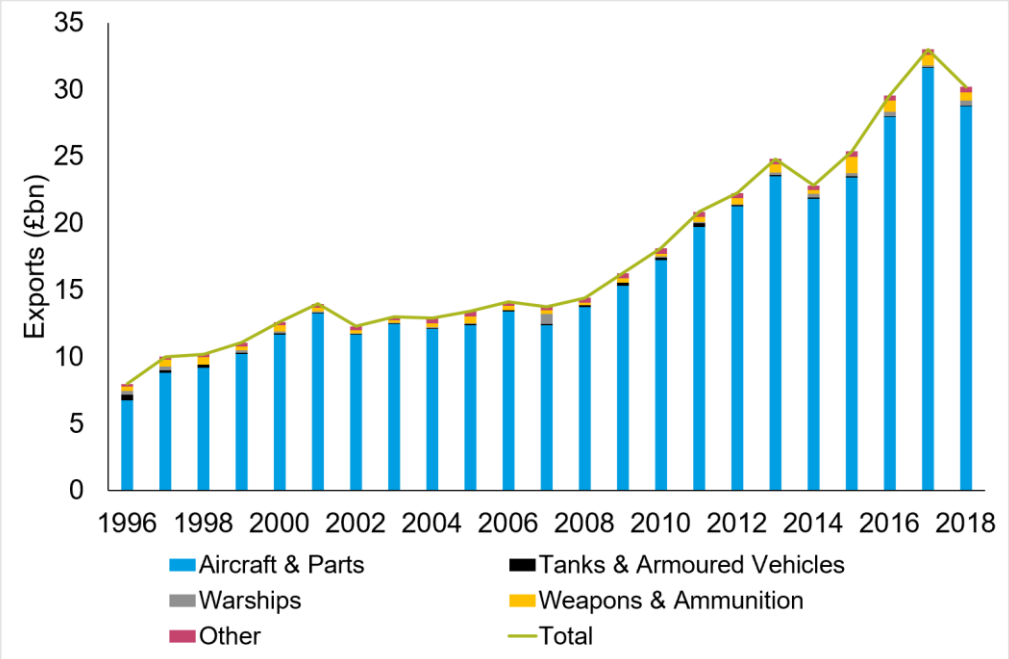
The OTS data cover UK exports for years 1996-2018. Due to changes to the commodity code classification over these years, certain defence-related codes have been introduced or discontinued, and a mapping exercise was performed to trace the historical code relationships. For example, the exports in code 88052100 Air combat simulators and parts thereof, were classed under Ground flying trainers codes 88052010 and 88052090 before 2002. For codes where similar aggregation or disaggregation[21] occurred, shares in the last available year were used to estimate exports according to the current classification of defence-related codes.

Exports in defence-related codes more than tripled in nominal terms between 1996 and 2018

The values of the defence-related exports for broad product categories are presented in Figure 3-1. The overall exports of defence-related goods more than tripled in nominal terms, from £8bn in 1996 to £30bn in 2018. Products in the broad category Aircraft & Parts account for the vast majority of defence-related exports.

[21] Cases where discontinued or new codes do not map one-to-one

Figure 3-1: UK defence-related exports (1996-2018)



Sources: CE calculations based on HMRC OTS.

Estimates of UK defence exports using defence shares

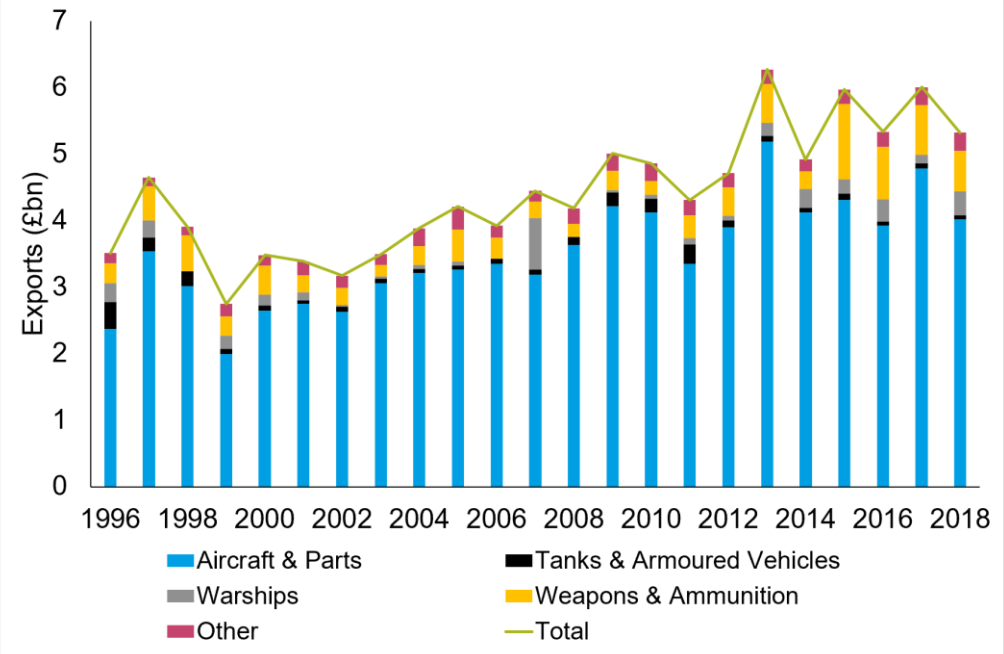
In nominal terms, UK defence exports have grown on average by around 3% pa over the last 20 years

To isolate the component of defence-related goods for defence use, the estimates of defence-related exports are multiplied by a defence-use ratio. The most appropriate defence-use ratios have been selected on the basis of their availability and the strength of the underlying assumptions[22].

The headline estimates of UK defence exports are presented in Figure 3-2. Total defence exports in nominal terms increased by close to 50% between 1996 and 2018, from just above £3.5bn to £5.3bn. The average annual growth rate of estimated defence exports (3.3% pa) is lower than the average annual growth of defence-related exports (6.6% pa). The implied share of defence-related exports for defence use decreased from 44% in 1996 to 18% in 2018.

[22] The assumptions are discussed in more detail in section 3.4

Figure 3-2: UK exports for defence use - combined method (1996-2018)



Sources: CE calculations based on HMRC OTS, ONS Prodcom and ONS Supply and Use Tables (SUTs).

The exports of Warships, likely due to the large item value of delivered vessels, varied significantly over the years: while in 2006 and 2008 no exports of Warships were recorded, in 2007 exports exceeded £750m. Exports in broad categories of smaller items, such as Weapons & Ammunition, Tanks & Armoured Vehicles and those classified as Other[23], are less volatile, with the exception of a steep increase in exports of Weapons & Ammunition in years after 2015.

Estimated defence exports of aircraft and parts are influenced by changes in o/t civil and Prodcom military ratios

A relatively large increase in estimated defence exports in category Aircraft and Parts in 1997 and 2013 corresponds to increases in the estimated defence shares from historical o/t civil ratios in 1997 (by 5 pp to 40%) and (indirectly through extrapolation) from the Prodcom military ratio in 2013 (increase by 4 pp to 22%).

Between 1998 and 1999, the o/t civil share for Aircraft & Parts decreased from 33% to 20%. This is driven by large declines in o/t civil share for two commodity codes[24]:

- 88023000 Aeroplanes and other aircraft, of an unladen weight exceeding 2000kg but not exceeding 15000kg; and
- 88033000 Other parts of aeroplanes or helicopters.

These commodity codes were the largest exports by value, accounting for nearly £2.5bn of exports in 1998.

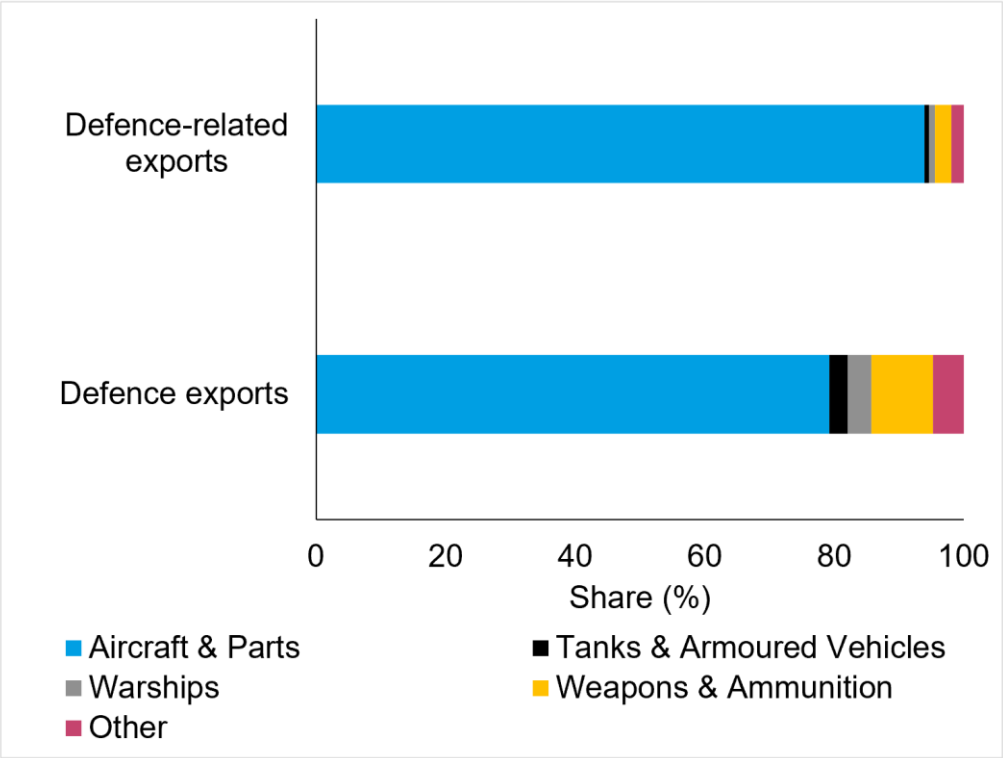
The average composition of products underpinning defence and defence-related exports over 1996-2018 is presented in Figure 3-3. As the estimated

[23] Other category includes items such as radar apparatus, liquid-crystal devices and telescopic sights for fitting onto arms and pneumatic tyres for 'other than civil' aircraft.

[24] The estimates of the full data series are provided in an Excel workbook accompanying this final report.

defence shares for product categories such as Warships, Tanks, Armoured Vehicles are higher than for Aircraft & Parts, their relative share of UK defence exports increases in comparison to their share in UK defence-related exports. The exports of Aircraft & Parts, however, still dominate; constituting between 68% (1996) and 88% (2003) of total UK defence exports.

Figure 3-3: Shares in defence exports and defence-related exports by broad product category (1996-2018)



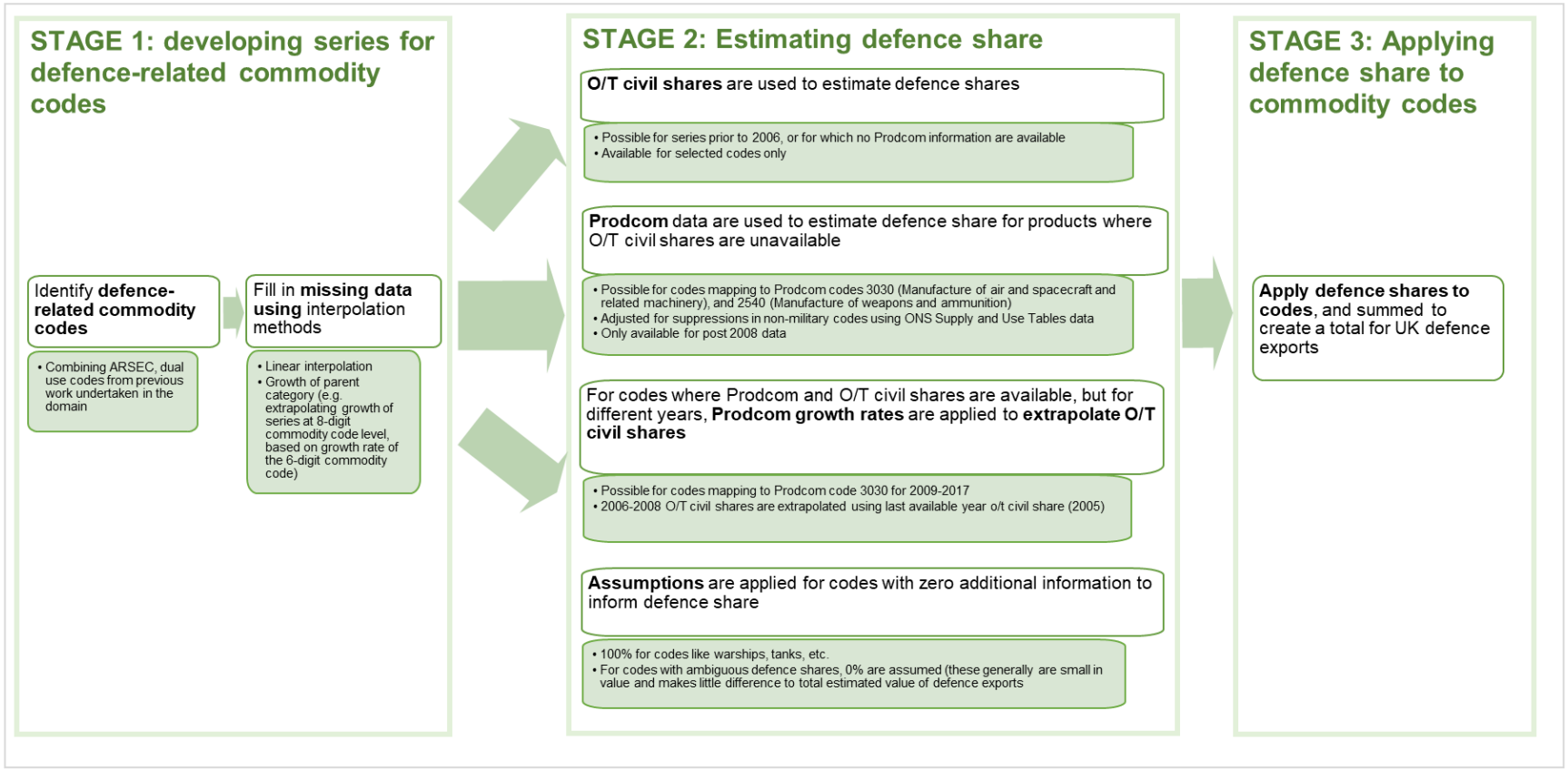
Sources: CE calculations based on HMRC OTS, ONS Prodcom and ONS SUTs.

3.4 Assumptions and sensitivity analysis associated with the estimate

A mixed-methods approach

The OTS approach estimates presented in Section 3.3 are based on a method combining various ways of estimating defence share for historical HMRC OTS data, relying on information from HMRC OTS, ONS Prodcom and ONS Supply and Use Tables (SUTs). The calculation process is outlined in Figure 3-4, with the methods applied to each code to estimate defence share outlined in more detail in Table 3-2 to Table 3-5.

Figure 3-4: Estimating defence exports using trade in goods data



Sources: CE analysis.

Table 3-2: Assumption-based shares by commodity code and name

Assumption-based shares
36010000 Propellant powders
36020000 Prepared explosives o/t propellant powders, incl. Gelatinous
36030010 Safety fuses; detonating fuses
36030090 Detonators & percussion caps
36049000 Pyrotechnic articles o/t articles for signalling/entertainment
87100000 Tanks and other armoured fighting vehicles, motorised, whether or not fitted with weapons, and parts of such vehicles, n.e.s.
89061000 Warships
90139010 Parts & accessories for liquid crystal devices

Sources: CE.

Table 3-3: 'Other than civil'-based shares by commodity code and name

O/t civil shares (for entire period of estimation)
40113000 New pneumatic tyres, of rubber, of a kind used for aircraft
85261000 Radar apparatus
90131000 Telescopic sights for fitting to arms; periscopes
90139090 Other pts & acc o/t liquid crystal devices

Sources: CE.

Table 3-4: Prodcom-based shares by commodity code and name

Prodcom (for entire period of estimation)
88010090 Kites and other non-powered aircraft (excl. gliders, hang gliders, balloons and children's kites)
88051010 Aircraft launching gear and parts thereof, n.e.s. (excl. motor winches for launching gliders)
88051090 Deck-arrestor or similar gear for aircraft and parts thereof, n.e.s.
88052100 Air combat simulators and parts thereof
93011000 Artillery weapons 'e.g. guns, howitzers and mortars'
93012000 Rocket launchers; flame-throwers; grenade launchers; torpedo tubes and similar projectors
93019000 Military weapons, incl. sub-machine guns (excl. artillery weapons, rocket launchers, flame-throwers, grenade launchers, torpedo tubes and similar projectors, revolvers and pistols of heading 9302 and cutting and thrusting weapons of heading 9307)
93020000 Revolvers and pistols, other than those of heading 9303 or 9304
93051000 Parts and accessories of articles of headings 9301 to 9304: of revolvers or pistols
93059100 Parts and accessories of articles of headings 9301 to 9304: other: of military weapons of heading 9301
93063010 Other cartridges and parts thereof: for revolvers and pistols of heading 9302 and for submachine guns of heading 9301
93063030 Other cartridges and parts thereof: for military weapons
93069010 Other [munitions and ammunition] for military purposes
93070000 Swords, cutlasses, bayonets, lances and similar arms and parts thereof and scabbards and sheaths therefore.

Sources: CE.

Table 3-5: Combined-method* shares by commodity code and name

Code and description
84071000 Spark-ignition reciprocating or rotary internal combustion piston engine, for aircraft
84091000 Parts suitable for use solely or principally with internal combustion piston engine for aircraft, n.e.s.
84111100 Turbojets of a thrust <= 25 kN
84111100 Turbojets of a thrust > 25 kN but <= 44 kN
84111230 Turbojets of a thrust > 44 kN but <= 132 kN
84111280 Turbojets of a thrust > 132 kN
84112100 Turbopropellers of a power <= 1.100 kW
84112220 Turbopropellers of a power > 1.100 kW but <= 3.730 kW
84112280 Turbopropellers of a power > 3.730 kW
84119100 Parts of turbojets or turbopropellers, n.e.s.
84121000 Reaction engines other than turbojets
88010010 Gliders, without motor and not capable of being fitted with a motor, and hang gliders; balloons and dirigibles (excl. party balloons)
88021100 Helicopters of an unladen weight <= 2.000 kg
88021200 Helicopters: of an unladen weight exceeding 2000kg
88022000 Aeroplanes and other aircraft, of an unladen weight not exceeding 2000kg
88022000 Aeroplanes and other aircraft, of an unladen weight exceeding 2000kg but not exceeding 15000kg
88023000 Aeroplanes and other aircraft, of an unladen weight exceeding 15000kg
88031000 Propellers and rotors and parts thereof
88032000 Under-carriages and parts thereof
88033000 Other parts of aeroplanes or helicopters
88039090 Parts of aircraft, n.e.s. (excl. of spacecraft, incl. satellites, and suborbital and spacecraft launch vehicles)
88052900 Ground flying trainers and parts thereof, n.e.s. (excl. air combat simulators and parts thereof)

Notes: * Combined method denote using different assumptions over time; more specifically, o/t civil shares up to 2005, extrapolated o/t civil shares up to 2008, and applying growth rates of Prodcom military share to 2008 extrapolated o/t civil shares thereafter. Prodcom military shares have been corrected for suppressions using SUTs data.
Sources: CE.

The combined-methods approach uses a combination of:

- historical o/t civil shares;
- defence sales data from Prodcom;
- turnover figures from SUTs; and
- assumptions about shares.

The combined-methods approach is considered to be the most appropriate, due to the varying availability of data to inform shares for defence use across time and commodity codes. O/t civil shares and Prodcom military shares supplement each other in terms of their coverage of commodity codes and years. Their combined coverage, however, is not complete and for certain products, extrapolations across time are used in addition to assumption-based shares.

Methods based on OTS data likely provide upper-bound estimates

Estimates based on OTS data are likely to be close to upper bounds of defence exports (of goods) due to the assumptions used in obtaining the defence shares. The key reason for this is that o/t civil codes include exports of non-defence goods. Previous studies indicate that o/t civil codes included items classified as 'other than civil' on the basis of the end-use control (as defined by the EU[25]), which may include non-defence items. There may therefore be positive bias to the overall defence exports estimates.

Conversely, an underestimate of defence exports using OTS-based estimates arises due to the absence of data on exports of defence services. It is, however, impossible to obtain an indication of the relative magnitude of the negative services bias against the magnitude of the positive bias due to overestimation of defence shares based on historical o/t civil codes.

Findings from the sensitivity analysis

Section B.6 in Appendix B presents detailed sensitivity analysis of alternative methods to approximate shares for defence use. Based on the sensitivity analysis, the key conclusions include:

- Estimates based solely on extrapolations of o/t civil codes (which are discontinued from 2005 onwards) become less reliable the more recent the estimation year. This is because extrapolation based on 2005 shares cannot account for the volatility of share for defence use across time.

Applying defence shares based on UK sales could overestimate UK defence exports

- Defence shares based on UK sales can be considered as a weighted average of the defence content of sales to the UK market and defence content of sales to the export market. If the defence content of sales to the domestic market is considerably higher than the defence content of sales to the export market, using the Prodcom defence content by itself would overestimate exports for defence use.

The combined-methods approach assumes that the domestic and export defence markets grow at the same rate

- The preferred (combined) approach circumvents this concern by applying the growth rates of Prodcom defence shares over time to extrapolate historical o/t civil shares forward. This method does not require the defence shares to be identical for domestic and export markets to be reliable; rather, it only requires them to grow at the same rate. The implication also is that there is less discontinuity in the defence shares applied.
- Due to the extent of suppressions in Prodcom data, turnover figures used for calculating defence shares are obtained from UK SUTs. These figures are assessed as a more consistent measure, albeit with the caveat that they could be inaccurate due to methodological differences between data organised at sector level (SUTs) and product level (Prodcom).
- The coverage of defence shares based on historical o/t civil codes is limited to 26 out of 48 defence-related codes. Similarly, the coverage of Prodcom codes is limited to certain items in Aircraft & Parts and Weapons categories. Estimates based solely on one of the two methods would require additional assumptions on the defence content in codes where defence shares are unavailable.
- The estimates are highly sensitive to the choice of the method of obtaining defence content shares, especially regarding aircraft and parts, given their dominance in defence-related goods.

[25] UKDS Review Team (2005).

3.5 Concluding remarks and recommendations

Using combined o/t civil and Prodcom defence shares improves coverage

The method that we consider to be most sensible for estimating defence export deliveries using OTS data is the combined-methods approach, which extrapolates forward historical o/t civil shares using growth rates obtained from timelier Prodcom military sales data. This method appears more complete than methods which use only extrapolated o/t civil shares because of the complementary coverage of Prodcom defence shares in terms of commodity codes and later years (o/t civil shares are not available after 2005).

Nevertheless, their combined coverage is not comprehensive, and for certain products and years where neither are available, extrapolations across time are used, as well as assumption-based shares.

The key difficulty with verifying the reliability of this approach is the lack of overlapping codes and years that would allow direct comparisons of defence shares estimated using o/t civil shares with defence shares estimated using Prodcom data and other sources. For items where only Prodcom-based defence shares are used (mainly military weapons as listed in Table 3-4), the strong assumption of identical defence shares for domestic and export markets must hold for estimates to be reliable. For codes relying on a combined approach (Table 3-5) – which comprise the majority of defence and defence-related exports – the method requires defence sales to the domestic market and defence sales to the export market to grow at the same rate.

It is possible that the assumption of equal growth of sales to the domestic and export markets does not hold. Additionally, Prodcom military share growth rates can only be calculated for broad product categories, and these categories exclude some defence-related goods or include non-defence related goods.

Even in the historical data where o/t civil commodity codes can act as a proxy for defence shares, estimates are likely to be upper-bound estimates due to the inclusion of non-defence goods in o/t civil codes. As in most instances where the historical o/t civil defence shares are extrapolated forwards, bias in these shares would carry over to the estimates for years after 2005.

These issues with obtaining defence-related shares contribute to the overall assessment of limited reliability of estimates based on OTS data.

The potential to improve OTS-based estimates is limited

Additional sources of data could be employed to improve the reliability of the estimates in the future or to verify/challenge the underpinning assumptions (although the potential for substantial improvements is considered limited). Currently, the application of growth rates in Prodcom sales-based defence shares to exports data is based on the assumption of the same growth rate of defence shares for domestic and foreign markets, and for certain codes, on the stronger assumption of identical defence shares. To verify this assumption, micro-level Prodcom data could be linked to micro-level ABS surveys to obtain the relationship between the military share of output and the share of output exported at the statistical unit level (enterprise). If, for example, the evidence suggests that the enterprises dealing primarily in military production are more likely to export than non-military enterprises, the Prodcom military ratios could be appropriately adjusted. This could be achieved by estimating independent defence shares for domestic and exports markets.

Alternatively, defence shares based on Customs Processing Codes (CPC) could be further explored and applied to the defence-related exports. Concerns

over the reliability of this method however have been previously documented, with the significant amount of goods classified for military processing being of non-military nature (Baldock, Lonsdale and Sams, 2006). The coverage of the CPC method is currently limited to extra-EU exports, requiring additional assumptions on UK-EU trade.

Additional primary data collection may be required to improve the reliability of the OTS estimate

If there is scope to collect new data, one avenue for further exploration is including additional questions to the questionnaire that underpins the Prodcom data. The questionnaire currently requests businesses to submit information on sales of military goods (described in Appendix B), and so a possible extension could be to ask for the value of sales specifically for the export market as well.

4 Comparisons of DSE and OTS defence exports estimates

Key points

- A comparison of the DSE and OTS approaches reveals that the OTS estimate is unlikely to capture variation in defence exports over time, because it relies on extrapolations based on pre-2006 data. The OTS approach also results in partial estimates of defence exports as it captures goods deliveries only.
- The DSE approach has the deficiency of failing to account for order cancellations. It may also be potentially affected by the sampling inaccuracy in the SIPRI database (representativeness assumption) and the use of TIV to calculate the delivery schedule.
- Considering the overall strength of the assumptions and the potential to refine the estimate, and of the two approaches considered, the DSE approach is preferred going forward. By employing the firm-level DSE dataset, future studies could verify the accuracy of order years in the SIPRI schedule, the reliability of the representativeness assumption, and the validity of using TIV values.

4.1 Introduction

This chapter compares the estimates of UK defence exports derived from the DSE approach and the OTS approach, in order to provide further insight into the relative weaknesses and strengths of each method.

Section 4.2 begins by contrasting the key differences in assumptions of each method, highlighting sensitivities and potential inaccuracies. Where potential inaccuracies are identified, the direction of the bias (if biases are present) is considered and contrasted. The section goes on to discuss differences in overall trends between the two methods and potential explanations for differences.

Section 4.3 outlines notable discrepancies between the two measures, focusing on two concrete instances in detail. Section 4.4 summarises the results of the chapter and provides concluding remarks.

4.2 Comparison of assumptions, sensitivities and trends between DSE and OTS estimates

Both approaches require assumptions about 'true' defence exports

As discussed in Chapters 2 and 3, both approaches for estimating UK defence export deliveries require various assumptions. This includes suppositions about the 'true' flow of defence exports and about the content and nature of the data sources underpinning the approaches. The first objective of this chapter is to contrast the premises that each measure is based on, and in doing so, consider the relative robustness of each estimate.

SIPRI data capture only a small sample of military transfers, but are assumed to be a representative sample

- **Sampling error**

  By using official sources, the OTS approach eliminates the need for restrictive assumptions about how well the sample data represent the population. OTS data can be thought of as an exhaustive estimate of goods trade, but data gaps and suppressions result in less-than-perfect coverage. Sources used to estimate defence shares are generally based on sufficiently large samples.

  In contrast, the DSE approach requires some moderate assumptions about sample representativeness. The SIPRI data used to estimate delivery schedules are based on a small sample of major military transfers. Inaccuracy could therefore creep in, if large orders within the sample affect the representativeness of order-delivery lags. However, it is unlikely that violations to this assumption would lead to substantial bias (i.e. the inaccuracy will be roughly zero on average).

The OTS approach does not account for exports of defence services

- **Defence exports in services**

  The OTS approach only captures trade in goods. Exclusion of defence exports in services will lead to a downward bias in the measure. The magnitude of this bias depends on the magnitude of 'true' UK defence services exports relative to UK defence goods exports.

  The DSE approach includes services in its (orders) data.

The OTS approach relies on estimated defence content shares which are likely biased

- **Variation in the defence share**

  For certain years and products, the OTS approach implicitly smooths the defence share in goods exports over time and estimates trends using evidence from production data (see Chapter 3 for full description). This means that spikes and dips in defence exports may not be well captured in the OTS estimate, especially after 2005, when estimates of defence shares for many products use extrapolated o/t civil defence shares. This would cause inaccuracy in the year-on-year estimate. Bias could potentially result if there have been notable shifts in defence shares since 2005 which have not been captured by the method. Even a small overestimation of o/t civil defence shares could lead to large absolute differences, as o/t civil defence shares are used in obtaining defence exports for the majority of items, including aircraft and parts.

  The DSE approach, as a customer-based measure, circumvents the need to calculate the defence share because the civil content of goods exports is already excluded from the primary data.

The DSE approach does not account for order cancellations

- **Cancellation of orders and undelivered items**

  The OTS measure is unaffected by cancellations and undelivered items because it is derived from data on deliveries rather than data on orders. The OTS data capture deliveries directly.

  The DSE approach is able to estimate and capture the impact of items which are not yet delivered but also not cancelled. However, the method fails to accommodate cancellations. This will lead to an upward bias in the measure. The magnitude of the impact of cancellations is discussed in Chapter 2.

Small defence exports may not be captured by the DSE approach

- **Other coverage considerations**

  There are no additional coverage issues which affect the OTS approach which are not already mentioned.

  The DSE approach is sensitive to the coverage of the defence exports survey. Despite being a voluntary survey, a high proportion of defence exports are reportedly captured (94%). The 6% deficiency in coverage includes the approximate value of orders received by firms that are not included in the survey, and orders of value less than £10,000.

As a result, the measures are robust to different factors

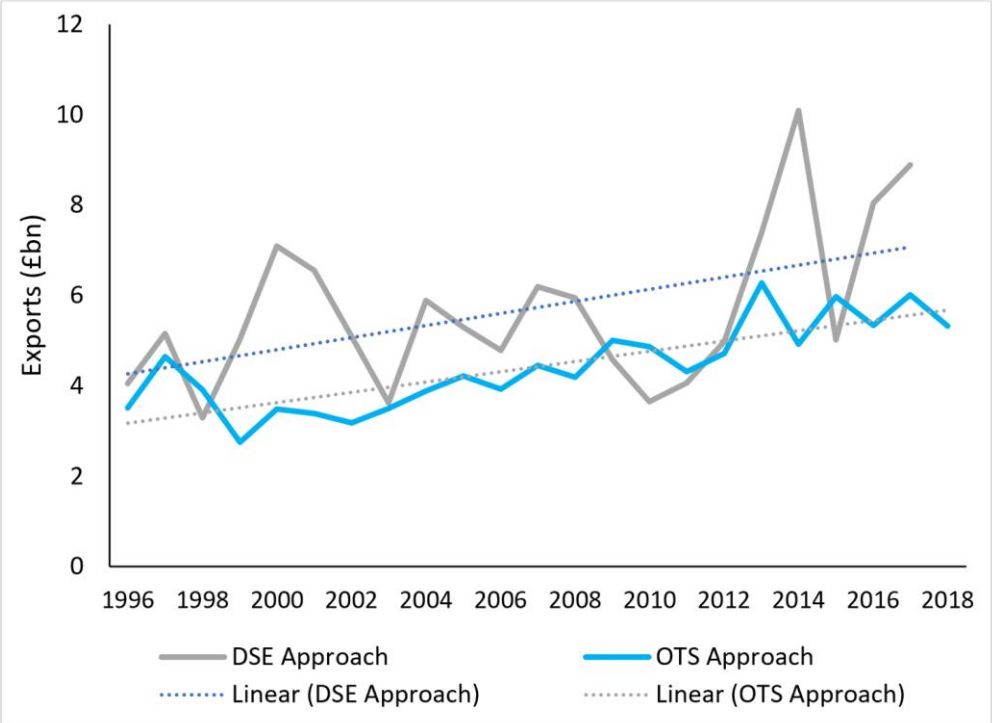
With respect to the points listed above, the DSE approach can be thought to be relatively more robust to volatility in year-on-year defence shares (resulting from lumpy orders), post-2005 trends in typical defence shares and the contribution of services to defence exports. Conversely, the OTS approach is relatively more robust to cancellations of orders, sampling errors and coverage issues in the primary data on defence-related exports.

The comparison of UK defence exports estimated using the OTS approach with the estimates using the DSE approach is presented in Figure 4-1.

The OTS measure is less volatile, likely due to assumptions underpinning the estimate

Unsurprisingly, the series based on OTS data is less volatile than the estimate from SIPRI, as it relies on extrapolations and the application of growth rates to defence shares over time. At the same time, it results in a lower estimate than the DSE approach.

Figure 4-1: Estimated UK defence exports based on adjusted Prodcom shares and o/t civil share extrapolation



Sources: CE calculations, based on: HMRC OTS, ONS Prodcom, ONS SUTs, SIPRI ATD (Trade Registers and TIV tables); DIT DSE (UK defence and security export figures).

The 1997-2017 trend is different between the two measures

Between 1997 and 2017 the annual growth[26] of the DSE estimate averaged 9.1% pa, exceeding the 4.0% pa average growth rate of the estimate based on the OTS approach.

One explanation for the deviation in apparent average growth could be the spurious effect of the selected period of estimation. The estimated trends are very sensitive to the choice of start and end years, especially given the high volatility in the DSE series. For instance, if the period selected were over 2000 to 2015, then the average growth rate in the DSE series would be 4.7% pa.

Differences in estimates from the two approaches could be due to the contribution of services, or to diverging trends in defence export shares

Another explanation for the higher average growth rate between 1997 and 2017 could be an increasing contribution of services exports. As mentioned earlier, services are not included in the OTS measure. Therefore, if services exports are increasing over time, this could cause a growing wedge between the two measures.

Finally, the diverging trends could be explained by trends in defence shares that are not sufficiently captured in the OTS estimate. If UK defence export shares were increasingly under-estimated over time (e.g. because of increasing defence shares in exports since 2005), then this could lead to a divergence in long-run trends between the two measures.

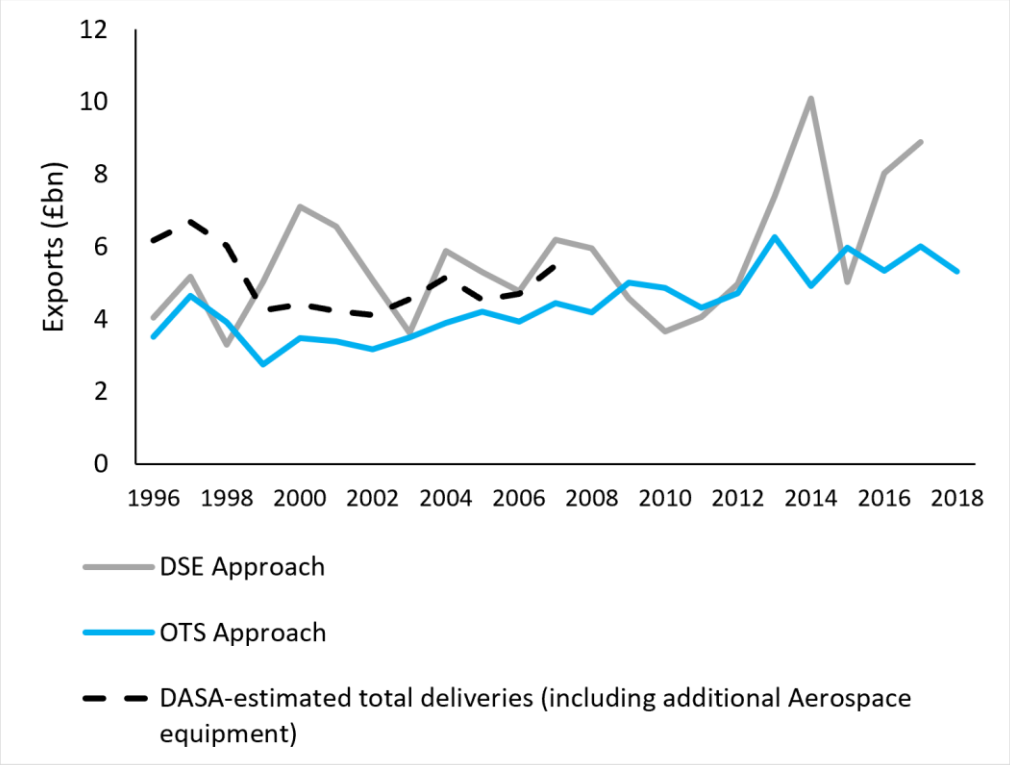
Figure 4-2 presents the comparison of estimates based on the OTS and DSE approaches to the historical DASA estimates of deliveries, which were published by the Ministry of Defence (MoD) up to 2007 (Bennett, 2007).

The historical DASA estimates are based on the OTS exports data in codes related to defence products, as well as additional data reported by the Society of British Aerospace Companies (SBAC) and data on exports of defence services. It should be noted that at the time of publication, there were significant problems with the definition, consistency and coverage of defence-related exports data, which led to the discontinuation of the publication in later years. The estimates therefore should be interpreted with caution.

Given the reliance of the DASA method on OTS data, it is unsurprising that the trends in the series closely resemble those observed in the OTS-based estimate. The DASA estimate is consistently higher than the OTS estimate. The difference was approximately £2.7bn in 1996, but the gap narrowed to close to £1bn in years after 1999. This difference is likely due to the additional defence exports identified by DASA from SBAC, application of a correction to the value of exports informed by the Known Military Trader list, as well as the services component identified from sources other than OTS. Importantly, according to DASA (Bennett, 2007), aerospace and services exports accounted for the largest share of defence exports – between 79% to 94% (depending on year) – which is similar to the share obtained in the OTS estimate. This to some extent may serve as information cross-validating the OTS estimate for this product type.

[26] Calculated as an arithmetic average of annual growth rates over the period

Figure 4-2: Comparison of OTS, DSE and historical DASA defence export deliveries estimates



Sources: DASA and CE calculations based on HMRC OTS, ONS Prodcom, ONS SUTs and DSE.

4.3 Key discrepancies between the DSE and the OTS estimates

The greatest differences between the DSE and the OTS estimates are observed in years 1998-2001 and in 2014 (see **Error! Reference source not found.**).

The spike in the DSE estimate in 2014 is likely due to violations to the representativeness assumption (i.e. that DSE orders are well represented by SIPRI in terms of delivery years). This is driven in particular by a large delivery of frigates in 2014 reported in the SIPRI data. While this result is seen, to a certain extent, in the OTS data for 89061000 – 'Warships', the overall OTS-based estimate declines in that year.

The spike in DSE-estimated defence exports in 2000, driven by deliveries of aircraft, submarines and armoured vehicles, to some extent corresponds to data from OTS. The decline in estimated total defence exports using OTS data is, however, driven by declines in estimated defence exports of other items, such as 88033000 – 'Other parts of aeroplanes or helicopters' and 93069010 – 'Other munitions and ammunition for military purposes'. In comparison to estimates of exports of warships, OTS-based estimates of aircraft parts and ammunition exports are assessed as being less reliable. Trends in exports of these codes cannot be compared with SIPRI deliveries data, as no comparable armament types exist for these items.

A more detailed discussion of the analysis of the discrepancies is available in Appendix C.

4.4 Concluding remarks and recommendations

This chapter has reviewed assumptions, trends and volatility in both the DSE-based and OTS-based estimates of defence exports. To the extent possible, differences between the two measures were traced back to the main drivers and the over-arching narrative of both measures was contrasted.

In sum, the DSE approach can be thought as relatively more robust to volatility in year-on-year defence shares (resulting from lumpy orders), recent trends in typical defence shares and the contribution of services to defence exports. Conversely, the OTS approach is relatively more robust to cancellations of orders, sampling errors and coverage issues in the primary data.

According to both approaches, UK defence exports experienced growth since 1997. The estimated growth rate is higher for the DSE-based estimate (although, due to volatility of the series, it is very sensitive to the period of estimation).

Exports in 1998-2000 and 2014 were considered in an in-depth comparison of the series, as the estimates for these years show a notable divergence in the total UK defence exports between the DSE and OTS approaches.

Even detailed assessments are not sufficient to determine which estimate is closer to true defence exports

The detailed examination of defence exports in 2000-2001 and 2014 provides wider context to the assessment of strengths and weaknesses of each method, but is not sufficient to determine with confidence which estimate is closer to true defence exports in these years.

As the reliability of defence-content shares for OTS-based estimates varies across products (due to the method of obtaining defence shares) and time (due to extrapolations), estimates for certain products in certain years can be assessed as more reliable than others. Nevertheless, the overall estimate of defence exports based on OTS is driven by dual-use products in the category Aircraft & Parts, where the reliability of defence shares is assessed as relatively low. Additionally, the smoothing effect of extrapolations means that the method does not fully capture variation in defence exports over time.

The DSE approach does not rely on estimates of defence content as it is based strictly on defence orders data. This advantage over the OTS-based estimate is, however, dependent on the reliability of the estimated delivery schedule. Inaccuracies might stem from violation to the representativeness assumption and/or unaccounted cancellations. DSE data also cover exports of defence services (though it is not possible to estimate the overall importance of services in UK defence exports based on the available data). It is therefore unknown whether the bias in the OTS-based estimate due to the omission of services is higher than the bias stemming from the 94% coverage of defence exports in the DSE data.

Therefore, due to the fundamental differences in both measures, it is very difficult to compare the two appropriately. The orders data used in the DSE approach do not provide a detailed enough product breakdown to compare with OTS data. In addition, SIPRI data cannot be compared to OTS data directly because the reported values are expressed in TIV in the former dataset. The delivery schedule can also not be applied to the DSE orders data on an order-by-order basis because this would require exhaustiveness of the SIPRI data – a stronger assumption than we require for the aggregate-level estimate. More generally, this issue demonstrates weaknesses in the DSE approach in

providing granular data on defence by product category. The extent to which these weaknesses can be mitigated depends on the quality of the detail in the DSE microdata.

Full DSE data could potentially improve the reliability of the DSE approach in further research

As discussed in Chapter 3, the scope for improvement of OTS-based estimates using micro-level data or Customs Processing Codes is likely limited, and the main weaknesses of the method stemming from the low reliability of defence shares and lack of data on services exports will persist. On the other hand, for the DSE approach, use of the micro-level DSE dataset could result in substantial improvements to the reliability of the delivery schedule (discussed in detail in Section 2.4).

While currently it is not possible to determine concretely which method is more reliable, the orders-level DSE dataset has the potential to improve the reliability of the DSE estimate. If the aforementioned improvements can be achieved using micro-level data, the DSE approach might emerge as the leading method. If, however, significant discrepancies between micro-level DSE data and SIPRI are found, the reliability of the approach could be undermined.

5 UK defence exports by destination

Key points

- The OTS data capture UK exports of goods by partner country. However, bilateral trade data on defence-related goods are subject to additional suppressions that introduce substantial gaps and make OTS bilateral trade data unsuitable for estimating UK defence exports by destination country.
- A better approach to estimating defence exports by destination country is to allocate OTS-based estimates of total UK defence exports of goods to partner countries based on country shares (obtained from SIPRI as averages over 1990-2017), by broad armament categories (such as air, land and navy). Even so, it should be noted that these estimates are approximate and subject to a number of caveats. They also differ from other defence export sources (including HMRC OTS data) due to differences in coverage and methodology.
- From the estimates, the largest importer of UK defence goods is Saudi Arabia, which accounted for 21% of UK exports between 2016 and 2018. It was followed by the US, with a share of 19%, China (9%) and India (8%).
- The reliability of these estimates is assessed as low. The monetary estimate suffers from the same deficiencies as the OTS approach to estimating total UK defence export deliveries, and from additional weaknesses of country shares in UK defence exports obtained from the SIPRI database.
- Large differences are found when comparing SIPRI country shares with country shares in the World Military Expenditure and Arms Transfer (WMEAT) Database by the US Department of State[27]. In the WMEAT database, the US share of UK defence exports is three times higher than the estimate based on SIPRI and OTS data. These differences are likely a result of methodological differences.
- Methodological differences mean that these estimates can also differ from the crude HMRC data or estimates from other defence sources such as DSE or Strategic Export Controls Licensing Statistics[28].

5.1 Introduction

Aggregate data on UK defence exports of goods (i.e. UK goods exports to the World) are published by HMRC in its OTS data. However, producing reliable estimates of UK defence exports by country of destination is not possible due to the high rate of suppression in the OTS data. For many of the codes identified as either ARSEC or dual-use, exports by destination country are suppressed.

This chapter explores alternative options for estimating UK exports by destination country. Estimates are derived for the top 10 importers of UK defence goods in 2017 according to the SIPRI Database (based on TIV value imported in 2017[29]).

[27] US Department of State (2018a).

[28] DIT DSE (2019b)

[29] SIPRI (2018b).

Section 5.2 outlines the limitations of the OTS data and considers what might be the most sensible approach to estimating UK defence export deliveries by destination. Section 5.3 presents the estimates based on the main identified method of estimating defence exports by destination country. Section 5.4 compares this estimate with an alternative way of estimating UK exports by destination countries – using WMEAT data. Section 5.5 summarises the findings.

5.2 Applying a defence share to OTS data to estimate defence exports by destination country

Defence-related trade data

One option considered for estimating UK defence exports by destination country was to apply a similar method to the OTS approach of estimating total UK defence export deliveries: extracting bilateral trade data for each defence-related commodity code and then trying to identify the proportion 'for defence use'.

Extensive suppressions are present in bilateral OTS trade data

The key dataset for this approach is the OTS. However, in addition to the suppressions present at the level of total UK exports, further codes are suppressed at 'country and port' level. This means that bilateral trade data for defence-related goods are unavailable for these codes. The commodity codes relating to these suppressions are presented in Table 5-1. In many cases, suppressions were present for all (or nearly all) years, rendering gap-filling techniques unreliable.

Table 5-1: Commodity codes for which trade data are suppressed by destination

Commodity code	Code description
85261000	Radar apparatus
87100000	Tanks and other armoured fighting vehicles, motorised, whether or not fitted with weapons, and parts of such vehicles, n.e.s.
88010010	Gliders, without motor and not capable of being fitted with a motor, and hang gliders; balloons and dirigibles (excl. party balloons)
88010090	Kites and other non-powered aircraft (excl. gliders, hang gliders, balloons and children's kites)
88022000	Aeroplanes and other aircraft, of an unladen weight not exceeding 2000kg
88039090	Parts of aircraft, n.e.s. (excl. of spacecraft, incl. satellites, and suborbital and spacecraft launch vehicles)
88051010	Aircraft launching gear and parts thereof, n.e.s. (excl. motor winches for launching gliders)
88051090	Deck-arrestor or similar gear for aircraft and parts thereof, n.e.s.
88052100	Air combat simulators and parts thereof
88052900	Ground flying trainers and parts thereof, n.e.s. (excl. air combat simulators and parts thereof)
89061000	Warships
93011000	Artillery weapons 'e.g. guns, howitzers and mortars'
93012000	Rocket launchers; flame-throwers; grenade launchers; torpedo tubes and similar projectors
93019000	Military weapons, incl. sub-machine guns (excl. artillery weapons, rocket launchers, flame-throwers, grenade launchers, torpedo tubes and similar projectors, revolvers and pistols of heading 9302 and cutting and t...
93051000	Parts and accessories of articles of headings 9301 to 9304: of revolvers or pistols
93059100	Parts and accessories of articles of headings 9301 to 9304: other: of military weapons of heading 9301
93063010	Other cartridges and parts thereof: for revolvers and pistols of heading 9302 and for submachine guns of heading 9301
93063030	Other cartridges and parts thereof: for military weapons
93069010	Other [munitions and ammunition] for military purposes

Sources: HMRC OTS.

The lumpiness of defence deliveries makes gap filling unfeasible

Due to the lumpy nature of defence deliveries, data-imputation techniques, such as linear interpolation, are less reliable for estimating bilateral trade. The bilateral exports for a particular year and code may likely be dependent on a single one-off order from the country in question (in contrast to total UK exports, where overlapping one-off deals with different countries may smooth out some of the lumpiness).

Due to suppressions country level o/t civil shares cannot be obtained

Furthermore, even if the OTS bilateral trade data are not heavily suppressed, there are notable challenges in estimating a defence share to apply to exports of defence-related items by recipient country. The first major challenge is the lack of detail in Prodcom data, which do not identify UK sales by destination country. In an ideal case, the available data would permit the estimation of UK export defence shares by product and by destination country. However, this is unfeasible due to data constraints.

An alternative option could rely on applying the same defence shares by product to all recipient countries. In this case, variation in export values by recipient would be driven by variation in total export values of defence-related goods. This approach would therefore assume that the defence shares are similar across countries.

Defence shares likely vary across countries

This assumption is likely unrealistic and would lead to potentially significant mis-estimation in the defence share of defence-related goods. Consider the example of UK helicopter exports to South Korea and Germany. South Korea is a major recipient country for UK exports of military (anti-submarine) helicopters. In 2016, shipments of approximately £350m worth of military helicopters were reportedly delivered[30]. Evidence in the OTS reported that, between 2015 and 2016, deliveries of heavy helicopters increased by 1650% (from £9m to £150m). Thus, the evidence strongly points towards a very high defence share for exports of helicopters to Korea in 2016.

If we applied the same export shares for heavy helicopters (approximately 29% according to Prodcom), then we would considerably underestimate defence exports to South Korea. Other notable large deliveries of military helicopters to South Korea are also reported in the early 2000s.

Germany is also a reasonably significant market for UK exports of heavy helicopters, with OTS reporting £26m of exports in 2016. Unlike South Korea however, since 2000, there have been no reported exports of military helicopters either in DIT DSE 'UK Defence Sales in the Public Domain' or in SIPRI ATD. Thus, in contrast to South Korea, UK defence exports would be overestimated in the case of Germany, if the defence shares were to be assumed identical across countries.

More generally, adopting such an approach will fail to capture the considerable variation in demand for defence products across countries. Defence exports to major defence export recipient countries such as South Korea, Saudi Arabia, Oman and Indonesia would likely be underestimated using this approach.

Applying a defence share to bilateral OTS data is unfeasible

In summary, an approach similar to that identified in Chapter 3 to estimate total UK defence exports appears unfeasible. This is because:

- the OTS bilateral trade data for defence-related goods are heavily suppressed;
- there are no identified sources that can inform share for defence use on a partner-country basis.

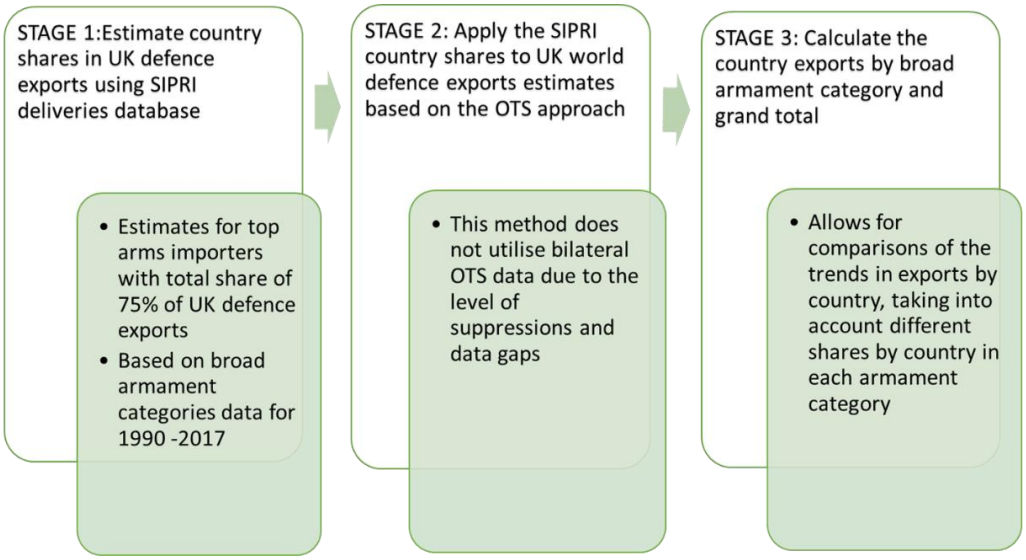
5.3 Using SIPRI data to estimate UK defence exports by destination country

SIPRI data can be used to obtain country shares

A preferred alternative approach to obtaining UK defence exports by destination country relies on estimates of country shares in UK military exports based on SIPRI delivery schedule data and TIV, and applying these to the total UK defence goods exports estimate. The estimation process is outlined in Figure 5-1.

[30] According to publicly available DIT DSE UK sales data.

Figure 5-1: Process map for obtaining UK defence exports by country



Sources: CE analysis.

Table 5-1 presents the estimates obtained from applying SIPRI country shares to the overall UK defence goods exports estimate based on the method outlined in Appendix D. Sixteen key importing countries for which the estimates were obtained account for over 75% of total UK defence goods exports. The largest importers include Saudi Arabia, with a 21% share of the total, the US (19%), China (9%) and India (8%).

It is important to note that since the country shares for particular armament categories are constant for the entire 1996-2018 period (presented in Appendix D), the single source of variation in proportion over the years is the changing composition of UK exports in particular armament categories. For example, while exports to both Jordan and Oman decreased over 1996-2005, exports to the US and China increased in the same period. Jordan and Oman were the primary recipients of UK exports of Tanks and Armoured vehicles, which saw a large drop in exports in that period. On the other hand, the US and China primarily imported items in Aircraft and Engines categories, and total UK exports of these items substantially increased in the same period.

Table 5-1: Estimates of UK defence exports by destination country (£m)

Country	1996-2000	2001-2005	2006-2010	2011-2015	2016-2018	*Implied country share (1996-2018)*
Saudi Arabia	4,131	3,790	4,643	5,221	3,347	*21%*
USA	3,310	3,416	4,027	5,137	3,352	*19%*
China	1,130	1,726	2,166	2,462	1,408	*9%*
India	1,550	1,462	1,765	1,966	1,270	*8%*
Oman	826	608	792	947	622	*4%*
Jordan	707	365	475	712	432	*3%*
Indonesia	467	344	462	536	364	*2%*
South Korea	397	394	461	505	328	*2%*
Australia	319	311	341	409	282	*2%*
Canada	324	248	347	374	289	*2%*
UAE	186	201	254	282	171	*1%*
France	123	188	238	271	154	*1%*
Algeria	106	92	118	131	87	*1%*
Germany	88	105	110	114	77	*0%*
Chile	107	43	105	105	96	*0%*
Pakistan	89	42	89	92	79	*0%*
World total	18,307	18,162	22,432	26,191	16,668	*100%*

Sources: CE calculations based on HMRC OTS and SIPRI database.

The reliability of these estimates is directly related to the reliability of the estimate of total defence goods exports based on OTS data, as well as additional uncertainties due to:

- **Reliance on TIV in SIPRI to obtain country defence shares.** While this only requires that TIV estimates are consistent within the broad armament categories, it is difficult to verify whether TIV estimates are highly correlated with the monetary value of exported items.
- **Differences in the coverage of the SIPRI dataset and identified defence items in OTS.** The mapping of 46 OTS codes to 8 broad SIPRI armament types requires further assumptions, and certain large codes in OTS, such as those relating to aircraft parts, do not have a directly corresponding SIPRI armament category. Country shares for these items are therefore based on imputation of country shares in a similar armament category (Aircraft & Parts).
- **Averaging of SIPRI-estimated country shares over 1990-2017 period.** While averaging mitigates the potential inaccuracies that could stem from inaccuracies in reported delivery years in SIPRI, it potentially masks any trends in changing country shares over the estimation period.

5.4 An alternative source: WMEAT

Country shares can be cross-validated against WMEAT database

The WMEAT database, compiled by the US Department of State, provides an alternative source of data on bilateral defence trade. WMEAT estimates have been compiled since the 1960s and currently cover military trade in goods and services of over 170 countries, accounting for over 99% of the world GDP[31]. Detailed descriptions of the WMEAT methodology and comparisons to SIPRI-obtained country shares are available in Appendix D.

Data on UK exports by country of destination (Table III in WMEAT database) are available from 2009 to 2017 for three-year intervals. Only the aggregated totals for military goods and services are available.

SIPRI country rankings are broadly consistent with WMEAT, but for some countries shares differ

For both WMEAT and SIPRI estimates, Saudi Arabia emerges as the largest importer for the available data (2009-2017), with an estimated share of 37% based on WMEAT data, and 46% for SIPRI data. While for both methods the US ranks as the second largest importer, the estimated share based on WMEAT data is over three times higher, at 35%, compared to 11% for SIPRI. The estimated shares for India place it as the third largest importer according to both methods, with an estimated share in UK exports of 7% based on WMEAT data and 10% based on SIPRI data.

The differences in estimated country shares are most likely due to methodological discrepancies. It is unclear whether the reported high coverage of the WMEAT database refers only to the main table in the WMEAT database on states' military expenditures, or also to data on military exports. Due to very limited information on sources and methodologies underpinning the WMEAT database, the estimates cannot be reliably assessed.

5.5 Concluding remarks and recommendations

OTS bilateral trade data on defence-related exports is incomplete

The OTS bilateral trade data on UK exports of defence-related goods cannot be reliably used to estimate defence exports on a destination-country basis due to suppressions and data gaps.

An alternative method based on country shares from SIPRI deliveries data was selected. The country shares are obtained in seven broad armament categories, allowing the assumption of identical country share for each product type to be relaxed. The results are consistent with the hypothesised cross-country differences in demand for UK land, air and naval defence products.

These country shares are subsequently applied to total UK defence goods exports, estimated using the OTS approach described in Chapter 3. The estimates indicate that Saudi Arabia is the largest importer of UK defence goods with a share of 21% of the total over 1996-2018, followed by the US (19%), China (9%) and India (8%).

Estimates of defence exports by country presented in this chapter differ from the HMRC OTS data or other defence exports sources, and are approximate and subject to the numerous caveats described in other sections of this chapter. The method employed in this chapter is based on a combination of HMRC OTS and SIPRI statistics. SIPRI statistics cover exports of licenses and equipment

[31] US Department of State (2018b)

for local production, as well as physical exports. The SIPRI dataset also outlines export deliveries by end-user, rather than the physical flow of products.

A cross-validation of the recipient country shares obtained from SIPRI against WMEAT database reveals broad consistency of the rankings of the key destination countries, but some sizeable differences in shares of each partner country. The shares of UK exports to the US and Saudi Arabia are estimated to be much higher and much lower, respectively, in WMEAT. The discrepancies could be potentially explained by methodological differences (though the documentation of the WMEAT military transfers database is too limited to be able to verify sources of such differences, or the reliability or robustness of the preferred method).

6 Comparisons with G7 economies

Key points

- Poor data availability significantly limits the credibility of comparable defence export estimates for other G7 countries..
- Although other G7 countries use nomenclature which are similar in structure to UK OTS statistics and, hence, they can be consulted to identify comparable defence-related items, accurately estimating defence-related exports for the other G7 countries is challenging.
- Data availability across countries is limited and uneven due to suppressions. Using only unsuppressed data to estimate defence-related exports would introduce uncertainty, because we would not know whether cross-country variation in estimates are driven by export performance or data suppressions.
- Due to data limitations, the estimates rely on defence shares that are assumed to be constant either over time or across broad product categories for all G7 countries except the US. This introduces the risk of (potentially substantial) inaccuracies.
- Goods for military purpose can be more easily isolated in the US trade statistics. However, substantial discrepancies with other sources, such as US government bulletins, are found.
- Producing credible and comparable estimates of cross-country defence exports is considered to be beyond the scope of the publicly available data and extreme caution is advised when consulting the estimates.

6.1 Introduction

The data operations presented in Chapter 3 (i.e. estimating defence exports using detailed trade in goods data and defence shares) can, in theory, also be applied to other countries. Depending on the reliability of the resultant measure, this could provide an indication of the relative performance of the UK relative to other countries.

This chapter determines the extent to which G7 defence exports can be estimated. The chapter considers the calculation of defence export deliveries using trade data published by UN Comtrade, Eurostat, and other official sources. It considers the estimation of defence shares using a range of sources such as parliamentary reports and publications from sector organisations.

Section 6.2 focuses on the feasibility of isolating defence-related goods (i.e. not distinguishing between civil and defence use). The section also discusses some of the key barriers to estimating defence-related exports, such as data suppression. Section 6.3 explores the feasibility and reliability of estimating defence shares for each country and commodity code. Based on these findings the credibility of an estimate of G7 defence exports is discussed. Section 6.4 offers our assessment as well as overall recommendations for the application of this exercise.

6.2 Estimating G7 defence-related goods exports

Defence-related items refer to exported products that can be used for defence purposes, but can also be used for other purposes not related to the defence

sector (the product coverage of defence-related items is proposed and discussed in Section 3.2). An estimate of defence-related goods is used as a basis for defence exports (by applying the share of defence-related goods for defence use).

It is possible to identify the relevant commodity codes for G7 countries, but the ability to compare defence-related exports across countries is limited

The nomenclature used in trade statistics for G7 countries[32] is comparable and (with some exceptions[33]) detailed enough to identify defence-related goods exports according to the commodity codes used for the UK in Chapter 3; namely, codes used for military or dual-use purposes.

However, the extent to which the data can be used to make cross-country comparisons is limited. The first major barrier to cross-country comparability – and indeed the reliability of the estimate in general – is data suppression. Especially for France, Germany and Italy, many commodity codes are suppressed:

- 87100000 Tanks and other armoured fighting vehicles is suppressed for France and Italy;
- 89061000 Warships is suppressed for France, Germany and Italy;
- 9301 Military weapons (incl. artillery, rocket launchers and sub-machine guns) is suppressed for France, Germany and Italy;
- 9302-9306 Munitions and ammunition is suppressed entirely for France and partially for Germany and Italy.

Suppressions are a concern because the coverage of the defence sector is incomplete

Suppressions are a concern because it means that a part of the defence-related goods is excluded from the measure. This is problematic because the number of suppressions – and hence the coverage of defence exports – is not consistent across countries. This means that it is not always possible to deduce whether cross-country variation in exports is driven by differences in 'true' trade flows or by differences in the number of suppressions.

Differences in statistical methodology also limit cross-country comparability

Moreover, the extent to which the series can be compared across countries is also limited by methodological differences in the trade statistics. Although the statistical sources are harmonised – for example through the System of National Accounts (2008) and HS Coding Systems – there are still differences in the way that primary data are collected and stratified.

For example, trade in goods data from Eurostat Comext are used for France, Germany and Italy (full details are contained in Appendix E). Comext trade data are built from two main datasets: Extrastat and Intrastat[34]. Extrastat captures trade in goods with Non-EU countries via customs declarations submitted by businesses. Estimates on trade in goods with EU countries are based on the Intrastat survey, completed by businesses whose trade with the EU exceeds a certain threshold. The thresholds which determine eligibility for exemption from participating in the survey are determined by each member state.

The application of exemption thresholds is an example of methodological differences which could limit the comparability of trade data. For instance, UK

[32] The trade sources used in the feasibility study are listed on a country-by-country basis, in the Appendix.

[33] Some commodity codes could not be identified for Japan, most prominently: exports of Turbojets and turbo propellers; Aircraft launching gear and parts thereof; Artillery weapons; Rocket launchers; and Warships.

[34] Eurostat (2019).

exports to Germany would exclude primary data from exemption-eligible SMEs while US exports to Germany would include all customs declarations (i.e. all deliveries above $2,500 in value) (US Census Bureau, n.d. b).

For full details on G7 defence-related goods, see Appendix E.

6.3 Estimating G7 exports for defence use

Data availability considerably limits the credibility of the estimates of defence shares that are applied to defence-related exports to estimate G7 defence exports.

For all G7 countries, estimating the defence share requires additional data sources

For most of the G7 countries, no detail on the defence content of each product was provided in the trade dataset and, consequently, shares had to be estimated from other sources. The exception to this is the US, for which data on exports are often provided to a 10-digit level, including detail on whether the product in question was for military purposes. Some additional sources were required for specific products.

For all G7 countries, except the US, the available data did not allow for time-variant defence shares and consequently, the proportion of exports for defence use is assumed to be the same in all years (though different across products).

Time-invariant defence shares limit the validity of the analysis of trends

This is problematic because it limits the extent to which trends over time can be deduced. For instance, suppose that defence-related goods exports are constant over time but that the defence share is increasing on average. This would mean that the 'true' value of defence exports is increasing over time, but that the estimate based on time-invariant defence shares would report no trend.

Time-invariant defence shares are also problematic from the perspective of year-on-year accuracy. The lumpiness of defence exports means that the true defence share is likely to be volatile. Any changes to defence exports that result from unusually large dispatches would therefore not be captured by the measure.

As an extension of this principle, it also means that the measure of defence exports is highly sensitive to the year or period used to estimate defence shares. Suppose the data sources used to estimate the defence share correspond to the year 2017. As there is no guarantee that 2017 is typical or representative of defence shares in other years, this could lead to over-estimation (or under-estimation) of defence exports in all other years. This is especially pertinent because the year used for estimating defence shares was selected solely on the basis of data availability.

The same defence share is often applied to blocks of commodity codes

Moreover, it often is not possible to estimate defence shares for each commodity code, and consequently the same defence share is often applied to blocks of commodity codes. For instance, in the case of Italy, the same defence share is applied to all commodity codes under the parent category of Aircraft & Parts. This means that variation in the defence share across product categories within Aircraft & Parts is not captured. This compounds the issues associated with accuracy and validity of trends discussed above.

Estimates of Germany defence exports require especially strong assumptions

Germany in particular requires strong assumptions for the estimation of defence shares. This is because, in the case of Germany, the share of goods exported for defence use is estimated using licence data. Licence purchases and licence use are not always well-aligned. Resultantly, there may be instances where licences are purchased but not in the same quantity as exports (i.e. not all licences are used) or even instances where the licences are not used at all.

Estimated export levels for the US raise questions about the reliability of the metric

Moreover, the levels of trade that result from the analysis raise questions about the reliability of the metric. US defence exports are estimated to be around £13bn in 2017. This result is contradicted by other sources describing US government-to-government Foreign Military Sales (FMS)[35], which was reportedly over $190bn in 2018. A potential explanation for this could be the relative coverage of defence exports sold by governments and ministries of defence (distinct from exports sold by the private sector).

Full details of defence shares, defence exports, methods and sources on a country-by-country basis are provided in Appendix E.

6.4 Concluding remarks and recommendations

Trade data and defence shares were applied to estimate G7 defence exports

This chapter has sought to gauge the feasibility of producing comparable and reliable defence export measures in G7 countries. A result of the exercise was that it is technically feasible to produce an estimate of defence exports for G7 countries. Trade data are available for all G7 countries using the Harmonised System nomenclature, and it is possible to produce a rough defence share based on a combination of government reports, sector organisations and licence documents.

The G7 defence exports estimates are unreliable and lacking credibility

However, although it is possible to produce an estimate of G7 defence exports, the resultant measure is relatively unreliable and arguably lacking credibility. Firstly, the impact of suppressions in the trade data is a concern. For France, Italy and (to a lesser extent) Germany, data on many defence-related goods are suppressed (e.g. munitions and warships) and thus are omitted from the estimate. These omissions lead to a downward bias in the overall measure and limit the extent to which the results can be compared, because the suppressions vary across countries and time.

Many assumptions are needed to estimate defence shares for the G7 countries

In addition, assumptions required to estimate defence shares are a potential source of inaccuracy. One such assumption is time-invariance. In most cases, the defence share is assumed to be fixed over time, meaning that year-on-year variation in the contribution of civil exports to exports of defence-related goods is not captured. As a result, it is often impossible to ascertain whether time-trends in defence-related exports are driven by civil or defence use.

Another assumption is that many diverse product categories are allocated the same defence share. For example, the same defence share is applied to all commodity codes belonging to Aircraft & Parts for Italy. In reality, some commodity codes will have a higher defence share than others. In treating blocks of commodity codes as being equal, this limits the power of the measure to reliably identify trends and patterns.

With regard to the strength of the assumptions required to estimate defence shares, US defence exports is, in principle, the most robust. For many

[35] Defense News (2018c).

commodity codes, defence exports can be taken directly from US census bureau data due to the level of detail in the trade data (10-digit). This means that there is less reliance on assumed defence shares.

The results appear to be dubious in several areas

However, the resultant measure for the US is dubious in several areas. The reported defence share of aircraft and parts appears to be implausibly high given the US's role in civil aviation and aerospace. Moreover, the measure of total US defence exports appears to contradict bulletins on US military transfers to foreign governments.

Producing credible and comparable estimates of cross-country defence exports is beyond the scope of the available data

Finally, although the trade sources are harmonised, there is still scope for divergence in the way that primary data are collected and stratified (e.g. the use of administrative or departmental sources to estimate government-to-government trade). Cross-country comparability of trade levels is therefore limited, meaning that it is not possible to reliably rank countries by exports of defence-related products.

For the reasons stated, we strongly recommend that caution is taken when the G7 defence trade metrics are consulted. Producing credible and comparable estimates of cross-country defence exports is likely beyond the scope of the publicly available data.

7 Conclusions

7.1 Key findings

Key strengths and weaknesses of the DSE and OTS approaches to estimating UK defence exports (on a delivery basis) have been further crystallised as a result of the analysis conducted in this project.

It is worth emphasising that this project has focused predominantly on furthering the understanding of how to estimate UK defence export deliveries in the short-term. Medium and longer-term options were identified in the feasibility study.

Assessment of the DSE approach

Application of the DSE approach has indicated that the method is transparent, and relatively easy to implement. While the comparability with other official datasets is questionable, in isolation the method is self-contained and feasible to implement for a long time series, assuming the validity of the underpinning datasets/information from SIPRI and DSE.

The DSE approach eliminates the need to estimate civil-defence shares

The greatest advantage of this approach is that it eliminates the need to estimate civil-defence shares. The primary data already isolates the defence content of the exports by restricting the sample frame to 'known defence exporters'[36]. Furthermore, as data on civil and non-civil use are limited post-2005, the DSE approach has the advantage of not being distorted by changes in the civil-defence share over time.

In conjunction, it is possible to decompose the estimates of UK defence export deliveries for each year into the contribution of individual deliveries, based on the order-level information from SIPRI. This increases the transparency of the approach, as it is possible to trace the volatility in the estimated series to individual orders (or lack thereof).

Nevertheless, a limitation of the approach is that the process of transposing orders to deliveries involves 'losing' certain years in the time-horizon. For instance, the orders data begin in 1988, so the approach will not provide a reliable measure of deliveries in 1988. This is because many of the deliveries in that year will have been ordered in previous years, which are, by definition, beyond the coverage of the orders data. In other words, a reliable time series of deliveries can be constructed only for years which are sufficiently well covered in the backlog of orders.

The DSE approach also relies on the information obtained from SIPRI being representative of the DSE export orders data; that is, there is sufficient alignment between the two datasets to permit the application of the delivery schedule to export order values.

However, the method relies on trend-indicator values as a statistical weight

In addition, a limitation of the DSE approach is that, when constructing the delivery schedule, it relies on trend-indicator values (TIV) as an indication of trade rather than the actual value of the sale. The final measure of defence export deliveries is the value of the sale, from the (transformed) DSE data. However, the statistical weight used to transform it uses TIV. TIV may not be sufficiently representative if order prices bear little correlation to the input costs (the latter on which the TIV measure is based).

[36] DIT DSE (2019a).

However, there are several reasons for using TIV as a statistical weight. Firstly, it is a consistent metric which is available for all delivered items. Secondly, although the approximate value of the deal is included occasionally in the comments section of the trade register, there is no consistent methodology which guides this estimate and, as a result, it is unclear how this value is calculated.

Assessment of the OTS approach

For the OTS approach, the work to develop estimates of UK defence exports using trade in goods data is relatively well-established and predates the work undertaken for this project. The identification of the relevant commodity codes and, to some extent, the techniques to partial out 'for defence use' implemented in this project build on research that has been conducted in the past. Therefore, our assessment is that there should not be too many technical or implementational barriers for DIT to adopt this approach, given their existing familiarity with the data.

One advantage of the approach is that, for specific commodity codes which are unsuppressed and there is not a need to apply defence shares, the approach can identify UK defence export deliveries (such as warships) relatively well. However, given the dominance of aircraft and aircraft-related defence sales, for which a defence share needs to be applied, the advantage has limited impact on the overall estimate of UK defence export deliveries.

The core dataset (OTS data) used for developing the estimate is very reliable, and gives a precise indication of the timing of deliveries, based on an internationally recognised and established conventions, albeit for goods only. It can be argued that in comparison to the DSE approach (which depends on non-official data obtained from SIPRI and survey-based statistics of defence orders), more confidence can be placed on the underpinning dataset used to derive the OTS estimate.

Existing reports indicate that previous attempts to use OTS data have explored similar datasets and sources, and, despite the number of years since those publications, the number of new sources which could be used to determine the component for defence use is limited. As a result, the limitations identified in previous publications persist.

Recent publications are of limited value for identifying defence share

Attempts to make use of more up-to-date data sources have yielded findings of limited usefulness in terms of taking the OTS approach forward. The use of SIPRI data to estimate the defence share was assessed to be of limited usefulness. The use of Prodcom data brings with it implicit assumptions surrounding the relationship between production of defence goods and exports of defence goods, and that relationship is not always obvious.

In addition, there are some commodity codes for which *no* methods have been identified for estimating the share for defence use (and so assumptions have to be applied).

The way of deriving defence share considered most sensible is a combined-method approach that incorporates as much information across years and products as possible. In practice, this means that the method considered most suitable uses both other than (o/t) civil shares from data pre-2006, as well as data from Prodcom for the latest years (with adjustments using data from SUTs to account for suppressions).

Estimating UK defence export deliveries by destination country

The level of granularity required to estimate UK defence export deliveries by destination country creates an additional challenge, because the data of UK goods exports by destination country are often suppressed or incomplete for many of the defence-related commodity codes. Furthermore, extending the OTS approach by extracting bilateral defence-related exports data and applying defence shares is considered unreliable and unfeasible.

As a result, it is considered most feasible to estimate UK defence export deliveries by destination, first by estimating total UK defence export deliveries (to the world), then by applying destination country shares. This would be conducted at broad product category levels, to account for heterogenous demand for UK defence products.

The suggested method to distribute UK defence exports by destination country is to use SIPRI data on deliveries to map total defence exports to defence exports by destination country. This relies on internal consistency of SIPRI, as well as the reliability of the estimate of total UK defence exports. This method, therefore, is not dissimilar to the principles underpinning the DSE approach of estimating total UK defence exports.

Furthermore, the approach relies on the coverage of 'defence' in SIPRI and OTS data being comparable. While it may be possible to derive a rough correspondence based on product groups and qualitative descriptions, the lack of an established mapping between the classifications used in the two sources means that the coverage across the sources remains an uncertainty associated with this approach.

Comparing UK defence export deliveries with other G7 countries

There are available sources for determining defence-related goods in all other G7 countries. These sources are based on trade in goods data and consistent with those adopted for estimating UK defence export deliveries to the world. For Germany, France and Italy, Eurostat Comext is a convenient source for compiling the data for defence-related commodity codes. For the US, Japan and Canada, national sources are used, as these often provide a higher-level of commodity detail than the UN Comtrade database. A key limitation, however, is the degree of suppressions in the data; for countries such as Germany, France and Italy, the level of suppressions is higher than for the UK, rendering the potential for comparing estimates of total defence-related exports (for both civil and defence use) to be extremely limited.

Identifying for defence-use requires additional and often unrealistic assumptions. A variety of different sources needs to be consulted and many ad-hoc (and often restrictive) assumptions need to be made. In instances where a source provides insight into defence exports, there is often not an obvious mapping to commodity codes, and typically the methodology for deriving those estimates cannot be traced. In the instance of France, for example, even though data on defence exports are available at the 2-digit NACE Rev. 2 level, the data are only available for one year, and it is unclear how the authors arrived at the estimation of defence values.

The exception to this is the US, for which more detailed defence data are available; trade data for commodity codes are available at the ten-digit level, which identifies for-defence use. However, cross-checking the implied defence shares with other countries' implied defence shares casts uncertainty regarding the reliability of the estimates.

Overall, the findings suggest that there is very limited potential to directly compare UK defence exports with the performance of other G7 countries based on the available data.

7.2 Developing an estimate of UK defence exports

Based on the work undertaken, and in the context of the project aim to estimate UK defence exports on a delivery basis, the key findings are:

Estimating UK defence export deliveries

- **While it is feasible to obtain estimates using both methods, the approach based on DSE and SIPRI data emerges as the recommended approach.** Although both approaches are imperfect, and are subject to assumptions and uncertainties, the overall strength of the assumptions and the scope for refinement suggest that the DSE approach is currently the preferred approach, and more suitable for future attempts to estimate UK defence exports on a delivery basis.
- **Based on the DSE approach, the defence exports on a delivery basis were estimated at £8.9bn in 2017.** The exports show an increasing trend between 1996 and 2017, although they appear to be volatile across years. The DSE approach in most years results in an estimate higher than that developed using OTS approach. These differences in the estimated exports and volatility of both series can be attributed to methodological differences.
- **The assumptions underpinning the DSE approach are considered to be more viable and less restrictive than the assumptions underpinning the OTS approach.** The primary concern surrounding the OTS approach is the lack of reliable and up-to-date data on the defence-use share of defence-related exports. From the analysis, the estimates are highly sensitive to the method of obtaining defence shares.
- **Very few up-to-date datasets can inform the defence content share of defence-related exports using the OTS approach, resulting in decreasing reliability of the estimates in the future.** The historical defence shares are extrapolated over many years, and therefore, the method is unable to fully reflect the variation in defence exports. For many defence-related goods, extrapolations use UK sales data rather than UK exports, and therefore rely on strong assumptions of the relationship between total sales and exports.
- **The OTS approach is highly sensitive to the method of obtaining the defence share for the Aircraft & Parts category.** This is because these codes dominate in terms of magnitude relative to other defence-related commodity codes, and as such the defence share assumptions for these codes have large implications on the estimate of the total UK defence exports deliveries. This also has implications on how comparable the OTS-based estimates are with the DSE-based estimates (in principle, the OTS-based estimate should always be lower in any given year, as it omits exports of services, and accounts for cancellations).
- **There is little that can be done to improve the robustness of the OTS estimate given the available data**. While there are uncertainties and potential inaccuracies associated with the SIPRI and DSE approach, some of the uncertainties can be validated by a more in-depth exploration of the DSE orders-level data.

- **The DSE approach arguably improves for estimates of deliveries in recent years, compared to earlier years.** When estimating the deliveries in any given year based on past orders, arguably, the longer the historical time series of orders before the delivery year, the better the estimate of deliveries in that given year.
- **There is, however, limited scope to cross-compare DSE approach estimates against other official data sources, restricting the potential to validate the derived estimates**.
- **Further work exploring the DSE microdata can help validate (or reject) some of the assumptions used.** In particular, it would enable a better understanding of the sample composition of DSE export orders, and the extent to which orders misalignment across years could lead to mis-estimation based on the publicly available data.
- **If there is scope for additional data collection, then it would be fruitful to consider introducing new questions to Prodcom and DSE export orders data on defence export deliveries.** Detailed exploration of the available datasets identified two data sources that could consider additional questions on defence export deliveries. The two data sources are: Prodcom, for which companies surveyed identify the proportion of products sold that are for defence use (and therefore additional questions may seek to identify the proportion of products sold for export for defence use); and company returns that underpin the DSE defence export orders publication (additional questions may seek to ask firms about export deliveries, in addition to existing data obtained on export orders).

Estimating UK defence exports by destination country

- **The preferred estimate of UK defence exports by destination relies on combining the information from SIPRI with the estimates of total UK defence export deliveries using OTS data.** Given the heterogeneity of UK defence exports by country, year and product type, it is imperative that any method to estimate exports by destination country is not overly reliant on assumptions relating to UK defence exports to the world. Therefore, the suggested method relies on country and product-level data to distribute total UK defence exports by product category and country. Even so, the accuracy of the estimate and method is judged as limited.

Estimating defence exports for other G7 countries

- **Caution must be exercised in trying to compare UK defence export performance with other G7 countries using the available data.** Restrictive assumptions are often needed to develop the 'for defence use' share of each commodity code because of limited data availability. Furthermore, in instances where data are available to inform the defence share, the level of detail is often insufficient to identify the defence share at the commodity-code level, or the methodology underpinning the data cannot be readily identified (and as such cannot be assessed for its reliability and robustness). In other cases, data for some goods are suppressed entirely, reducing the reliability of the measure and the extent to which estimates of defence exports can be compared across countries.

Appendix A Detailed description of DSE approach methodology

A.1 Overview

The approach to estimating UK defence exports using a delivery schedule and DSE data has 6 main steps:

4. Match, merge and validate the SIPRI data (trade registers and trend-indicator values [TIV] tables)
5. Estimate the TIV of undelivered items
6. Estimate the share of delivered items by delivery year for each order year
7. Collate the proportion of deliveries into a matrix
8. Apply the matrix to orders data to produce an estimate of deliveries
9. Adjust the estimate to account for pre-1988 orders

This section discusses the methodology and data requirements of this process in greater detail.

A.2 Data requirements

Three main data sources are used in the DSE approach: (1) SIPRI trade registers[37]; (2) SIPRI trend-indicator value (TIV) tables; and (3) DIT DSE UK defence export figures[38].

SIPRI data are compiled from various public sources

SIPRI data are compiled from various public sources, such as:

- defence White Papers and similar policy documents;
- press releases, annual reports and other information published by arms producing companies;
- the United Nations Register of Conventional Arms (UNROCA);
- national reports on arms exports and imports;
- defence budget documents and parliamentary records; and,
- newspapers and other periodicals.

SIPRI trade registers are detailed written reports of the observed international flow of major conventional arms. Arms flows (or arms transfers) are defined as the physical transfer of military equipment, the transfer of technology or provision of a licence to manufacture a product abroad.

SIPRI trade registers include detail on both the year of order and year(s) of delivery

Most importantly, SIPRI trade registers include detail on both the year of order and year(s) of delivery. There is also a relatively high level of detail on the nature and volume of the items transferred. The broad product description (e.g. FGA aircraft) is provided alongside the specific product designation (e.g. Typhoon Block-20) for all items listed in the register. The number of items ordered and delivered so far are also included. Detail on the recipient is available. Finally, any further information about the deal or item is provided in a comments section. This occasionally includes information regarding the sale value of the item or the trade deal to which the transfer is attributed.

[37] SIPRI (2018b).

[38] DIT DSE (2019a).

SIPRI provide a consistent metric of the volume of international arms transfers

SIPRI also provides a consistent metric of the volume of international transfers of arms: the trend-indicator value (TIV). The TIV is calculated using the known unit production costs of a core set of major conventional arms. Using these core unit costs, the TIV for all items is calculated by interpolating between the core set of unit costs based on various weapon characteristics such as weight, speed and range.

SIPRI has recently increased the functionality of their TIV tables to enable the user to extract all data on arms transfers. This increases the usefulness of the source and, thus, these data play a considerable role in the estimation of the delivery schedule.

For the purpose of this report, the publicly available DIT DSE defence orders figures are used.

A.3 Description of methodology

Trade registers and TIV tables were merged

The first step taken in the estimation of the delivery schedule was to match and merge the data from SIPRI trade registers and TIV tables. There are typically more entries in the TIV tables than the trade registers. This is because each entry in the TIV table represents a delivery, whereas each entry in the trade register can be thought of as an order (with the possibility of the order being undelivered).

In order to make full use of the details in the SIPRI ATD, it was necessary to combine the TIV dataset with the trade register.

In the first instance, this was done by identifying unique entries in both the trade register and the TIV tables. The variables used to match were product designation, order year and recipient country. Four outcomes occurred as a result of this process:

1. **The data were matched 1-to-1**: This occurs where there is a single delivery year.
2. **The data were matched n-to-1:** This occurs where there are multiple delivery years for the same order, but all deliveries have the same Deal ID in the TIV tables. In this instance, the entry in the trade register is repeated.
3. **There are no matches in the TIV tables:** This occurs only for recent years, where an order has not been delivered. In this instance, the unmatched trade register entry is added to the merged dataset with * added for TIV variables.
4. **The item in the trade register is not unique:** This occurs where there have been multiple orders of the same item, by the same country, in the same year. In this instance, we match again using quantities delivered for each unique Deal ID.

The matched data were validated using spot checks

The risk associated with data-matching is that it is possible to incorrectly merge data entries which do not belong to one another. To mitigate this risk, the following steps were taken:

- The matching process was automated to avoid human error.
- Automated tests were run to check for the quality of the matches.

- Several spot checks were carried out on the merged dataset to ensure the validity of the dataset.
- The final merged data were inspected for each order year when added to the delivery schedule dataset.
- After carrying out the checks listed above, the results indicate that the data were matched to a high-degree of confidence.

TIV was estimated for undelivered items

For transfers which have been ordered but not yet delivered, these will appear in the trade registers but not in the TIV tables. Thus, for undelivered items, TIV had to be estimated on the basis of previous trades of the same/similar products. In most cases, there were examples of identical products which were recently transferred, and it was therefore possible to produce a reliable estimate. In cases where examples of identical products were not available in the trade history of UK exports, TIV values of the parent category were used.

Several weapon designations needed to be approximated using TIV values from the parent category

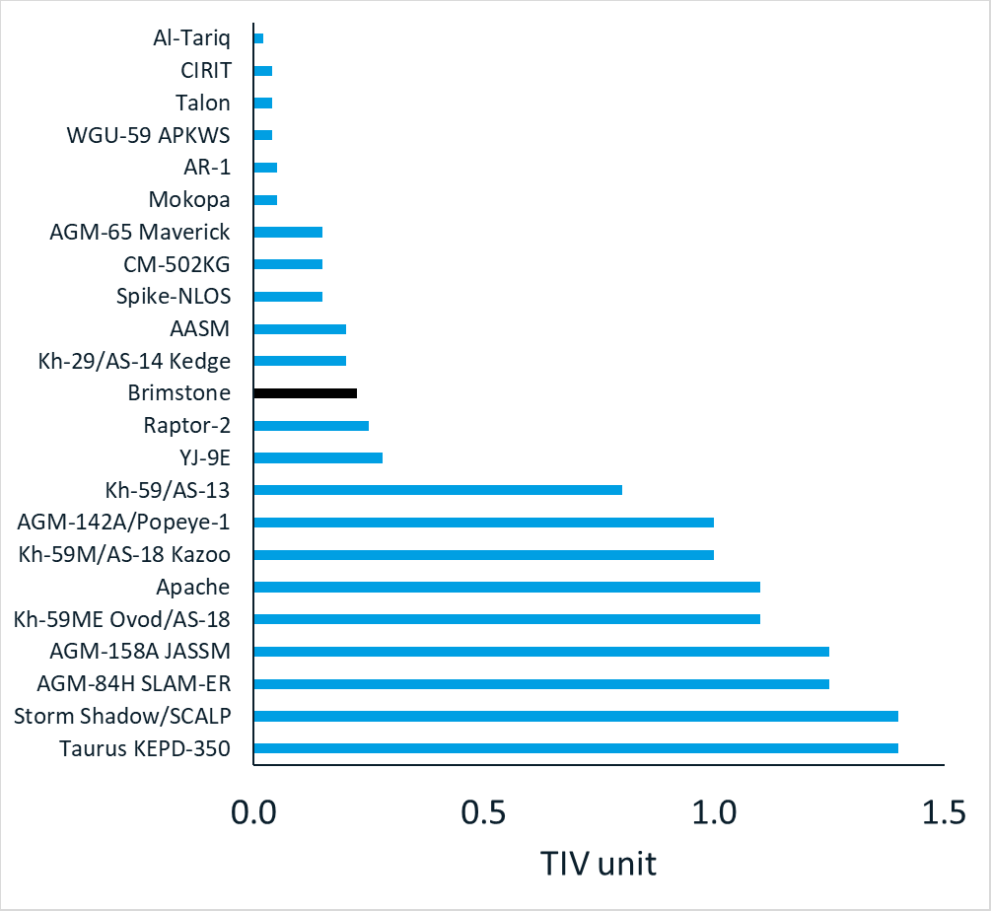
Four weapon designations have no previous trade deals to estimate their unit value and must be approximated using TIV values from the parent category:

- Brimstone
- CAMM
- Ocean
- Raven ES-05

Figure A-1 presents the distribution of TIV unit values among the parent category of Brimstone, Air-to-Surface Missiles (ASM). The TIV unit of Brimstone is estimated using the median value of parent category (0.225). A very large variation in TIV units is observed across the parent category with the largest TIV unit being 70-times larger than the smallest, and over 10-times larger than the current estimate for Brimstone.

However, the only appearance of Brimstone items in UK export trade is in 2017 as an export to Saudi Arabia. Because a high percentage of orders in 2017 are already undelivered (98.35%), the delivery schedule is not sensitive to the TIV unit value, increasing the proportion of undelivered items to 98.89% where the highest observed TIV is adopted.

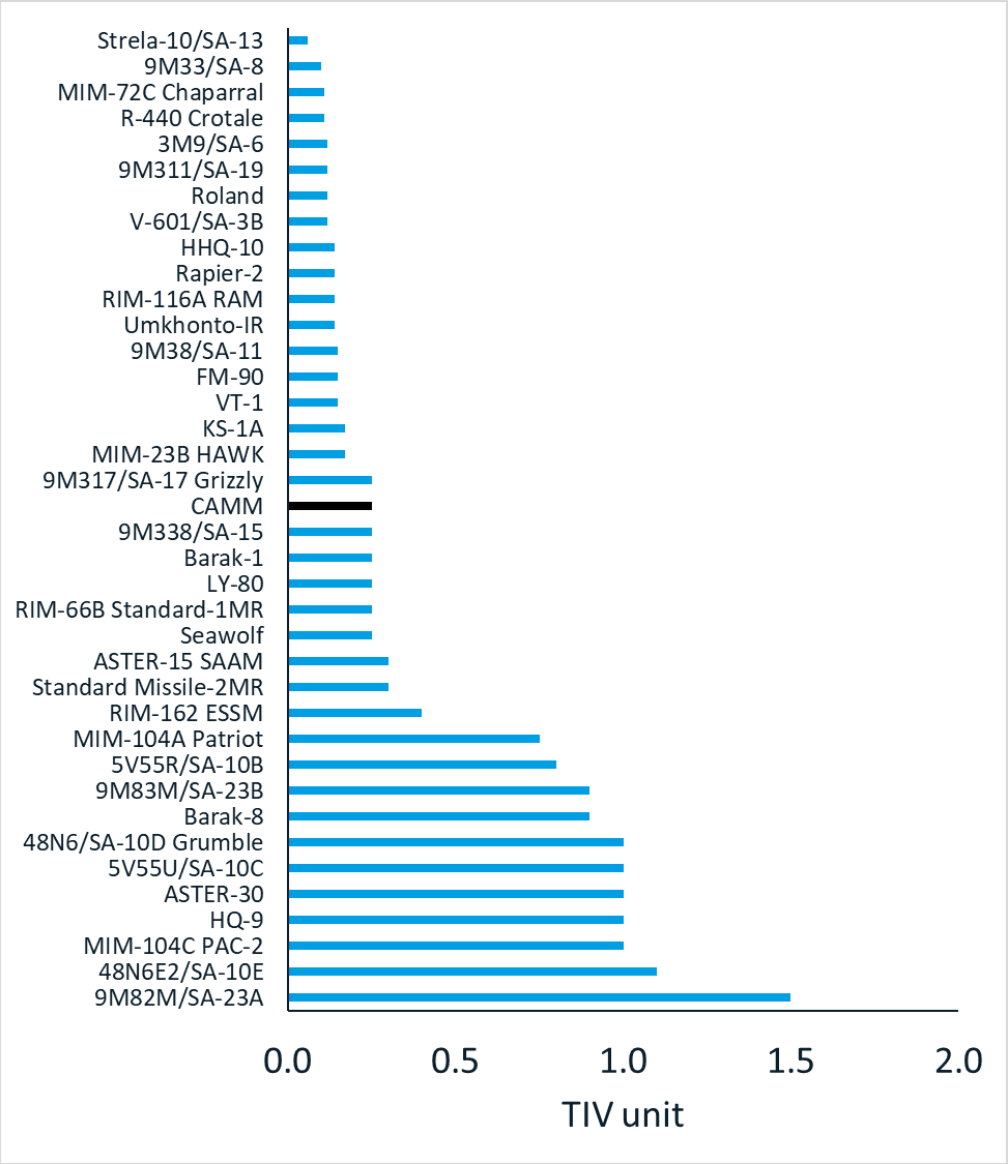
Figure A-1: Distribution of TIV units for Air-to-Surface Missiles (Brimstone estimate included)



Sources: SIPRI ATD (Trade Registers and TIV tables).

Figure A-2 presents the equivalent distribution for Surface-to-Air Missiles (SAM), with CAMM TIV approximated as 0.25 per unit. There is also considerable variation in the TIV estimate of this weapon type with the highest TIV unit amounting to 25-times that of the lowest. It is not possible to deduce the sensitivity of the delivery schedule to the estimated TIV unit because, in many cases, the number of units sold is unknown.

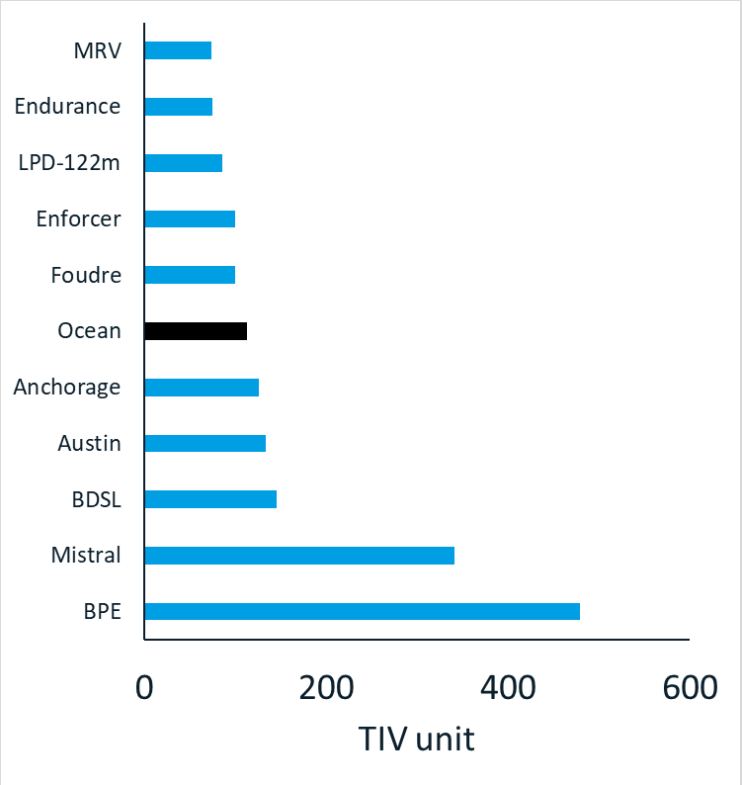
Figure A-2: Distribution of TIV units for Surface-to-Air Missiles (CAMM estimate included)



Sources: SIPRI ATD (Trade Registers and TIV tables).

Figure A-3 illustrates the TIV units for items classified as Amphibious Assault Ships. Relative to missiles, there is less variation in the TIV unit across weapon designations, with the most valuable items amounting to less than seven times that of the lowest value items per unit. Moreover, as only one of these items was ordered, and as the order was received in 2017 (connotations discussed earlier), the delivery schedule is not sensitive to the way the TIV unit of Ocean vessels is estimated.

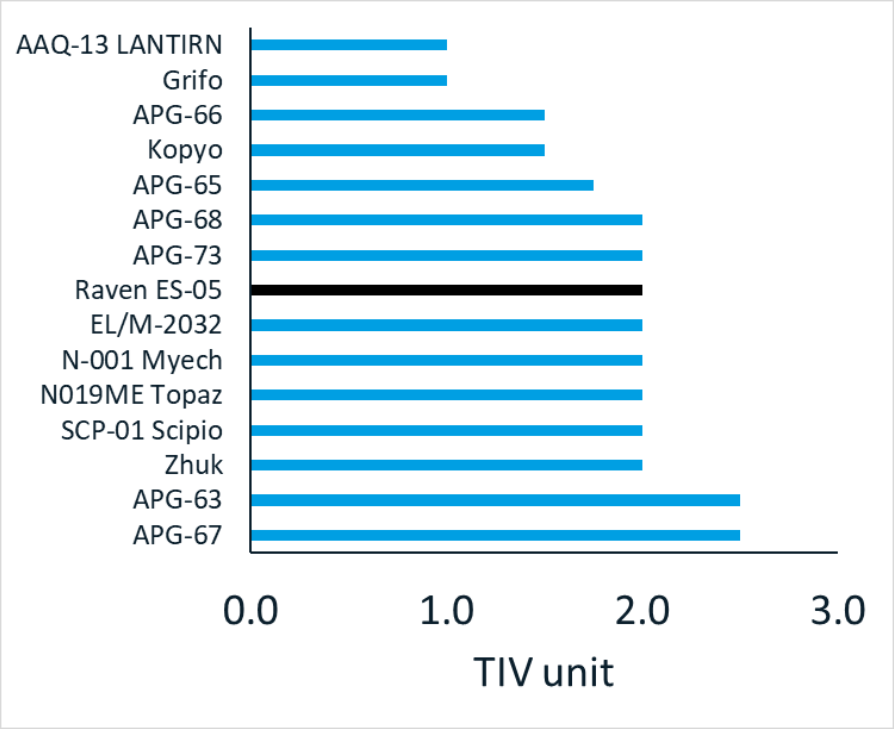
Figure A-3: Distribution of TIV units for Amphibious Assault Ships (Ocean estimate included)



Sources: SIPRI ATD (Trade Registers and TIV tables).

Finally, the TIV unit of Combat Aircraft Radar is presented below. There is noticeably little variation in TIV units across weapon designations, with the highest value item only 25% higher than the Raven ES-05 (estimated using the median), and 2.5-times higher than the lowest value item. Despite this, the estimation of TIV units for this value is still the most sensitive in percentage terms. If TIV were the observed maximum (2.5) rather than the median (2), this would lead to a 2 percentage point increase in the percentage of undelivered items in 2014 (73% from 71%). Conversely, if the TIV unit were the observed minimum, this would lead to a 6 ppt decrease (65%).

Figure A-4: Distribution of TIV units for Combat Aircraft Radar (Raven ES-05 estimate included)



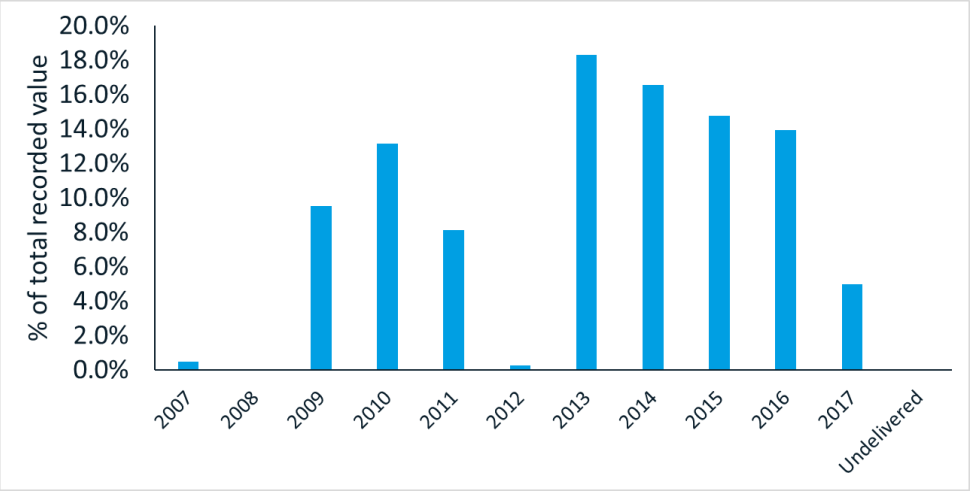
Sources: SIPRI ATD (Trade Registers and TIV tables).

A proportional delivery schedule is constructed for each order year

Once the SIPRI data have been merged and the TIV of undelivered items have been estimated, it is possible to build a proportional delivery schedule. This is done by compiling all orders pertaining to a single year and calculating the volume of trade that has been delivered across the proceeding years. The volume of undelivered orders is also included on the basis of undelivered items in the trade register.

Figure A-5 presents an example of what such a delivery schedule would look like. The example is taken from the provisional delivery schedule for Phase 2 (all arms) ordered in 2007.

Figure A-5: Delivery Schedule for Defence Exports Ordered in 2007



Sources: SIPRI ATD (Trade Registers and TIV tables).

The result is a matrix which converts orders to deliveries

When a delivery schedule for all relevant order years has been constructed the mapping can be structured into 'matrix form' such that all delivery and order years are represented. This is the final product of the delivery mapping analysis and can be applied directly to orders data to estimate deliveries. The matrix estimated from this analysis is presented in Section 2.2.

If **X** is the delivery matrix – containing elements which describe the proportion of orders in year *i* were delivered in year *j* – and **o** is a vector of defence orders, then the product of the two matrices will be an estimate of deliveries.

$$\begin{bmatrix} x_{1988,1988} & \cdots & x_{t,1988} \\ \vdots & \ddots & \vdots \\ x_{1988,t} & \cdots & x_{t,t} \end{bmatrix} \begin{bmatrix} O_{1988} \\ \vdots \\ O_t \end{bmatrix} = \begin{bmatrix} D_{1988} \\ \vdots \\ D_t \end{bmatrix}$$

Finally, an additional adjustment is made

Finally, an additional adjustment is made to account for orders which are received before 1988. This is done using TIV values in the SIPRI dataset. Specifically, the SIPRI TIV tables can be used to estimate the share of TIV deliveries in all years which are ordered before 1988. Once this is calculated, the inverse is multiplied to the initial deliveries estimate.

For example, suppose the initial estimate of deliveries in 1995 is £10bn based on orders data over 1988-1995, but we suspect that this estimate undervalues defence deliveries because some deliveries in 1995 were from orders received before 1988 (and are therefore not included in the DSE data). Suppose we approximate the share of orders received before 1988 (using TIV values) to be 80%. We conclude that the current estimate for 1995 deliveries captures 80% of the value of deliveries and can adjust proportionally. The adjusted estimate would be £10bn x 1/0.8 = £12.5bn.

Appendix B Methods for estimating defence share of defence-related goods exports

B.1 Historical 'other than civil' shares

Description of findings

One method to derive estimates of the share for defence use is to adopt the implied defence share based on 'for civil use' and o/t civil use in the historical OTS data. This is only possible for selected commodity codes (a subset of those considered as dual-use, and none of those classed as military). The estimates of the defence share for these commodity codes using this method are outlined in

Table B-1.

Table B-1: Implied defence shares based on historical o/t civil codes (%).

Description	1996	2000	2005	Average (1996-2005)
New pneumatic tyres, of rubber, of a kind used for aircraft	40	59	27	41
Spark-ignition reciprocating or rotary internal combustion piston engine, for aircraft	55	47	52	58
Parts suitable for use solely or principally with internal combustion piston engine for aircraft, n.e.s.	66	77	67	68
Turbojets of a thrust <= 25 kN	62	70	92	74
Turbojets of a thrust > 25 kN but <= 44 kN*	10	5	3	5
Turbojets of a thrust > 44 kN but <= 132 kN*	10	5	3	5
Turbojets of a thrust > 132 kN*	10	5	3	5
Turbopropellers of a power <= 1.100 kW	36	37	94	38
Turbopropellers of a power > 1.100 kW but <= 3.730 kW**	90	48	80	81
Turbopropellers of a power > 3.730 kW**	90	48	80	81
Parts of turbojets or turbopropellers, n.e.s.	28	24	43	33
Reaction engines other than turbojets	71	88	38	73
Radar apparatus	96	96	98	96
Gliders, without motor and not capable of being fitted with a motor, and hang gliders; balloons and dirigibles (excl. party balloons)	22	14	36	26
Helicopters of an unladen weight <= 2.000 kg	31	3	1	3
Helicopters: of an unladen weight exceeding 2000kg	67	94	86	86
Aeroplanes and other aircraft, of an unladen weight not exceeding 2000kg	97	30	49	79
Aeroplanes and other aircraft, of an unladen weight exceeding 2000kg but not exceeding 15000kg	70	66	4	74
Aeroplanes and other aircraft, of an unladen weight exceeding 15000kg	0	6	11	4
Propellers and rotors and parts thereof	39	39	50	34
Under-carriages and parts thereof	16	5	14	10
Other parts of aeroplanes or helicopters	44	22	23	28
Parts of aircraft, n.e.s. (excl. of spacecraft, incl. satellites, and suborbital and spacecraft launch vehicles)	N/A	61	71	67
Ground flying trainers and parts thereof, n.e.s. (excl. air combat simulators and parts thereof	45	4	21	8
Telescopic sights for fitting to arms; periscopes; telescopes designed to form parts of machines, appliances, instruments or apparatus of Ch. 84, 85 or 90	-	-	-	71
Other pts & acc o/t liquid crystal devices	-	-	-	5

Notes: * Estimates are based on commodity Turbojets: for use o/t civil aircraft. ** Estimates are based on commodity Turbo-propellers & other engines & motors o/t civil of a power >1100KW.

Sources: CE calculations based on HMRC OTS.

The estimated o/t civil shares vary significantly across the years for multiple commodity codes. This could be explained by the nature of large orders and deliveries for certain items, such as aircraft and their parts, which account for majority of the codes. Defence shares for 'Telescopic sights for fitting to arms; periscopes; telescopes designed to form parts of machines, appliances, instruments or apparatus of Ch. 84, 85 or 90' and 'Other pts & acc o/t liquid crystal devices' are based on codes introduced in 2017, which identified separately components for arms[39].

Assumptions and sensitivity analysis

The 'civil' and 'other than civil' shares are only available for years 1996-2005, and hence, it is necessary to extrapolate these defence shares forwards.

Three methods of extrapolating value of exports in historical o/t civil codes have been evaluated as part of the exercise. These methods involved extrapolating the historical o/t civil ratios forwards based on:

- Method 1: taking the last year of available o/t civil share of the commodity code (typically 2005);
- Method 2: average of all available years when o/t civil share of the code could be obtained (typically 1996-2005);
- Method 3: applying the average growth rate of the o/t civil share over time to the o/t civil share in the last available year.

To calculate UK defence exports using extrapolated historical o/t civil shares, numerous assumptions are required.

'Other than civil use' does not only constitute goods for defence use

The strongest and most rigid assumption underpinning any use of o/t civil use ratios as a proxy for defence use is the assumption that exports in historical o/t civil codes cover only defence items. From the Pilot Military Trade Validation Exercise conducted by HMRC[40], this has been confirmed to not be the case, with a substantial amount of exports in these codes being of non-military nature and classified under the o/t civil code due to end use control criteria[41]. The assumed share is therefore likely an upper-bound estimate of defence content in these codes.

Using extrapolation methods 1 and 2, the ratios for defence use would remain constant going forwards. From the comparison of the historical ratios obtained using different years in

[39] These shares are based on the assumption that 100% of arms components in these codes are for military use. The shares can therefore be applied simultaneously with defence shares obtained for the relevant corresponding arms codes under additional assumptions.

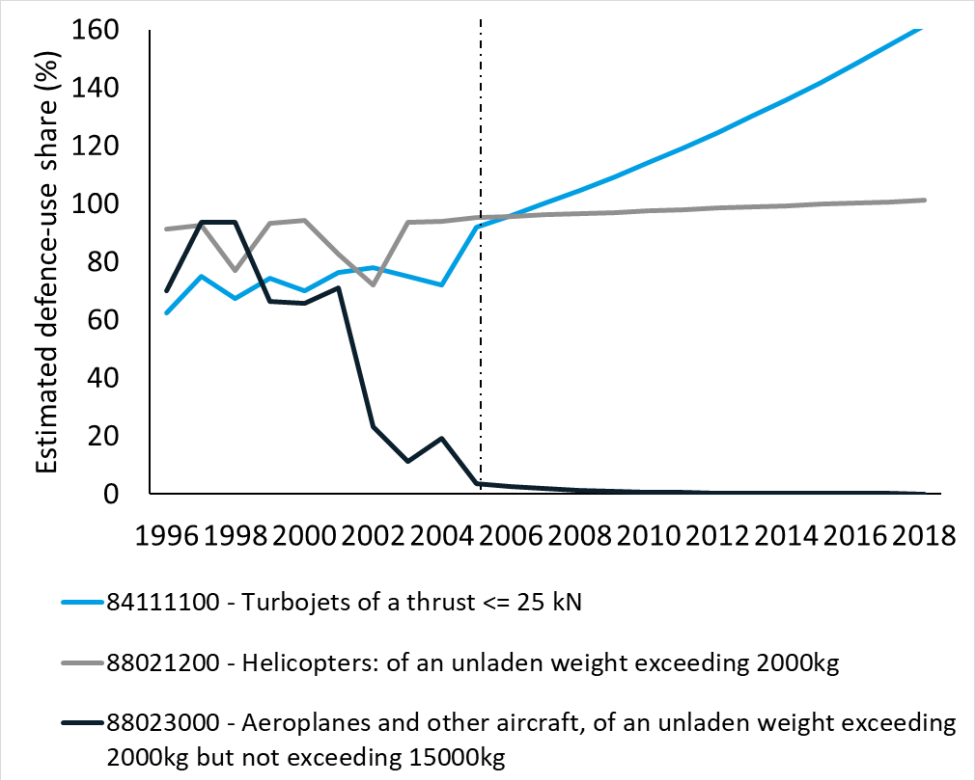
[40] Baldock, Lonsdale and Sams (2006).

[41] UKDS Review Team (2005)

Table B-1, ratios varied greatly across years, likely reflecting the 'lumpiness' of defence deliveries. In this case, between extrapolation methods 1 and 2, the latter (average o/t civil ratio calculated for all available years) may potentially serve as a more reliable method, provided that there was no underlying time trend in the relative share of defence to civil exports in these codes, and assuming that the series of interest is not necessarily the export value on a year-by-year basis.

Extrapolation method 3 which uses the trends in estimated defence shares (rather than the levels), is not considered a viable approach. In most cases at the individual product level, no apparent time trends were observed. In cases where a trend was observed, the estimated growth rates of o/t civil share were implausibly fast: implying that within only few years, o/t civil exports would account for all (100%) exports in that category, or none (0%), as presented for selected codes in Figure B-1.

Figure B-1: Extrapolations of selected o/t civil ratios based on the average growth rates in 1996-2005



Notes: O/t civil ratios for 2006-2017 have been extrapolated using 1996-2005 growth rates, and reach implausible values.
Sources: CE calculations based on HMRC OTS.

Additional assumptions must be employed to apply the extrapolated o/t civil ratios to codes which have been subsumed or split out during revisions to the classification on which the data are based. For example, this is observed in the case of 'Turbopropellers of a power > 1.100 kW but <= 3.730 kW' and 'Turbopropellers of a power > 3.730 kW', which were subsumed into a single code in 2006 given revisions to the Combined Nomenclature classification system.

B.2 UK Prodcom

Description of findings

UK Prodcom data on UK business sales distinguish between sales of products based on their use for civil and military purpose. The estimated military shares of UK output are based on two broad Prodcom codes:

- 30309999 – 'Manufacture, installation and repair of military aircraft and parts thereof', as part of the general-use code 3030 – 'Manufacture of air and spacecraft and related machinery'
- 25408999 – 'Manufacture of military weapons and parts thereof', as part of the general-use code 2540 – 'Manufacture of weapons and ammunition'

From the CN8-Prodcom correspondence tables, these two Prodcom codes correspond to multiple OTS codes classed as military and dual use, which are presented in table B-2

Table B-2: Defence shares based on Prodcom codes (%)

OTS Code	Prodcom code	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
84071000 84091000 84111100 84111210 84111230 84111280 84112100 84112220 84112280 84119100 84121000 88010010 88010090 88021100 88021200 88022000 88023000 88024000 88031000 88032000 88033000 88052100 88052900	3030 - Manufacture of air and spacecraft and related machinery	44	50	47	43	43	44	40	40	34	36
93020000 93051000 93063010	2540 - Manufacture of weapons and ammunition	-	-	-	96	96	95	94	-	-	-

Sources: RAMON classification tables (Eurostat, n.d. a); ONS; CE calculations.

The estimated defence shares for the UK Prodcom code 3030 show a declining trend, with the estimated military share of about 47% in 2008-2010, declining to about 37% in 2015-2017 period. For Prodcom 2540, the military share ranged between 94 to 96%, although data are available only for the 4-year period between 2011 and 2014.

Coverage and comparability

In past Quality and Methodology Information publications of Prodcom data, the ONS has highlighted concerns regarding the discrepancies between international trade statistics data (OTS in this context) and the Prodcom data. Before 2013, Prodcom data were published alongside trade data obtained from the OTS database, but this was discontinued given these concerns (p.8, ONS, 2018a). A reference made to further efforts to review the trade data with a view to reintroducing it for comparability (ibid.) cannot be sourced. As a result, the direct comparability of between Prodcom and OTS statistics should be treated with caution.

Prodcom and OTS data are not necessarily consistent due to coverage and valuation discrepancies

The following relevant discrepancies are outlined in metadata documents (ONS, 2018a):

- Coverage – Prodcom records the value of UK manufacturers' product sales, whereas OTS covers total UK goods exports.

- Valuation – Prodcom data are valued at price sold by UK manufacturers, whereas trade statistics record value of goods exports on a FOB delivery terms basis.

These differences in coverage and valuation could exert a downward bias to Prodcom data relative to OTS (and thus a lower estimate of civil share, resulting in a higher estimate of o/t civil share).

Other assumptions

- In addition, applying the military share of UK output to obtain the defence share of exports requires an assumption that these shares are identical for domestic market and exports market.
- Furthermore, the level of aggregation in Prodcom data makes it impossible to calculate individual defence shares for specific OTS codes of interest. While for some codes it is plausible to assume these to be identical across the broad parent category of products, certain codes are likely to be significantly above or below the weighted average obtained from Prodcom data.
- This is especially relevant for obtaining the defence share of OTS codes mapping to Prodcom 2540 – 'Manufacture of weapons and ammunition'. Multiple other commodity codes, which have not been classed as military and dual use, map to Prodcom 2540. At the same time OTS code 93020000 – 'Revolvers and pistols (excl. those of heading 9303 or 9304 and sub-machine guns for military purposes)' explicitly excludes small arms for military purposes, but maps to Prodcom 2540.

The Prodcom data collection methods are currently based on paper questionnaires and, at present, there are no plans to introduce electronic collection methods until 2021. In the initial collection from the statistical unit (enterprise), matching of products to Prodcom codes is conducted by ONS on the basis of product descriptions. In further collections, ONS provides pre-filled questionnaires with previously registered product categories, as well as additional space for new products (not fitting the pre-populated categories), which are subsequently matched to other Prodcom codes by ONS upon the receipt of the response. The reliability of the Prodcom military and non-military use classification is therefore dependent on the accuracy of product descriptions and accurate disclosure of sales of new products.

The Prodcom survey covers all enterprises in employment size bands over 100 employees. For SIC sectors where a large variance in produced goods is found, the survey includes all enterprises with more than 20 employees. The sampling rate of defence-related manufacturing enterprises therefore should be sufficient to accurately represent the industry composition of sales.

The resulting defence shares obtained using Prodcom are substantially higher than these obtained using o/t civil ratios, which, as previously discussed, on their own could be considered an upper-bound estimate of the defence share for the considered codes. The comparisons between Prodcom and o/t civil defence shares, however, cannot be made directly as the periods for which they were obtained do not overlap (o/t civil shares could be obtained for years 1996-2005, while Prodcom military shares could be obtained only for years 2008-2017). As an extension, other sources of data could be employed to verify these assumptions independently, such as the technical knowledge on arms use in these categories.

On the other hand, the limited coverage of Prodcom military shares could, to some extent, be overcome by applying them to similar OTS codes not directly mapping to Prodcom, and extrapolations across years.

B.3 SIPRI exports in units

Description of findings

In this approach, SIPRI data on deliveries of defence exports, measured in units, are compared to HMRC OTS data on exports (in units) in the corresponding codes to obtain their defence share. The mapping of OTS Codes to SIPRI Armament Categories and detailed descriptions of the methodology are available in Appendix F.

Selected estimates of defence shares for product categories corresponding to military and dual use codes where OTS data in units are presented in Table B-3.

Table B-3: Estimated defence shares based on SIPRI data in selected years (%)

Identified SIPRI category	Corresponding OTS commodity code (for which there is no unit suppression)	1996	2005	2010	2017
Turbofan and Turbojet engines	84111100 84111210 84111230 84111280	1	1.2	1.9	0.1
Turboshaft and turbopropeller engines	84112100 84112220 84112280	1.9	2.2	0	0
Helicopters	88021200 88021200	-	-	-	1.9
Aeroplanes	88022000 88023000 88024000	-	-	-	1.5

Sources: CE calculations based on SIPRI database and HMRC OTS.

The estimated defence shares based on units are considerably lower compared to estimates obtained using alternative methods and show great variance over time. For example, for Turbofan and Turbojet engines, the estimated defence share based on units ranged from 0.04% in 2016 to 4.5% in 2012, which could be driven by the bulky nature of defence deliveries registered in SIPRI database. The average estimated defence shares in units of production for codes comprising of engines for aircraft are below 1%. The estimated shares are greater for Helicopters and Airplanes categories, although these are based on 2015-2017 data – the only years where overlapping data from both sources were available.

Assumptions and sensitivity analysis

The premise underpinning the validity of the method is the assumption of full coverage of military exports in SIPRI data for the corresponding items in OTS codes. The estimated shares therefore should be viewed as the lower-bound estimate of defence exports for the corresponding codes, as the coverage of SIPRI data is likely less than comprehensive. The coverage of the SIPRI database is considered in detail in Chapter 2.

The key difficulty in applying the defence shares based on units to derive the defence exports in value is the requirement for additional assumption on the relative value per unit of defence and civil use items.

If the defence shares in units were to be applied directly to estimate defence share in values, the implicit assumption would be setting equal price per unit for military and civil items. To assess the feasibility of such assumptions, OTS trade data were extracted for products which distinguish between civil and o/t civil codes in the historical data, on both a monetary value and per unit basis.

The value per unit comparisons of civil and o/t civil codes could only be obtained for codes included in the broad 'Turbofan and Turbojet' and 'Turboshafts and Turbopropellers' categories[42]. For these codes, the values per unit estimated using HMRC data did not appear sensible, and varied greatly across years, rendering the method unreliable.

Furthermore, the level of suppressions in OTS data in units greatly limits the availability of ratios, and these could only be obtained for dual use commodity codes identified in Table B-3.

The results are limited in their plausibility

Estimates of the defence share for OTS codes based on SIPRI deliveries in units present an alternative insight, which is assessed as downward-biased and close to the lower-bound, compared to using o/t civil ratios and UK Prodcom shares.

Due to suppressions of OTS exports data in units, only a narrow group of dual-use codes can be analysed, and it is unlikely that the estimated shares could be reliably applied to other products, especially in military codes.

B.4 Europroms

An alternative strand of investigation centred around estimating defence shares based on Eurostat Europroms exports data. In addition to the data provided in the UK Prodcom dataset, Eurostat Europroms seem at first glance to provide information at the same level of detail as UK Prodcom, but for 2009 onwards. Therefore, in comparing the Europroms data (which cover exports of items for civil use) with the HMRC data at the product level (which covers both civil and non-civil use), it could be possible to construct an estimate of 'other than civil' share, which would allow to estimate defence share of exports for more recent years than what is available in HMRC data.

Europroms data do not provide additional information on UK defence exports

However, through further investigation, the individual codes in Europroms that specify 'for civil use' are assessed to be a misleading choice of labelling. In further detail, the trade data found in Europroms are compiled using data from the Comext database, through mapping the relevant commodities from the Comext classification (defined under the Combined Nomenclature classification – the same as OTS) to the Prodcom classification (of which the first four digits are equivalent to the NACE classification system). The Comext data are compiled from the OTS database. The OTS data for the equivalent commodity codes (covered for both civil and non-civil use) are directly transposed to the Comext data, with no adjustments to partial out the component for civil use.

For example, data on exports for Prodcom code 30303200, are labelled in Europroms as 'Aeroplanes and other aircraft of an unladen weight <= 2 000 kg, for civil use'. This is equivalent in monetary value to data in Comext for code

[42] For certain codes within these items additional assumptions are required. Due to 2005 merging of civil and o/t civil codes, products in these codes have been disaggregated based on thrust or power, which previously was not the case.

'88022000 (aeroplanes and other powered aircraft of an unladen weight <= 2.000 kg (excl. helicopters and dirigibles))'. At the same time, the Comext data are equivalent in monetary terms for this series to the data reported in the OTS (converted from Sterling to Euros). As a result, this indicates misleading 'civil use' labelling in Europroms.

Given these findings, Europroms data are assessed to be of no usefulness for our purpose.

B.5 ITC Trade Map database

The trade database maintained by the ITC comprises of data from UN Comtrade and supplementary resources for over 5000 products[43], and was examined as a potential source of data to estimate UK defence exports.

ITC Trade Map does not provide additional insight on UK defence exports

From the data assessment, the exports data collected by the ITC do not provide greater disaggregation than data available in OTS. The 10-digit National Tariff Line (NTL) level data for all military and dual use codes do not provide further disaggregation than CN8. Where 10-digit level data are available, 8-digit codes are suffixed with '00', and the relationship between exports in the 10-digit code and exports in the 8-digit category is 1:1.

In comparison to OTS data, there appear to be additional gaps due to suppressions. For example, higher level aggregation data, where individual codes have been supressed, is available in the OTS database, but not in ITC Trade Map database.

Given these findings, ITC Trade Map data do not provide a greater level of disaggregation than OTS data, and are assessed to be less reliable.

B.6 Sensitivity analysis of selected methods

To test the sensitivity of the total defence exports estimate to the choice of assumptions, alternative estimates based on extrapolated o/t civil ratios have been calculated and compared to the estimates based on the combined o/t civil and Prodcom method, as well as the mixed approach described in Chapter 3.

Two alternative methods of extrapolating o/t civil ratios are considered:

- extrapolation of the o/t civil ratios using the last available year data
- extrapolation of the average o/t civil ratios calculated on the basis of all available years in which the o/t civil code is available (based on a weighted average)

Estimates based on extrapolated o/t civil ratios rely on additional assumption-based shares for codes where o/t civil ratios could not be obtained. For these codes, assumed defence shares are set to 0% if the code is classified as 'dual use', and at 100% if the code is listed in ARSEC.

Figure B-2 presents a comparison of estimated UK defence exports using three methods:

- combined o/t civil and Prodcom ratios;
- o/t civil last available year ratio;

[43] ITC Trade Map (n.d.)

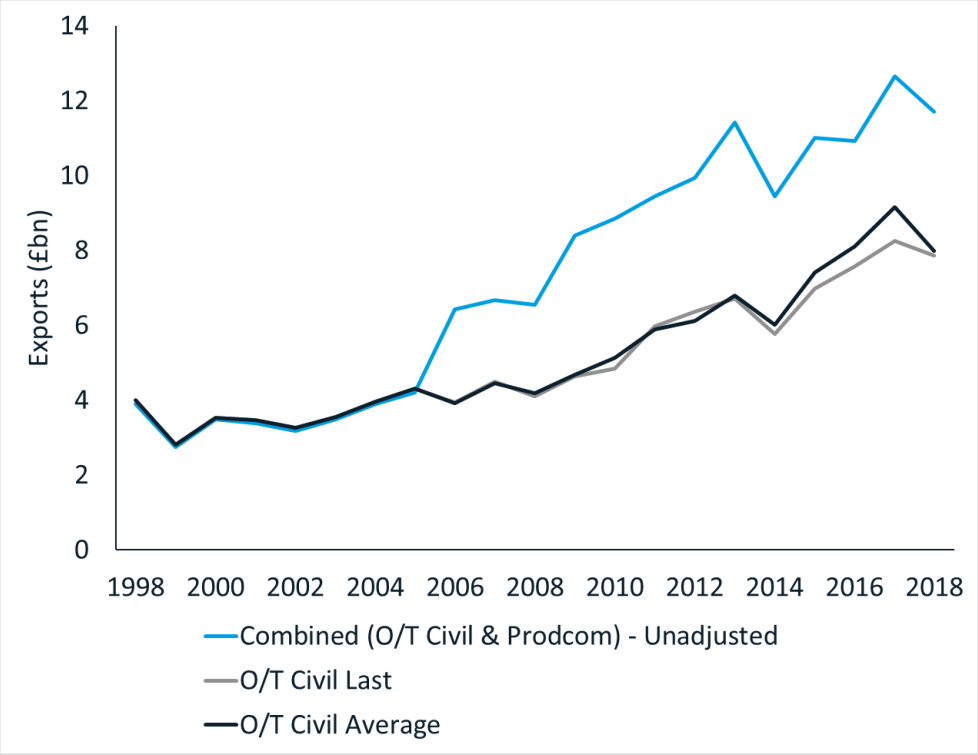
- o/t civil average ratio.

Estimates diverge after 2006 due to differences in estimated defence shares for Aircraft & Parts

The estimated defence exports are not substantially different in years prior to 2006[44]. However, the estimated exports using combined o/t civil and Prodcom ratios (method one) depart from the o/t civil ratios (methods two and three) in later years by close to £2bn. These differences are driven by the difference in the estimated defence share for products under the broad Aircraft & Parts category.

For products in other broad categories, the estimated or assumed defence content shares are relatively similar. The estimated military share of weapons and ammunition products based on Prodcom code 2540 ranges between 94% and 96%, relatively similar to the assumption-based share of 100% used in estimates based on extrapolated o/t civil ratios. For products under broad categories 'Tanks & armoured vehicles' and 'Warships', all compared methods utilise assumption-based defence share of 100%.

Figure B-2: Comparison of UK defence exports using various defence shares assumptions



Sources: CE calculations based on HMRC OTS and ONS Prodcom.

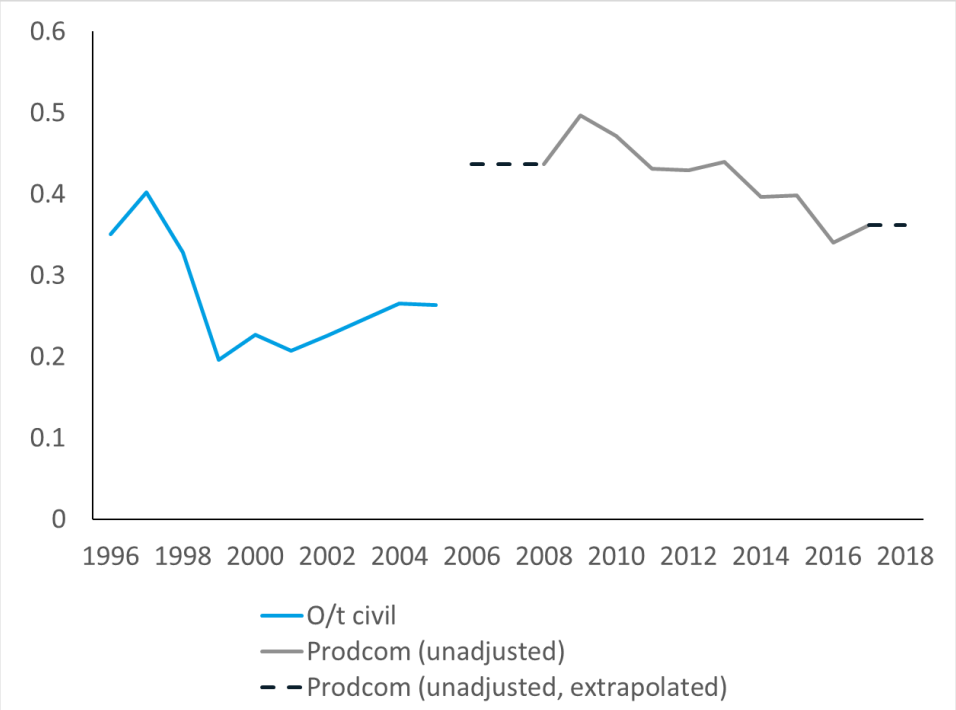
The comparison of the estimated defence share for Aircraft & Parts category using the two methods is presented in Figure B-3. As there are no overlapping years where Prodcom and o/t civil defence shares are simultaneously available, the series cannot be directly compared. A declining trend in Prodcom 3030 data can be observed since 2009, however no such trend is evident from the historical o/t civil ratios in previous years.

While the difference between 2005 o/t civil and extrapolated to 2006 Prodcom share is substantial and could be linked to the methodological differences

[44] Note that for years 1996-2005, estimates using extrapolated o/t civil last year ratios and o/t civil average ratios are identical by definition, as extrapolations are applied for years after 2006.

between the two methods, year-on-year changes of similar magnitude in o/t civil ratio have been estimated between 1998 and 1999.

Figure B-3: Comparison of defence content estimates for Aircraft & Parts



Sources: CE calculations based on HMRC OTS and ONS Prodcom.

The sharp decline in the o/t civil ratio between 1998 and 1999 can be traced to a fall in exports in historical o/t civil codes 88023090 'Aeroplanes and other aircraft, of an unladen weight exceeding 2000kg but not exceeding 15000kg', and 88033090 'Other parts of aeroplanes or helicopters', exports of which declined by over £1.5bn combined. The exports of corresponding items identified using DSE and SIPRI data for these years reveal that the decline in exports of Aeroplanes under the o/t civil code 88023090 could potentially be linked to an end of deliveries of Tornado IDS jets to Saudi Arabia in 1998[45].

It is uncertain if differences between o/t civil and Prodcom defence shares are due to methodology

While similar effects could explain the difference between 2005 o/t civil ratio and 2006 Prodcom military ratio, methodological differences could not be ruled out.

A possible contribution to the difference may stem from the correspondence between aircraft and parts OTS codes and Prodcom 3030 code. In addition to military and dual-use OTS codes, other items map to Prodcom 3030 code, such as items under OTS codes 94019010 (aircraft seats) and 880260 (spacecraft, satellites and launch vehicles). The Prodcom military share is therefore also dependent on the military content of UK sales for these products.

Importantly, a number of Prodcom codes for items classified as aircraft and parts for non-military use is subject to suppressions. Due to these suppressions, the estimated military shares based on Prodcom data are likely to be upper-bound estimates. It is also likely that the observed decline in the Prodcom military share from 44% in 2008 to 36% in 2017 could be explained by the

[45] This inference is based on the data on individual orders and deliveries as reported in the SIPRI ATD.

evolution of the list of suppressed civil use codes. While the number of suppressed codes did not decline over the period, a few large Prodcom codes were suppressed, including 30306030 - 'Reconditioning of civil aircraft engines' which became suppressed in 2010, and 30305050 – 'Undercarriages and parts thereof', which became suppressed in 2014. It is, however, impossible to reliably estimate the share of suppressions for non-military Prodcom codes, as some of them have been suppressed for all years.

Prodcom-estimated defence content is also based on UK sales data, rather than exports data only, and structural differences in defence production for domestic and foreign markets may be of relevance.

The OTS estimate based on combined approach is much higher than other estimates

Figure B-4 presents the comparison of UK defence exports estimates between approaches based on OTS data and an alternative approach based on the DSE data mapped using deliveries schedule obtained from SIPRI data described in Chapter 2. The estimated UK exports using combined o/t civil shares are lower than the DSE estimates for years 1996-2005. For later years, the estimates based on o/t civil and Prodcom defence shares are higher than the DSE estimates, while the exports figures based on extrapolated o/t civil ratios remain relatively close to the estimate obtained using the DSE approach.

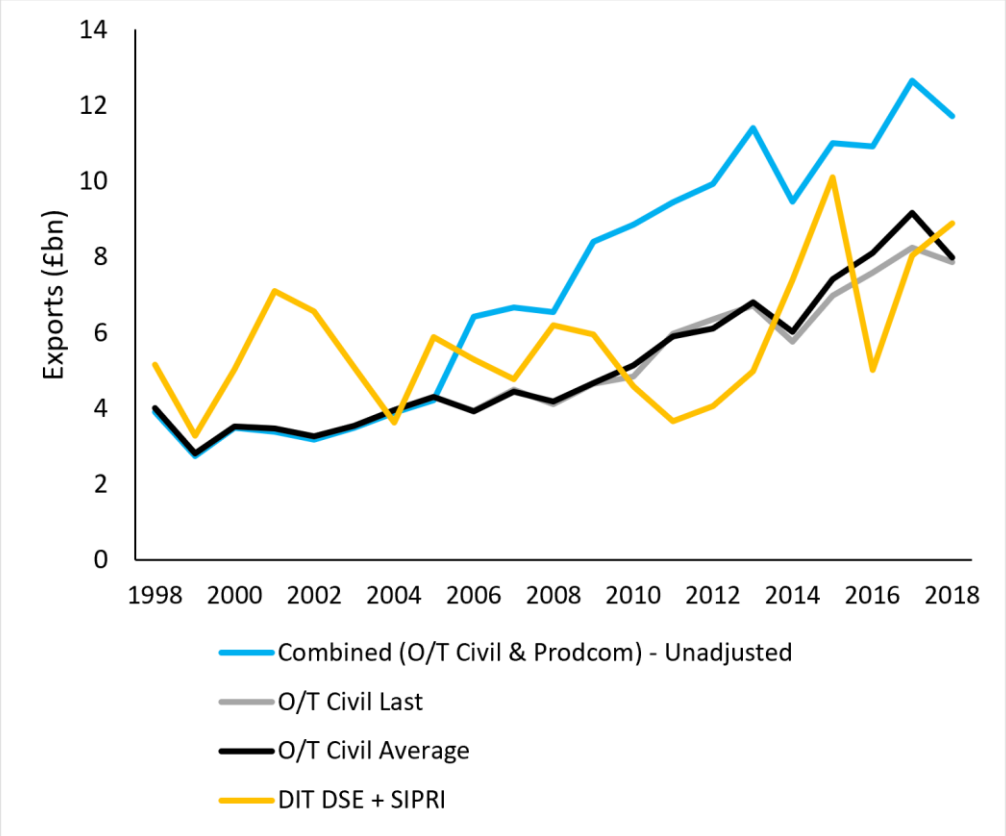
Importantly, the volatility of the estimate obtained using the DSE approach is much higher compared to the series based on the OTS data. An increasing trend is, however, evident for all series. This is perhaps unsurprising, as estimating UK defence export deliveries from HMRC OTS data relies on assumptions that result in averaging either across time or across commodity codes. These estimates could be interpreted as approximations of the long-run average, and therefore omit some of the year-on-year specificities.

The OTS approach likely results in upper-bound estimates of goods exports

The estimates based on the OTS approach can be thought of as likely upper-bound estimates of goods exports. The key contributing factor to the upper-bound assessment is the inclusion of non-defence items exports in o/t civil codes, on which the defence shares are based[46].

[46] Baldock, Lonsdale and Sams (2006).

Figure B-4: Comparison of defence exports estimates: the OTS approach and the DSE approach



Sources: CE calculations based on HMRC OTS, ONS Prodcom, DIT DSE data and SIPRI.

Extrapolating o/t civil defence shares using Prodcom growth rates

As mentioned previously, a key driver of total UK defence exports is the outturn for turbojets, parts of turbojets, as well as parts aircraft. Correspondingly, the defence share assumptions that apply to codes corresponding to these items would have a major impact on the estimate of total UK defence export deliveries.

A sensitivity analysis was conducted to consider the implications of different defence share assumptions for commodity codes using the combined method for estimating defence share over time. In particular, the sensitivity analysis considered the possible implications of:

- the implied defence share obtained from Prodcom being driven by suppressions
- the implied defence share obtained from Prodcom being driven by domestic purchases of aerospace and aerospace parts;

The preferred method of using the Prodcom implied defence shares was considered to tackle these issues. This involved:

- replacing the total aerospace product sales from Prodcom with a similar measure found in the National Accounts[47] (Total domestic output of products at basic prices from SUTs). The national accounts data could potentially suffer less from issues of suppressions, given the lower level of detail presented (only for product 30.3, as opposed to 6-digit code disaggregation

[47] ONS (2018b).

in Prodcom). Using this figure gives an adjusted implied defence share using SUTs and Prodcom data.

- extrapolating forwards the last available o/t civil share to the latest year of data, using year-on-year growth in the adjusted implied defence share estimated using Prodcom and SUTs.

Data for the adjusted implied share are presented in Table B-4. In earlier years the implied defence share using the adjusted measure is slightly higher, the highest point being 49% in 2009. In 2017, however, the adjusted defence share is lower, potentially reflecting the higher number of suppressions (notwithstanding the caution that data from Prodcom and SUTs may not be directly comparable).

Table B-4: Prodcom shares and adjusted Prodcom shares obtained using SUTs

	Defence share obtained using Prodcom data only (Prodcom 3030) (%)	Adjusted defence share obtained using Prodcom and SUTs data (SIC 30.3) (%)
2008	44	45
2009	50	49
2010	47	42
2011	43	31
2012	43	33
2013	44	41
2014	40	36
2015	40	34
2016	34	27
2017*	36	27

Notes: *SUTs figure for 2017 is extrapolated based on 2016 data and growth rate for the similar measure in Prodcom.
Sources: CE calculations based on ONS SUTs and ONS Prodcom.

The year-on-year change in defence shares in the adjusted measure was used to project forwards the average o/t civil shares over time, for each commodity code. This method therefore does not rely on the assumption of identical defence shares for domestic and exports markets. Rather it only requires that defence shares for domestic and exports market change at the same rate, which can be thought of as a less restrictive assumption.

For one code ('Helicopters: of an unladen weight exceeding 2000kg'), the extrapolated o/t civil share had to be capped at 100%.

Appendix C Discrepancies between the DSE and OTS estimates

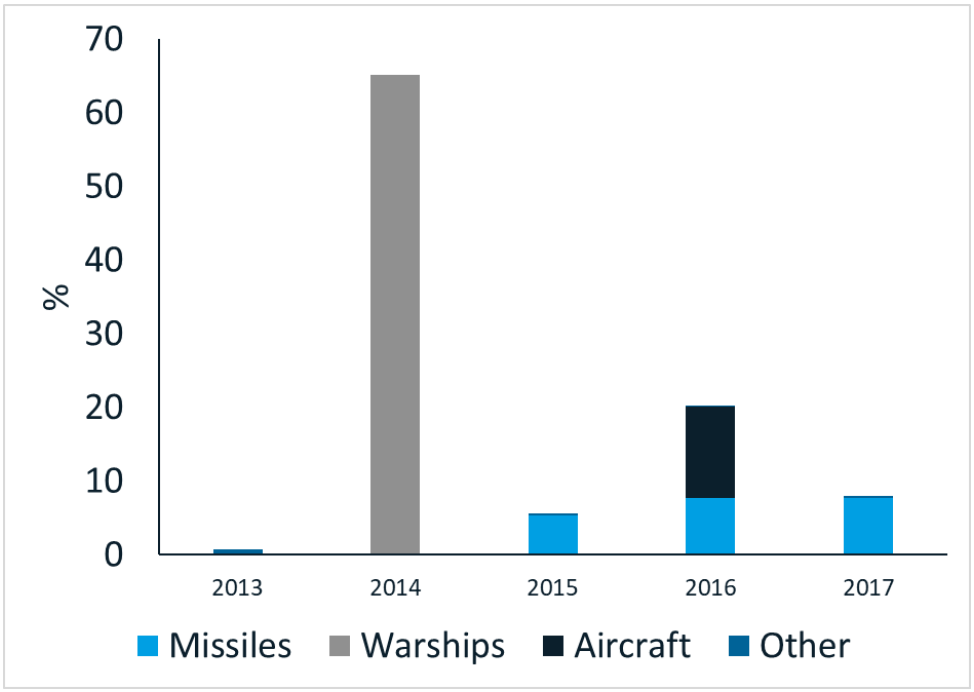
This section provides detailed analysis supporting the comparisons of DSE and OTS defence exports estimates presented in Chapter 4. The analysis is focused on two periods during which the estimates of defence exports diverged the most between the two approaches: 2014-2015 and 1998-2001.

C.1 Discrepancies between the DSE and OTS estimates

Analysis of a spike in estimated DSE deliveries in 2014

Further investigation of the volatility in DSE estimates revealed that the 2014 spike and the subsequent 2015 dip in defence exports are due to the particularly high fraction of orders placed in 2013 being reported as delivered in 2014. According to the SIPRI delivery schedule, the large proportion of 2013 orders allocated to the 2014 delivery year was attributed to high value deliveries of frigates (Warships), as presented in Figure C-1**Error! Reference source not found.**.

Figure C-1: Delivery schedule for 2013 orders by product and delivery year (based on TIV)



Sources: CE calculations based on SIPRI ATD.

A closer look at OTS-estimated exports for the corresponding commodity code 89061000 – 'Warships', is presented in Table C-1**Error! Reference source not found.**. The reliability of these figures is assessed to be high, as in this instance there is not a need to apply a defence share, given the designation of the code implying strict defence use. Export of Warships increased to £277m in 2014 according to OTS.

Table C-1: Defence exports of selected influential OTS codes (£m)

OTS Code	2012	2013	2014	2015	2016
89061000 - Warships	66	196	277	211	337
84119100 - Parts of turbojets…*	1,486	1,806	1,277	1,237	1,129
93069010 - Other [munitions and ammunition]…*	315	480	180	799	507

Notes: *OTS code names are abridged
Sources: CE calculations based on HMRC OTS, ONS Prodcom, ONS SUTs.

The difference between the estimates is likely related to a large delivery of warships in the SIPRI data

It is not possible to draw a direct comparison between the OTS estimate and export deliveries in the DSE measure due to the absence of product detail in the DSE data. It is also not appropriate to compare the result with the SIPRI data because trade value is expressed in terms of TIV. Application of the delivery schedule on an order-by-order basis (i.e. including SIRPI product detail) is also implausible because this would require SIPRI trade data to be exhaustive – a stronger assumption than what is required for the aggregate analysis.

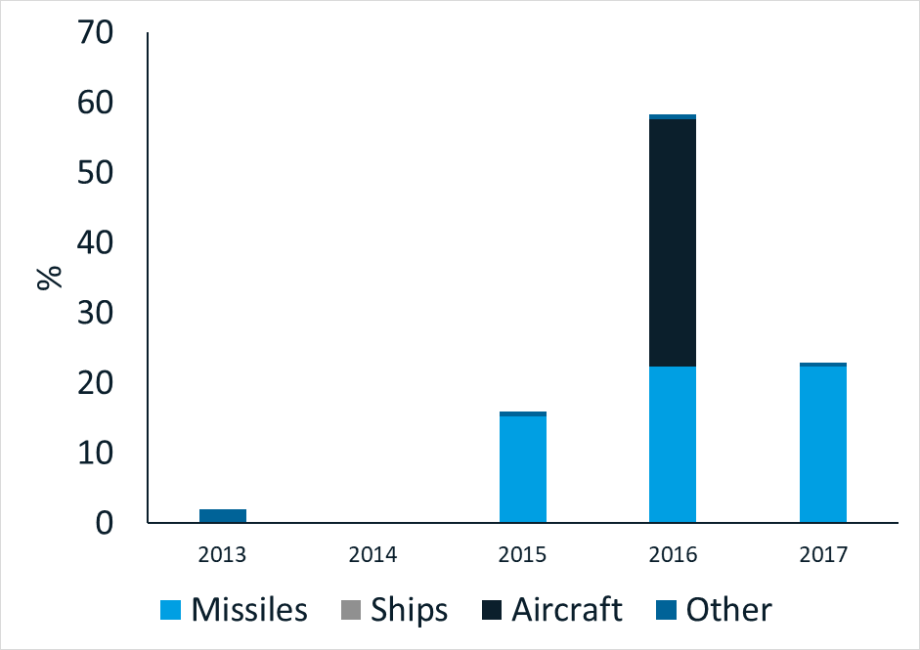
However, the spike in TIV of warships in the delivery schedule means that £6.3bn (64.5%) of 2013 orders are allocated to the 2014 delivery year, as presented in Figure 2-1. Such a large proportion of orders being allocated to a single delivery year is very unusual in the delivery schedule, and not supported by results based on OTS.

Over-representation of warships in the SIPRI data likely contributed to the differences between the two estimates

This outcome is likely the result of a violation to the representativeness assumption (described in Section 2.3). According to the sample of orders reported in the SIPRI trade registers and TIV tables, around 65% of the orders made in 2013 were attributed to warships delivered in 2014 (Table C-2**Error! Reference source not found.**). Given the considerations listed above, it would appear that warships are overrepresented in the SIPRI sample in TIV terms. Assuming this to be the case, it is likely that an excessive proportion of revenues from orders in 2013 is allocated to the 2014 delivery year. It is likely instead that a greater percentage should be distributed to 2015 and 2016. For comparison, the resultant delivery schedule if warships were excluded is provided in Figure C-2**Error! Reference source not found.**.

It is also possible that relative prices of items in TIV have an impact on the result. Reportedly, frigates delivered to Brunei are over 10 times more valuable per unit than AW-159 Wildcat helicopters (delivered in 2016). If this relative price is incorrect, then this could be a source of inaccuracy in the delivery matrix.

Figure C-2: Delivery schedule for 2013 orders by product and delivery year (warships removed)



Sources: CE calculations based on SIPRI ATD.

The fall in defence export deliveries in 2014 according to the OTS approach is driven by aircraft parts and ammunition

The overall 2014 decline in estimated defence exports based on OTS data can be attributed to substantial declines in two influential codes: 84119100 - Parts of turbojets and code 93069010 - Other [munitions and ammunition]. The developments in these codes, presented in Table C-1**Error! Reference source not found.**, cannot be verified by SIPRI deliveries data, as these cannot be reliably mapped to any of the SIPRI armament categories based on their names. It should be noted that the estimated decline in defence exports of 84119100 – 'Parts of turbojets' was driven not only by the decline of the defence share from 30% to 26%, but equally, by the overall decline in defence-related exports in that code (from £6.0bn in 2013 to £4.9bn in 2014).

In summary, the discrepancy between DSE and OTS-based estimates in 2014 could be traced mainly to the very large reported delivery of frigates according to the SIPRI database. The increase in the corresponding OTS code 89061000 – 'Warships', however, was moderate, and the overall decline of the OTS-based estimate is due to substantial declines in exports of other items. The estimate of defence exports of 89061000 – 'Warships' can be assessed as one of the more reliable estimates of the OTS approach due to the likely accuracy of 100% defence share based on defence-specific designation of the code. The same confidence, however, cannot be placed in estimates of defence shares for most other OTS codes, especially the defence-related dual-use codes for items such as aircraft and parts, which drive the total estimate for the period.

Analysis of a spike in estimated DSE deliveries in 2000

The same steps were undertaken to investigate a spike in DSE deliveries between 1998 and 2001, with estimated deliveries of £6.6bn in 2001, up from £3.3bn in 1998. In contrast, the OTS-estimated exports decreased in the same period, from £3.9bn in 1998, to £3.4bn in 2001 (as presented in Figure 3-2). It should be noted that OTS estimates for these years are largely obtained directly from data reported for the historic o/t civil commodity codes, without the need to extrapolate o/t civil defence shares.

According to the SIPRI delivery schedule presented in Table C-2**Error! Reference source not found.**, large shares of orders placed in 1997 and 1998 were delivered in 2000. 1998 and 1997 were also the years with the largest value of orders during that decade.

Table C-2: Share of 1990-2000 orders delivered in years 1999 and 2000

Year	Orders (£bn)	% of order delivered in 1999	% of order delivered in 2000
1990	4.4	0%	0%
1991	3.4	3%	3%
1992	4.5	34%	5%
1993	4.5	1%	0%
1994	4.2	6%	3%
1995	4.9	11%	9%
1996	4.6	29%	25%
1997	5.5	7%	38%
1998	5.9	3%	24%
1999	4.8	1%	13%
2000	4.7	0%	3%

Sources: CE calculations based on DSE and SIPRI database.

Multiple deliveries in SIPRI can be linked to the 2000 spike in the DSE estimate

Unlike the 2014 spike in DSE deliveries, which was linked to one particular delivery, the 2000 spike can be attributed to multiple deliveries of different items. SIPRI data on selected high-TIV items delivered in 2000 are presented in Table C-3**Error! Reference source not found.**. By far, the largest reported as delivered item was a submarine (delivered to Canada), followed by smaller deliveries of helicopters, tanks and aircraft (to various countries).

Table C-3: Selected large TIV orders scheduled for delivery in 2000

Description	Designation	Order date	Numbers delivered	TIV delivery values
Submarine	Upholder	1998	1	260
ASW Helicopter	Super Lynx-100	1997	7	95
Tank	Challenger-2	1997	20	85
Trainer/combat ac	Hawk-100	1997	6	60
Trainer/combat ac	Hawk-100	1997	6	60
Transport aircraft	C-130H Hercules	1998	2	37
Patrol craft	Protector	1998	3	33
Anti-ship missile	Sea Skua	1997	80	24
Patrol craft	Cyclone	1997	1	22

Sources: CE calculations based on DSE and SIPRI database.

Developments in corresponding OTS codes do not fully correspond to items seen in SIPRI deliveries data

Estimates of exports in OTS codes corresponding to these SIPRI deliveries are presented in Table C-4 for 1998-2001. Exports of Aeroplanes and helicopters saw a substantial increase in 2000 to £526m, which could reflect large deliveries of Super Lynx-100 ASW helicopters and Hawk-100 aircraft presented in Table C-3**Error! Reference source not found.**. It is important to note, however, that according to the OTS data, exports of military Aeroplanes and helicopters in 1998 were even higher than in 2000, at £703m.

Exports of Warships increased in the analysed period, from zero in 1998, to £199m in 1999 and £160m in 2000. This value could be linked to the reported delivery of an Upholder submarine and four Patrol crafts in the same year. According to the OTS estimate, the exports of Tanks and other armoured vehicles stood at £80m in 2000. Dividing this amount by the number of Challenger-2 tanks delivered in that year (20) according to the SIPRI database (SIPRI, 2018b), the resulting unit value is close to £4m, which is not implausible. Investigation of exports of these items therefore does not provide suggestions as to why OTS-based estimates of total defence exports diverged from the DSE estimate. Exports of Warships and 'Tanks and other armoured vehicles' assume 100% defence content in these codes, implying that the OTS estimates are likely an upper bound. The DSE estimate could, however, be affected by incorrect estimates of delivery year, or differences between TIV and monetary value of the transaction due to discounts and other factors.

Exports of other items, such as aircraft parts (OTS 88033000 and 88039090) and munitions and ammunition (OTS 93069010) declined in 1999 before picking up in 2000, and contributed to the same trend in estimated defence exports using OTS data. Items in these codes could not be reliably mapped to any of the SIPRI broad armament categories to allow comparisons to deliveries data.

Table C-4: Exports in selected OTS codes (£m, 1998-2001)

OTS Code	Description	1998	1999	2000	2001
87100000	Tanks and other armoured vehicles	218	70	80	55
Multiple*	Aeroplanes and helicopters	703	283	526	254
89061000	Warships	0	199	160	120
88033000	Other parts of aeroplanes or helicopters	1292	480	998	1044
88039090	Parts of aircraft, n.e.s	-**	411	216	168
93069010	Other [munitions and ammunition]	458	238	379	170

Notes: * Sum of OTS codes: 88021100, 88021200, 88022000, 88023000, 88024000
** Code emerged from 88039099 in 1999.
Sources: CE analysis based on OTS, ONS Prodcom, ONS SUTs.

The difference between DSE and OTS estimates in years 2000 and 2001 could not be linked to any specific discrepancy between the datasets at the product level. Dividing the OTS estimate of the monetary value of exports of these products by the number of units delivered reported in SIPRI database results in values per unit which are plausible. Other codes driving the OTS estimate could not be reliably mapped to orders in SIPRI to allow such comparison to fully investigate the potential sources of the discrepancy.

OTS-based estimates between 1998 and 2001 are driven by exports of aircraft and parts

It is difficult to assess which estimate is closer to true defence exports for this period. Difficulties in identifying defence components and the reliance on extrapolations in OTS estimates could suggest that the DSE approach is likely better at capturing spikes and declines in defence exports. At the same time, DSE-based estimates may be biased due to the inaccuracies in the estimated delivery schedule.

Appendix D UK defence exports by destination

D.1 Country shares in UK defence exports using the SIPRI ATD

To obtain country defence shares in UK defence exports, defence-related codes have been mapped to broad SIPRI armament categories and additional composite categories to achieve the most accurate mapping. This was conducted based on the type of a product and its intended use (air, land and naval weaponry). Such mapping is preferred due to the hypothesised country differences: for example, island countries, such as Indonesia, may rely to a greater degree on naval defence, while other countries, such as India and Saudi Arabia, are known for their reliance on an air force.

Country shares of UK defence exports have been estimated using SIPRI deliveries data and their estimated TIV for years 1990-2017. Table D-1 presents the estimated country shares for seven broad product categories. The detailed mapping of individual OTS codes to armament categories is presented in Appendix F.

Country shares in UK defence exports differ among armament types

From the estimated shares, differences in country shares among armament categories become evident. According to SIPRI data, Indonesia accounted for 8% of total UK exports of military ships, but only 3% of military aircraft exports. On the other hand, Saudi Arabia and India have been the biggest importers of UK military aircraft, accounting for 42% and 15% of the total military aircraft exports respectively, but only 2% and 1% of the total exports of military ships.

China and the US emerge as the largest importers of UK military aircraft engines, each accounting for nearly a quarter of UK exports. The US is also by far the largest importer of artillery, at 81% of the total UK artillery exports, as well as the third largest importer of military aircraft.

Table D-1: Estimates of country shares in UK defence exports based on SIPRI deliveries and TIV data 1990-2017 (%)

% share	Missiles	Aircraft	Engines	Sensors	Armoured vehicles	Ships	Artillery	Other	Total (all categories)
Algeria	0	1	0	0	0	1	0	0	1
Australia	2	2	0	7	0	1	6	5	2
China	0	0	28	4	0	0	0	0	2
France	1	0	3	0	0	0	0	15	1
Germany	0	1	0	5	0	0	0	5	1
India	0	15	0	8	0	1	0	0	8
Indonesia	2	3	0	2	7	8	0	0	3
Saudi Arabia	28	42	0	2	4	2	1	6	22
South Korea	2	4	0	6	0	0	0	0	2
UAE	10	1	1	0	0	0	0	3	2
United States	1	13	25	7	0	6	81	38	14
Canada	3	1	0	6	0	14	2	7	4
Chile	2	0	0	0	0	10	0	0	2
Jordan	0	0	0	0	37	0	0	0	1
Oman	4	5	0	2	15	9	0	0	5
Pakistan	0	0	0	0	0	7	0	0	2
Sum of shares of listed countries	53	87	57	49	63	61	90	79	72

Sources: CE calculations based on SIPRI database.

D.2 Comparison of SIPRI-estimated country shares to the WMEAT Database

Country shares can be cross-validated against the WMEAT database

An alternative source of data on UK defence exports by country is the WMEAT database, compiled by the US Department of State. WMEAT estimates have been compiled since the 1960s and currently cover military trade in goods and services by over 170 countries, accounting for over 99% of the world GDP[48].

Data on UK exports by country of destination (Table III in the WMEAT database) are available from 2009 to 2017 for three-year intervals. Only the aggregated totals for military goods and services are available. Table D-2: presents WMEAT country shares obtained by dividing the UK transfers of arms to the given country by the total UK transfers. These are presented against the corresponding country shares obtained from the SIPRI database based on exports in all armament categories.

SIPRI country rankings are broadly consistent with WMEAT, but shares differ for some countries

In both data sources, Saudi Arabia emerges as the largest importer between 2009 and 2017, with an estimated share of 37% based on WMEAT data, and 46% share based on SIPRI data. While for both methods the US ranks as the second largest importer, the estimated share using WMEAT data is over three times higher, at 35%, compared to 11% in SIPRI data. The estimated shares for India place it as the third largest importer according to both methods, with an estimated share of 7% based on WMEAT data and 10% based on SIPRI data.

The differences in estimated country shares are most likely due to the methodological discrepancies between the datasets. It is unclear whether the reported coverage of the WMEAT database refers to the coverage of the indicators regarding military expenditures by country, but not transfers (exports). For example, the high share of UK defence exports going to the US in the WMEAT data may be explained by superior coverage of US military imports and exports compared to other countries. Indeed, according to WMEAT documentation, the estimates of US imports are based on Census Bureau of the Department of Commerce (Census EID), and direct expenditures abroad by the Department of Defence[49]. In contrast, sources of data on transfers of defence goods and services between countries other than the US are described as 'US Government Sources'. Given the difference in sources, the coverage of military transfers between countries other than the US could potentially be inconsistent with the coverage of military transfers involving the US. If this is true, then it could also explain the relatively low estimate of the total UK military transfers, averaging $3.1bn annually over 2009-2017 period, which is below the value of UK defence trade reported in other sources. The low estimate in WMEAT could also be attributed to differences in definitions of military goods and services, but this is not possible to verify, as no clear description is available on the methodology.

In a sensitivity exercise, WMEAT country shares are applied to OTS estimates of total defence exports and compared to the estimates based on the (main) approach that uses SIPRI-based country shares. The estimates for combined

[48] US Department of State (2018b).

[49] Ibid.

three-year periods, as well as the combined 2009-2017 estimate[50], are presented in Table D-2.

It should be noted that this comparison is different from the direct comparison of country shares, as the SIPRI-estimated country shares for broad armament categories in total defence exports are effectively re-balanced when applied to OTS total exports estimate. This is because the shares of SIPRI broad armament categories in the total defence exports in SIPRI are different to the shares of the corresponding OTS codes in the total OTS defence exports estimate. In contrast, WMEAT-based country shares are not re-balanced when applied to the OTS estimate, because they are estimated on the basis of total defence exports (not disaggregated by product).

Based on 2009-2017 totals obtained using WMEAT country shares, the top importers were the US, Saudi Arabia, India and Oman. The differences in shares (as percentages of calculated shares) between SIPRI and WMEAT estimates are moderate for countries such as Saudi Arabia and Oman, but extremely high for countries such as China and the US. As 0% country shares were obtained from WMEAT database for Canada, Jordan, South Korea and UAE, estimates are substantially different to these obtained using SIPRI country shares.

Table D-2: Country shares in UK defence exports based on WMEAT and SIPRI data (%)

% share	WMEAT 2009-11	SIPRI 2009-11	WMEAT 2012-14	SIPRI 2012-14	WMEAT 2015-17	SIPRI 2015-17	WMEAT 2009-17	SIPRI 2009-17
Algeria	0	3	0	0	0	2	0	1
Australia	1	2	1	2	N/A	0	N/A	1
Canada	0	1	0	0	0	0	0	0
Chile	N/A	0	N/A	0	N/A	0	N/A	0
China	0	4	0	3	0	2	0	3
France	0	0	N/A	0	0	0	N/A	0
Germany	1	0	0	0	0	0	0	0
India	10	12	6	11	5	10	7	10
Indonesia	0	0	3	14	0	16	1	6
Jordan	0	0	0	0	0	0	0	0
Oman	N/A	0	9	11	5	14	5	9
Pakistan	N/A	0	N/A	0	1	0	0	0
Saudi Arabia	37	45	26	38	46	53	37	46
South Korea	N/A	0	0	0	0	3	N/A	1
UAE	0	0	0	2	0	0	0	1
US	43	21	40	8	25	3	35	11

Notes: N/A denotes data gaps in WMEAT database.
Sources: CE calculations based on WMEAT database and SIPRI database.

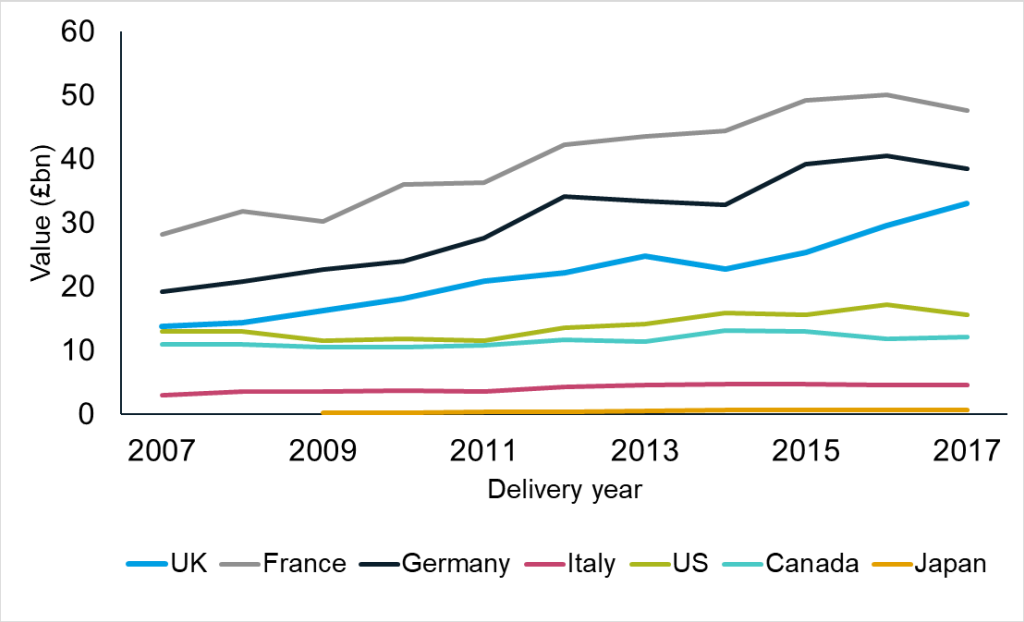
[50] For the purpose of calculations of 2009-2017 estimate based on WMEAT country share, in cases where three-year WMEAT country share was unavailable (denoted as N/A), it was assumed at 0%.

Appendix E Estimation of G7 defence goods exports

E.1 G7 defence-related goods

Figure E-1 presents the aggregate export value of *defence-related* items across G7 countries. Defence-related items are those that can be used for defence purposes, but can also be used for other purposes not related to the defence sector (the product coverage of defence-related items is proposed and discussed in Section 3.2).

Figure E-1: Exports of defence-related goods from G7 countries 2007-2017



Sources: CE calculations, based on: HMRC OTS, Eurostat Comext, US Census Bureau, Statistics Canada and Japanese National Statistics Office.

Defence-related goods exported by UK, Germany and France have increased considerably since 2007

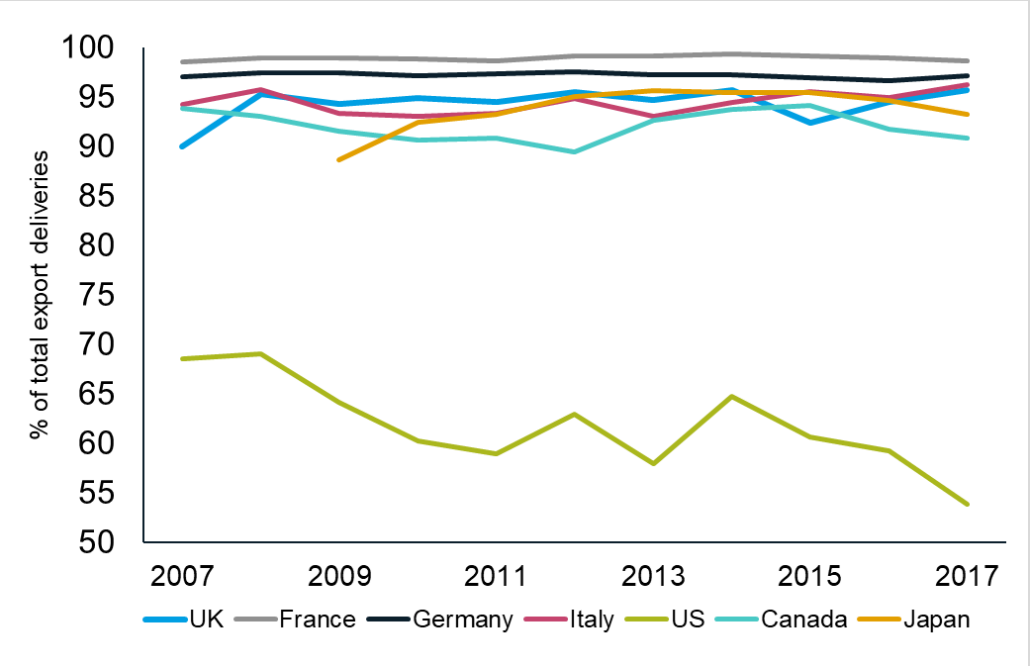
With regard to trends over time, we see in Figure E-1 that growth rates of defence-related goods exported by the UK, Germany and France were very high relative to other G7 countries. Annual growth rates over 2008-2017 averaged 9.4%, 7.6% and 5.7% for the UK, Germany and France, respectively.

For most G7 countries, defence-related exports are dominated by Aircraft and Parts. Figure E-2 shows the percentage of defence-related items which are attributable to exports of aircraft and parts. We see that, for almost all G7 countries, the percentage share of aircraft and parts is somewhere in the region of 90-100%.

Most G7 countries predominantly export aircraft; the US is an exception

The notable exception to this rule is the US which also exports a large volume of other defence-related equipment, such as Weapons and Ammunition (24% of total in 2017) and Tanks (9% of total in 2017). We also observe a decreasing trend in proportions of aircraft exports over time, with the US increasing the proportion of land and sea defence-related exports since 2007. No such trends are observed in other G7 countries.

Figure E-2: Proportion of defence-related goods exports attributable to Aircraft & Parts exports



Sources: CE calculations, based on: HMRC OTS, Eurostat Comext, US Census Bureau, Statistics Canada and Japanese National Statistics Office.

E.2 G7 defence exports

Table E-1 presents the implied shares of broad product categories across G7 countries[51]. For many sectors and countries, there is no available defence share because total exports of defence-related products is not reported. In these instances, the figure in the table is reported as not applicable (N/A).

The implied defence share of aircraft and parts varies greatly across countries

One key result that emerges is that, according to the trade data described above, a very large share (95%) of Aircraft & Parts exported by the US is for military purposes. In contrast, a very low defence share for Aircraft & Parts is observed for France, Germany and Canada.

However, as mentioned in Chapter 6, this result should be interpreted with caution given the robustness of the assumptions required and the variation in the methods and nature of the data sources used. It is therefore not possible to ascertain whether the variation in the defence share is driven by real differences in the composition of trade, or by variation in the data sources used.

[51] Note that the defence share is estimated on a product by product basis across the 47 commodity codes identifies as being defence-related. The results in the table are thus the sum of all products belonging to each broad sector divided by the sum of defence-only products belonging to each broad sector.

Table E-1: Effective defence shares for G7 countries over 2007-2017 (%)

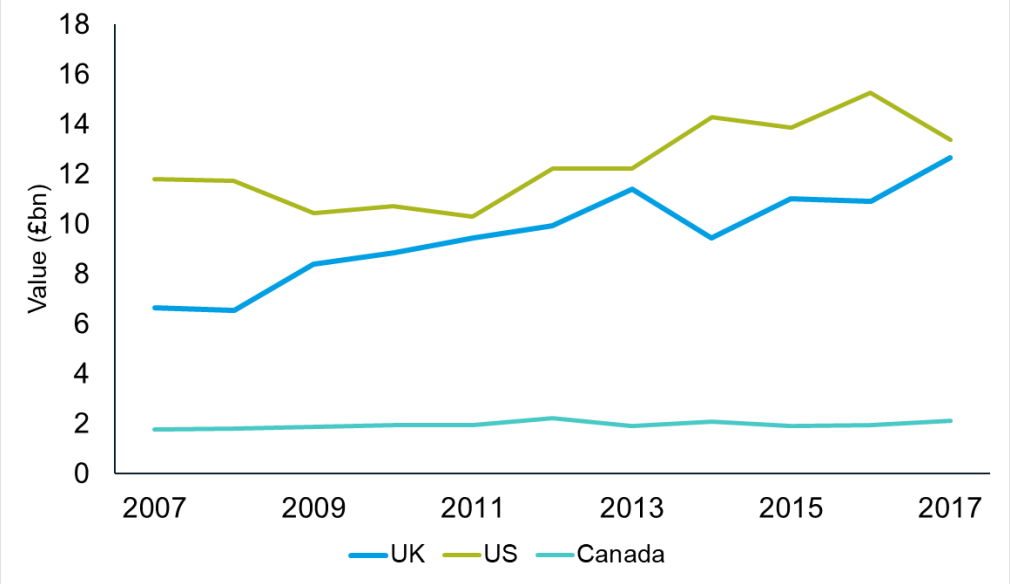
% defence share	UK	France	Germany	Italy	USA	Canada	Japan
Aircraft & Parts	41	5	15	30	95	12	31
Tanks & Armoured Vehicles	100	N/A	18	N/A	100	100	100
Warships	100	N/A	N/A	N/A	100	100	N/A
Weapons & Ammunition	95	86	100	100	100	100	100
Other	58	3	4	5	29	59	8

Sources: CE calculations based on HMRC OTS, UK Prodcom, Eurostat Comext, US Census Bureau, Statistics Canada, Japanese National Statistics Office, Ministry and Industry reports and World Input Output Database.

Growth rates in estimated UK defence exports appear to outstrip the US and Canada

Figure E-3 compares UK defence exports[52] to the corresponding exports of the US and Canada after applying defence shares in the feasibility exercise. The results are fairly striking, indicating a rapid expansion of UK defence exports (7.3% pa) over 2007-2017, relative to the US (1.7% pa) and Canada (2.1% pa). However, the corresponding average growth rates are highly sensitive to the start and end years which are selected. If the period 2009-2014 is selected, then the result is reversed (i.e. the US outstrips UK growth).

Figure E-3: UK defence exports compared to defence exports from the US and Canada



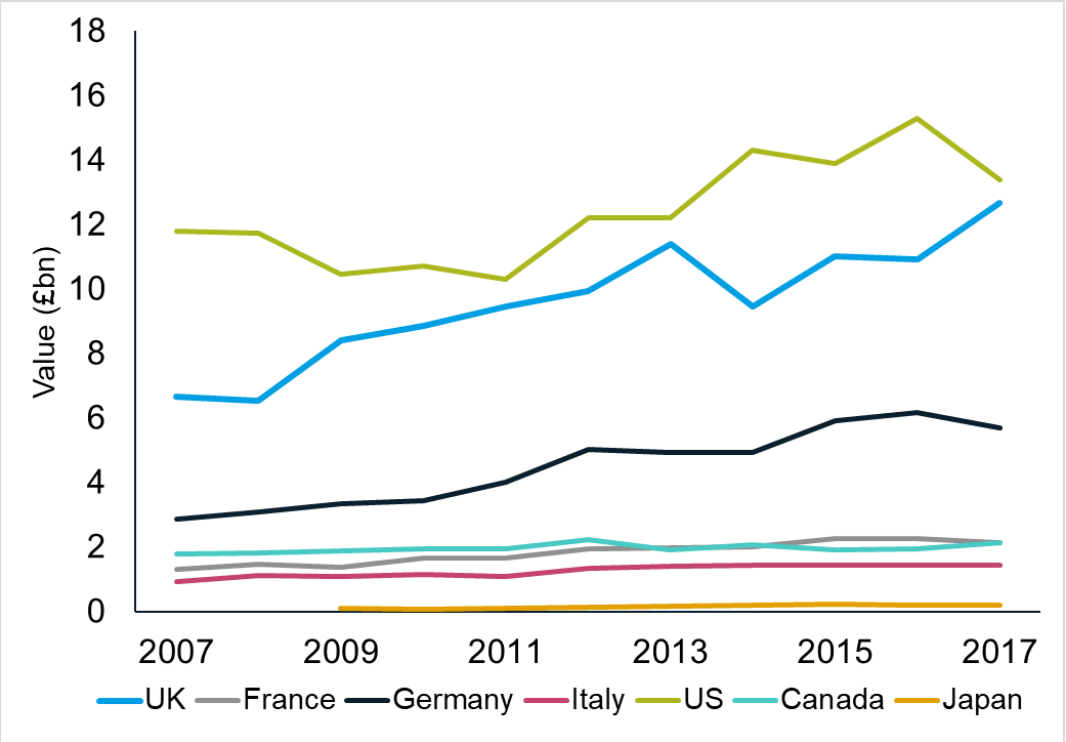
Sources: CE calculations based on HMRC OTS, UK Prodcom, US Census Bureau, Statistics Canada, Ministry and Industry reports and World Input Output Database.

A similar trend of defence export expansion is observed in Germany

When we expand the selection of comparison countries to include all G7 countries (see Figure E-4), we observe a similar trend of defence export expansion in Germany (and to a lesser extent France) over the 2007-2017 period.

[52] As presented in Chapter 3, combined shares method.

Figure E-4: UK defence exports compared to all G7 countries



Sources: CE calculations based on HMRC OTS, UK PRODCOM, Eurostat Comext, US Census Bureau, Statistics Canada, Japanese National Statistics Office, Ministry and Industry reports and World Input Output Database.

Fixed defence shares could be skewing the results

While this could be an indication of defence export trends in Northern Europe, caution must be exercised when interpreting the result. Due to the assumptions required for estimating defence shares for France and Germany, in particular a fixed defence share (of defence-related exports), the reliability of this finding is questionable.

For instance, it is likely that the defence share varies considerably over time. But due to data limitations a single defence share is applied to all years in the series (for each product). However, it could be the case that German defence exports have not been increasing rapidly over the period. By using a fixed defence share, this detail is lost and leads in all likelihood to the mis-estimation of German defence exports.

E.3 Data sources and assumptions for non-UK G7 estimates

Given the limitations and variation of the existing trade data for non-UK G7 countries, various sources and methods were consulted to estimate defence exports. This section outlines the sources, methods and corresponding assumptions entailed in estimating non-UK G7 defence exports.

France assumptions

Defence-related export goods are defined at the 8-digit HS commodity code level. For France, the source of export volume data was Eurostat Comext (Eurostat, n.d. b). Equivalent publications and data sources used for estimating defence shares for the UK were either unavailable or did not provide data for defence shares for France at the 8-digit level. The key source used to estimate

the defence shares for defence-related goods was a 2018 bulletin published by the Economic Observatory for Defence (in French)[53].

The key source used to estimate French defence shares was a bulletin by the Economic Observatory for Defence

The report provides 2017 export data on defence-related goods that are for non-civil use (*exportations de matériels de guerre*) at the NACE (Rev.2) level[54] for:

- 84 Nuclear Reactors, Boilers, Machinery and Mechanical Appliances; Parts Thereof;
- 85 Electrical Machinery and Equipment and Parts Thereof; Sound Recorders and Reproducers, Television Image and Sound Recorders and Reproducers, and Parts and Accessories of Such Articles;
- 87 Vehicles Other Than Railway or Tramway Rolling-Stock, and Parts and Accessories Thereof;
- 88 Aircraft, Spacecraft, and Parts Thereof;
- 89 Ships, Boats and Floating Structures; and
- 90 Optical, Photographic, Cinematographic, Measuring, Checking, Precision, Medical or Surgical Instruments and Apparatus; Parts and Accessories Thereof.
- 93 Arms and Ammunition; Parts and Accessories Thereof.

There were consistency issues between Eurostat Comext and the Defence bulletin

For NACE 93 (Arms and Ammunition; Parts and Accessories Thereof), the export figure reported in Eurostat Comext was considerably smaller than the reported value by the Economic Observatory for Defence. This discrepancy may be explained by the data-sensitivity of this product category and the fact that most product sub-categories within NACE 93 are not reported at all in Eurostat Comext. Thus, in this case another source was used to get an estimation of the share, namely the 2017 Statistical Yearbook of Defence (original in French)[55].

This report provides data on 2017 exports of Arms and Ammunition for Civilian Use (Armes à Feu et Munitions à Usage Civil). In our approach, the category Weapons & Ammunition can be considered as being equal to NACE 93. Based on this source, the share of civilian use within total export data and consequently, share of non-civilian use, can be derived.

Due to the low availability of data, a time-invariant defence share has to be assumed for each commodity code. A key assumption, therefore, is that the defence share of exports does not vary over time. Given the lumpiness of defence exports, this assumption is unlikely to hold in practice.

The number of suppressions in the French trade data was a concern

In addition, the number of suppressions in the trade data is a concern. Data for a number of product categories were not included in the Comext trade data. Key categories include: Tanks and Other Armoured Fighting Vehicles; Warships; Artillery Weapons; and Munitions and Ammunition. In instances where suppressions occur, these products will be entirely missing from the measure, therefore it is likely that the value of defence-related goods is underestimated in the case of France.

[53] Ministère des Armees (2018).

[54] Corresponds directly to Standard Industrial Classification (2007).

[55] Ministère des Armees (2017).

Defence shares lacked product detail

Moreover, the defence shares are often taken to a 2-digit level, which means that it does not account for potential differences in the defence share across products within the same 2-digit product category (e.g. Electrical Machinery and Equipment).

Germany assumptions

Defence-related exports for Germany were also sourced from Eurostat Comext[56] and defined at the 8-digit level. Similar to France, equivalent publications and data sources used for estimating defence shares for the UK were either unavailable or did not provide data for defence shares for Germany. Instead, the key source used to estimate defence shares was reports by the German Government on export policy for conventional military equipment[57] [58].

The value of issued licenses was used to proxy the value of German defence exports

Specifically, the value of issued licenses was used to proxy the value of defence-related export goods for defence-use. To export military equipment, war weapons and dual-use items (i.e. items not specifically designed for military purposes but that could be used as such) from Germany, goods must have an export licence to leave the country. Products that are required to have a licence are assumed to be for defence-related use and vice versa.

However, licence issuance is not a good measure of exports

Due to the periods of validity of the licences, the issuance of the licence and its utilisation for the actual export may take place in different calendar years and thus in different reference periods. It could also be the case that, although a licence has been issued, there is no export because the corresponding procurement project has been postponed or abandoned in the country of final destination. Both considerations affect the credibility of the result. In particular, the latter instance (i.e. licence issuance but not use) could cause the measure to overestimate the value of German defence exports. This should be taken into account when interpreting the measure.

The aforementioned report lists individual export licences issued in 2017 by Export List (EL) categories. Individual export licenses cover about 95% of total issued licenses value in 2017 (the other type being collective export licenses, for which data was not provided in the report), therefore this can be considered as representative for total licenses by product groups. After this, export list categories could often be matched with existing NACE-digit categories. Wherever a match could be made, this allowed for the calculation of defence-use purpose goods within total NACE-level export goods.

There were consistency issues between Eurostat Comext and German Federation reports

In the case of NACE 36 (Explosives; Pyrotechnic Products; Matches; Pyrophoric Alloys; Certain Combustible Preparations) and NACE 93 (Arms and Ammunition; Parts and Accessories Thereof), the export figures reported in Eurostat Comext were considerably smaller than the ones reported with licences in the Federal Republic reports. This discrepancy could be explained by the data-sensitivity of these product categories – a proportion of trade might be supressed – and the fact that most product sub-categories within NACE 93 are not reported at all in Eurostat Comext. Where the value of export licences exceeded the value of trade in Comext, 100% defence share was assumed. This result further undermines the credibility of the measure.

[56] Eurostat (n.d. b).

[57] Federal Ministry for Economic Affairs and Energy (2018a).

[58] Federal Ministry for Economic Affairs and Energy (2018b).

Suppressions were also an issue for German trade data

Moreover, there are several commodity codes for which export data are suppressed. As mentioned earlier, suppressions will mean that a certain proportion of defence-related goods will be omitted from the measure, thereby underestimating the total. However, fewer items are supressed for Germany than for France. Data on German exports of Tanks and Armoured Vehicles are available for 2009 and 2013 for instance.

Italy assumptions

Defence-related exports for Italy were also sourced from Eurostat Comext[59]. Similar to other EU27 countries, in the case of Italy, equivalent publications and data sources used for estimating defence shares for the UK were either unavailable or did not provide data for defence shares.

Italian defence shares were estimated on the basis of a parliamentary report

The defence shares were therefore estimated on the basis of a parliamentary report[60]. The document presents data on military exports in 2017 and therefore can be used to estimate a defence share.

The parliamentary report uses a military-specific classification and therefore there was no pre-defined mapping to other known common classifications (e.g. NACE). Therefore, the matching process between HS and the classification in the report had to be made based on the interpretation of the product name. Though imperfect, the nomenclature was matched to a reasonable degree of confidence.

Suppressions in the Italian trade data were also a concern

Similar to France, the number of suppressions in the trade data is a concern. Data for a number of product categories were not included in the Comext trade data. Key categories include: Tanks and other Armoured Fighting Vehicles; Warships; Artillery Weapons; and Munitions and Ammunition. Due to the amount of supressed data, it is likely that the value of defence-related goods is underestimated in the case of Italy.

For the certain goods, a 100% share was assumed due to the nature of the product. These goods belong mainly to weaponry and military equipment.

United States assumptions

For the US, defence-related exports were sourced from the US Census Bureau[61]. The degree of detail available in this dataset varies, with trade being shown at a 4-digit, 6-digit and 10-digit level (HS classification).

Where items were shown at a 10-digit level, defence shares could be taken directly from the export data

Where items are shown at a 10-digit level, it is possible to infer the proportion of the good sold for military purposes. This allowed the defence share (in some cases) to be taken directly form the trade data with no need for further approximation using external sources. In instances where this occurs, this improves the robustness of estimate because the only assumption required is that the official US census data is accurate and credible. This distinction was available notably for many products under Aircraft & Parts.

In some cases, defence shares were estimated using the parent category or external reports

For products for which there is less detail available, but which are related to Aircraft & Parts (e.g. Reaction Engines Other than Turbojets), defence shares are estimated using typical defence shares in the parent category or defence shares in comparable product categories.

[59] Eurostat (n.d. b).

[60] Senato Della Repubblica (2018).

[61] US Census Bureau (n.d. a).

For some products, external sources are still required to estimate defence shares (e.g. Radar). In these cases, a Deloitte report[62] on US aerospace and defence was used.

Canada assumptions

Similar to the US, trade statistics for Canada were taken from national sources[63]. The available data contained less detail (6-digit HS classification) than that of US, meaning that additional sources are required to estimate defence shares.

Canadian defence shares rely on a Government departmental report

The key source adopted to estimate defence shares in Canada was a report by the Department of Innovation, Science and Economic Development on the state of Canada's defence industry[64], and selected industry surveys[6566]. Principally, survey data on aerospace allowed the computation of a defence share for aircraft exports. This share was then applied to all the products related to aircraft.

This process assumes that all products that relate to aerospace have a similar defence share. In practice, this might not be the case which would lead to inaccuracy, both over time and across product categories.

For certain goods, a 100% share was assumed due to the nature of the product. These goods belong mainly to Weapons & Ammunition.

Japan assumptions

Trade data for Japan were taken from the national statistics office[67] and are available to a 9-digit level, meaning that it is not possible to deduce military-use from the trade statistics alone.

The defence shares for Japan were calculated using evidence from sector organisations and World Input-Output tables

The defence share for the aerospace sector was calculated using evidence from the Society of Japanese Aerospace Companies[68]. The result is a single defence share which is applied to all products which come under the heading of Aircraft & Parts. As a single share is applied to various products and years, this assumes that all products that relate to aerospace have a similar defence share. As discussed in the case of Canada, this might not be the case.

For Radar apparatus and optical equipment, World input-output tables were consulted to estimate the share[69]. Correspondence tables were used to determine which NACE sector the good belonged to (NACE 26) and then, the share of Japan goods going from this industry to the Rest of World's NACE 84 sector (Public administration, defence, social security) was computed. Similar to Canada and the US, certain goods were assumed to have a 100% defence share given their nature.

[62] Deloitte (2017).

[63] Government of Canada (n.d.).

[64] ISED and CADSI (2018).

[65] Statistics Canada (2016).

[66] Ibid.

[67] National Statistics Center (2018).

[68] The Society of Japanese Aerospace Companies (2017).

[69] Timmer et al. (2015).

Appendix F Nomenclature and classification mapping

F.1 Mapping OTS defence-related codes to SIPRI armament categories

Table F-1 presents the suggested mapping of defence-related OTS codes to SIPRI armament categories. In addition to seven initial armament categories (Artillery, Missiles, Aircraft, Engines, Sensors, Armoured Vehicles and Other), composite categories were developed to best match the description and intended use of the corresponding items. For example, for certain items covered under broad OTS codes 90 and 93, a composite category comprising of SIPRI armament categories Artillery and Armoured Vehicles was developed.

Table F-1: Mapping of defence-related OTS codes to SIPRI armament categories

OTS Code	Description	SIPRI Armament Category
36010000	Propellant powders	Missiles
36020000	Prepared explosives o/t propellant powders, incl. Gelatinous	Missiles
36030010	Safety fuses; detonating fuses	Missiles
36030090	Detonators & percussion caps	Missiles
36049000	Pyrotechnic articles o/t articles for signalling/entertainment	Missiles
40113000	New pneumatic tyres, of rubber, of a kind used for aircraft	Aircraft
84071000	Spark-ignition reciprocating or rotary internal combustion piston engine, for aircraft	Engines
84091000	Parts suitable for use solely or principally with internal combustion piston engine for aircraft, n.e.s.	Engines
84111100	Turbojets of a thrust <= 25 kN	Engines
84111210	Turbojets of a thrust > 25 kN but <= 44 kN	Engines
84111230	Turbojets of a thrust > 44 kN but <= 132 kN	Engines
84111280	Turbojets of a thrust > 132 kN	Engines
84112100	Turbopropellers of a power <= 1.100 kW	Engines
84112220	Turbopropellers of a power > 1.100 kW but <= 3.730 kW	Engines
84112280	Turbopropellers of a power > 3.730 kW	Engines
84119100	Parts of turbojets or turbopropellers, n.e.s.	Engines
84121000	Reaction engines other than turbojets	Missiles
85261000	Radar apparatus	Sensors
87100000	Tanks and other armoured fighting vehicles, motorised, whether or not fitted with weapons, and parts of such vehicles, n.e.s.	Armoured Vehicles
88010010	Gliders, without motor and not capable of being fitted with a motor, and hang gliders; balloons and dirigibles (excl. party balloons)	Aircraft
88010090	Kites and other non-powered aircraft (excl. gliders, hang gliders, balloons and children's kites)	Aircraft
88021100	Helicopters of an unladen weight <= 2.000 kg	Aircraft
88021200	Helicopters: of an unladen weight exceeding 2000kg	Aircraft

88022000	Aeroplanes and other aircraft, of an unladen weight not exceeding 2000kg	Aircraft
88023000	Aeroplanes and other aircraft, of an unladen weight exceeding 2000kg but not exceeding 15000kg	Aircraft
88024000	Aeroplanes and other aircraft, of an unladen weight exceeding 15000kg	Aircraft
88031000	Propellers and rotors and parts thereof	Aircraft
88032000	Under-carriages and parts thereof	Aircraft
88033000	Other parts of aeroplanes or helicopters	Aircraft
88039090	Parts of aircraft, n.e.s. (excl. of spacecraft, incl. satellites, and suborbital and spacecraft launch vehicles)	Aircraft
88051010	Aircraft launching gear and parts thereof, n.e.s. (excl. motor winches for launching gliders)	Aircraft & Other
88051090	Deck-arrestor or similar gear for aircraft and parts thereof, n.e.s.	Aircraft & Other
88052100	Air combat simulators and parts thereof	Aircraft & Other
88052900	Ground flying trainers and parts thereof, n.e.s. (excl. air combat simulators and parts thereof)	Aircraft & Other
89061000	Warships	Ships
90131000	Telescopic sights for fitting to arms; periscopes; telescopes designed to form parts of machines, appliances, instruments or apparatus of Ch. 84, 85 or 90	Artillery & Armoured Vehicles
90139010	Parts & accessories for liquid crystal devices	Artillery & Armoured Vehicles
90139090	Other pts & acc o/t liquid crystal devices	Artillery & Armoured Vehicles
93011000	Artillery weapons ‘e.g. guns, howitzers and mortars’	Artillery
93012000	Rocket launchers; flame-throwers; grenade launchers; torpedo tubes and similar projectors	Artillery & Armoured Vehicles
93019000	Military weapons, incl. sub-machine guns (excl. artillery weapons, rocket launchers, flame-throwers, grenade launchers, torpedo tubes and similar projectors, revolvers and pistols of heading 9302 and cutting and t...	Artillery & Armoured Vehicles
93020000	Revolvers and pistols, other than those of heading 9303 or 9304	Artillery & Armoured Vehicles
93051000	Parts and accessories of articles of headings 9301 to 9304: of revolvers or pistols	Artillery & Armoured Vehicles
93059100	Parts and accessories of articles of headings 9301 to 9304: other: of military weapons of heading 9301	Artillery & Armoured Vehicles
93063010	Other cartridges and parts thereof: for revolvers and pistols of heading 9302 and for submachine guns of heading 9301	Artillery & Armoured Vehicles
93063030	Other cartridges and parts thereof: for military weapons	Artillery & Armoured Vehicles
93069010	Other [munitions and ammunition] for military purposes	Artillery & Armoured Vehicles
93070000	Swords, cutlasses, bayonets, lances and similar arms and parts thereof and scabbards and sheaths therefore.	Artillery & Armoured Vehicles

Sources: CE analysis.

Appendix G References

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