Chapter 1
Networked Corruption Risks in European Defence Procurement

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Abstract In this chapter we study corruption risks in EU defence procurement. Defense procurement has long been thought to present significant potential for corruption and state capture. Using a large dataset of contracts covering nearly ten years and applying an objective corruption risk indicator, we find strong empirical support for this hypothesis. In nearly all countries our corruption risk indicator is higher for military contracts than for contracts in general. By mapping national markets as complex networks, we find that risks are significantly clustered, suggesting potential islands of state capture. The centralization of corruption risk varies from country to country: in some corruption risk is significantly higher in the periphery, while in others it is significantly higher in the center of the market. We argue that network maps of procurement markets are an effective tool to highlight hotspots of corruption risk, especially in the overall high risk context of defense contracting.

1.1 Introduction

Public procurement is one of the government activities most vulnerable to corruption [23, 35]. Risks are even higher in the field of defence due to the large amounts of money involved, the complex and high-value contracts, high market concentration, and the fact that governments themselves are the enforcers of secrecy [26]. The

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defence procurement market has certain aspects which distinguish it from general public procurement, both in terms of market structure and regulation, which may limit efficiency and fair competition. While efficiency and quality of defence spending are of great importance for the public good via their impact on national security, citizens have limited options for monitoring and holding the government accountable in this field due to confidentiality, and a relative scarcity of publicly available information.

This chapter aims to gauge the extent and types of state capture in defence procurement across the EU. We go beyond measuring corruption risks by assessing the phenomenon of state capture drawing on recent complex network based approaches [8, 12, 34]. According to this conceptual and analytical framework, state capture is not just widespread corruption, but a tight clustering of corrupt actors and ties among them, typically centred around certain public organisations, government functions, or supply markets. Going beyond blanket averages of risks in countries or markets, measuring the distribution of corruption risk in procurement markets mapped as complex networks reveals a variety of ways in which corruption is organized.

This perspective on corruption risk has high relevance for anti-corruption policy, as captured clusters are expected to behave differently, thus demanding different solutions. Addressing state capture is especially relevant in defence procurement as the low number of contracting authorities and suppliers, the complex technology, typically large contract values and high degrees of secrecy in national security decisions create an environment of interdependence among insiders, and limit the capacity of outsiders to effectively monitor wrongdoing. Whether a high corruption risk cluster is central or peripheral in a country's military procurement market clearly has implications for underlying mechanisms and potential solutions.

To explore state capture in defence procurement we first apply a robust measure of corruption risk in public procurement transactions to a curated dataset of EU defence contracts. We report country-level corruption risk averages and compare them with non-military procurement outcomes, finding that military contracts tend to have higher corruption risk. To analyze the distribution of risks and assess potential clusters of corrupt capture, we construct a contracting network of organisations. We demonstrate that corruption risks are far from uniformly distributed in a majority of the markets we study. Researchers studying British and French military procurement have used our identification of key organizations that are central in their markets and have high corruption risk as a starting point for in-depth investigations into state capture [28, 27].

The rest of the chapter is organised as follows. We first provide an overview of the legal and economic factors which differentiate defence procurement from general procurement, including national security concerns, market structure, and the nuances of relevant EU legislation. We also review the findings of the literature addressing defence procurement in terms of market structure, corruption risks, and state capture.

We then describe the data sources we used to carry out the quantitative analysis, including the Corruption Risk Index we adapted from previous work [9], comparing military procurement risk with general procurement risk across the countries in our sample. We then proceed with a network analysis of these markets - highlight the highly non-random distribution of risk in most countries. We also consider the

extent to which corruption risk appears in the center or periphery of various country markets. The last section summarises findings and formulates recommendations for policymakers and future research.

1.2 Defence Procurement in the EU

Although there is no single clear definition of defence procurement which is widely accepted by experts of the field, there is certainly a distinction between the products belonging to the very core of national security functions of the State – such as ammunition, submarines and vehicles for transporting troops – and the whole range of products acquired by authorities operating in the field of defence, which also includes goods and services necessary to fulfil administrative functions, such as office furniture and basic IT services. These two categories can be referred to as the narrow and the wide definitions of defence procurement [25]. The former covers goods and services which were manufactured or intended to be used for purely military purposes, especially armaments. Dual-use products and technologies can also be included if they were acquired for military use. The latter encompasses the totality of goods and services procured by entities related to national security.

The narrow and wide definitions of defence procurement draw attention to the fact that some goods and services in the field of defence are more affected by national security considerations than others. In this sense, the procurement of more sensitive goods requires a regulatory regime which acknowledges the defence-specific characteristics of this sector and finds the balance between openness and transparency of the procurement process on the one hand, and protection of the core security concerns on the other hand [25]. In contrast, the acquisition of non-sensitive defence-related supplies is quite similar to 'general' public procurement, so lack of transparency and restrictive procedures cannot be justified necessarily. This report focuses on sensitive goods and services in the field of defence, that is, the *narrow* definition of defence procurement. This means in practice that it is not the buyer but the product that determines whether we consider a tender as defense-related or not. For instance, we do not consider all purchases of ministries of defense as defense - related.

1.2.1 Defence procurement market size

The 27 member states of the EU plus the UK spent 205 billion euros on defence in 2017 according to Eurostat, which is 1.7% of the GDP of these countries on average. However, this value covers several different types of expenses, such as salaries, foreign military aid, etc. so it cannot be used directly as an estimation of the total value of defence-related public procurement in Europe. The European Commission provides a method for the estimation of defence procurement in its working document *Evaluation of Directive 2009/81/EC on public procurement in the fields of defence*

and security which is based on 2010-2014 Eurostat data, where the total general government expenditure on military defence is further disaggregated into specific national accounts components. The maximum total value of military procurement can be estimated as the sum of 'Intermediate consumption' and 'Gross fixed capital formation'. The time series can be extended for the period 2007-2017 using the newest Eurostat data, see Table 1.2.1.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
EU28	79	81	79	79	78	80	80	81	90	91	94
EU28/EEA	83	86	84	84	83	85	85	86	95	97	100

Table 1.1 EU+UK and EU+UK+EEA annual defence procurement spending, rounded to the nearest billion Euro, sourced from Eurostat.

1.2.2 Defence market: buyers and suppliers

Although in most countries the primary buyers of defence goods and services are ministries of defence, other types of entities also appear in this market, such as law enforcement and detention systems. While defence ministries are responsible for handling territorial threats and military crises, other institutions can be responsible for a wide range of tasks (e.g. combating terrorism or providing airport security). The number of potential buyers varies greatly among the subcategories of defence goods: only ministries of defence buy warships, but there are more potential buyers for firearms.

The suppliers of defence procurement are not clearly distinguishable from companies manufacturing "civilian" goods. Many companies, which produce goods for military use, have also other fields of activities without military character, and dual-use technologies are especially hard to be classified. In any case, two distinctions should definitely be considered when analysing defence procurement. First, there is an important difference between prime contractors - or system integrators – on the one hand, which are large companies capable of delivering complex security solutions (usually they are the ones signing contracts with buyers), and smaller companies on the other hand, which are usually subcontractors of the prime contractors. Naturally, these roles are not fixed, a middle-size firm may be the contracting partner of a buying entity in one transaction, and subcontractor in another; however, this flexibility strongly depends on the type of goods and the contract size. Second, the sensitivity of goods is an important factor. The market of core defence goods - or armaments - has certain characteristics which differentiates it from "civilian" markets, while this is less relevant in case of non-sensitive goods. To sum up, differentiating

factors apply mostly for prime contractors operating in core defence markets, and these impacts fade gradually as we go deeper into the supply chain, entering the market of non-sensitive defence-related goods and services.

The total turnover of the defence industry sector was 97.3 billion euros in 2014, and 500 000 people were directly employed in this sector. However, defence capabilities are not evenly distributed among member states. EU countries can be classified into four broad groups based on their prime contractors and the size of their defence industry sector in general [33]. France and the UK are in the first group on account of their extensive defence industries, their status as nuclear powers, and their permanent seats in the UN Security Council. The second group contains countries with significant capacities: Germany, Italy, Sweden, and Spain, while the third group covers countries with limited capacities: Belgium, Finland, the Netherlands, Poland, Czech Republic, Romania, and Denmark. All other countries are in the fourth group with very limited or no defence capacities at all. It worth mentioning that even in countries with the largest defence industry, capacities are not enough to provide full range of equipment which results in a pressure for cooperation and mergers both at national and European level. This phenomenon has also consequences for competition: in case of expensive high-end technology such as aerospace technologies, competition is bound to be very limited, while competition can emerge in other sectors such as ships and vehicles.

Extensive supply chains are also an important characteristic of the defence industry, especially for complex contracts. The distribution of subcontractors is more even among EU countries than the distribution of prime contractors. Subcontracting is an opportunity for small and medium enterprises (SMEs) to participate in the defence industry.

National markets of certain goods and services are often characterised by monopsony, i.e. only one buyer on the market, and monopoly or oligopoly, i.e. only one or very few suppliers on the market, at the same time. The low number of actors, accompanied by protectionism, makes the relationship between governments and national champions often interdependent. This applies even more so to countries where the state has ownership in the biggest and strategically most important defence companies, e.g. in France, Portugal, Poland and Germany. Consequently, decisions regarding defence procurement depend not only on value for money and budget considerations, but industrial policy, employment, control over know-hows, and national security reasons, or any combination of these. This often leads to a setting in which the national champion has certain benefits that potentially distort competition, e.g. it is subject to tax exemptions, or contracts are awarded to it even if there would be other options.

At the European level, the defence market is characterised by fragmentation and duplication, which results in inefficiencies thanks to the lack of economies of scale. Inefficiency could mean not only higher prices but lower quality and longer completion time too, which could raise concerns regarding national security in the long term. In this sense, opening up the EU internal market for defence products is of high importance, which is addressed by a range of interventions, including Directive

2009/81/EC on defence and sensitive security procurement, however, there is still room for improvement.

1.3 Related Work

Competition, transparency and corruption risks are studied by academia as well as international think tanks and NGOs such as Transparency International Defence and Security Programme, the Stockholm International Peace Research Institute (SIPRI), and the Geneva Centre for the Democratic Control of Armed Forces (DCAF). These studies often use surveys and case studies from all around the world to illustrate problematic areas in military procurement and to recommend tools to tackle them. Survey data typically means that cross-country research makes use of corruption perceptions indices. Case studies are based on in-depth systematic data collection (both qualitative and quantitative) of selected events, organisations or countries. While the lack of broad scope mean that it is difficult to extrapolate to other settings, these research projects are still helpful in identifying key problems and vulnerabilities in defence procurement. Beyond exploring problems, advocacy organizations and think tanks usually draw up recommendations, that is, steps towards a solution: lowering corruption risks, more transparency, and better value for money.

In this section we survey related work on corruption risks in defence procurement. First we review work on how defence procurement has unique corruption risks, distinguishing it from other public sector activities. Next we describe the overall market structure of the defence sector, again suggesting ways in which its organization differs from that of other sectors. Finally, we review relevant literature on the measurement of corruption risk in procurement.

1.3.1 Distinguished corruption risks in defence procurement

Gupta et al. use aggregated budget data and corruption perception indicators to test the relationship between corruption and high levels of military spending in 120 countries in the period of 1985-1998 [16]. Their results indicate that corruption - measured by Transparency International's Corruption Perception Index and International Country Risk Guide Index - is indeed associated with higher military spending, measured by its share in both GDP and total government spending. This result supports the statement that military spending is associated with higher level of corruption risks compared to procurement in general, but it leaves open the question how corruption is done and what can be done to mitigate the risk.

According to Feinstein, Holden and Pace, the following built-in features of the arms trade make this field prone to corruption: a) the secrecy related to national security and commercial confidentiality, b) the close personal relationships between buyers, suppliers and their brokers, c) the complexity, fragmentation, and often

opacity of global production, transportation and financial networks, d) the technical specificity of products, e) procurement pressures, and f) the high financial rewards coupled with a lack of consequences of wrongdoings [11]. Most of these factors appear also on the list of inherent risks and factors facilitating state capture in general [24], namely, technical complexity, opacity of decision making, stable policy networks with repeated interactions over time. This implies that besides one-off instances of corruption, state capture risks also have to be considered in the field of defence procurement.

Feinstein, Holden and Pace also describe the most frequently used methods to acquire undue influence in the arms trade, which are the following: a) bribery (often through a third party which provides a legal remove between the supplier and the corrupting act), b) failure to declare a conflict of interest, c) the promise of post-employment, or revolving door, which blurs the line between the state and the defence industry and d) the offer of preferential business access, which is often related to offsets, e.g. public officials are offered cheap or free shares in companies that have been founded in furtherance of an offset programme [11]. Most of these means (except for bribery) assume a stable, long-lasting relationship in the background, rather than a one-off transaction, which point at likely state capture in this field.

A comprehensive report of Transparency International's defence and Security Programme [17] explores the extent and the reasons behind non-competitive defence contracts in order to formulate recommendations for various actors in this field. They attempted to collect qualitative and quantitative defence procurement data from 45 defence ministries with special attention to non-competitive procedures, which they identified as a corruption risk in itself, but they only succeeded in seven countries, which in itself is a telling example of data challenges in this area. The countries participating in the research had single sourcing percentages between 9% (Bulgaria) and 55% (United Kingdom) in defence procurement, with even higher rates if we narrow down the analysis to armaments only. The following barriers to open competition were identified: 1) the protection of the national defence industry by over-using Article 346 of TFEU, 2) restrictive requirements in the request for tenders, 3) excessive use of classification, even in case of non-sensitive defence related information, 4) limited license rights, which often lead to a situation where repair and maintenance of an equipment can be done only by one contractor, i.e. the original supplier, 5) lack of unification of standards and interoperability of equipment.

Another report of TI UK analyses the corruption risks associated with defence offsets through three case studies [20]. Defence offsets are arrangements between the purchasing government and a supplier from another country, where the latter is obliged to invest a certain share of the contract in the importing country either through defence-related projects (e.g. by subcontracting), or through activities not related to defence such as purchases of other goods and services. The percentage of the offsets contract is often very high, even above 100%, and they are highly susceptible to corruption due to their complexity and a reduced level of scrutiny compared to the main arms deal. The study identifies three main categories of corruption risks from offsets: 1) influencing the need for a particular defence acquisition, 2) influencing the

decision for the main contract, 3) allowing favours to be repaid to corrupt government officials via the offset contracts.

1.3.2 Defence procurement market structure

The analysis of market structure complements the assessment of potential state capture in the field of defence procurement. The markets in which buyers and suppliers are embedded can both influence behavior and reflect existing arrangements. Factors such as market concentration and buyer centralization are often studied theoretically, for instance via principal-agent models [21] or by models of competition [14] or by contrasting auction formats [5]. Recognizing that defense markets often mix and match sub-market types (monopsony, oligopoly, etc.), we focus on the empirical structure of these markets, observing them as they are and relating them to risk indicator outcomes. Nevertheless, it is important to give an overview of the general patterns of structure in these markets.

The relationships of companies in the defence industry is often described as a hierarchy of 'tiers'. Prime contractors (or 'primes') are on the top of this pyramid. They are specialised in defence production and sell complex products, such as weapon systems to the end users, i.e. mainly government agencies and ministries of defence. Below that is the first tier containing system providers, who are the producers of complete subsystems or major components. They are the final step before the product reaches the prime contractor, who may complete the product or simply organise the shipment, marketing, etc. Below the first tier, there are second tier and third tier companies, often producing dual-use components for military purposes after being integrated into larger systems. They are not always listed as defence producers because they usually produce non-defence goods too. Most academic studies exploring European defence market structures focus on prime contractors, and the consolidation process at European-level. Very little evidence is available on first-tier, second tier (and lower tier) companies and the market processes at the national level.

Carril and Duggan analyse the impact of increasing concentration of the 1990's US defence market on procurement outcome variables [2]. Using micro-level data (US's Department of defence contract awards), they find that market concentration made the procurement process less competitive, which was evidenced by the increasing share of contracts awarded without competition, or via single-bid solicitations. Contracts tended to shift from fixed-price towards cost-plus contracts. However, they found no evidence that consolidation led to a significant increase in acquisition costs of large weapon systems, neither to increased spending at the product market level. The government's buyer power constrained firms from exercising any additional market power gained from consolidation.

The structure of the defence market is analysed from a political-business perspective by Neil and Taylor who describe different paths of restructuring after the Cold War in the United States and Europe, focusing on prime contractors [22]. They show

that while the major approach of consolidation in the US was merger and acquisition, in Europe, more cautious approach was applied, which consisted of a wide range of tools for consolidation such as strategic alliances, minority shareholdings, and joint ventures. The study states that whilst the core drivers of consolidation were similar in the US and Europe, the more complex relationship-system of European defence companies, which emerged due to the many national champions involved, may be an advantage in the global market, where flexibility and the ability to deal with cultural and political differences have great significance.

To sum up, there is evidence in the literature that defence procurement is especially prone to low level of competition, lack of transparency and corruption risks compared to 'general' procurement. Recent case studies of the British and French defence procurement markets confirm that these risks manifest in complex ways [28, 27]. The reasons include, on the one hand, the extensive use the notion of national security which limits the usability of usual monitoring mechanisms; on the other hand, the size, complexity and technical specificity of major arms programmes making hiding corruption relatively easy. An empirical study of the Spanish defense industry highlights great heterogeneity in performance and efficiency within a national market [6]. The level of competition and the power relations among buyers and suppliers strongly depend on the specific product and market: corruption risk likely varies across subsectors as well.

1.3.3 Measuring corruption risk

Having established that the defence industry, in particular its procurement arm, merits examination, we turn to the topic of measuring corruption risks. An emerging field of research quantifies corruption risks in public procurement using contract-level indicators that track the extent to which a contract's award deviated from a norm of free and impartial competition [9].

For example, a contract awarded directly to a firm without competition clearly present a corruption risk. Competitors are often excluded in subtle ways, for instance by onerous and specific requirements for past experience or by the imposition of an impossibly short deadline to submit tenders. In these cases, the requirements might be tailored to the favored firm and the firm can be tipped off ahead of time about the call for tenders. Pooled together into a composite measure, these indicators provide a fine-grained, data-driven proxy for corruption risk in procurement contracts. Aggregated to regional and national levels, these indicators have a strong correlation with generally accepted measures of corruption prevalence [7]. They have been used to evaluate, among other things, the effectiveness of meritocratic promotion in improving quality of government [3].

Another great advantage of these micro-level measures of corruption risk is that they offer the opportunity to study the distribution of corruption risks within a country, market, or region. By mapping procurement markets as bipartite networks of contracting among buyers and suppliers, one can go beyond averages and study

the complex organization of corruption. In general, it is known that corruption risks predict missing contracting edges, suggesting that corruption is about exclusion of non-favored competitors [10]. Corruption risks are also reflected in market structure across politically meaningful elections: network neighborhoods of high corruption risk actors rewire significantly across change in government [10]. While corruption risk indicators alone cannot prove corruption has taken place, they offer an alternative perspective on this important issue by searching for traces of organized bad behavior in broad data.

The network perspective has also given new insight into the phenomenon of capture of specific parts of a state by corrupt actors[12]. This manifests as clusters of highly corrupt actors in procurement market networks [34]. When such clusters exist in the center of a country's procurement network, this suggests that the situation is especially dire [8]. Altogether, this line of research reflects a growing recognition that corruption and economic crime in general is organized among many individuals and actors in a complex way [31, 30, 19, 18, 1].

1.4 Data

In this section we outline the data sources we used for our analysis and the major steps we took to prepare the data for analysis.

1.4.1 Tenders Electronic Daily - TED

We collected contracts from a centralized database known as Tenders Electronic Daily (TED), the official EU portal for contract notices and awards. On the site, contracting authorities publish their calls for tenders and contract award notices above certain value thresholds, which differs for goods, services and works. Notices on TED contain the most important pieces of information on the tendering process such as: the title and description of the tender, publication date and bidding deadline, estimated and final value, information on the tendering procedure and the identity of the buyer and the winner. Before we could use this dataset for analysis, entity deduplication was necessary. Available public contracting data does not typically assign unique identifiers to entities involved in the contracting process. In other words, buyers and suppliers of goods and services are identified by plain text names and not tax numbers. For example, a contract awarded by the British Ministry of defence to BAE Systems may list "MoD" as the buyer, and "BAE Systems, Ltd." as the supplier. Another contract between the same two entities may list "Ministry of defence" and "BAE Systems". In order to properly analyse these markets, it is important to identify and merge the aliases of both buyers and suppliers as accurately as possible.

Following deduplication, we considered all awarded contracts from 2006 to 2016, and filtered the data for contracts pertaining to defence-related activities. There are two ways in which we label a contract as military-related: a) one of the Common Procurement Vocabulary (CPV) product codes listed in the tender documentation comes from a list of curated codes deemed military related (see Appendix B on CPV codes), or b) the contract falls under the purview of the EU Directive 2009/81/EC on defence and sensitive security procurement. The resulting dataset contains 18,608 contracts. We plot the count of military contracts in our database in Figure 1.1. Unsurprisingly, we generally have more contracts from larger countries. In a parallel effort to collect data on procurement from media reports, we found a significant amount of procurement contracts that were missing from the data, suggesting a major transparency failure, see: [4].

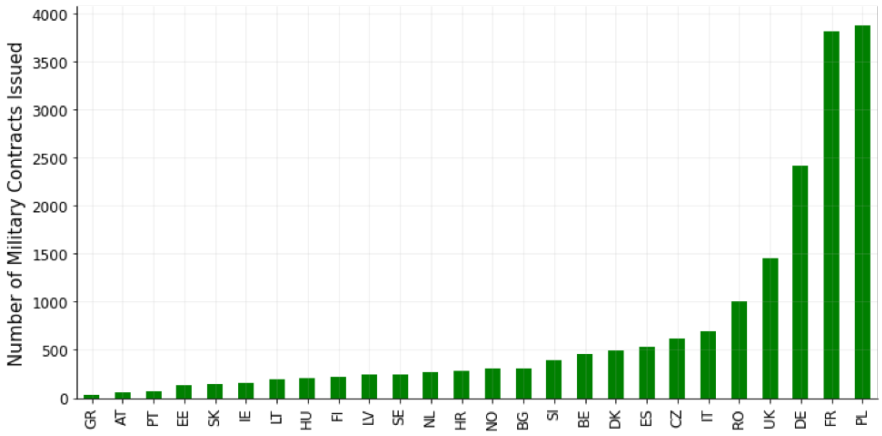

Fig. 1.1 Number of military-related procurement contracts per country.

1.5 Measuring Corruption Risks

To quantify the corruption risks at the contract level, we adapt two objective corruption risk indicators from the academic literature [9]. Such indicators count "red flags" in how a contract was awarded, capturing competition or transparency-limiting tricks that have been used to steer contracts to preferred winners. The first contract level indicator is single bidding: did the contract attract only a single offer from the private sector? This indicator considers only the outcome: whether there was competition for the contract.

The second indicator we consider is a composite index of red flags. In addition to the single bidding rate, we consider:

- Procedure type: was the contract not awarded by an open competition (i.e. by direct negotiation or by an invitation-only procedure)?
- Length of advertisement period: was the time to submit bids notably short?
- Evaluation criteria: to what extent were the bid evaluation criteria subjective (i.e. referring to unmeasurable notions of quality rather than objective criteria such as price, length of warranty, etc.)
- Call for tender publication: was the call for bids published in the official national or European procurement journal?
- Length of decision period: was the duration of the decision period either very short (indicating a premediated decision) or very long (indicating possible legal challenges)?

We count the number of red flags for each contract (and divide by 6) to arrive at its Corruption Risk Index (CRI). For instance, a contract awarded to a single bidder with a very short time to submit bids would have a score of 2/6. The CRI has been amply used in the literature on corruption in public tenders. Fazekas and Kocsis find that contract CRI scores tend to be higher for contracts awarded to winners registered in tax havens (2009-2014) [7]. Similarly, they find that single-bidder and high CRI contracts are associated with higher prices. This indicator directly captures corruption as unwarranted barriers to entry to privilege well-connected contractors in detriment of potential competitors. We plot the average CRI scores with bootstrapped 95% confidence intervals for defence procurements in Figure1.2.

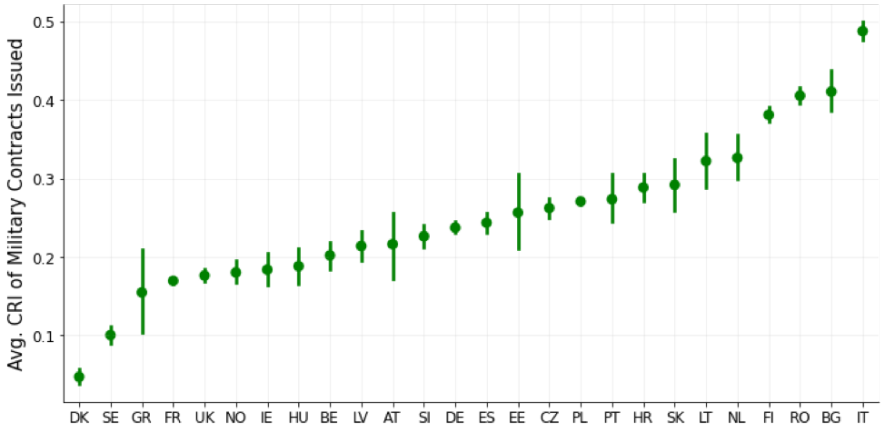

Fig. 1.2 Average Corruption Risk Index (CRI) scores on military contracts by country, from 2008-2016. The CRI tracks the presence of six red flags in the contract award process. Error bars represent 95% bootstrapped confidence intervals.

For both indicators, we observe significant heterogeneity in corruption risks across countries. In Denmark, less than 1 in 10 military-related procurement contracts are awarded to a single bidder while in Italy, every second military contract is awarded in this way. While the overall picture confirms typical rankings of corruption and

quality of government in EU countries [34], there are important exceptions. Finland usually ranks in good governance rankings - here we observe that Finnish military procurement contracts are often awarded with many red flags. Finland's unique geopolitical history as independent state between NATO and the USSR suggests that many military suppliers are Finnish. The Finnish state, like the Latvian one, may prioritize the onshore presence of critical suppliers over competitive market outcomes. Greece on the other hand has a relatively good scoring defense procurement market.

To better understand how military procurement differs from procurement in general in, we plot the average CRI score of each country's entire procurement market (including traditional products such as road repair, medicine, school lunches) against their average military procurement CRI in Figure 1.3. This provides us with a baseline for comparisons, highlighting again the Finnish, Greek, and Latvian cases as interesting outliers against the trend.

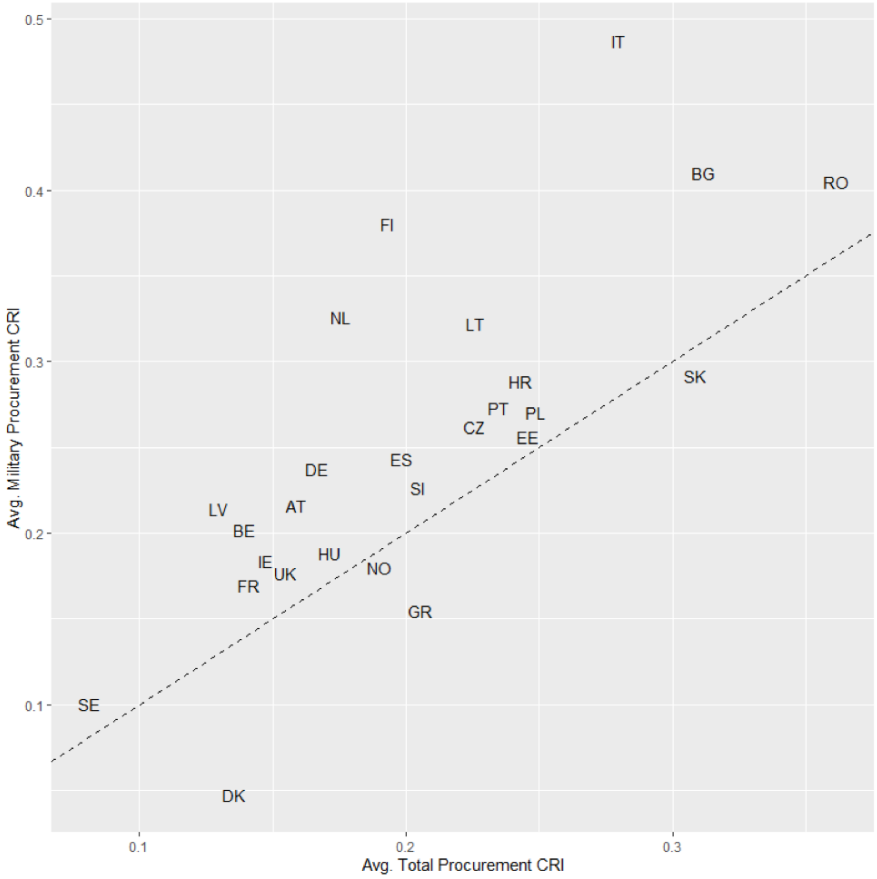

Fig. 1.3 Comparing average CRI scores for all contracts vs only military contracts, by country.

We draw two conclusions from this plot. The first is that in most countries military procurement contracts have higher corruption-risk scores than other contracts, most countries are above the 45-degree line. Second, there are significant outliers, indicating that military procurement carries significantly more (or less) corruption risk in certain countries. In Italy, Bulgaria, Finland and the Netherlands, military procurement has significantly higher corruption risks than procurement in general. The opposite is true in Denmark: there military procurement contracts have less corruption risk than other kinds of procurement, on average.

1.5.1 Key Suppliers

Within each country there is significant heterogeneity in the corruption-risk scores of military contracts. Some buyer and supplier relationships seem significantly more corrupt than others. In Table1.2 we present the top suppliers, by number of contracts won, for a selection of countries. We also report their average corruption risk indicator scores. We note that in some countries, the largest private sector winners seem to have high corruption risks, while in others they have rather low corruption risks. This will motivate our network analysis of these markets in the following section.

1.5.2 Network Analysis

The heterogeneity of corruption risk scores within specific national procurement markets for defence contracts raises several questions:

- How are corruption risks distributed within these markets?
- Are corruption risks clustered (i.e. are there groups of densely connected buyers and suppliers which are more corrupt than average)?
- Do corruption risks arise in the centre of the market, or rather in the periphery?

As noted above, the tools of network science can be fruitfully applied to these questions. We first map procurement markets as bipartite (sometimes called two-mode) networks, noting that visual representations of the markets are themselves useful. We then develop measures to answer our questions.

We map defence procurement markets as networks in the following way: nodes are buyers and suppliers of public contracts. They are connected by an edge if they have a contracting relationship, i.e. if buyer A contracts with supplier Z, they are connected in the network. Mathematically, we describe the markets as bipartite graphs G, consisting of two kinds of nodes B, the buyers, and S, the suppliers of military contracts. An buyer $b \in B$ is connected by an edge $e_{b,s}$ with a supplier $s \in S$ if they have a contracting relationship.

In the visualizations below, gold nodes are buyers and black nodes are supplier. We colour the edges red if the average CRI of the contracts between the two nodes

Winner Name	No. of Contracts	Avg. CRI*	Single Bidding Rate*
Italy			
Agustawestland Spa.	30	0.56	0.68
Selex Es Spa.	20	0.53	0.52
Oto Melara Spa.	17	0.49	0.49
Piaggio Aero Industries Spa.	13	0.56	0.77
Alfredo Grassi Spa.	12	0.39	0.17
UK			
Mott McDonald Limited	23	0.05	0
Ch2M Hill United Kingdom	20	0.05	0
Lion Apparel System Limited	20	0.03	0.009
Hunter Apparel Solutions Ltd.	18	0.02	0
Parsons Brinckerhoff Ltd.	17	0.05	0
France			
Lognavcm	78	0.08	0.01
Balsan	54	0.16	0.25
Mainco	50	0.09	0.003
Gk Professional	49	0.14	0.16
P Poinsot	40	0.11	0.08
Germany			
Kraussmaffei Wegmann Gmbh. Co. Kg.	83	0.30	0.67
Rheinmetall Landsysteme Gmbh.	76	0.2	0.3
Ffg Flensburger Fahrzeugbau Gesellschaft Mbh.	63	0.19	0.1
Ruag Ammotec Gmbh.	59	0.32	0.51
Scharrer Konfektions Gmbh. Co. Kg.	44	0.17	0.07

Table 1.2 Top winners of defence contracts in Italy, the UK, France, and Germany by number of contracts. Note: When data for CRI or Single Bidder is unavailable (NAs), we impute the country average. The assumption being that lack of information of on a given tender implies that its corruption risk is at least at the level of the country's average.

is at least one standard deviation above the market average. The nodes are placed using a physics-inspired algorithm: nodes are treated as charged particles which repel each other, while edges act as springs, pulling connected nodes closer to each other [13]. We visualize three national markets: Italy, the UK, and Germany in Figure 1.4. These are among the larger markets in our dataset and cover a range of corruption risk outcomes. The regularities we observe in their network structure suggests how we might compare all of the countries in our dataset using network-measures.

We can draw a few qualitative conclusions from the networks of Italy, UK, and Germany. The first is that corruption risks seem to be clustered: red edges seem more prevalent in certain parts of the network than others. The second is that corruption risks appear more common near the centre of the network. Finally, in all three countries there are different types of buyers: some are hubs issuing contracts to many suppliers, while others issue contracts to only a few suppliers. To make these notions more precise, we can use methods to quantify the clustering and centralization of corruption risks in procurement markets mapped as networks.

To calculate the clustering of corruption risk we calculate the average correlation of an edge's CRI with that of its neighbours. In other words, we quantify the extent to which knowing one edge's CRI allows us to predict the CRI of neighbouring edges.

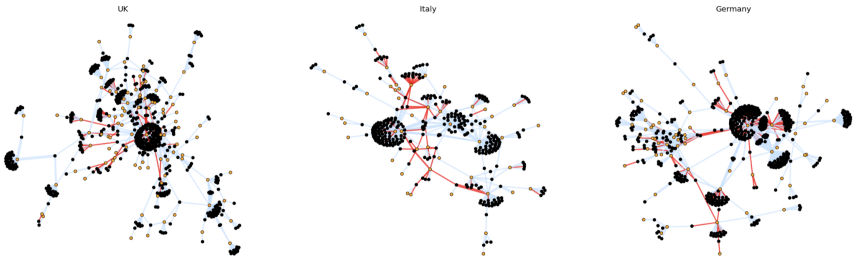

Fig. 1.4 The military procurement networks of Italy, the UK, and Germany. Gold nodes are buyers and black nodes are suppliers. Edges indicate contracting relationships, with red edges highlighting relationships in which the average Corruption Risk Index (CRI) score is at least one standard deviation above the average in that country. We observe that high corruption risk edges appear to cluster together.

If the correlation is high, it means that neighbours of high CRI edges are more likely to have high CRI, and vice versa. Mathematically, given an edge $e_{b,s}$ representing a contracting relationship between buyer b and supplier s, we first calculate the average CRI of the contracts between b and s. We then consider the adjacent edges, i.e. those edges who have either b as buyer or s as supplier and average the CRI across those edges. We calculate the Pearson ρ correlation between these two CRI scores.

We normalize the correlation using a permutation test, to enable comparisons between countries. In particular, we recalculated the edge-CRI correlation after shuffling the CRI outcomes across contracts. Repeating this one hundred times, we calculated a Z-score for each market, subtracting the observed correlation from the average correlation under randomization, then dividing by the standard deviation of the correlation under randomization.

In Figure 1.5 we see that in most defence procurement markets, corruption risks are significantly clustered. This is especially true in the larger markets. This confirms our intuition from the network diagrams: if you find one red edge (a high corruption risk relationship), it is likely that edges around that buyer node will also be red. This is in line with our expectations that corruption risks are not randomly distributed across buyer-supplier relationships, but rather clustered around key institutions – see Fazekas and Toth [8].

To quantify the idea that corruption risks seem more prevalent at the centre of the market, we calculate the so-called closeness centrality of each buyer and relate this with the average CRI of the contracts it issues. Closeness centrality is inversely proportional to a node's distance to all other nodes in the network. If one node is close to many other nodes, it is in some sense central in the network, while if it is very far from other nodes, it is in the periphery. Mathematically, we calculate the closeness centrality C of a node x as:

$$C(x) = \frac{N}{\sum_{y \in G} d(y,x)}$$

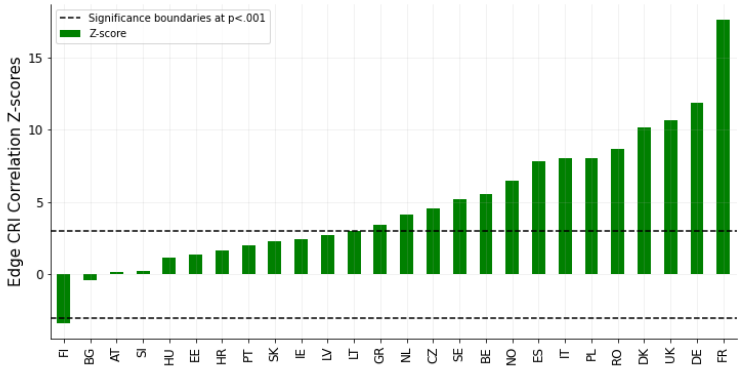

Fig. 1.5 The edge-clustering of corruption risk in different countries. We calculate correlation of corruption risk on neighboring edges in each country's procurement market, and compare it against a shuffled null model.

where d denotes the network distance between two nodes. We focus our attention on the buyers, the public institutions issuing defense contracts. We calculate the Pearson ρ correlation of their average CRI scores with their closeness centrality score, seeking to quantify whether buyers in the center of the network are issuing more or less risky contracts.

In Figure 1.6 we plot these correlations. We find that in some countries such as the Netherlands, Finland, Slovenia and Germany, corruption risk is more prevalent in the centre of the market (indicated by a high correlation between buyer closeness and CRI). There are also countries where corruption risk is more prevalent in the periphery of the market such as Greece, Portugal and Estonia. This again highlights the non-uniform distribution of corruption risks in these markets.

In summary, network science methods enable us to map public procurement markets in an interesting way. They can also help us quantify intuitions about the distribution of corruption risk in a market. We find that in general, corruption risk is clustered, indicating systematic state capture rather than a random phenomenon. On the other hand, corruption risk is not always more common in either the center or periphery of a market. In some countries corruption risk is more common among core institutions, while in others it thrives on the periphery.

Taken together, our framework generates a natural typology of corruption risks in defense markets. For instance: corruption risks in Finnish defense procurement contracting are relatively high, unclustered, and tend to appear more in the center of the network than its periphery. The Greek market has relatively low corruption risks, a moderate amount of clustering, and has higher risks in its periphery than among its central institutions. While a detailed comparison of different markets is beyond the scope of the chapter, these findings suggest how our framework can be applied to understand the distribution of risks.

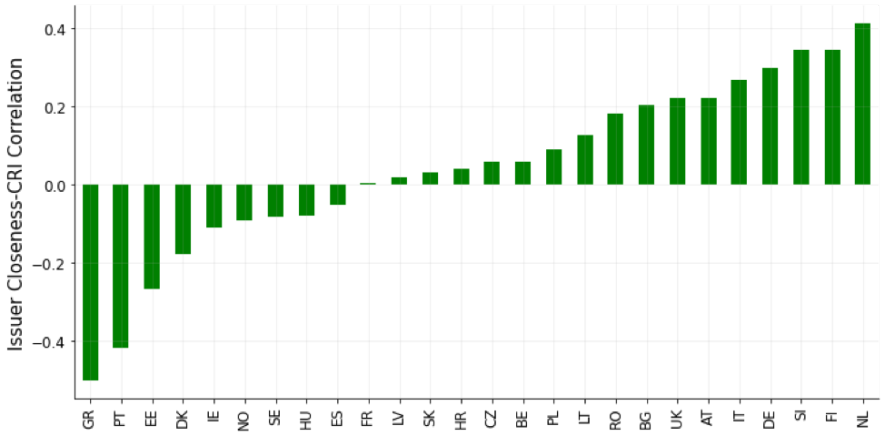

Fig. 1.6 The correlation between closeness centrality of buyers and their corruption risk scores by country. A high correlation suggests that corruption risk is higher in the center of the network.

1.6 Discussion

In this chapter we carried out a quantitative analysis of corruption and state capture risks in the field of defence procurement in Europe. First, we collected data using official and alternative sources to tackle the challenges typical for this sector, namely the relatively low level of transparency compared to most other procurement markets. We found that the use of alternative sources such as news articles is ambiguous: while the lack of exact details limits the usability of such additional data for research purposes; media often reports on the large value strategic purchases which are typically not published on official tendering websites. As a consequence, alternative sources cover a larger share of total defence procurement expenditure than notices published on the official platform in many countries. In this sense, they increase transparency significantly, and they raise public interest towards defence procurement, which creates a pressure to publish better, more comprehensive official datasets in the long run.

We analysed the large database of contracts collected from Tenders Electronic Daily from several perspectives. We began by identifying the typical corruption risk in defence contracting, finding great heterogeneity across EU countries. For instance, while roughly every other military contract awarded in Italy from 2006 to 2016 was awarded to a single bidder, only one in twenty contracts in Denmark were awarded in such a way. This reflects the situation in public procurement more generally, though it is in some sense surprising given that military procurement is high profile and perhaps more internationally relevant than procurement of local roads or health services.

Within-countries, we observed a significant positive correlation between corruption risk in the military procurement sector and corruption risks in procurement more generally. In other words, corruption risks in military procurement closely

reflect corruption risk patterns at the national level. Overall, military procurement risks are higher than other procurement sectors in nearly all European countries. The largest corruption risk premiums in military procurement over risk in other kinds of procurement exist in Italy, the Netherlands, Finland, and Bulgaria.

A significant advantage of measuring corruption risk using contracting data is that it enables micro-level analyses of key actors. By listing the corruption risk scores of top winning firms in different countries, we observed that distribution of corruption risks within countries can be quite heterogeneous. For instance, while the overall corruption risk rate of contracts awarded in Germany was moderate, some frequent winners had single bidding rates of over 50%, while others had single bidding rates below 10%. In Italy on the other hand, nearly all of the top winners had single bidding rates above 50%. This suggests that corruption risks are not randomly distributed in different markets. The findings are used to identify certain high-risk networks of buyers and suppliers where detailed field research was carried out in order to explore them in more detail. The results of two such case studies using our findings indicate how network analysis can complement qualitative investigations [27, 28].

We took another look at the distribution of corruption risks across the contracting relationships between buyers and suppliers using network analysis. By visualising the markets as networks, we could demonstrate more clearly what we claimed before: that corruption risks are not random, but rather clustered in the relationships of distinguished buyers and suppliers. Such networks offer analysts and the authorities a bird's eye view of the distribution of corruption risks in the market and state capture by implication. It also offers a framework to quantify the nature of corruption in a given market, for instance if it is more often present in the centre of a market or in its periphery. We found examples of both kinds of markets, underscoring that corruption risks manifest themselves in different ways in different countries. We argue that a network map of markets provides a useful tool to understand these complex differences both at a glance and with a view to investigate them further. Even more broadly, networks are able to highlight important emergent properties of economic interactions embedded in social and political life [32, 29].

We highlight several avenues for future work, building on our findings and methods. The most obvious way to generalize our work is to expand the number of countries considered. Certainly our work was facilitated by the existence of a cross-country comparable data portal for procurement awards in the EU. While similar data sources exist for countries outside the EU, making them comparable (owing to varying regulations and reporting thresholds, for example) is a considerable task. That said, our framework could be applied to these interesting cases. As a share of GDP, military spending is significantly higher in Russia, China, and the US compared to the EU and UK. Emerging market countries are also major customers of defense firms. Tracking the behavior of multinational defense contractors in these markets is one possible direction. Here again networks can provide substantial value: analysis of financial transactions, ownership structures and board members can yield surprising insights [15].

To sum up, network methods are an effective monitoring tool, as well as a quantitative framework to understand the organization of corruption in procurement

markets. As corruption and more generally state capture are phenomena which cannot be neatly characterized as either entirely micro or macro, network analysis is a useful lens through which they can be observed.

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