Dealing with Defence-specific Purchasing Power

A Discussion and Further Development on Current Methodology

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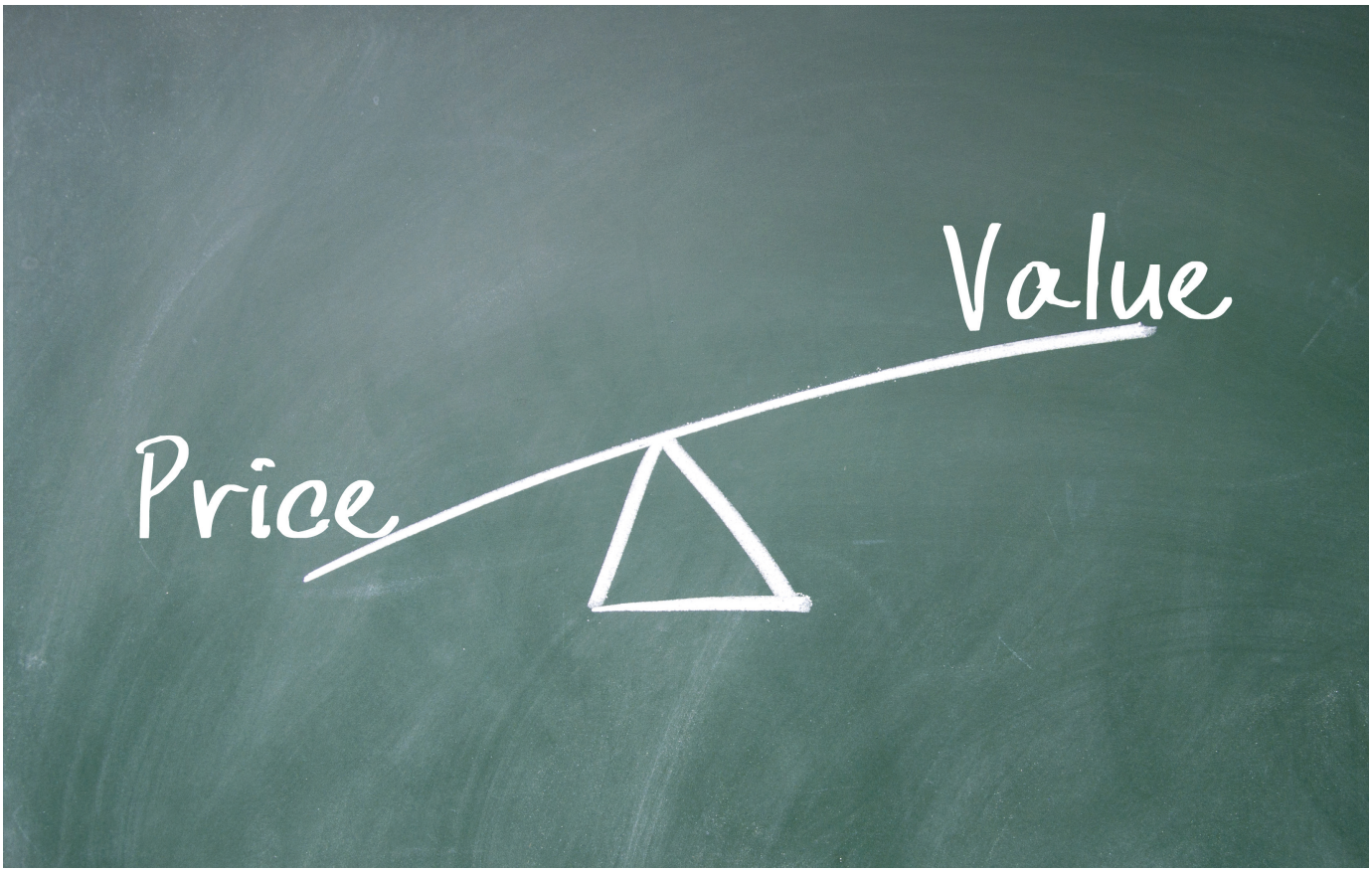

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Summary

This report aims at developing the methodology for international comparisons of military expenditure. Previous studies have found that the choice of conversion method when comparing expenditure between countries can have a substantial impact on outcomes. Traditional conversion methods include market exchange rates (MER) and purchasing power parity (PPP) for GDP. However, a defence-specific PPP (DS PPP) is preferable. The contribution of the report is threefold. Firstly, the report provides an overview of methodological issues with the different conversion methods. Secondly, the Swedish military expenditure data is reclassified in order to be comparable to the military expenditure of Poland and the UK. Thirdly, a DS PPP is constructed to compare military expenditure between the aforementioned countries. The expectation from previous studies is that the PPP measures should yield higher estimates compared to MER especially for Poland, whereas the difference should be smaller for the UK. The results are in line with the expectations to some extent, but, notably, in the case of Poland the DS PPP estimate does not differ much from the MER estimate. However, the results depend largely on the input values of the DS PPP. This study is a contribution to a topic that needs further discussion.

Keywords: military expenditure, defence-specific, purchasing power parity, market exchange rates

Sammanfattning

Den här rapporten syftar till att vidareutveckla metoden för internationella jämförelser av militära utgifter. Tidigare studier har visat att valet av metod för att konvertera försvarsutgifter i olika valutor kan ha en stor påverkan på resultatet. Traditionella konverteringsmetoder inkluderar växelkurser och köpkraftspariteter för BNP. Försvarsspecifika köpkraftspariteter (DS PPP) är dock att föredra. Rapportens bidrag är trefaldigt. För det första ges en genomgång av metodologiska problem relaterade till de olika konverteringsmetoderna. För det andra klassificeras de svenska militära utgifterna om för att bli jämförbara med Polens och Storbritanniens militära utgifter. För det tredje konstrueras ett försvarsspecifikt köpkraftsparitetsmått för att jämföra militära utgifter mellan ovan nämnda länder. Enligt tidigare studier förväntas PPP-måtten ge högre skattningar av de militära utgifterna särskilt för Polen, medan skillnaderna för Storbritannien förväntas vara mindre. Resultaten är i linje med förväntningarna i viss utsträckning, men noterbart är att skattningen som bygger på försvarsspecifika köpkraftspariteter inte skiljer sig avsevärt från skattningen med växelkurser för Polen. Resultaten beror dock på valet av inputvariabler. Den här studien är ett bidrag till ett ämne som kräver vidare diskussion.

Nyckelord: militära utgifter, försvarsspecifik, köpkraftspariteter, växelkurser

Foreword

The Swedish Defence Research Agency (FOI) has a long-established tradition of conducting research related to military expenditure. Over time, defence economic research at FOI has come to focus not only on how much different countries spend on their military, but also on what different countries get from their military spending. The Defence Economic Outlook report series provides an assessment of the global power balance between major powers such as the US, China, Russia and major Western European countries in terms of military expenditure, equipment quantities and equipment quality. An assessment based on these factors relates closely to the question of potential differences in purchasing power between different countries, especially between lower-income countries such as China, India and Russia compared to higher-income countries such as the US and Western European countries. Any marked difference in military purchasing power could have significant consequences for how we view the global power balance.

In this report, the authors Maria Ädel, Andreas Johnson and Tobias Junerfält explore the issue of defence-specific purchasing power by describing the logic behind purchasing power parities and their applicability to the defence sector. The authors discuss several previously used methods when estimating defence-specific purchasing power and present a method of their own, comparing military expenditure of higher-income countries Sweden and the UK to the relatively lower-income country of Poland when adjusting for defence-specific purchasing power. By doing so, the authors make a valuable contribution to our understanding of purchasing power and its application within the defence sector. Another important contribution in this report is the matching between expenditure posts or appropriations within the Swedish defence budget and the NATO military expenditure categories of Personnel, Equipment, Infrastructure and Other.

The report is written within the Defence Economics and Materiel Supply project on behalf of the Swedish Ministry of Defence. The project and the authors of this report would like to express our sincere gratitude to Cecilie Sendstad at the Norwegian Defence Research Establishment (FFI) for her valuable comments and suggestions when reviewing the research methodology and conclusions of this report. We would also like to thank Richard Langlais for reviewing the English language of this report and providing suggestions for editing.

Per Olsson (FOI)

Project manager, Defence Economics and Materiel Supply

Stockholm, January 2022

Abbreviations

DS PPP – Defence-specific purchasing power parity

FEER – Fundamental equilibrium exchange rate

FMV – Swedish Defence Materiel Administration

FOI – Swedish Defence Research Agency

GBP – British pound sterling

GDP – Gross domestic product

GNP – Gross national product

GUS – Statistics Poland

ICP – International Comparison Programme

ILO – International Labour Organisation

IMF – International Monetary Fund

MER – Market exchange rate

NATO – North Atlantic Treaty Organization

OECD – Organisation for Economic Co-operation and Development

PLN – Polish złoty

PPP – Purchasing power parity

SCB – Statistics Sweden

SEK – Swedish krona

SIPRI – Stockholm International Peace Research Institute

TIV – Trend-indicator value

UK – United Kingdom

UNODA – United Nations Office for Disarmament Affairs

US – United States

USD – United States dollar

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1 Introduction

Data on military expenditure is often used to analyse military strength, allowing defence researchers to identify trends over time and to make comparisons between countries. The Swedish Defence Research Agency (FOI) regularly provides the Swedish Ministry of Defence with studies, such as the *Defence Economic Outlook* report series, on military expenditure. The latter, to which the current study also belongs, aim to further the understanding of what different countries actually get from their military expenditure. This study provides valuable insights regarding issues and necessary assumptions when comparing military expenditure between countries. By analysing differing purchasing power parities between countries, measures of military expenditure can be more precise. This is one important input when assessing countries' military capability. For example, studies such as Robertson and Sin (2017) and Connolly (2019) have shown that the military expenditures of China and Russia can be seen to differ substantially when purchasing power parities are taken into account.

Estimates of a given country's military expenditure risk being misleading if based on conversion rates that are poorly fitted to the compared basket of expenditure items. It is hence important for the analysis of military expenditure to study the options of conversion methods. It is not, however, an easy task. While the construction of a detailed and comprehensive defence-specific purchasing power parity (DS PPP) measure would be preferable, obstructing factors such as unavailability of data, irregular purchases and unique military settings stand in the way.

This study outlines the use of PPP measurements when comparing military expenditure across countries. It also develops upon the work of previous studies to construct a DS PPP measure. By looking into different conversion methods, this study attempts to further the current understanding of their limitations and add to the methodological discussion in regard to comparing military expenditure across countries. By exploring the available data and by studying the specific conditions of Sweden, Poland and the United Kingdom (UK), the study discusses which of the available conversion methods should be used to compare these countries. Based on this discussion, the study thereafter constructs a DS PPP.

1.1 Background

There are known issues concerning the accuracy of military expenditure data, see for example Smith (2017). Previous studies, e.g., United Nations (1985), Heston and Aten (1993), SIPRI (2006), Robertson and Sin (2017), Robertson (2019), the US Department of State (2019), and Robertson (2021), have also found that the choice of conversion method when comparing military expenditure measured in different currencies can have a substantial impact. This is largely connected to the theory known as the 'Penn effect', associated with Balassa (1964) and Samuelson (1994), which states that market exchange rates (MER) tend to overstate the gross national product (GNP) of higher-income countries and underestimate the GNP of lower-income countries.

Military expenditure is often measured in terms of USD MER. However, this risks resulting in misleading estimates, for mainly two reasons. First, MER can fluctuate over time. If a given currency was to depreciate against the USD it would seem that military expenditure had decreased, even if it were to remain unchanged. Secondly, MER does not account for differences in purchasing power. The latter becomes most evident when comparing economies with different income levels, as MER, as stated above, generally tends to overstate spending levels of higher-income countries and understate spending of lower-income countries. Studies such as Robertson and Sin (2017) and Connolly (2019) have shown that using MER for international comparison tends to underestimate the military expenditures of China and Russia. For example, Robertson and Sin (2017) found that Chinese military expenditure relative to the US is almost twice as large if purchasing power parity (PPP) for GDP are

used instead of MER. The latest issue of FOI's *Defence Economic Outlook* (Olsson et al. 2020) also indicates that there is a discrepancy between major actors such as the US, China, and Russia between levels of military expenditure (in MER) and military equipment quantities.

1.2 Research objective

This study aims to further develop the methodology in international comparisons of military expenditure, building on previous studies. Furthermore, existing methodological difficulties involved in comparisons of military expenditure are discussed. The aim of the methodological review and discussion is to provide a broad overview of existing methods and issues currently scattered among multiple studies.

In addition, the study also attempts to construct a DS PPP for Sweden in relation to a country with a comparatively lower income level, in this case Poland, and a country with a similar income level, the UK.[1] In order to do this, Swedish military expenditure data first has to be matched with those of Poland and the UK, using a common nomenclature. Furthermore, the DS PPP, together with other PPP measurements, is compared to MER as a conversion method for analysing military expenditure estimates across the three economies.

Research questions:

1. What conversion methods exist for conducting international comparisons of military expenditure, and what methodological issues are there?
2. How can Swedish military expenditure data be matched, using a common nomenclature, with the data for Poland and the UK?
3. Based on matched data, how can a DS PPP be constructed to facilitate a comparison of military expenditure between Sweden, Poland and the UK?

1.3 Method and data

In order to answer the first research question, the study discusses the available conversion methods and the methodological difficulties involved. The fundamental challenge is how to convert expenditure expressed in different currencies into a common unit that allows for international comparisons. The methods include MER conversion and conversion using PPP rates, including different approaches when constructing DS PPPs. For this purpose, the methods and results of previous studies are also discussed. This overview serves to illustrate the application of various conversion methods, as well as providing a basis for discussing the strengths and weaknesses with each approach.

In order to provide further insights into the methodology of comparisons of military expenditure, the study discusses how a DS PPP, based on the method of PPP for GDP used by the International Comparison Programme (ICP), would be constructed. The classification system used for ICP is the same as that used for national accounts (World Bank 2021a). However, the ICP classification is not detailed enough for the defence sector. Therefore, to answer the second research question, the North Atlantic Treaty Organization (NATO) classification of military expenditure is used. In NATO's model, the data is presented in four categories: Equipment, Personnel, Infrastructure and Other. See Chapter 3 for the methodological discussion and for descriptions of the conversion methods used for the DS PPP constructed in this study to answer the third research question. The data published by NATO uses the same classification for all member countries, which facilitates this study's comparison of Poland and the UK. However, since Sweden is not a member of NATO, the data for Sweden needs to be matched to fit into NATO's classification model. It would have been preferable to have access to more disaggregated data, but such data is not openly available.

[1] In 2019, Sweden had a GDP PPP per capita of 55,660 USD (IMF 2021a), Poland had a GDP PPP per capita of 34,690 USD (IMF 2021b), and the United Kingdom had a GDP PPP per capita of 48,600 USD (IMF 2021c).

The number of countries chosen for a comparison of military expenditure data considered for the scope of this study has been limited to three: Sweden, Poland and the UK. There are several reasons for including Sweden. Firstly, the availability of Swedish military expenditure data is relatively high. Secondly, the authors of the study have more detailed knowledge of Swedish conditions. Thirdly, the fact that Sweden is not a NATO member country means that the matching between Swedish expenditure data and the NATO nomenclature could provide helpful insights for future analyses of military expenditure between NATO members and non-NATO members. The argument for including the UK and Poland is based on the availability of NATO data. This inclusion also allows for comparing Swedish military expenditure to a country with a similar income level (the UK) and a country with a lower income level (Poland), and to see whether DS PPP indeed has an impact on the estimate of military expenditure in relation to other countries, as suggested by previous studies. From a security policy standpoint, it may seem more interesting to include countries such as China and Russia. However, even though China and Russia are interesting study cases, the lack of transparency surrounding the distribution of military expenditure was deemed to be an obstacle that outweighs the potential benefits of including those countries in this study.

The time period chosen for the comparison of military expenditure data has been limited to one year, 2019. This was the most recent year for which military expenditure data was available. An additional reason for choosing this year was that there did not appear to be any irregularities during a review of the countries' military expenditure data. A time period stretching over more than one year could have been chosen, but, considering the methodological focus of the study, the decision to pick a single year was taken. The data on military expenditure for the UK and Poland has been retrieved from the NATO annual report, whereas the data on Swedish military expenditure was collected from different sources, such as annual reports of the Swedish Armed Forces and other government agencies, and thereafter categorised to match the NATO data.

A detailed description of the NATO nomenclature is not publicly available. Therefore, there may be methodological discrepancies in the process of matching Swedish data. This is explained more thoroughly in Section 4.1 and in the Appendix. Furthermore, certain delimitations had to be made when mapping Swedish military expenditure. Within the scope of this study, governmental expenditure not specifically allocated toward national military defence has not been taken into account. This means that other government expenditure categories, such as international cooperation, the coast guard, and civil defence have been excluded.

MER were collected from the Riksbank of Sweden (2021) and are measured as annual averages. GDP data for the productivity factor was collected from the Penn World Table (2021). Wage statistics, used to estimate PPPs for Personnel expenditure, were retrieved from Statistics Sweden (SCB 2021), Statistics Poland (GUS 2021) and, in the case of the UK, from the International Labour Organisation (ILO 2021). PPP indices for non-residential buildings and civil engineering work, used to estimate PPPs for Infrastructure expenditure, were collected from Eurostat (2021).

1.4 Outline

The outline of this report is as follows. Chapter 2 provides a theoretical overview of the PPP concept and how it relates to MER. It also provides an overview of how previous studies have attempted to construct a DS PPP. Chapter 3 describes preferable approaches and methodological issues with constructing DS PPP measures, and includes the DS PPP method used in this study. Chapter 4 presents and analyses the results. Chapter 5 presents a summary and conclusions. The Appendix provides the details describing the matching of Swedish military expenditure with the NATO nomenclature.

2 Theoretical overview

This chapter discusses the caveats of different conversion methods and why price differences matter in the comparison of expenditure between countries. The chapter also provides an overview of the approaches used in previous studies in constructing DS PPP measurements.

2.1 Market exchange rate

Military expenditure is often compared in terms of market exchange rate (MER), with the USD as benchmark. MER have some convenient characteristics. Data availability is high; timely and transparent data is available for extended time periods for most countries, allowing for large data sets.

However, there are several problems involved in using MER when comparing military expenditure between countries, and it risks causing error in international comparisons (Robertson 2019). Besides the above-mentioned problem, that MER tends to overstate the economy of higher-income countries and understate that of lower-income countries, because of price differences, there are other issues. For instance, MER are generally volatile and fluctuate on a daily basis, and over longer time periods significant variations are possible. This means that an arbitrary selection of the date for the currency conversion can have a major impact on the expenditure estimate.

Two assumptions have to hold in order for MER to result in fair estimates of relative values between countries. Firstly, there needs to be perfect arbitrage, i.e., the law of one price holds. Secondly, currency supply and demand need to be driven by international trade. However, not all goods and services are traded internationally and hence price differences occur. Furthermore, supply and demand for currencies are affected by other factors besides those from international trade, such as currency speculation, government intervention, interest rates and capital flows (Eurostat-OECD 2012, 15).

Most developed economies have flexible exchange rate regimes, where the exchange rate is decided by market forces. However, many developing economies still have fixed exchange rate regimes, where the government to varying extent manages the exchange rate. Such exchange rates do not fully reflect market forces and therefore the problem of understating or overstating military expenditure can be enhanced.

For some economies, MER are strongly correlated to specific economic factors. For example, the movement of the Russian rouble tends to correlate with changes in oil prices because of the importance of oil exports for both the Russian economy and capital flows. Sharp increases or decreases in oil prices tend to have substantial effects on the rouble MER vis-a-vis the US dollar. Consequently, converting Russian military expenditure measured in local currency into US dollars could result in a potentially significant error. Connolly (2019) showed that Russian military expenditure appeared to have decreased 2014–2015 when expressed in US dollars but showed an increase when presented in Russian roubles. The decrease was due to the depreciation of the rouble against the US dollar caused by falling oil prices.

Two additional issues with using MER for international comparisons, not only for military expenditure but also in general, are that goods and services often have different relative prices within a country, and that non-traded goods are relatively cheap in poorer countries (Robertson & Sin 2017, 93). Furthermore, the extent to which the economy consists of non-traded goods also differs between different countries (US Department of State 2019, 26). The idea in using a PPP method is to avoid or at least mitigate the errors arising from using MER.

A high level of international trade tends to move an MER towards its fundamental equilibrium exchange rate (FEER). The FEER is the exchange rate that is consistent with macroeconomic balance[2] (Williamson 1994). Consequently, using an MER is more suitable for countries where trade is substantial in terms of share of GDP. Conversely, for closed economies, using the MER for international comparisons might be inappropriate, as foreign trade only affects a small part of the economy.

2.2 Price differences and PPP

If every country were to meet the same prices on the international market, i.e., if the law of one price were to hold, PPP and MER would be equal. In this case, demand and supply for currency is only driven by international trade and all goods and services are tradable (Eurostat-OECD 2012). Globalisation has long shaped the world and today goods and services are traded widely at a global level. In reality, however, there are several factors that lead to different prices between countries. For instance, there are goods and services that are not traded, often referred to as "non-tradables". Some services are offered across countries more easily due to the spread of the Internet, but there are still services that are not tradable, such as haircuts, tourist attractions and car mechanics.

International comparisons of values of goods and services have historically been made using MER. Due to the various issues raised in Section 2.1, estimates based on MER risk being misleading in the context of international comparisons. An example of this is when the GDP of the US is compared with that of China; using an MER estimate, the US economy is still larger than China's, whereas the relationship is inversed if the sizes of the economies are instead expressed in PPP terms (World Bank 2021b). The value of a currency is influenced, as mentioned above, by several factors other than demand for goods and services, such as currency speculation, government intervention, interest rates and capital flows. Therefore, the MER differs from the PPP rate (Eurostat-OECD 2012).

Balassa (1964) showed that there is a systematic relationship between PPP and MER both within a country as well as between countries. Balassa (1964) argued that this relationship could help explain over- and undervaluation of currencies, as well as to provide insights on differences in income levels. Balassa (1964) also stated that MER overstates the GNP of high-income countries. This later became known as the "Penn effect" and implies that the MER systematically overstates the difference of real per capita income between high- and low-income countries (Samuelson 1994).

In order to address the issues with MER when comparing GDP between countries, PPP is often used. PPP rates convert values in local currencies into a common price basis using a standard international unit of account. The purpose is thus to give an indication of the price in a certain country to purchase the same goods and services as you would get for one currency unit in the reference country, usually using the US dollar as the baseline currency (SIPRI 2006, 370–373). The original way to calculate PPP rates presupposes an identical 'basket' of goods and services in each of the countries to be compared. The comparison generates quotas of price differences between countries. The quotas represent how many units of country A's currency are needed to buy a certain basket of goods and services in relation to country B's currency for the same basket. When price differences are taken into account, expenditure can be compared between countries in real terms.

PPPs for GDP are constructed by the ICP (World Bank 2021a). The ICP PPPs are based on GDP in its weight allocation and basket composition, since the main purpose is to compare GDP across countries. ICP regularly publishes PPP-based GDP; the latest comparison used 2017 as the base year and was published in May 2020 (World Bank 2021a). The previous reference year was 2011. The most extensive survey of PPPs, which includes all regions of

[2] Macroeconomic balance is generally interpreted as the situation when the economy is operating at full employment and there is low inflation and a sustainable current account.

the world, is hence only published around every 6 years. In between these years, the PPPs are extrapolated using price indices (see for instance IMF).

PPP figures are calculated by collecting prices for a basket of goods and services that is both representative as well as comparable between the countries in the survey. The prices should be collected at the same point in time.

The PPP between the UK and Sweden could be expressed as:

$$PPP_{UK/SWE} = P_{UK} / P_{SWE}$$

P_{Swe} is the price of the basket in SEK and P_{UK} is the price of the same basket in the UK in pounds (GBP).

A simplified example: suppose that the price of one litre of gasoline[3] is 14 SEK in Sweden and 1.80 GBP in the UK. 1.8/14 = 0.13, in other words the PPP ratio between the UK and Sweden of a litre of gasoline would then be 0.13 GBP to 1 SEK.

In reality, the calculation is much more complex since the basket needs to represent the whole economy, i.e., the countries' GDPs. Apart from the challenge of finding a sufficient amount of goods and services that can be compared between countries, there are some other challenges involved in calculating PPPs. Comparing similar goods and services across countries is one example. In calculating PPP, both identical and generic goods are compared between the countries. In some cases, the identical goods are unavailable, in which case the country should collect prices for an equivalent good. If the goods compared are not identical or equivalent, there is a risk that the difference in price level will be due to differences in quality rather than volume (Eurostat-OECD, 2012).

PPP rates can be calculated at different levels of abstraction. The first and most aggregated approach is to obtain a PPP rate at the GDP level. This is the PPP counterpart for using MER covering all goods and services. The second approach limits the PPP rate calculation to a lower level, for example government expenditure, which can be a suitable measurement if the 'basket' of expenditures in question is to a large extent made up of government salaries (SIPRI 2006, 379–380).

PPP comparisons are base-country invariant, i.e., the PPP rate in relation to another country will be the same regardless of the base economy. For instance, the PPP rate between Poland and the UK will be the same independently of whether the US or EU27 is used as base. Furthermore, PPP rates are transitive, which means that comparisons between two countries are valid even if drawn via a third country (SIPRI 2006, 373). The basic principle is simple: national average expenditures are divided by national average prices, which produces quantity estimates that can be revalued using uniform average international prices. However, to perform the necessary calculations, a vast amount of price and quantity data may have to be collected, and an appropriate aggregation formula has to be chosen (SIPRI 2006, 370–373).

There are also certain issues with the PPP approach. One issue is that a certain item can be widely more common, and thus likely to be cheaper, in one country than in another. If a certain item is more commonly purchased in one country, its unit price is also likely to be affected by such things as bulk prices, which further complicates comparison. A more measured approach is to aggregate so-called 'basic headings' (e.g., defence materiel), which are comprised of similar types of goods and services that form a 'basket' of expenditures representative for each country. Each of these 'basic headings' can then be combined with price ratios, reflecting the corresponding average exchange ratios between countries for that collection of items (SIPRI 2006, 375–376).

[3] All goods that are compared need to be stated in detail. In this case, whether it is 95 or 98 octane would for instance be specified.

Another issue pointed out by SIPRI is that PPP has lower reliability in comparison to MER in the sense that PPP is a non-comprehensive statistical survey. It is rather a collection of prices for a selection of goods and services meant to represent the whole economy. Furthermore, for the years in between benchmark years, price indices are used to extrapolate PPP rates, which brings further uncertainty to the statistics (SIPRI 2021b).

2.3 Purchasing power of military expenditure

There are specific challenges associated with using PPP for international comparisons of military expenditure. Since there is no universal DS PPP, the only PPP available is the survey that is based on the economy as a whole, PPP for GDP. This measure does not necessarily reflect prices representative for the defence sector. In order for the PPP-for-GDP rate to fit the military expenditure, there are certain conditions that need to be met. Firstly, the share of non-tradables in the country's defence sector needs to correspond to the share of non-tradables in the whole economy. Secondly, the prices of those defence sector goods need to differ from the base country to the same extent as prices of non-tradables in the whole economy. If the first condition does not hold true, a lower share of non-tradables in the country's defence sector needs to be offset by higher prices for those non-tradables, or vice versa. In other words, the defence sector has to be comparable to the economy as a whole (US Department of State 2019). Examples of non-tradable defence-related goods and services include state-of-the-art technology that is subject to export restrictions, as well as defence industry labour and military personnel. Equipment sold on the international market by a country's defence industry is an example of a tradable good.

Another issue with employing PPP for GDP for comparisons of military expenditure is that the economy-wide inflation rate might be different from the inflation rate for military goods and services (Connolly 2019, 13).

Robertson (2021) finds that there is a discrepancy between military expenditure in terms of a military PPP constructed in the study and in terms of PPP for GDP. It is explained above that PPP for GDP should measure the whole economy from the expenditure side. Therefore, the prices collected are of goods and services representative of the particular expenditure. The service that the military provides cannot be priced, since it is not sold in the same manner as services are sold in the private sector. It is similar to other public services provided by the government, such as police forces or fire departments. Since it is not possible to summarise the value added of the produced services, national accounts have instead adopted the method, called the input price approach, of adding up the cost of producing the services. In order to be consistent with the national accounts, the same approach is used for the calculation of PPP (Eurostat-OECD 2012, 185). This method could also be used for DS PPPs; however, the challenges arise when the comparison is made between countries.

Constructing a DS PPP entails finding goods and services that represent the military expenditure of the countries to be compared. A general problem when constructing a DS PPP is to identify the items to be priced and to find appropriate prices. Equipment items are often unique and adapted to the specific needs of the procuring countries. The large materiel systems have life cycles that often stretch over several decades. Therefore, it is difficult to find representative military materiel that is at the same time comparable to similar military materiel from or in other countries. Robertson emphasises the importance of measuring the items per effective unit, due to differences in quality between countries (Robertson 2021, 6).

In some cases, the items can be more straightforward to identify, such as when determining the salary of infantry soldiers with known service records. However, the salary of conscripted soldiers is harder to identify (SIPRI 2006, 381). Furthermore, there is still the issue of data availability. There could be substantial differences for individual economies, depending on wage levels and whether a system of conscripts or professional soldiers is used. Also, the structure of total government expenditure may not correspond well with total military expenditure, especially in such cases where the latter to a large extent is made up of equipment costs (SIPRI 2006, 379–380).

However, US Department of State (2019) also notes that a defence-sector-specific PPP rate for military expenditure produced by using limited and internationally available data might still be better than converting both military expenditure and GDP at the same rate.

2.4 Previous studies on DS PPP

A study from the United Nations (1985) is one of the first attempts to construct a military price index. It is arguably the study that has come closest to resembling the GDP PPP survey by the World Bank, ICP, when it comes to constructing a DS PPP. Questionnaires were used in order to solicit participating countries, namely Australia, Austria, Finland, Italy, Norway, Sweden, the UK and US, for specific data according to four major cost categories: Operating costs, Procurement, Construction, and Research and Development. For each category, expenditure was further divided into subcategories. Data was requested for the years 1980, 1981, and 1982.

The study provides an illustration of the methodological difficulties involved in constructing a DS PPP. For the Operating costs category, the main problem was how to handle the fact that for some countries, military personnel consist mainly of conscripts, while other countries rely on enlisted privates. The problem was handled by attributing conscripts with more than six months of training a military value similar to the one for enlisted privates, while conscripts with less than six months of training were treated as a separate item. For the Procurement category, certain types of items were specified, and participating countries were asked to find such items. The task of matching items from different countries was difficult and it was not possible to construct price indices for all countries. Issues with this included the difficulty in identifying comparable procurement items, as well as low data availability. For the Construction category, the report had to use civilian construction price indices. Finally, for the Research and Development category, prices for a selected number of items within the Operating costs category had to be used, assuming these could function as proxies for similar items in the R&D category. United Nations (1985) finds that the differences between civilian and military indices were large enough to provide a strong argument for constructing PPP indices for military expenditure.

Heston and Aten (1993) construct PPPs for military expenditure for a large number of countries. In the article military PPPs are approximated by weighting components of civilian output that approximately correspond to military items. Countries are divided into different groups according to data availability. The starting point is the eight countries in United Nations (1985) for which military PPPs were constructed. To this group, additional countries with a varying amount of data are added. The idea is to find relationships for the countries where the most data related to military price levels is available and apply these relationships to countries for which data is less abundant.

For many countries, there is no direct estimate of personnel expenditures. Heston and Aten (1993) use two different approaches to construct estimates:

1. Distribution of military expenditure between personnel and other expenditures for the countries that have actually reported a distribution (assigning expenditures based on similarities between countries).
2. Estimation of shares of personnel expenditure based on a regression equation for the 27 countries that have reported a distribution of military expenditures.

A geometric average of these two estimates is thereafter calculated. Furthermore, the article uses data for military spending reported to the UN by 27 countries, as well as data from Sivard (1983) and United States Arms Control and Disarmament Agency (1987), to specify another regression equation. The equation is used to form estimates of total military expenditure for the remaining countries. The study continues by using the total expenditures and shares of personnel in military expenditure to approximate military PPPs. Another regression equation is specified to provide estimates of the military PPP and real expenditures for most of the remaining countries. Using this methodology, Heston and Aten (1993) are

able to present estimates of real military expenditure and military PPPs for 134 countries in total, although the reliability of the estimates varies. The contribution of the article is the conversion of national military expenditure data to comparable quantities measured in international dollars.

In recent years, Robertson and Sin (2017) developed a military unit cost index in order to convert nominal expenditure into real military expenditure. This study uses manufacturing industry productivity rates to appreciate corresponding productivity rates for military sector personnel. Data is collected from the Penn World Table to adjust the productivity rate of workers between China and the US. In comparison to collecting prices in accordance with the ICP approach, this approach does not have the same issues with data availability. However, the validity of the results is highly dependent on the validity of each respective proxy[4] measurement.

In order to construct a price deflator to be applied in the context of military services, the first step was to produce an index of input prices. To determine input, three broad categories common for most military budgets were used: Personnel, Operations and Procurement. For Personnel, nominal wage ratios were used. Operations include a mix of traded and non-traded goods; hence, the PPP exchange rate was used as an approximation. For Equipment, the assumption was that a large amount of military equipment is tradable or produced using tradable components, and thus arbitrage, or the law of one price, was assumed. Apart from input and corresponding prices, the weighting of different input prices also required identification. This was done by simply considering each input's share of total costs. To form a unit cost index, Robertson and Sin (2017) employ standard index number theory, by combining input shares and prices. The results of the study indicate that the real military expenditure of China relative to the US was closer to PPP comparisons than to MER comparisons.

Robertson (2019) shows how a DS PPP can be constructed using widely available data. The study compares the prices of the components of military expenditure in order to construct an index of relative military input costs (RMC index) using the standard military budget reporting categories, Personnel, Operations, and Equipment expenditure. These categories are used to construct an input cost index based on prices and expenditure shares in the defence budget.

Robertson (2019) uses a Törnqvist index that allows for calculating relative input costs based on relative input prices and also controls for substitution bias. For Personnel, the average wage rate per effective worker across countries is used. Relative Equipment costs are approximated by the MER between country *i* and *k*. A standard average price PPP exchange rate is used as an approximation for the relative price of Operations. The data for the three categories are collected from the Penn World Tables. Expenditure share data is collected from the United Nations Office for Disarmament Affairs (UNODA). Actual military expenditure is taken from SIPRI. Robertson (2019) computes estimates for relative military cost indices for 58 countries from 2000 to 2017, finding that MER tends to understate the real purchasing power of military expenditure. The Relative Military Cost index (RMC) DS PPP implies much higher real military purchasing power.

Robertson (2021) constructs a military purchasing price index for 59 countries. The index is constructed by using cost minimisation and index number theory. Personnel data is estimated by dividing military personnel expenditure by number of personnel. Moreover, a productive factor is then used to control for differences in efficiency of labour between countries. For the Equipment category, PPP for machinery and equipment from the international comparison program (ICP) is used. Finally, for the Operations category, PPP for GDP, also from ICP, is used. The study found that the difference of using the military PPP exchange rate from using MER is that the share of the United States in world military expenditure drops from 41 per cent to 26 per cent.

[4] A proxy is a substitute that represents the variable of interest.

US Department of State (2019) constructs a DS PPP using proxy measurements. In US Department of State (2019), a conversion method that involves a DS PPP rate for military expenditure together with a PPP for GDP is described. With the assumption that prices for non-tradables remain the same across a country's economy, the expectation is that a country with a defence sector with considerably fewer non-tradables than its economy on average will have a DS PPP rate closer to MER than to PPP for GDP. If the country's defence sector is only slightly less non-tradable-intensive than its economy on average, however, the DS PPP rate will instead be closer to PPP for GDP than to MER. In US Department of State (2019), military capital-intensity (in terms of military expenditure per armed forces member) is employed as an approximation of the defence sector tradable-intensity, as well as economy-wide capital-intensity as an approximation of economy-wide tradable-intensity. The underlying assumption is that, even though labour usually constitutes the largest non-tradable in most economies, it is not the only non-tradable, nor is labour always entirely non-tradable. Capital, which is also not entirely tradable internationally, is thus used as a substitute for labour (lower labour-intensity means higher capital-intensity, and vice versa), since the data necessary to calculate military expenditure per armed forces member has higher international availability.

2.5 Summary of chapter

This chapter discusses the theory behind price differences and the different methods for comparing expenditure between countries. The last section reviews previous studies that have attempted to construct a DS PPP. The theoretical background provided by this chapter serves as a basis for the methodological discussion in the next chapter.

3 Methodological discussion

The ideal situation for obtaining a DS PPP would be to use the same method as ICP, i.e., strive to gather complete data of military expenditure for the specific point in time for each selected country, including expenditure for personnel, materiel, infrastructure, etc. Furthermore, in order to calculate PPP, there is a need to collect prices for a set of representative goods and services. This approach, if executed successfully, would entail high validity. This chapter describes possible approaches for how to produce DS PPP measurements for each of the categories of the NATO nomenclature: Equipment, Personnel, Infrastructure, and Other. There is also a description of specific issues in constructing DS PPP measurements for each expenditure category. These approaches are based on the theoretical background and previous studies described in Chapter 2.

Furthermore, this chapter contains descriptions of the methods used in this study to construct DS PPP measurements for Sweden, Poland and the UK using the various proxy measures and approaches identified in previous studies.

3.1 Equipment

For the Equipment category, the preferable approach to constructing DS PPP measurements would include the collection of prices for representative and comparable military materiel for each country involved in the comparison, during a given time period. This was what the United Nations (1985) study attempted to do. Given perfect data availability, the first point of action in order to construct PPP measurements for military materiel would be to determine what equipment categories are of most relevance in the comparison between the different countries, i.e., categories that constitute a substantial share of each of the involved countries' materiel expenditure during the given time period. With this approach, it is not important whether the materiel is domestically produced or imported because the prices would reflect the specific prices met by each country's government at the time of purchase.

The next step would be to select comparable materiel for each equipment category, for each country, during the given time period. It is desirable to find as many comparable purchases within each equipment category as possible, in order to increase the reliability of the comparison. The comparability, i.e., the similarity in performance, of equipment models within the same category, needs to be determined, using one or several appropriate quality parameters for each category.

As previously mentioned, PPPs are calculated at a specific point in time. A reference year is used for when the goods and services are compared. In reality, military materiel is purchased irregularly and countries usually do not have a synchronised life cycle of the materiel systems. Hence, the prices need to be adjusted to the reference year. Since the materiel quantity differs between purchases, it is the unit cost of each equipment model that needs to be established before comparisons between the different countries can be made.

The approach described above provides a good basis for how to establish PPP measurements for the Equipment category. In reality, however, data collection is fraught with difficulty. For the ideal DS PPP, there are certain preconditions that need to be in place, the lack of which will impact the possibility of establishing proper comparisons.

One of these preconditions is that the countries involved in the comparison to some degree need to have similar distributions between different equipment categories. If there are few similarities in the type of materiel the involved countries acquire, there will also likely be a lack of comparable materiel acquisitions. As an illustration, see Figure 3.1, below. It shows the distribution of materiel imports for the UK, Sweden and Poland during the period 2011–2020. Even though there are examples of arms categories that are imported by all three countries, the shares between different categories differ to a large degree. For example, aircraft is a major import category for the UK but a small one for Poland. Furthermore, only imports are taken into account, whereas domestically acquired arms are left out, because of

a lack of data. These factors make it difficult to determine the representability of a certain arms category for the purpose of a cross-country comparison, even in the case where transactions of similar equipment within the category can be identified.

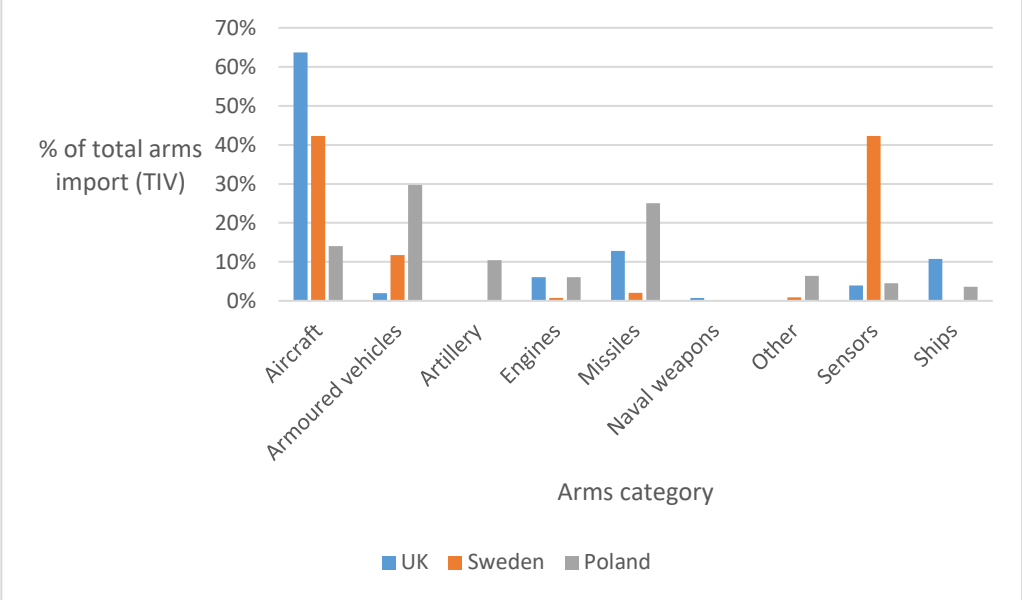

Figure 3.1 Share of total arms import 2011–2020 by major arms category, based on TIV[5] values. Source: SIPRI (2021a).

Another desirable condition would be for the selected acquisitions to have taken place within a limited time span. Comparing transactions that are too far apart in time means that factors such as inflation need to be taken into account. Furthermore, a fundamental issue is the limited amount of detailed information available concerning military materiel acquisitions, especially in terms of financial values. The SIPRI Arms Transfers Database provides details regarding international arms transactions, but price information is only available in some cases. In cases where the transaction price is available, it can still be difficult to determine the unit cost for a specific weapon system, as transaction prices to a varying degree also include other items, such as training, support and offsets. Furthermore, some transactions are part of broader deals or projects, where price information is only available for the deal or project as a whole, and not in terms of unit costs. However, the SIPRI Arms Transfers Database is not the sole source of information regarding international arms transactions; news articles, governmental documents, press releases, etc., can sometimes serve as alternative or complementary sources. These additional sources are even more relevant when it comes to information concerning acquisitions of domestically produced materiel, since such acquisitions are not covered by the SIPRI Arms Transfers Database.

Even so, finding detailed and comprehensive information regarding both imports and domestic acquisitions remains a considerable obstacle. Therefore, it is difficult to construct a DS PPP in the method described above. If the distribution between domestically produced and imported materiel is unknown, it is also difficult to use MER as a measure for the share of the materiel expenditure that is acquired on the international market. Moreover, using MER to appreciate the prices of imported materiel is in itself a simplification. For example, imported materiel is sometimes assembled in the target country, which means that, e.g., prices for non-tradables such as local labour end up being a factor, anyway. There are also other possible factors that could make MER comparisons misleading for international arms transactions, such as offsets, materiel provided partially as aid, or differences in negotiation power. Hence, prices on the international market are not the same for all countries.

[5] Trend-indicator value (TIV) is a SIPRI unit used to represent the transfer of military resources, based on known unit production costs of a core set of weapons. See SIPRI (2021d) for more details.

Several of the issues mentioned in United Nations (1985) remain obstacles today, even though data availability has improved during the past decades, for example due to the rise of the Internet. One of the issues touched upon in United Nations (1985) is that stable price comparisons of materiel acquisitions between the different countries involved presuppose that relevant acquisitions have actually taken place within a limited time span. Additionally, even if materiel acquisitions within the same equipment categories have taken place during the given time period for each country involved, the acquisitions do not necessarily consist of models of comparable quality. A possible, partial solution to this issue would be to calculate estimates of the quality gaps.

However, this is closely related to another issue identified in United Nations (1985), which is of equal relevance today. It is the issue of comparing the military value of different models within the same arms category. First of all, it is difficult to identify an appropriate quality parameter that can serve as a proxy for military performance. Military materiel systems are complex, and estimating the comparability between two different models, e.g., two different kinds of tanks, by one single parameter, such as speed or tonnage, is seldom sufficient (Olsson 2018). In order to make such quality assessments, it is necessary to have a high degree of information and a transparent framework. If credible quality assessments cannot be made, estimates of quality gaps between different models are also difficult to achieve.

To illustrate the above-mentioned factors, Table 3.1, below, presents sample transactions for Sweden, the UK and Poland. Any conclusion on representativeness for total Equipment expenditure, including both imported and domestically produced materiel, cannot be drawn since there is only information on imported materiel available. However, the example is provided to illustrate the complexity in constructing a DS PPP, given the particular characteristics of the military sector.

Table 3.1 Example of information extracted from SIPRI Arms Transfers Database

Country (recipient)	Equipment category	Model name	Year of order/ year of delivery	Includes	Unit cost (thousand USD)
Sweden	Anti-tank missile	NLAW	2005/2009–2012	-	32
UK	Anti-tank missile	AGM-114K Hellfire	2012/2013	-	73
Poland	Anti-tank missile	Spike-MR/LR	2015/2018–2020	Offsets, launcher	152

Three different models of anti-tank missiles, one for each country, have been identified, as well as their respective unit costs in USD. This can be considered somewhat of a rare case, where the price has successfully been identified for all transactions involved, even though the year of order/year of delivery differs to some extent, which necessitates taking the effect of inflation into account. However, there are remaining issues: how to separate the share constituted by offsets and launchers (see the “Includes” column above) in the Polish import from the unit cost of the anti-tank missile itself, and how to establish the comparability of the three different models. Even though all three models fall under the category of Anti-tank missile in the SIPRI Arms Transfers Database, it does not mean that they are of comparable quality. As mentioned above, a proxy performance parameter, such as missile velocity or range, could be used for quality comparisons. Nevertheless, such single parameter comparisons will never be fully convincing, and even if multiple parameters are used in parallel the final assessment will always be arbitrary, to some extent.

Again, whether the item compared is imported or domestically produced is unimportant if the actual transaction price is available and the materiel is comparable. However, if this is not the case and a proxy is used, knowing the share of imports can indicate whether the MER is a good estimator or to which extent it could be used in combination with a PPP measure.

With the above reasoning as background, the initial approach for the Equipment DS PPP was to find prices for comparable materiel acquisitions for each of the three countries involved, and thereafter produce DS PPP measurements representative of each country's actual materiel expenditure. However, due to aforementioned issues, such as low data availability related to import prices and domestic acquisitions, difficulty with quality comparisons, etc., the decision was made to abandon this approach in favour of proxy measurements.

All three countries have significant domestic defence industries, even though they differ in size and structure, while at the same time trading military materiel on the international market. Since military materiel is traded internationally, it can be argued that MER would be representative. Previous studies, such as Robertson and Sin (2017) and Robertson (2019), have used MER for this reason. However, there are alternative ways to handle Equipment expenditure. Since the included countries not only acquire military materiel internationally but also have domestic defence industries that provide the armed forces with materiel, MER is not necessarily representative due to not taking the differences in purchasing power into account.

An alternative to using MER is to use PPP for GDP or a sub-index such as PPP for gross fixed capital formation[6] (which is used as a proxy for the defence sector by OECD-Eurostat and the World Bank). However, using PPP for GDP as a conversion method comes with certain issues, such as the role of non-tradables, as mentioned in US Department of State (2019). For example, if the share of non-tradables in the defence sector differs from the overall share of non-tradables in the whole economy, PPP for GDP measures are less reliable. Since the share of non-tradables in the defence sector is difficult to identify, using PPP for GDP as a conversion method for the Equipment category may be misleading. Furthermore, prices for nationally purchased equipment do not necessarily follow the same rules as investments in non-defence-related goods within a country. Moreover, since the distribution between imported and domestically produced materiel could not be ascertained due to lack of data, an assumption about the distribution would have to be made, introducing additional uncertainty. Since the sizes of the defence industries in Sweden, Poland and the UK differ, the distribution likely varies between the countries involved.

Due to more uncertainties in using PPP for GDP, or a sub-index, than with using MER, the decision was made to convert Equipment expenditure using MER.

3.2 Personnel

For the Personnel category, the preferable and most comprehensive approach to constructing DS PPP measurements would be to measure the price of the actual military service. However, since the service is not sold on the market per se, this is not possible. The ideal input price approach would involve mapping military wages for each country involved in the comparison, during a given time period. This can be done at different levels of abstraction; the lower the level of abstraction, the higher the precision of the measurement is likely to be. At the lowest level of abstraction, this would mean identifying the wage levels of all different military and civilian ranks within each country's military, while also establishing cross-country comparability. For example, the wage of an army officer of a certain rank in Country A needs to be compared to the wage of an army officer of the corresponding rank in Country B. At the highest level of abstraction, average wage levels for the entire personnel forces of each country's military would be identified and compared. It is also important to bear in mind that even though actual military wages would be used, this is an input price approach. In general, it would be better to collect the actual prices of the service; however, this is difficult for public services.

[6] Gross fixed capital formation is defined by OECD as: "the acquisition of produced assets (including purchases of second-hand assets), including the production of such assets by producers for their own use, including disposals." The measure consists of nationally reported prices for equipment goods as well as construction.

However, the Personnel category faces methodological issues similar to those of the Equipment category. Data availability for military wage levels is often low, and varies to a high degree between countries. A fine-grained international comparison of wages in different parts of a country's military organisation, or between different ranks, is impossible to accomplish without a very high degree of data access, something that foreign observers can only dream of obtaining. As mentioned in SIPRI (2006), it is especially difficult to identify salaries for conscripted soldiers. Even in cases where the average wage level for the military of a certain country can be identified at a high level of abstraction, it is difficult to identify the international comparability of the underlying data. The fact that there are organisational differences between the militaries of different countries, in terms of personnel composition (including differences in conscription policies), and the structure of ranking systems, etc., lowers the reliability of high-level comparisons based on average values.

When it came to deciding the DS PPP conversion method for the Personnel category, the initial approach of mapping wage levels in detail was quickly abandoned due to low data availability. Instead, proxy measurements were used.

Military personnel are not traded internationally and, hence, local conditions are the main factor affecting the price of labour. Therefore, the MER is likely to be a poor fit for this category.

At first, the question of whether or not the method from Robertson (2021) could be used, which would mean that an average wage level was obtained by dividing total personnel expenditure with the number of personnel, was explored. However, there were several issues involved in identifying comparable personnel numbers for the three countries. The military personnel numbers reported in NATO (2021) for Poland and the UK are not presented in detail, and there are likely to be differences between NATO members as to how military personnel amounts are defined. There are at least four different categories of military personnel, including active military personnel, part-time military personnel, reservists, and conscripted soldiers. It is not entirely obvious which of these categories are taken into account in the reported figures for Poland and the UK. Organisational differences between each country's armed forces exacerbate this issue; for instance, Poland and the UK do not have military conscription, while Sweden does. These issues make it difficult to determine the correct personnel amount for a proper comparison, hence this method was abandoned.

Instead, public sector wages in each country were used as a proxy. Specifically, wages for sector O, 'Public administration and defence; compulsory social security', according to NACE,[7] were retrieved from SCB (2021), GUS (2021), and the ILO (2021), respectively. ILO was used as a substitute in the case of the UK, because it was not possible to find comparable sector O data in the Office for National Statistics datasets.

However, by using an average wage level for the whole sector, the different compositions of the defence sector between the countries are not taken into account. A difference of particular significance is the fact that Sweden has conscription, whereas the UK and Poland do not. Furthermore, it is likely the case that the three countries differ in regard to how many military personnel the different ranks or categories include, which might also affect the representability of the average wage level used.

Moreover, the military personnel in each country, of different ranks and categories, may differ in their level of experience and, by extension, productivity. Therefore, the quality of military service provided by the different countries varies. In order to adjust for differences in the quality of the service, or more specifically the efficiency of the workers, this study's approach is inspired by Robertson and Sin (2017), where a proxy measure is used to estimate productivity. The proxy measure in Robertson and Sin (2017) is based on a combination of the human capital index and years of schooling, whereas in this study an approximation

[7] NACE is a classification of economic activities used by the European Union. The acronym originates from the French term "nomenclature statistique des activités économiques dans la Communauté européenne"

based on GDP and labour hours is used. Through data from the Penn World Table (2021), a productivity factor is calculated according to the methodology below.

$$\frac{GDP}{Workers} = GDP_w$$

$$\frac{GDP_w}{Hours} = GDP_h$$

Where *Workers* is number of persons engaged and *Hours* is average annual hours worked by persons engaged. The productivity factor is used to adjust the wages before calculating a PPP between the countries in the study.

Sweden is used as a base for the productivity factor:

$$\frac{GDP_{hi}}{GDP_{hSWE}} = \hat{\theta}_{iSWE}$$

Where $\hat{\theta}_{iSWE}$ represents productivity factor for country i in relation to Sweden.

3.3 Infrastructure

For the Infrastructure category, the preferable and most comprehensive approach to constructing DS PPP measurements would involve mapping construction expenditure and prices for each country involved in the comparison, during a given time period. For each country, separate expenditures for different categories of construction projects, e.g., warehouses and barracks, need to be identified. These expenditures can thereafter be used in order to determine prices for specific construction projects, which can then be compared category-wise between each involved country, in order to produce PPP measurements that as a whole are representative of the actual composition of military construction in each country.

However, as with the previous two categories, the Infrastructure category faces issues with low data availability. It is difficult, or impossible, to identify prices for specific construction projects. Similar to a lot of military-related information, this is partly due to the sensitive nature of such data. It is also related to accounting practices; it is hard to perfectly separate infrastructure investment expenditure from other expenditure, such as administration and maintenance. This makes low-level price comparisons of infrastructure investment projects hard to achieve. In this context, however, it is worth mentioning that infrastructure tends to constitute a very minor share of total military expenditure. Inadequate comparisons of infrastructure expenditure between countries consequently have little impact on the comparison as a whole.

Considering the issues stated above, DS PPP measurements for the Infrastructure category based on price comparisons of similar military construction projects between the three countries were deemed difficult to achieve. Moreover, infrastructure constitutes a very small share of total military expenditure for all countries involved. This fact also contributed to the decision to abandon attempts at extensive data collection in favour of proxy measurements.

As is the case in the United Nations (1985) study, this report makes use of civilian construction price indices to approximate military construction prices. Eurostat (2021) has a PPP-based Construction price index, which consists of three sub-indices: Residential buildings, Non-residential buildings, and Civilian engineering works. Among these sub-indices, Non-residential buildings and Civilian engineering works were judged to be the most suitable in approximating military construction projects. Furthermore, the decision was made to weigh these two sub-indices evenly, i.e., 50 per cent each, due to a lack of information regarding actual shares of different types of military construction projects for Sweden, Poland and the UK.

3.4 Other

The final category in the NATO nomenclature, Other, is a composite category that consists of items that do not naturally fit into the other three expenditure categories, e.g., petroleum products, rents and non-equipment-related research and development. To produce an ideal DS PPP measurement for this category would mean aggregating separate PPP measurements for each partial component. The identification of specific prices for the different components would require a unique method in each case, and thus cannot be described using a general methodology.

The Other category faces issues similar to those of the previous categories. Data availability is low for many low-level military expenditure components, and international quality comparisons, e.g., for research and development, are hard to accomplish.

As for the DS PPP conversion method for the Other category in this study, producing low-level DS PPP measurements for each subcomponent was not a viable option, seeing as the category is heterogeneous and contains disparate items, as mentioned above. It was also partly due to the fact that detailed information of the specific contents of this category was not obtainable for the UK and Poland. However, even if such information had been available, international quality comparisons for the various subcomponents would have been either very time-consuming or impossible. Instead, the authors had to resort to proxy measurements.

Due to the heterogeneity of the category, a suitable conversion method was hard to find, which is why the decision was made to use a combination of MER and PPP for GDP, in order to account for both tradable and non-tradable items. It would also have been preferable to calculate the shares of tradables and non-tradables, but considering the lack of detailed information the decision, it was decided to assume an even split, i.e., 50 per cent each.

3.5 Summary of chapter

This chapter describes possible approaches to producing DS PPP measurements for each of the expenditure categories of the NATO nomenclature. The chapter also discusses the strengths and weaknesses of the different approaches in order to select suitable conversion methods for each category. These conversion methods are then used to construct a DS PPP for Sweden, Poland and the United Kingdom, in the next chapter.

4 Matching data and constructing a DS PPP

This chapter starts by describing the process of matching the Swedish military expenditure to the NATO nomenclature. Furthermore, it describes how the different DS PPP conversion methods selected in Chapter 3 are constructed. The results are then analysed and compared to military expenditure converted using MER, and PPP for GDP, as well as PPP for government expenditure.

4.1 Matching Swedish military expenditure with NATO nomenclature

In this report, the objective is to adjust Swedish military expenditure in a way that allows comparison of major expenditure categories with those of the NATO countries Poland and the UK.

As mentioned in previous chapters, comparing military expenditure between countries demands an adaptation to a common nomenclature. There are three reasons for using the NATO nomenclature (NATO 2021) in this study. Firstly, two out of the three countries are NATO members and hence the collection of data is carried out using the same method. Secondly, the data can be divided into four main categories, namely Equipment, Personnel, Infrastructure, and Other, as opposed to for instance SIPRI data, where military expenditure is compared at the aggregated level. Thirdly, the data is complete and reported annually for the member countries.

An alternative source for disaggregated data is the United Nations Office for Disarmament Affairs (UNODA). However, the regularity of providing data to UNODA is inconsistent for many countries. Among the countries included in this study, the data coverage was satisfactory for Poland and Sweden, but insufficient for the UK. The study does, however, use UNODA when calculating the Equipment share for Sweden. This process is explained further in the Appendix.

The Swedish Government Annual Report for 2019 provides an overview of Swedish military expenditure for that year, divided into 12 different appropriations (Skr. 2019/20:101, 6–7). The total sum for military expenditure in 2019 was 55.4 billion SEK. It was easy to categorise some of the appropriations according to the NATO definition of Equipment, Personnel, Infrastructure and Other, whereas some needed further investigation and division. In cases where further subdivision of the appropriations was deemed necessary, the annual reports of relevant government agencies were referred to. The decision whether to subdivide the appropriations into their subcomponents or not was based on the relative size of each appropriation compared to the total military expenditure for 2019. Due to the fact that a majority of the appropriations did not account for more than a few per cent of total military expenditure each, the decision was made to subdivide only expenditure that exceeded more than 100 million SEK. However, in some cases, subdivisions were not possible because of data constraints. Infrastructure was one of the cases that needed further research.

Investments on infrastructure were estimated by the rents expenditure of the Swedish Armed Forces minus the share directed towards administration and management. The share was estimated by a representative of the Swedish Armed Forces.

For NATO countries, pension costs for retirees, including both military and civilian employees of military departments, are included in the Personnel expenditure, regardless of the actual structure of the pension system in each member country (NATO 2021, 141). In the case of Swedish military expenditure, pension costs for current employees in the defence sector are included in the personnel expenses for each relevant government agency, e.g., under Appropriation 1:1.1 for the Swedish Armed Forces (Försvarsmakten 2020a, 89). This

means that pension costs are accounted for in the total military expenditures for Sweden, Poland, and the UK, even though various issues in terms of comparability remain.

Furthermore, in the case of Sweden, personnel expenses derived from civilian personnel within the armed forces and various other government agencies in the defence sector are also counted as Personnel expenditure (see Appendix). It is not obvious whether or not Poland and the UK have used the same classification when reporting their military expenditure figures to NATO.

The result of matching Swedish military expenditure in 2019 with the NATO expenditure categories is presented in Table 4.1.1, below (for further details of the matching process, see the Appendix).

Table 4.1.1 Swedish military expenditure in 2019, according to NATO nomenclature

NATO main category	Expenditure amount, million SEK	Share (%)
Equipment	15,200	27
Personnel	21,019	38
Infrastructure	960	2
Other	18,229	33
Total sum	55,409	100

Sweden had a total military expenditure of 55.4 billion SEK in 2019 (Skr. 2019/20:101. 6–7). In the same year, the military expenditures for the UK and Poland were 46.5 billion GBP and 45.4 billion PLN, respectively (NATO 2021).

Table 4.1.2, below, presents the shares for different military expenditure categories for Sweden, the UK and Poland.

Table 4.1.2 Comparing category shares between Sweden, the UK and Poland

NATO main category	Sweden, share (%)	UK, share (%)	Poland, share (%)
Equipment	27	23	23
Personnel	38	34	48
Infrastructure	2	2	4
Other	33	41	25
Total sum	100	100	100

The distribution of military expenditure differs between the countries. The UK and Poland are slightly above NATO's internally agreed minimum level for Equipment expenditure of 20 per cent, whereas in 2019 Sweden devoted 27 per cent to military materiel. The largest share for Poland is constituted by Personnel, at 48 per cent in 2019. The largest share of military expenditure for the UK was allocated to the Other category, which is slightly problematic for this analysis since this category is the most heterogeneous and ambiguous of the four.

According to the NATO nomenclature (NATO 2021, 140), the Other category contains:

> "… operations and maintenance expenditure, other R&D expenditure and expenditure not allocated among above-mentioned categories."

The description is not detailed, and since it absorbs *expenditure not allocated among above-mentioned categories,* the contents may differ between the countries. Furthermore, it means that it is difficult to know whether the contents are affected by national or international prices, i.e., this impedes the decision of which conversion method should be used when comparing the expenditure between countries.

4.2 Conversion of military expenditure

In this section, the calculations for this study's DS PPP composition are presented category-wise, based on the conversion methods described in Chapter 3. Comparisons are also made between the results for Sweden, Poland, and the UK, using all of the conversion methods identified in the study.

One of this study's research objectives is to construct a DS PPP for Sweden in relation to a country with a lower income level (Poland) and a country with a similar income level (the UK). Studying countries with different income levels allows for analysing what impact a DS PPP has on estimates of military expenditure when compared to using MER, PPP for GDP, or PPP for government expenditure. As argued above, the choice of conversion method can have a substantial impact.

It is important to emphasise that the suitability of a certain conversion method should only be based on whether the contents match the expenditure in question. The effect of the different conversion methods on the estimated size of the expenditure is only relevant in the discussion of the importance of the choice of method. It does not entail which of the methods should be used. However, the different outcomes indicate that military expenditure can easily be misinterpreted.

There is also reason to question the accuracy of the various proxy indices used for the calculation of DS PPP for the different expenditure categories. There might be other proxy indices that would better reflect the actual contents of the expenditure category in question for one or several of the countries involved. Furthermore, in cases where multiple proxy indices are used in parallel, the relative shares assumed for each component might not be representative of actual shares.

4.2.1 Equipment

The share of Equipment expenditure of total military expenditure was used to establish the amount of Equipment expenditure for Sweden, Poland and the UK, respectively, in 2019. The MER for 2019 was then used to convert the Equipment expenditure into SEK. The resulting DS PPP is presented in Table 4.2.1, using Sweden as base.

Table 4.2.1 Calculation of DS PPP for Equipment, relative to Sweden, part 1

Country	Equipment exp. (millions)	MER	Equipment exp. (millions), MER	Equipment, DS PPP
Sweden	15,200 SEK	1	15,200 SEK	1
Poland	10,552 PLN	2.46	25,994 SEK	1.7
UK	10,627 GBP	12.07	128,227 SEK	8.4

Source: Riksbank of Sweden (2021).

The DS PPP result is also illustrated in Figure 4.2.1, below, together with results for MER, PPP for GDP, and PPP for government expenditure. Indices for the last two measures were retrieved from Eurostat (2021).

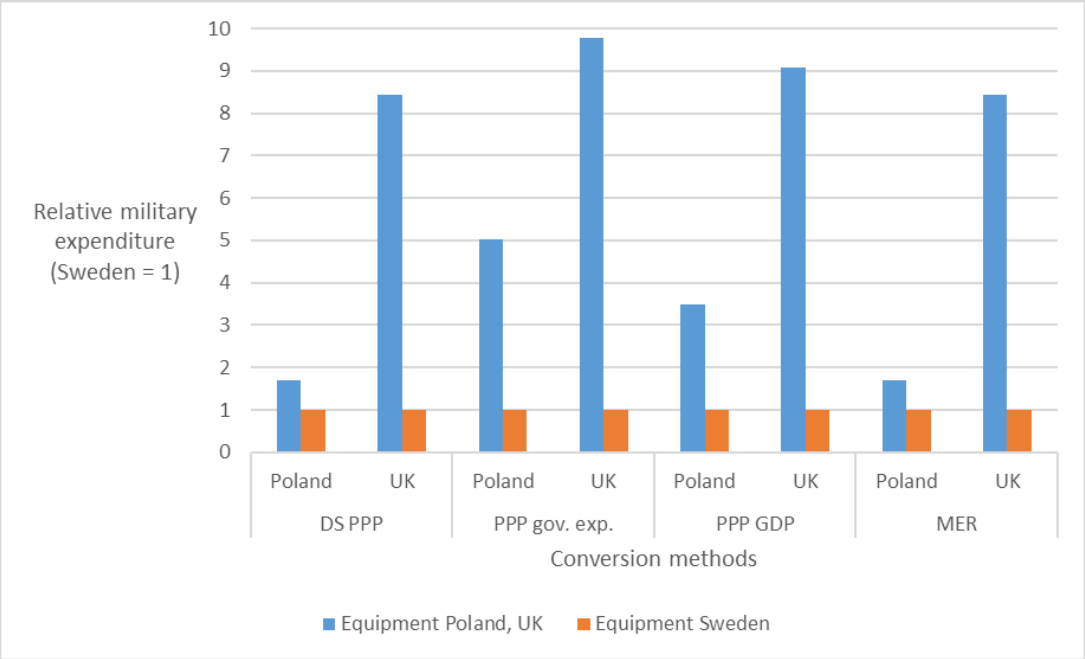

Figure 4.2.1 Differences in Equipment expenditure in relation to Sweden

Figure 4.2.1 shows how equipment expenditure differs between Poland and the UK, relative to Sweden, depending on which conversion method is used. As explained in Section 3.1, it is difficult to find a suitable conversion method for this category. All of the conversion methods for Equipment expenditure used in this study in fact serve as proxies, since none of them contain actual military materiel. As mentioned above, it was not possible to determine the distribution between imported and domestically produced military materiel and, as a consequence of differences in the size of the defence industries, the share likely varies between the countries involved. If the share of imports had been known, MER could have been used for this part of materiel expenditure and a PPP measure for the remaining part. Rather than basing the conversion upon assumptions of the share of imports, the use of MER for the DS PPP conversion was chosen for this study, which is why the bars for DS PPP are the same as the ones for MER. However, using the MER as conversion method for DS PPP means not taking into account the effects of local conditions on the defence industry.

PPP for government expenditure is probably the least suitable conversion method for this particular category, as government expenditure largely consists of items dissimilar to materiel investments. Since that sector is probably not affected by international trade, it is expected to result in the highest estimate. PPP for GDP could be an alternative, as it represents a general price level for the whole economy. However, since the defence sector differs from the civil sector, the use of PPP for GDP would mean additional uncertainties. Figure 4.2.1 shows a larger difference for Poland between DS PPP/MER and PPP for GDP than is the case with the UK, which is in line with expectations due to the Penn effect.

4.2.2 Personnel

The Personnel expenditure amount for Sweden, Poland and the UK was calculated based on the Personnel expenditure share of total military expenditure for each country during 2019. Thereafter, proxy wage levels were retrieved from national statistics for Sweden and Poland, and from the ILO for the UK. The data is illustrated in Table 4.2.2.

Table 4.2.2 Calculation of DS PPP for Personnel, relative to Sweden, part 1

Country	Personnel exp. (millions)	Average wage level
Sweden	21,019 SEK	38,311 SEK
Poland	21,989 PLN	5,978 PLN
UK	15,846 GBP	2,709 GBP

Sources: SCB (2021), GUS (2021), and ILO (2021).

A productivity factor also had to be calculated, as a proxy to estimate differences in quality or efficiency. This was done according to the method described in Section 3.2, above, by using data from the Penn World Table (2021), inspired by Robertson and Sin (2017). The result is shown in Table 4.2.3, where the productivity factor for each country is calculated, using Sweden as base.

Table 4.2.3 Calculation of DS PPP for Personnel, relative to Sweden, part 2

Country	GDP (PPP, million USD)	Number of employees (million)	Average annual hours	GDP/ number of employ-ees (mil-lion)	GDP/ hour	Productivity factor, in relation to Sweden
Sweden	560,961	5.0	1,605	112,144	69.9	1
Poland	1,259,694	16.2	2,022	77,956	38.5	0.55
UK	3,118,991	33.0	1,668	94,565	56.7	0.81

Sources: Penn World Table (2021) and Eurostat (2021).

The next step was to produce a PPP for Personnel. The average wage level in Table 4.2.2 was divided with the productivity factor in Table 4.2.3 for each country, to calculate effective wage. By dividing each of these effective wages with that of Sweden, the result is the PPP for Personnel with Sweden as base. Thereafter, the Personnel expenditure in DS PPP terms as well as in relative terms, with Sweden as base, is calculated. See Table 4.2.4, below, for the result.

Table 4.2.4 Calculation of DS PPP for Personnel, relative to Sweden, part 3

Country	Effective wage	Personnel, PPP	Personnel expenditure, PPP	Personnel, DS PPP
Sweden	38,311	1	21,019	1
Poland	10,836	0.28	77,745	3.70
UK	3,338	0.09	181,863	8.65

The DS PPP result is also illustrated in Figure 4.2.2, below, together with results for MER, PPP for GDP, and PPP for government expenditure.

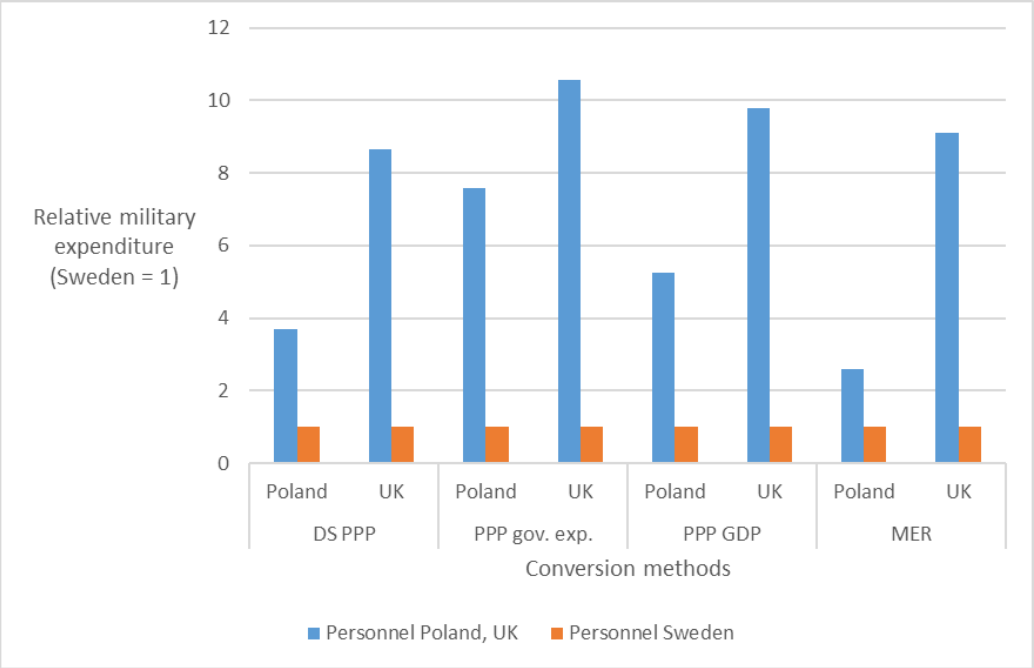

Figure 4.2.2 Differences in Personnel expenditure in relation to Sweden

According to Figure 4.2.2, the highest values for both Poland and the UK are obtained when the expenditure is presented in terms of PPP for government expenditure, which was also the case for Equipment. The PPP for GDP and DS PPP values for Poland are higher than that of MER, while the PPP for GDP and DS PPP values for the UK are lower than the MER value, but with a smaller difference. Considering the Penn effect, it is in line with expectations that the PPP measures yield higher values especially for Poland, given its relatively lower income.

Regarding the PPP for government expenditure value, it should be noted that average public wages are not necessarily representative for the military, and also that government expenditure also contains other expenditure besides from wages.

If the productivity factor is taken out of the equation, the result is increased DS PPP values for Poland and the UK, which both have productivity factors lower than that of Sweden. See Figure 4.2.3, below. The effective wage measure can be interpreted as an estimate of the price for one equally productive worker, in terms of each country's national currency. This means that lower productivity works as a counterweight to the lower labour price (in terms of average wage level), when comparing military expenditure between countries. The lower the productivity factor for Poland or the UK in comparison to Sweden, the higher the effective wage required per worker, and the lower the DS PPP value. Similarly, if the productivity factor remains constant, but the average wage level for Poland or the UK is increased, the DS PPP value also decreases.

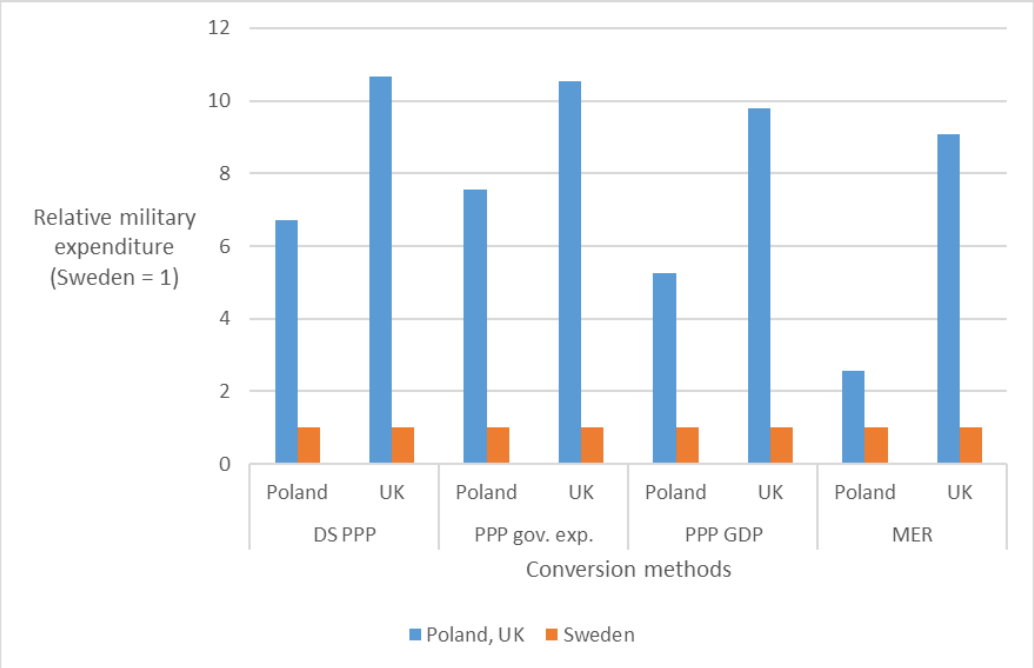

Figure 4.2.3 Differences in Personnel expenditure in relation to Sweden, productivity factor excluded

An attempt has thus been made to control for the difference in productivity through the use of a proxy productivity factor in the DS PPP. However, the productivity factor is based on the economy as a whole for each country, and might not be representative for military sector personnel. Depending on the way in which the productivity factor, i.e., the proxy variable used to control for differences in labour quality or efficiency, is constructed, the result may differ considerably.

Furthermore, it is difficult to control for different skill levels for the military's various ranks, as well as the personnel share of each rank, for each of the countries involved. It is important to note that the countries' personnel compositions might differ. A known difference between the countries is that Sweden has conscription, whereas the UK and Poland do not. The average wage level used in the DS PPP calculation does not take such organisational differences into account.

4.2.3 Infrastructure

The Infrastructure expenditure amounts for Sweden, Poland and the UK were calculated based on the Infrastructure expenditure share of total military expenditure for each country in 2019. An infrastructure PPP was calculated by taking the average of the PPP measures retrieved from Eurostat (2021) for Non-residential buildings and Civil engineering work (2019 rate). Infrastructure expenditure in DS PPP terms was thereafter calculated by dividing the infrastructure expenditure amount by the infrastructure PPP. These DS PPP values are then expressed in relative terms, with Sweden as base. See Tables 4.2.5 and 4.2.6, below, for the result.

Table 4.2.5 Calculation of DS PPP for Infrastructure, relative to Sweden, part 1

Country	Infrastructure exp. (millions)	Non-residential buildings, PPP	Civil engineering work, PPP	Infrastructure, PPP
Sweden	960 SEK	17.72	13.16	15.44
Poland	1,671 PLN	2.82	3.43	3.13
UK	981 GBP	1.02	0.98	1.00

Sources: Eurostat (2021).

Table 4.2.6 Calculation of DS PPP for Infrastructure, relative to Sweden, part 2

Country	Infrastructure exp. (millions), PPP	Infrastructure, DS PPP
Sweden	62	1
Poland	534	8.6
UK	979	15.8

The DS PPP result is illustrated in Figure 4.2.3, below, together with results for MER, PPP for GDP, and PPP for government expenditure.

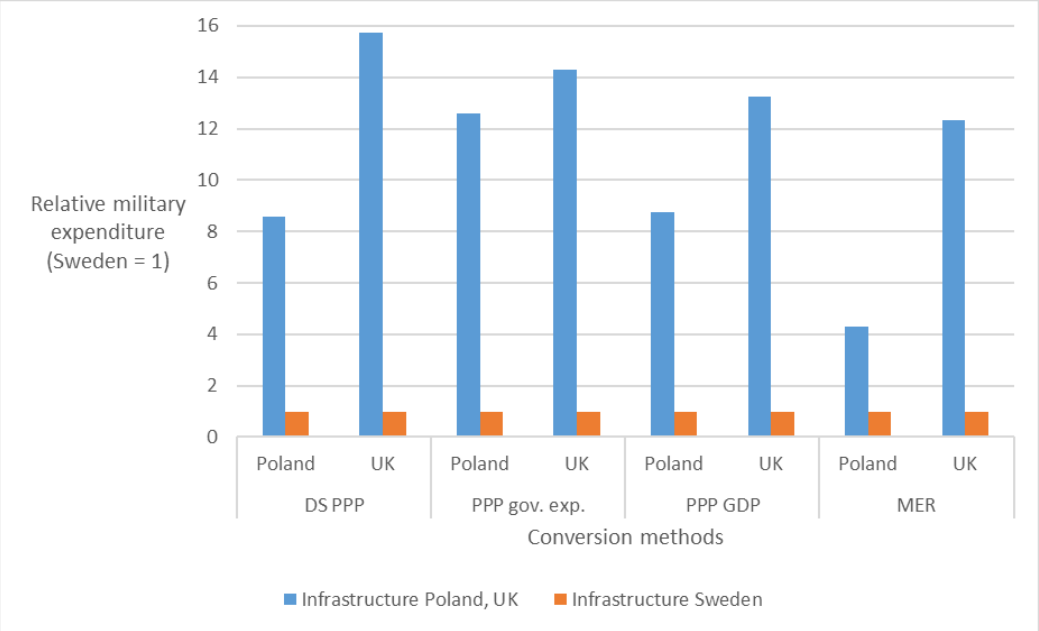

Figure 4.2.3 Differences in Infrastructure expenditure in relation to Sweden

As mentioned above, for this category attempts of extensive data collection were abandoned in favour of relying on proxy measurements. It was difficult to find prices for specific construction projects, therefore PPP measures from Eurostat (2021) were used to construct the DS PPP. As a consequence, a substantial amount of uncertainty is introduced. This is exacerbated by the decision to weigh the two Eurostat PPP measures evenly, lacking information to perform a more precise weighting. Consequently, the estimates for the Infrastructure category should be interpreted with caution. However, since the Infrastructure share of total military expenditure is relatively low for the three countries covered in this study, the impact on the estimate for total military expenditure should be limited.

Looking at the estimates for the Infrastructure category, Figure 4.2.3 shows that for the UK, expenditure expressed in terms of DS PPP produces the highest estimate. Furthermore, the ranking of the estimates is consistent since DS PPP is followed by PPP for government expenditure, PPP for GDP and, finally, MER. The differences between the conversion methods are limited. For Poland, however, the estimates differ to a large extent depending on the

conversion method used. PPP for government expenditure produces the highest estimate, followed by PPP for GDP, DS PPP and finally MER. Interestingly, using MER provides a result in the lowest estimate for both the UK and for Poland. It is in line with expectations that the differences are larger for Poland and smaller for the UK.

4.2.4 Other

The Other category was converted using both MER and PPP for GDP, i.e., PPP based on total GDP expenditure, and not a subdivision. In order to use both measures, the expenditure was divided by half, since there was no further information available on the contents of the categories that could facilitate a different division. The DS PPP for Other expenditure is thereafter calculated by taking the average value of the PPP for GDP and MER values, using Sweden as base. The result is presented in Tables 4.2.7 and 4.2.8, below.

Table 4.2.7 Calculation of DS PPP for Other, relative to Sweden, part 1

Country	Other exp. (millions)	Half of Other exp. (millions)	PPP for GDP (EU28 as base)	MER	Half of Other exp. (millions), PPP for GDP	Half of Other exp. (millions), MER
Sweden	18,282 SEK	9,114 SEK	12.94	1	704	9,114
Poland	11,192 PLN	5,596 PLN	1.00	2.46	5,614	13,785
UK	19,054 GBP	9,527 GBP	2.57	12.07	3,705	114,955

Sources: Eurostat (2021) and the Riksbank of Sweden (2021).

Table 4.2.8 Calculation of DS PPP for Other, relative to Sweden, part 2

Country	Other, PPP for GDP	Other, MER	Other, DS PPP
Sweden	1	1	1
Poland	7.97	1.51	4.74
UK	5.26	12.61	8.94

The DS PPP result is also illustrated in Figure 4.3.4, below, together with MER, PPP for GDP, and PPP for government expenditure.

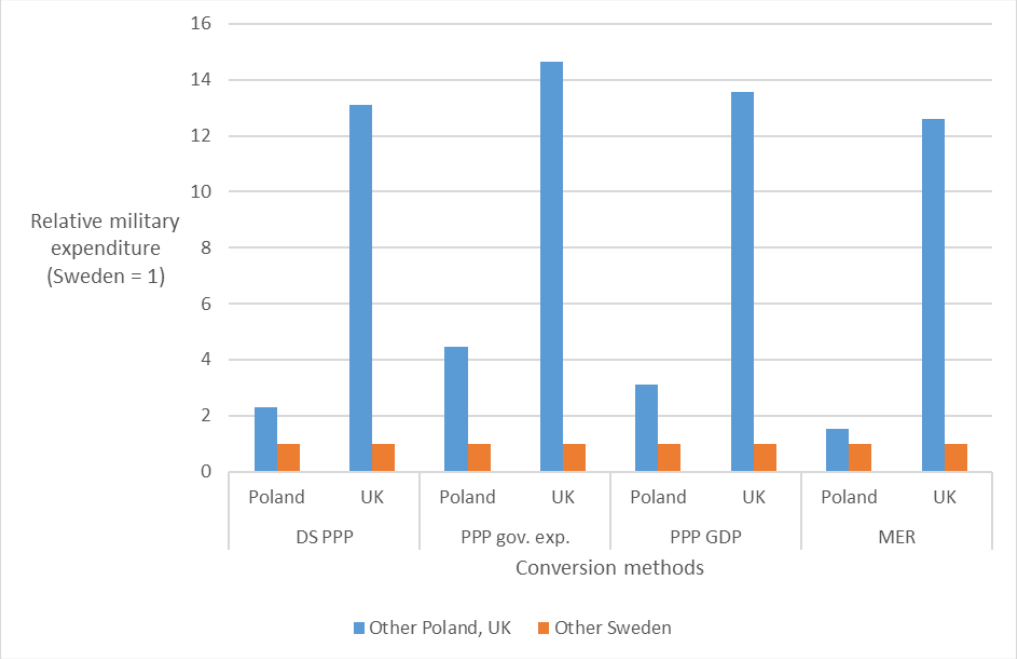

Figure 4.2.4 Differences in Other expenditure in relation to Sweden

Figure 4.2.4 presents the expenditure within the Other category for Poland and the UK, relative to Sweden. As mentioned above, this category is highly heterogeneous and contains, among other things, petroleum products, materiel maintenance, and non-equipment-related research and development. Consequently, it is difficult to find a suitable conversion method for the category as a whole. Furthermore, the category represents a large share of the UK's military expenditure (41 per cent, compared to 33 per cent for Sweden and 25 per cent for Poland). The authors have not been able to determine the reason for these differences. The heterogeneity of the Other category along with the decision to use the average of PPP for GDP and MER creates a lot of uncertainty for this category and makes a meaningful interpretation of the results in Figure 4.2.4 difficult.

The result for DS PPP for both Poland and the UK lies between the estimates of PPP for GDP and MER since it is based on a combination of these two conversion methods. There are large differences for Poland depending on which conversion method is used. For the UK, on the other hand, the conversion methods result in similar estimate levels. Interestingly, using MER provides a result in the lowest estimate for both Poland and the UK. The ranking of the estimates is the same for both countries; using PPP for government expenditure produces the highest estimate, followed by PPP for GDP, DS PPP, and finally MER.

4.3 Comparing total military expenditure

Figure 4.3.1 below presents the difference in total military expenditure for Poland and the UK relative to Sweden, using the four different conversion methods: DS PPP, PPP for government expenditure, PPP for GDP, and MER. The DS PPP is the sum of the four expenditure-category-specific measurements calculated in Section 4.2, above, also having taken into account the different expenditure shares for each country.

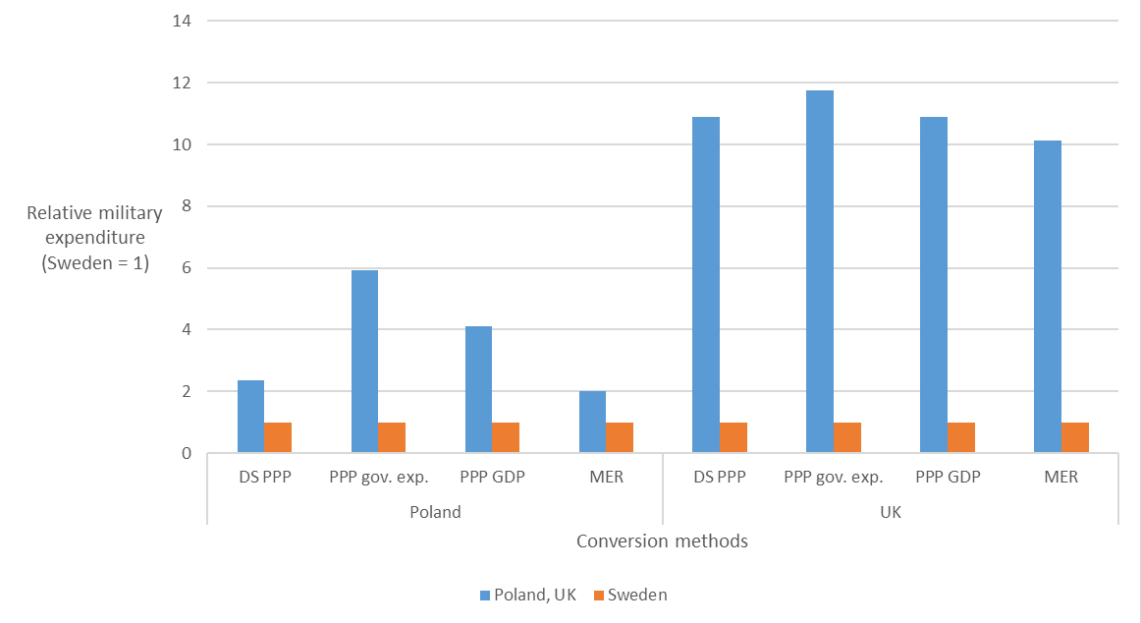

Figure 4.3.1 Differences in total military expenditure in relation to Sweden

For all conversion methods except DS PPP, the results are generally in line with results from previous studies. That is, if the Penn effect holds, i.e., if the expenditure is underestimated by MER for lower-income countries, PPP measures should produce higher expenditure values for those countries and produce opposite results for higher-income countries.

However, the DS PPP estimates diverge from this theory, at least in the case of Poland. This can partially be seen as a consequence of potentially invalid proxy measures in the DS PPP

calculations. For example, the Equipment calculation is based on MER conversion, which could be accurate depending on the country in question. It could also be misleading, to the extent that domestic production and non-tradables play an important role in materiel acquisitions. The Personnel calculation involves proxy measures that may or may not be accurate to account for actual differences in labour prices and productivity.

Given the high share of Personnel expenditure for all three countries, but especially for Poland (48 per cent of total expenditure in 2019), the accuracy of the Personnel DS PPP has a large impact on the DS PPP estimates for total military expenditure. The Infrastructure DS PPP calculations are also uncertain due to the proxy measures used, but the resulting Infrastructure DS PPP values do not have a large impact on the total DS PPP, given the low share of Infrastructure expenditure. The DS PPP for the last expenditure category, Other, is based on a combination of MER and PPP for GDP, which means that it will skew the total DS PPP results towards a value between these two measures. Whether this is representative of actual conditions or not depends on the composition of the Other expenditure, which as mentioned before is a heterogeneous category.

The low DS PPP estimates for total expenditure could also reflect actual conditions in the countries involved in the comparison. For example, if MER conversion turns out to measure relative Equipment expenditure in Sweden, Poland and the UK accurately, due to a high amount of tradables involved in materiel production, a lower value for DS PPP than for PPP for GDP might be justified. Furthermore, if military personnel quality or efficiency is indeed lower in Poland and the UK than in Sweden, and especially if it outweighs differences in wage levels, this should also be reflected in lower DS PPP values.

4.4 Summary of chapter

This chapter describes the process of matching the Swedish military expenditure to the NATO nomenclature. The chapter also includes the results of constructing a DS PPP based on the conversion methods selected in Chapter 3. These results are analysed and compared to other conversion methods.

5 Summary and conclusion

The aim of this study is to develop the methodology in international comparisons of military expenditure and add to a field that still consists of a relatively limited amount of studies. The subject is important, since military expenditure is oftentimes used in the analysis of military strength, and previous studies have shown that the choice of conversion method can have a significant effect on the results. One of the main foci has therefore been to provide a thorough review of the methodological issues in regard to comparing military expenditure between countries. The research questions stated below have been studied from a methodological point of view, and comparisons of the specific DS PPP results with previous studies are thus excluded.

The research questions of the study are:

1. What conversion methods exist for conducting international comparisons of military expenditure, and what methodological issues are there?
2. How can Swedish military expenditure data be matched, using a common nomenclature, with the data for Poland and the UK?
3. Based on matched data, how can a DS PPP be constructed to facilitate a comparison of military expenditure between Sweden, Poland and the UK?

Starting with the first research question, the study focuses on four different conversion methods for international comparisons of military expenditure: MER, PPP for GDP, PPP for government expenditure, and DS PPP. MER is convenient due to high data availability, but tends to overstate the economic power of higher-income countries and understate that of lower-income countries. Additional issues with MER include too high correlation to specific economic factors, such as oil prices, and its inability to account for non-traded goods being relatively cheap, in poorer countries and, within different countries, the different relative prices for goods and services. Unlike MER, PPP for GDP takes price differences between countries into account. However, PPP for GDP has the purpose of representing the whole economy and is therefore not adapted to the specific conditions of the military sector. Hence, this measure can also be misleading. PPP for government expenditure is also expected to differ from military expenditure. For instance, the salaries of the government in general do not necessarily reflect those of the military. Furthermore, prices for equipment expenditure are most likely very different from the estimation made by government expenditure.

DS PPP is supposedly the optimal conversion method for military expenditure, to the extent that it is based on a collection of specific prices from the defence sector. The preferred approach to constructing a DS PPP would be to follow the method of the ICP. This implies collecting prices for representative and comparable goods and services for each selected country at the same point in time. However, this is challenging with regard to the defence sector. Poor data availability is a well-known problem in studies of military expenditure, and is caused by various factors, including varying levels of transparency and irregular accounting practices. Other issues include how to make proper quality comparisons of military materiel or personnel, and how to account for organisational differences between the armed forces of different countries. All of these issues have been encountered during the course of this study, as well.

To answer the second research question, the study places much emphasis on the data and the process of matching the Swedish expenditure according to the NATO nomenclature. The idea is to produce comparable data that is then used for constructing the DS PPP. One of the major issues in comparing military expenditure between countries is the lack of detailed data. As mentioned above, SIPRI data has good coverage, but only at the aggregated level and not when divided into categories. The matching process of this study could serve as an example of how military expenditure can be compared between countries that have different classification systems, even though some issues remain with classifying certain types of expenditure, e.g., materiel expenditure, for which it is sometimes difficult to separate procurement expenditure from maintenance expenditure.

The third research question entails constructing a DS PPP in order to compare military expenditure between Sweden, Poland and the UK. The Personnel category was estimated by using wage statistics from the governmental sector, together with a productivity factor, to control for differences in efficiency between the countries. For the Equipment category, MER was used because of lack of data necessary for specific PPP measures. Using MER means that local conditions, which especially affect the prices of domestically purchased materiel, are not taken into account in the analysis. It should also be noted that even if all materiel were purchased on the international market, countries do not face the same price, which is the assumption when using MER. However, the available PPP measures would have represented the civil industry and are not necessarily representative for the military sector, since it has unique characteristics. For the Infrastructure category, an average of two PPP measures was used: PPP for Non-residential buildings and PPP for Civil engineering work. Lastly, for the category of Other, a combination of MER and PPP for GDP was used.

The results show that the PPP measures yield higher estimates of the military expenditure, in particular for Poland, which is in line with expectations, according to the Penn effect. However, the DS PPP does not differ much from MER at the total military expenditure for Poland, which is not the expected outcome. Possible explanations include invalid proxy measures, such as MER conversion for Equipment expenditure, in the DS PPP calculations, due to poor data availability. Regarding the DS PPP for the UK, it yields a higher estimate of military expenditure than MER, lower than PPP for government expenditure and almost the same as PPP for GDP. Again, whether this is to be expected or not depends on the validity of the proxy measures used in the calculations. MER has a relatively large impact on the DS PPP results for the UK, since it is used as conversion method for both the Equipment category and the Other category, which together constitute approximately two-thirds of the UK's total military expenditure. In regard to the Personnel category, the result depends a lot upon the validity of the efficiency factor used.

It is important to emphasise that the DS PPP results presented in this study only provide estimates of the size of relative military expenditure in terms of an input measure, not military capability. DS PPP only seeks to measure how much each country involved in the comparison gets out of their military expenditure in terms of comparable military goods and services, such as military materiel or personnel. It does not consider such things as how well these goods and services fit into the unique military structure in each country, or how the different expenditure categories (such as Equipment and Personnel) are interlinked. For example, a DS PPP value does not take into account the extent to which the military personnel are properly equipped for their task.

Furthermore, the analysis of the DS PPP results lacks generalisability due to the limited number of countries included in the comparison. For example, if more countries were included it would be easier to identify patterns in the DS PPP results, e.g., links between income level and outcome for a certain conversion method. Moreover, the data used for the comparisons is only based on a single year, 2019, rather than a longer time period. This adds uncertainty to the generalisability of the results.

However, the DS PPP conversion methods used in this study are by themselves generalisable, even if their applicability for non-NATO members is contingent upon first having matched national military expenditure with the NATO nomenclature. The methodological overview provides valuable insights regarding issues and necessary assumptions when comparing military expenditure between countries. The methodology of matching military expenditure to a common nomenclature can be used in similar studies in the future. The results from comparing the military expenditure between Sweden, Poland and the United Kingdom are inconclusive, i.e., conclusions about which of the conversion methods is most suitable for the specific countries cannot be drawn. However, the DS PPP constructed in this report is a contribution to the discussion of the significance of purchasing power parity when comparing military expenditure between countries.

For future studies, additional countries, with a wide range of income levels, could be included in the comparison. Furthermore, the DS PPP conversion methods in this study could

be refined in different ways. Additional work could be done on using different proxy measures, for example for the quality of military personnel, in order to test the robustness of results. Also, further attempts to collect certain key data could be made, for example concerning the shares between domestically produced and imported military materiel. Lastly, it would also be of interest to take a closer look at the specific conditions of the defence industries and sectors of the countries included.

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7 Appendix: Matching Swedish military expenditure with NATO nomenclature

This appendix provides the steps in the process of matching Swedish military expenditure to the NATO nomenclature.

Table 7.1, below, shows the subdivision for each main category. This is the lowest level available and therefore some assumptions had to be made. These are explained in further detail below.

Table 7.1 NATO nomenclature of military expenditure

1	Operating costs
1.1	Military personnel
1.1.1	Pay and allowances
1.1.2	Employer's contributions to retirement funds
1.1.3	Other
1.2	Civilian personnel
1.2.1	Pay and allowances
1.2.2	Employer's contributions to retirement funds
1.3	Pensions
1.3.1	Paid to military retirees
1.3.2	Paid to civilian retirees
1.4	Operations and maintenance
1.4.1	Ammunition and explosives (excluding nuclear)
1.4.2	Petroleum products
1.4.3	Spare parts
1.4.4	Other equipment and supplies
1.4.5	Rents
1.4.6	Other operations and maintenance
2	Procurement and construction
2.1	Major equipment
2.1.1	Missile systems
2.1.2	Missiles (conventional weapons)
2.1.3	Nuclear weapons
2.1.4	Aircraft
2.1.5	Artillery
2.1.6	Combat vehicles
2.1.7	Engineering equipment
2.1.8	Weapons and small arms
2.1.9	Transport vehicles
2.1.10	Ships and harbour craft
2.1.11	Electronic and communications equipment
2.2	National military construction
2.3	NATO common infrastructure
2.3.1	Expenditure as host country
2.3.2	Payments to other countries
2.3.3	Receipts from other countries
2.3.4	Land and utilities
3	Research and development
3.1	Devoted to major equipment
3.2	Other
4	Other expenditure
5	Total

Table 7.2 shows how the subcategories are divided into the four main categories.

Table 7.2 Main categories of NATO nomenclature for military expenditure

Equipment (lines 2.1 + 3.1)
Personnel (lines 1.1 + 1.2 + 1.3)
Infrastructure (lines 2.2 + 2.3)
Other (lines 1.4 + 3.2 + 4)

Table 7.3 Appropriation 1:1 Military operations and preparedness[8]

Appropriation/subcomponent	**Expenditure amount 2019, million SEK (% of total military expenditure**)	**NATO nomenclature**	**NATO main category**
1:1.1 Military operations and preparedness			
- Personnel expenses[9]	15,876 (28.7)	1.1.1 Pay and allowances	Personnel
- Rent expenses[10] (investments) - Rent expenses (rent)	960 (1.7) 1,950 (3.5)	2.2 National military construction 1.4.5 Rents	Infrastructure Other
- Maintenance of military equipment[11]	2,522 (4.6)	1.4.6 Other operations and maintenance	See separate calculation
- Purchased services[12]	1,853 (3.3)	1.4.6 Other operations and maintenance	Other
- Travel expenses[13]	669 (1.2)	1.1.3 Other	Personnel
- Remuneration for recruits, aspiring officers and conscripts[14]	667 (1.2)	1.1.1 Pay and allowances	Personnel
- Consulting expenses[15]	556 (1.0)	1.4.6 Other operations and maintenance	Other
- Other expenses (including, e.g., consumer goods and fuel)[16]	3,790 (6.8)	1.4.2 Petroleum products	Other
1:1.2 Military operations and preparedness – retirement benefits[17]	76 (0.1)	1.1.2 Employer's contributions to retirement funds	Personnel
1:1.3 Procurement and maintenance of military equipment and facilities[18]	6,742 (12.2)	2.1 Major equipment	See separate calculation
1:1.4 Swedish Military Intelligence and Security Service[19]	958 (1.7)	1.1.1 Military personnel	Personnel
Total sum	36,619 (66.1)		

[8] In Swedish: 'Förbandsverksamhet och beredskap'.
[9] In Swedish: 'Personalrelaterade kostnader'.
[10] In Swedish: 'Kostnader för lokalhyror'.
[11] In Swedish: 'Materielunderhåll'.
[12] In Swedish: 'Köpta tjänster'.
[13] In Swedish: 'Resekostnader'.
[14] In Swedish: 'Rekryt-, officersaspirants- och pliktersättningar'.
[15] In Swedish: 'Konsulttjänster'.
[16] In Swedish: 'Övrigt (inkl. ex förbrukningsmaterial och drivmedel)'.
[17] In Swedish: 'Förbandsverksamhet och beredskap – STÅP (statl. ålderspens. avg.)'.
[18] In Swedish: 'Vidmakthåll materiel & anläggningar'.
[19] In Swedish: 'MUST'.

The Swedish military expenditure was matched to the NATO nomenclature by looking into the different appropriations in which the expenditure is divided into in the Swedish yearly report for government expenditure. For more detailed information of the contents of the different appropriations, yearly reports from the different defence agencies were used. Expenditure amounts exceeding 100 million SEK were subdivided when possible. The threshold of 100 million SEK was set in order to avoid becoming too detailed in the calculations, since what is below that level does not mean a large share of the total military expenditure. Appropriation 1:1 represented almost two-thirds of total military expenditure in 2019, at 36.6 billion SEK. This motivated a subdivision of appropriation 1:1 into its subcomponents. The 2019 annual report of the Swedish Armed Forces provides detailed information for this purpose. According to that report, appropriation 1:1 can be divided into four subcomponents, 1:1.1-1:1.4 (Försvarsmakten 2020a, 13).

An ambiguous case is '1:1.3 Procurement and maintenance of military equipment and facilities'. Since the category contains both procurement and maintenance, it does not directly correspond to either '2.1 Major equipment' or '1.4 Operations and maintenance', nor are the respective shares for each category available. However, an assumption was made based on available data from UNODA (2021). These calculations are presented separately in Table 7.15, below.

Table 7.4 Appropriation 1:2 Swedish Armed Forces' international interventions[20]

Appropriation/ subcomponent	**Expenditure amount 2019, million SEK (% of total military expenditure)**	**NATO nomenclature**	**NATO main category**
1:2 Swedish Armed Forces' international interventions	980 (1.8)	4 Other expenditure	Other
Total sum	980 (1.8)		

Appropriation 1:2 represented a little less than 2 per cent of total military expenditure in 2019, at 980 million SEK. Further subdivision into its subcomponents was deemed unnecessary. The expenditure corresponds to '4 Other expenditure' in the NATO nomenclature.

Table 7.5 Appropriation 1:3 Procurement of military equipment and facilities[21]

Appropriation/ subcomponent	**Expenditure amount 2019, million SEK (% of total military expenditure)**	**NATO nomen clature**	**NATO main category**
1:3.1 Supplier expenses[22]	10,872 (19.6)	2.1 Major equipment	See separate calculation
1:3.2 Procurement of military equipment and facilties	2,776 (5.0)	2.1 Major equipment	See separate calculation
Total sum	13,648 (24.6)		

Appropriation 1:3 represented approximately a fourth of total military expenditure in 2019, at 13.6 billion SEK. This motivated a subdivision of appropriation 1:3 into its subcomponents, namely 1:3.1 and 1:3.2. However, both subcomponents still correspond to '2.1 Major equipment' in the NATO nomenclature. These expenditure amounts pertain to the Swedish Defence Materiel Administration and the Swedish Armed Forces, respectively (FMV 2020,

[20] In Swedish: 'Försvarsmaktens insatser internationellt'.
[21] In Swedish: 'Anskaffning materiel & anläggningar'.
[22] In Swedish: 'Leverantörsutgifter för leveranser (ram)'.

78; Försvarsmakten 2020a, 13). Since other shares of the Equipment category were unknown, the above expenditures for Swedish appropriation 1:3 are included in the separate calculation in Table 7.15, for Equipment and materiel maintenance.

Table 7.6 Appropriation 1:4 Research and technology development[23]

Appropriation/ subcomponent	Expenditure amount 2019, million SEK (% of total military expenditure)	NATO nomenclature	NATO main category
1:4 Research and technology development	687 (1.2)	3.2 Other	Other
Total sum	687 (1.2)		

Appropriation 1:4 represented slightly more than 1 per cent of total military expenditure in 2019, at 687 million SEK. The decision was made to assign the whole expenditure sum into '3.2 Other' in the NATO nomenclature, even though a minor share of the expenditure amount is derived from research related to major equipment, which would correspond to '3.1 Devoted to major equipment'. Since the expenditure amount was below the threshold set to 100 million SEK, a subdivision was not made.

Table 7.7 Appropriation 1:5 Foreign Intelligence Inspectorate[24]

Appropriation/ subcomponent	Expenditure amount 2019, million SEK (% of total military expenditure)	NATO nomenclature	NATO main category
1:5 Foreign Intelligence Inspectorate	10 (0.02)	1.2.1 Pay and allowances	Personnel
Total sum	10 (0.02)		

Appropriation 1:5 represented a relatively small share of total military expenditure, at 10 million SEK. The decision was made to assign the whole expenditure sum to '1.2.1 Pay and allowances' in the NATO nomenclature, even though a minor share of the expenditure amount is derived from other expenditure such as rent, which would correspond to '4 Other expenditure'. Due to the small expenditure amount, such a subdivision was deemed unnecessary.

Table 7.8 Appropriation 1:6 Swedish Defence Recruitment Agency[25]

Appropriation/ subcomponent	Expenditure amount 2019, million SEK (% of total military expenditure)	NATO nomenclature	NATO main category
1:6 Swedish Defence Recruitment Agency	198 (0.4)	1.2.1 Pay and allowances	Personnel
Total sum	198 (0.4)		

Appropriation 1:6 represented less than 1 per cent of total military expenditure in 2019, at 198 million SEK. The decision was made to assign the whole expenditure sum to '1.2.1 Pay and allowances' in the NATO nomenclature, even though a minor share of the expenditure amount is derived from other expenditure such as rent, which would correspond to '4 Other expenditure'. However, the expenditure amount did not exceed the threshold of 100 million and therefore no further subdivision was made.

[23] In Swedish: 'Forskning och teknikutveckling'.
[24] In Swedish: 'Statens inspektion för försvarsunderrättelseverksamheten'.
[25] In Swedish: 'Totalförsvarets rekryteringsmyndighet'.

Table 7.9 Appropriation 1:7 Officer training[26]

Appropriation/ subcomponent	Expenditure amount 2019, million SEK (% of total military expenditure)	NATO nomenclature	NATO main category
1:7 Officer training	224 (0.4)	1.2.1 Pay and allowances	Personnel
Total sum	224 (0.4)		

Appropriation 1:7 represented less than 1 per cent of total military expenditure in 2019, at 224 million SEK. The decision was made to assign the whole expenditure sum to '1.2.1 Pay and allowances' in the NATO nomenclature, with the assumption that the expenditure is derived from salaries to civilian personnel tasked with educating military officers. Further information on subcomponents is unknown.

Table 7.10 Appropriation 1:8 Swedish National Defence Radio Establishment[27]

Appropriation/ subcomponent	Expenditure amount 2019, million SEK (% of total military expenditure)	NATO nomenclature	NATO main category
1:8 Swedish National Defence Radio Establishment	1,217 (2.2)	1.2.1 Pay and allowances	Personnel
Total sum	1,217 (2.2)		

Appropriation 1:8 represented slightly more than 2 per cent of total military expenditure in 2019, at 1.2 billion SEK. The decision was made to assign the whole expenditure sum to '1.2.1 Pay and allowances' in the NATO nomenclature, even though a minor share of the expenditure amount is likely to be derived from other expenditure such as rent, which would correspond to '4 Other expenditure'. However, due to a lack of more detailed data, further subdivision was not possible.

Table 7.11 Appropriation 1:9 Swedish Defence Research Agency[28]

Appropriation/ subcomponent	Expenditure amount 2019, million SEK (% of total military expenditure)	NATO nomenclature	NATO main category
1:9 Swedish Defence Research Agency	228 (0.4)	3.2 Other	Other
Total sum	228 (0.4)		

Appropriation 1:9 represented less than 1 per cent of total military expenditure in 2019, at 228 million SEK. The expenditure corresponds to '3.2 Other' in the NATO nomenclature. Even though expenditures for government agencies have previously been regarded as '1.2.1 Pay and allowances', in this case an exception was made, since the expenditure was allocated to research-related activities, according to the 2019 yearly review of the Swedish Defence Research Agency (FOI 2020).

Table 7.12 Appropriation 1:10 Committees[29]

[26] In Swedish: 'Officersutbildning m.m.'.
[27] In Swedish: 'Försvarets radioanstalt'.
[28] In Swedish: 'Totalförsvarets forskningsinstitut'.
[29] In Swedish: 'Nämnder m.m.'.

Appropriation/ subcomponent	Expenditure amount 2019, million SEK (% of total military expenditure)	NATO nomenclature	NATO main category
1:10 Committees	6 (0.01)	1.2.1 Pay and allowances	Personnel
Total sum	6 (0.01)		

Appropriation 1:10 represented less than 1 per cent of total military expenditure in 2019, at 6 million SEK. Further subdivision into its subcomponents was deemed unnecessary. The expenditure corresponds to '1.2.1 Pay and allowances' in the NATO nomenclature.

Table 7.13 Appropriation 1:11 Swedish Defence Materiel Administration[30]

Appropriation/ subcomponent	Expenditure amount 2019, million SEK (% of total military expenditure)	NATO nomenclature	NATO main category
1:11 Swedish Defence Materiel Administration (minus 1:11.4)	1,109 (2)	1.2.1 Pay and allowances	Personnel
1:11.4 Direct expenditure for materiel procurement[31]	473 (0.9)	2.1 Major equipment	See separate calculation
Total sum	1,582 (2.9)		

Appropriation 1:11 represented almost 3 per cent of total military expenditure in 2019, at 1.6 billion SEK. The largest share of the appropriation corresponded to '1.2.1 Pay and allowances' in the NATO nomenclature. However, the subcomponent 1:11.4 'Direct expenditure for materiel procurement' exceeded the threshold of 100 million SEK and corresponds to '2.1 Major equipment'.

Table 7.14 Appropriation 1:12 Foreign Intelligence Court[32]

Appropriation/ subcomponent	Expenditure amount 2019, million SEK (% of total military expenditure)	NATO nomenclature	NATO main category
1:12 Foreign Intelligence Court	9 (0.02)	1.2.1 Pay and allowances	Personnel
Total sum	9 (0.02)		

Appropriation 1:12 represented less than 1 per cent of total military expenditure in 2019, at 9 million SEK. The decision was made to assign the whole expenditure sum to '1.2.1 Pay and allowances' in the NATO nomenclature, even though a minor share of the expenditure amount is derived from other expenditure, such as rent, which would correspond to '4 Other expenditure'. Due to the expenditure amount being lower than the threshold, no further subdivision was made.

[30] In Swedish: 'Försvarets materielverk'.
[31] In Swedish: 'Direkta utgifter i materielanskaffningen'.
[32] In Swedish: 'Försvarsunderrättelsedomstolen'.

Table 7.15 Separate calculation for equipment procurement and maintenance

Appropriation/ subcomponent	Expenditure amount, million SEK (% of total military expenditure)	NATO nomenclature	NATO main category
(1:1.1) Maintenance of military equipment[33]	2,522 (4.6)	1.4.6 Other operations and main tenance	Other
1:1.3 Procurement and maintenance of military equipment and facilities[34]	6,742 (12.2)	2.1 Major equipment	Equipment
1:3.1 Supplier expenses[35]	10,872 (19.6)	2.1 Major equipment	Equipment
1:3.2 Procurement of military equipment and facilities	2,776 (5.0)	2.1 Major equipment	Equipment
1:11.4 Direct expenditure for materiel procurement[36]	473 (0.9)	2.1 Major equipment	Equipment
Total sum	23,385		
65%	15,200	2.1 Major equipment	Equipment
35%	8,185	1.4.6 Other operations and maintenance	Other

The Swedish military expenditure for materiel is divided into investments and maintenance. However, maintenance is a mix of both repair work and of maintenance that can be classified as procurement. Therefore, in this study, a separate calculation has been made for equipment. All expenditures related to materiel and materiel maintenance have been summarised in the table above and divided according to the division based on reports to UNODA (2021) between the years 2002 and 2012. The assumption is therefore that the UNODA categories, 'Operations and Maintenance' and 'Procurement and Construction', make up NATO's '2.1 Major equipment', '1.4.6 Other operations and maintenance', and 'National military construction'. Construction expenditure was extracted from 'Procurement and Construction' by assuming that it had the same share as in 2019 (1.7 per cent); then, the shares for '2.1 Major equipment' and '1.4.6 Other operations and maintenance' were calculated, with the result being 65 per cent and 35 per cent, respectively. UNODA attempts to collect statistics on military expenditure at a disaggregated level. Countries are encouraged to report military expenditure annually (UNODA 2021).

Summary

The total expenditure of appropriations 1:1–1:12 in 2019 is approximately 55.4 billion SEK. The distribution of the Swedish military expenditure for 2019 is, according to the judgment of the authors and based on NATO's four main categories, as follows:

Table 7.16 Swedish Military Expenditure according to NATO nomenclature

NATO main category	Expenditure amount, million SEK	Share (%)
Equipment	15,200	27
Personnel	21,019	38
Infrastructure	960	2
Other	18,229	33
Total sum	55,409	100

[33] In Swedish: 'Materielunderhåll'.
[34] In Swedish: 'Vidmakthåll materiel & anläggningar'.
[35] In Swedish: 'Leverantörsutgifter för leveranser (ram)'.
[36] In Swedish: 'Direkta utgifter i materielanskaffningen'.

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