SINGLE BIDDING IN DEFENSE PROCUREMENT:

Corrupt Behavior of Defense Contractors

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AUTHOR’S DECLARATION

I, the undersigned, **Aleksandr Arsenev**, candidate for the MA degree in Public Policy, declare herewith that the present thesis is exclusively my own work, based on my research and only such external information as properly credited in notes and bibliography. I declare that no unidentified and illegitimate use was made of the work of others, and no part of the thesis infringes on any person’s or institution’s copyright. I also declare that no part of the thesis has been submitted in this form to any other institution of higher education for an academic degree.

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ABSTRACT

Caveats in national security might have exorbitant future costs, and may signal that there is something wrong with the state or its government. This paper addresses the issue of corruption within defense procurement by analyzing the behavior of defense contractors. We use the Defence Companies Index by Transparency International and 2012-2022 tender data of the European Union to look at whether the DCI listing impacts the rate of single bidding that a company commits. Surprisingly, in four modifications of binomial logit models with relevant controls and matching, we find that non-DCI companies have almost two times less odds to submit a single bid. This finding might run contrary to the automatic assumption that contractors in a spotlight of a large anti-corruption study would commit fewer potentially corrupt practices. We discuss the possible reasons for the relationship between DCI listing and single bidding in the dedicated final sections.

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CHAPTER 1 – INTRODUCTION

Defense is the main component of sovereignty, and the state is unquestionably the main actor in what concerns protection from external military threats. One could imagine the situation where economic development, cultural affairs, or even healthcare and schooling are left outside of the government's grasp altogether, or with only marginal interference from the state. This is evidently not the case for the concerns of national security, where states have solid and uncontended control over what they do in order to protect the homeland, the way of life, national interests, and so on. The area is existential for the citizens of every country, as they must be certain that the defense policy in place is sufficient to protect their lives from whichever external threats may arise.

In the author's view, suboptimal national security is therefore a good reason to democratically question the efficiency of the current government which administers it, as the said government is essentially foregoing its own primary duty and purpose. This issue is admittedly complex: there are unexpected events, material constraints, international arrangements, state secrecy, information asymmetries, and so on, which either limit the capability of the government to implement the best defense policy available, or limit the amount of knowledge that a citizen can obtain in order to effectively participate in the public discourse. In this study, however, we focus on the one ailment that we view as the most detrimental, undesirable, unnecessary, but rectifiable issue out of all that can happen to a country's national security – corruption within the defense procurement.

Generally, in order to obtain the necessary armaments, equipment, services, and technologies for the security needs, governments use public procurement. Because of its potential for corruption, this is a procedure that is already problematic by itself and precarious within many other areas – construction and oil and gas, among other (Surry 2006, 36). But the arms trade is estimated to be 40% corrupt (Feinstein, Holden, and Pace 2011, 1), which is the second worst result set aside only by public works (Surry 2006, 36). While in other industries corruption has its own grisly consequences, those that occur in defense procurement directly endanger the lives and futures of thousands. And these corrupt outcomes bring no or very little benefits and certainly are solvable.

We believe that this problem must be analyzed and mitigated. By establishing new mechanisms through which corruption happens in procurement, we will enable policymakers to take appropriate measure and address the roots of the problem. There is ample research on the detrimental effects of corrupt behavior in general, but more can be done in terms of analyzing, first, the defense industry, and second, company behavior, rather than behavior of public officials which as a rule attracts more attention from scholars.

This paper's aim is to look into a very specific sample of defense contractors – those included in the Defence Companies Index on Anti-Corruption and Corporate Transparency (Linney, Dowson-Zeidan, and Paukovic 2021) by Transparency International. We analyze whether the tender behavior of these large, well-known, and scrutinized companies – such as Rolls-Royce, Lockheed Martin, or Rheinmetall – is different from the rest. By researching the issue, we would discover *whether the differences in company characteristics affect how likely they are to commit corruption-prone acts.* Additionally, *we shed light on the DCI's selection and provide a possible reference point for future modifications of the study and negotiations with the counteragents.*

What we have found out is perhaps counterintuitive – the companies in the scope of the anti-corruption study by TI are more likely to submit a single bid, which is a practice frequently associated with corruption. Our explanation is that the nature of the defense market conditions the larger companies into single bidding if they want to keep afloat. Such companies have more connections and more political sway, and therefore they are more likely to require the services and/or be approached by the suppliers of corruption, public officials. As large, highly specific, or non-alternative contracts, the prevalence of which would explain why there is only one contractor, do not constitute the bulk of the tenders, we believe our explanation to be closer to truth. We discuss these findings in detail in the paper's latter parts.

The following chapter is a literature review of the contemporary scholarly works on corruption, and, specifically, corruption in public procurement and within the defense industry. We cover both the substantial and the methodological work we have found to be relevant for this research. We also discuss why single bidding is our indicator of choice for corruption risks. The second large chapter contains the empirical part of this study, where we describe the two datasets used in the paper – the DCI by Transparency International (Linney, Dowson-Zeidan, and Paukovic 2021) and the tender data from *Opentender.eu* (digiwhist 2022) – as well as their limitations; we then turn to the discussion of the variables of choice and the binomial logit models we have used to answer the core research question. The most relevant results, which are produced by the two logit regressions performed on matched data, are covered in the relevant subsections. The discussion, based mostly on these last two models, follows in the dedicated subsection along with reflections on the assumptions we have made in the paper, and the causal explanation of the relationship between DCI listing and single bidding. The conclusion chapter wraps up the findings and their practical implications, as well as suggests the areas for future research.

CHAPTER 2 – THEORETICAL FRAMEWORK

The role of this paragraph is in outlining the arrangement of the relevant terms in a way that would ensure a more effective consideration of the paper's empirical part and its inferences. We cannot deal here with the full discussions of the nature and typologies of corruption, or with a compendium of the best practices for regulating weapon companies. The goal of the section is to see how the interplay of multiple phenomena builds up the paper's research question: *How do features of defense companies affect their propensity towards corruption?* More precisely, we are looking at whether the contractors listed in the Defence Companies Index on Anti-Corruption and Corporate Transparency by Transparency International would behave differently from the rest (Fish et al. 2015; Linney, Dowson-Zeidan, and Paukovic 2021; Pyman et al. 2012), and if so – why.

Public procurement constitutes "about 12 percent of the global GDP or 11 trillion USD per year" (Bosio et al. 2020). It is an important governmental tool that is prone to corruption even in states with developed institutions (IMF 2019). Improving the outcomes in public procurement may therefore provide tangible benefits to society in the shape of more efficient policies, more budget money, and fewer consequences of corruption.

It is even more crucial to target the defense industry among all the other sectors, as it is critically cost-intensive, problematic, and prone to corrupt practices – the points which would be covered in the upcoming sections. Defense is an existential matter for everyone participating in a certain state, both as a citizen and as an official. Suboptimal defense procurement can endanger sovereignty and national security. The presence of corruption in the area of such extreme importance would demonstrate that the state is malfunctioning and has diminished ability in exercising its core functions. Understanding why corruption in the defense sector happens and combating it in both public officials and private companies should be, then, a high-priority task for any government.

2.1. Corruption

2.1.1. The Demand-Side of Corruption

From the standpoint of the demand part of the equation (Heimann and Boswell 1998), corruption is an "abuse of entrusted power for private gains" (Transparency International, n.d., 14; World Bank 1997, 8). In this definition, the "entrusted power" refers to the fact of holding a public office, and in fact the question of trust *per se* is not as important – that is, both politicians and bureaucrats must be included as those who are able to abuse their power, which blurs the line between those elected and those appointed.

A crucial corruption-enabling factor is not just a public office, but also the institutional arrangement it exists within (Everett, Neu, and Rahaman 2007, 519). On the one hand, it is specifically the national institutions – such as law enforcement agencies, parties, media, – that one can expect to inhibit the growth of corrupt practices and provide a deterrent to, or punishment for, the misbehaving officials. On the other hand, institutions can serve as a way for the corrupt to acquire and build up their entrusted power and extend the corruption networks by recruiting or coopting others, including those not generally involved into politics.

The institutions of a country are not simply given, as they come into being, exist, and evolve under the influences from political culture, economy, stability, poverty level, and so on. Researchers find that the combinations of poverty and growth, as well as inequality and growth, are statistically significant determinants of corruption (N'Zue and N'Guessan 2006). Corruption can also be entrenched in historical legacies with extremely varying longevities and roots (see, for example, Sandholtz and Taagepera 2005, 113; Stuart-Fox 2006, 71-73).

Market competition, openness of the economy, and bureaucrats' incentives are additional factors to consider (Ades and Di Tella 1996, 7). An IMF paper point out as determinants of corruption the quality of bureaucracy, public sector wages, rule of law, natural resources, economic competition, openness, and industrial policy (Gupta, de Mello, and Sharan 2000, 3). While we do not aim to cover the fundamental origins of corruption too extensively, a multitude of external characteristics has to be taken into account when considering any form of corruption and comparing countries to each other.

Moving one step up analytically, we can trace the differences in corruption levels not only to the innate differences between states, but also to their interaction. Corruption in one country may be a product of the actions of other governments, and rich and more developed countries with institutions generally viewed as well-functioning are not completely safe regardless of their governance quality. For instance, Sikka and Lehman (2015, 5-6) cover the government-to-government Al Yamamah contract where Saudi Arabia pressured the United Kingdom's National Audit Office into abandoning its investigation on the arms deal the Saudis had with the British defense company BAE Systems. In the context of the deal, the British company allegedly operated a "slush fund" set up for "greasing the wheels" with Saudi royals.

Developed countries may even export corruption to less well-off states, or use it for political leverage. Everett, Neu, and Rahaman (2007, 514, 525-532), in an analysis they label as "radical", find that the "rich" and "more developed" countries have occasionally weaponized the notion of corruption, and (mis)attributed the blame for it to poorer countries. In the same vein, Chang (2002, 69-123) points out the double standards and blame games that developed countries have historically employed in regard to poorer, "less free-market" countries in an astonishing amount of institutional and policy areas: from democracy, bureaucracy, and judiciary, to banking, securities, and intellectual property rights. The blame was frequently misplaced or short-sighted. It stands to reason that corruption might become another embodiment of the same habit. Taken together, these issues stand to reason that no country is safe from corruption – including both corruption imports and exports, and blame games.

The concluding general point on corruption is that it is an excruciatingly complex problem. A host of its causes exists at any societal level: personal gain, moral hazard, institutions, the economy, historical development, world politics, trade, and so on. In the following sections, we refine this more general idea of corruption and its causes into a streamlined framework that would be appropriate for the paper's analysis in what regards defense, private companies, and public procurement.

2.1.2. The Supply-Side of Corruption

The primary concern of this paper is the supply-side of corruption in public procurement (Heimann and Boswell 1998). While one must not exclude public officials from the analysis, it is the private sector that frequently acts as the end user. In other words, while bureaucrats and politicians provide the venues, these venues would have been derelict if it was not for those who want to use them. We do not view implied malice as *per se* the only determinant of why private companies may behave the way they do; rather, it is the list of specific benefits which becomes the more a hanging fruit the more institutional and other factors allow it. As this study deals primarily with corporate behavior on tenders, the supply side of corruption is something we should closely look into.

We cannot stress enough how extremely crucial this paragraph is for the whole study. The three major reasons for any company to engage in corrupt practices are: "to maintain higher prices, to maintain a market for outdated products, and to remain in the field of competition, especially if further sales can be secured at a later date" (Moody-Stuart 1997). These wide practices translate into illicit behavior, including *vis-à-vis* states, "stealing a march on competitors, at almost any price", pursuing business targets at any costs, etc. (Sikka and

Lehman 2015, 3). Pressure from competitors, market structures, the established practice of "greasing the palms", moral hazard, short office tenures, the frequent absence of individual responsibility, inefficient accounting, etc., motivate or condition businessmen into corruption (see, for example, Ades and Di Tella 1996; Sikka and Lehman 2015; Stuart-Fox 2006). Due to its inherent features which will be discussed in a later segment, the defense industry is specifically prone to any of these issues. This is a crucial point: firms in general may turn to corruption, but the reason for defense firms to do so is remarkably intensified by the tendencies within the defense sector, i.e.: secrecy, tight connections, harsh competition and market conditions, infrequent contracts, and so on. We kindly ask the reader to keep this point in mind throughout the paper, especially when we will come to the separate discussion of the defense industry.

Through non-market strategies, a company may secure its market position and revenues. In a sense, this reminisces of the Transparency International's definition of corruption: political power is abused in to reinforce private economic benefits (Transparency International, n.d.). "Corruption occurs at the interface of the public and private sectors" (Rose-Ackerman 1996, 1), but both within the supply-side private and the demand-side public sectors corruption is largely the same process of distilling political power into economic gain. For public officials, the said political power may refer to holding a specific office and exploiting connections within a constellation of institutions. For companies, the act of bribe is a material investment into political leverage which produces larger economic benefits thereafter. While private companies are not always state-affiliated, corruption itself is by nature deeply political for both sides of the bargain, and it is therefore crucial to study it within companies as much as within governments.

2.1.3. Consequences of Corruption

Corruption is detrimental as it damages public trust and policy efficiency. Rose-Ackerman (1996, 4) estimates that the presence of illegal payoffs increases contract prices and decreases the quality of public works by a margin of 30% to 50%. The evidence by Ades and Di Tella (1996, 9) reinforces this finding by claiming that “corruption-induced distortions” take away about a half of the effort in industrial policy and R&D”. Considering the average burden that large projects put on public funds, this fifty-percent change is daunting at best. A more industrially active state which, among all things, significantly supports its so-called “national champions” by providing them with preferential fiscal treatment may see 54% to 86% of the subsidy costs to get eaten up by corruption (Ades and Di Tella 1997, 1023, 1033-1034, 1037-1041). The key implication is that more active state involvement does breed more corruption, and state involvement on tenders within defense procurement is unlikely to be less problematic than the norm.

In the industry sectors where state intervention is frequent, the costs of corruption mount up further. Construction and public works are the first usual suspect in this regard. There are clear financial consequences such as increased construction and amortization costs, but, crucially, poor quality of the constructed roads and buildings and the neglect of safety regulations can result in human deaths (Kenny 2007, 4). According to statistics and surveys, construction is frequently corrupt, sometimes to unbelievable degrees, and for a good reason at that – it involves “large, complex, non-standard activities in which quality is very hard to assess”, with “a multitude of players”, both national and international ones, and active government participation (Kenny 2007, 1-3). Defense procurement has the same risky qualities.

Corruption is harmful not only momentarily, but also when put in a perspective – bureaucratic partiality lowers economic growth by deterring future investment, and installs self-reinforcing vicious cycles which gradually warp the incentive structures of public officials (Ades and Di Tella 1996, 6-9; Rose-Ackerman 2008, 330-331). There is ample evidence that corruption is a destructive phenomenon, so keeping it in check is an expedient policy goal. In this paper, the approach is to view corrupt practices as "sand" rather than "oil" in the machine (Ades and Di Tella 1996, 9-10), even though the opposite interpretation may make sense in some limited contexts when basic institutions of government are dysfunctional (Houston 2007, 326, 329).

2.1.4. Corruption Risk Index

We can broadly separate the main data sources on corruption into the following three types: legal (or, more precisely, law-based) data, survey-based data, and the so-called objective indicators. Historically, the first cohort of corruption studies focused on legal documents, but was rather a measurement of enforcement policies than of *per se* corruption and had poor comparability because of differing country-level legislations (Ades and Di Tella 1996, 1-2). At the turn of the century, legal evaluations gave way to perception surveys (Ades and Di Tella 1996, 1-2) which were an apparent step forward but suffered from their own survey-type, subjective, bias-prone nature. The situation with corruption review has overall improved since, but the types of studies we could single out as more reliable are still nascent.

Alternative indicators which can be seen as more objective have been in development along with other types of corruption evaluation. Namely, the Corruption Risk Index (Abdou et al. 2022; Czibik et al. 2020; Fazekas and Tóth 2016; Fazekas, Tóth, and King 2016) is in our view the optimal contemporary solution to the measurement and bias problems that seem to be inherent in the field. It is a composite index based on the so-called "red flags" – indicators of corrupt practices – acquired from interviews with experts and tested quantitatively.

The specific composition of the index varies from paper to paper which demonstrates that it is still a work in progress receiving constant specifications. Nonetheless, the three strongest sides of the Corruption Risk Index (CRI) in our view are its: (1) grounds in objective, public, freely available data; (2) cross-country and cross-industry comparability; and (3) composite nature and openness to further fine-tuning. These three advantages differentiate the CRI from other existing indices and reports – more so from the survey-type ones, but also to a considerable extent from similar studies grounded in objective data – as each of them lacks in at least one of these capacities[1].

While there are studies of various methodologies available, most of them might become problematic for further use in the research. Subjective studies are inherently biased, which might compromise this paper's final inferences and play into the general (unfavorable) narrative on specific countries. This would be a downside, because, as we have already demonstrated, a country's level of economic and institutional development is not something that can completely safeguard it from corrupt practices in the defense market from both the outsider companies and the national manufacturers.

Another issue is that the defense market is special: unlike most, it is tightly knit, clustered, sheltered, and highly secretive (see, for example, Czibik et al. 2020; Feinstein, Holden, and Pace 2011; Butler, Kenny, and Anchor 2000; Surry 2006). These characteristics may diminish the role of subjective indicators – if buyers and sellers know each other well, do not have much competition, and conduct deals on an irregular and clandestine basis, they might as well ignore the existing perceptions as they have superior knowledge about the way their market operates in reality. In this light, one can seriously doubt whether highly visible and public

[1] For a discussion on the other so-called "objective" measures, please see the paper by Fazekas, Tóth, and King (2016, 371-372). As the authors argue, the main problems of such studies are either the lack of scalability/comparability, or the lack of compositeness; therefore, they are either too costly to be upscaled, or do not capture the corruption process to a sufficient degree because of the focus on just one or too few red flags. For an overview of the discussion on the red flags in the literature, please see the paper by Abdou et al. (2022, 6). The issue here is similar: most of the studies reviewed only deal with a single red flag, which is a downside as there are multiple stages in the procurement process where corrupt practices can be introduced or adjusted.

perception indices, like the Transparency International's CPI, have influence on the behavior of agents within the defense industry or elsewhere.

At the same time, legal, institutional, and audit reports are detailed but poorly scalable or comparable and, given the secrecy, insulation, and high stakes around the defense industry, might be somehow pre-tampered or influenced by the governments. This situation in the field mostly leaves us with one option – to employ the indicators based on objective data rather than on surveys or legal procedures.

2.1.5. Corruption: Summary

In this section, we have outlined the general theoretical framework of this study in what concerns corruption – a highly complex phenomenon shaped by a multitude of various factors from different societal levels. While, within this problem, we recognize the importance of the supply-side of corruption – that is, the corruption of politicians and bureaucrats who provide the venues for illicit practices – we focus on the demand-side of corruption, as we are interested in how company characteristics shape company behavior. There are strong reasons that cause companies to adopt corrupt practices, and the nature of the defense industry exacerbates the problem.

2.2. Corruption in the Defense Industry

2.2.1. What Makes Defense Corrupt

The arms trade is estimated to be 40% corrupt (Feinstein, Holden, and Pace 2011, 1), rated as the second-most corrupt overall, superseded only by notorious public works and construction, and just above oil and gas (Surry 2006, 36)[2]. At the same time, the yearly sales of larger defense companies can exceed the GDP of many poor countries (Surry 2006, 36).

The reasons for, and practices of, corruption which were discussed in the previous section apply to defense very well. The corruption is 'hard-wired' within the defense sector due to its structural features:

> *"(a) the secrecy related to national security and commercial confidentiality; (b) the concomitant intimacy of buyers, suppliers and their brokers; (c) the sophistication, fragmentation and in many cases opacity of global production, transportation, and financial networks and instruments; (d) the technical specificity of the product; (e) procurement pressures; and (f) the high financial rewards coupled with a lack of consequences"* (Feinstein, Holden, and Pace 2011, 17; for similar reasoning, please see, for example, Gupta, de Mello, and Sharan 2000).

The unwillingness of governments to counteract corrupt practices within the industry is an additional reason that can serve as a catalyst (Perlo-Freeman 2018; here and further on until the end of the paragraph). In some instances, states avoid punishing their core defense companies for misbehavior. Sometimes the people involved enjoy political protection due to their position within or even outside the country, as was the case with the Al Yamamah deal we discussed. Aggressive competition with foreign contractors further raises the stakes and puts the domestic industry under more pressure (Gupta, de Mello, and Sharan 2000, 5). And because of the defense industry's nature, contracts of high value happen irregularly (for the discussion of aircraft, warships, and submarines as the most affected industries, see, e.g., Perlo-Freeman 2018, 38). Oftentimes these lucrative opportunities arise every five or ten

[2] Further details: according to an IMF Paper, bribes in weapon deals account for 15% of the total price (Tanzi 1998). Military aircraft is found to be the sector most susceptible to corruption (Hines 1995).

years, especially for more sophisticated products; and arms companies need to win these as they generally cannot operate exclusively in the domestic market and have to earn money elsewhere in order to keep afloat. In such circumstances, the failure to secure a contract or provide products of desirable quality can lead to a firm's "financial hiccup", temporary shutdown, or even closure, which makes operations in the defense market risky and in turn encourages risk-taking tactics – including corruption (Butler, Kenny, and Anchor 2000, 315). The state would also want to secure external contracts in order to support its own defense contractors, even if that involves ignoring the corruption that greases the wheels of the deal.

In sum, the "political will" and "defense policy forces" (Perlo-Freeman 2018, 45) are an important part of the story, and defense corruption is not just something happening between two individuals, or a firm and a state institution – the larger government frequently has a stake in the affair, because the government has a stake in its national defense. More corrupt countries also tend to have larger military spending and procurement (Gupta, de Mello, and Sharan 2000, 16). In this light, we cannot definitively say whether corruption or military spending comes first, and a finite decision would not make much sense regardless – the two exist within a self-reinforcing mechanism where secrecy breeds corruption, and corruption intensifies secrecy. What also matters is that the system is intertwined and there are direct links between state actions, the industry's structural features, and the resulting corruption.

What all these facts imply is that there are features which make corruption within the arms trade unlikely to disappear if the industry is to remain as is. Some of the features – modern financial structures, the levels of the technical difficulty, the secrecy, the politics involved – are essential and their effects unavoidable. Any groundbreaking historical future shift in them is unforeseeable, and therefore it makes sense to target the corruption-inducive characteristics and pathways within the defense industry that we are actually able to mitigate.

2.2.2. Mechanisms of Corruption

The four “most frequently used” methods to acquire undue influence in the sector are “(a) bribery[3], (b) the failure to declare a conflict of interest, (c) the promise of post-employment and (d) the offer of preferential business access” (Feinstein, Holden, and Pace 2011, 15-17). These methods of tilting individuals’ utility functions crucial, but in order to employ them for corruption, those interested generally have to somehow shape the market competition. Keeping the circumstances constant, the addition of an efficient competitor could increase exorbitantly the pool of people who should be bribed; involve more scrutiny into why the contract was awarded less cost-efficiently to a future employee or a revealed co-owner; or uncover that the offsets which are a part of the deal are going to come into the hands of a relative of the official interested. In short, greasing the palms does not work in the circumstances of effective competition, therefore the competition has to be pre-doctored in order for corruption to take place.

Public procurement, with a state actor buying goods from contractors under a tendering procedure, is a primary arena for illicit practices, as it is at this stage when those involved can employ a menu of methods to shape the competition and therefore avoid the nuisance and potential risks. Here, we are mostly speaking about the supply-side of corruption, with public officials exploiting their powers to bind the procedural framework in a desired direction.

The defense sector is problematic in terms of evaluation of procurement integrity because of the issues already discussed – the secrecy leading to omitted, missing, or altogether unregistered data; the technical specificities leading to the need in experts, high evaluation costs, and lackluster comparability; and the prevalent corruption, which is itself a big reason

[3] We should note that bribery is as a rule accomplished through third parties and not by the firm itself, and it can come in the shapes of ill-targeted offsets (which tend to receive remarkable attention in the field) and/or retrocommissions (Perlo-Freeman 2018, 43-44).

for the obscurement, the unreliability of objective data, and the unreliability of what we might know about this part of reality overall. Nonetheless, the ways to track corruption exist even in these thorny settings, and they are hardly different from other market segments.

Fazekas, Tóth, and King (2016, 372) outline three broad ways of tilting the competition which correspond to a specific stage of the public procurement process: limiting the set of bidders at the submission stage, unfair assessment during the assessment stage, and modifying performance conditions ex-post during delivery. The involved agents can get creative with how exactly they exploit the procedure by combining different methods during any or all the three steps if needed (Fazekas, Tóth, and King 2016). The paper presents the most comprehensive and detailed methodology of such methods out of all we have consulted with, and it points out the importance and the likely influence of, e.g.: single bidding, procedure type, submission period length (during submission); exclusion of all but one bids, and length of decision period (during assessment); and various contract modifications (during delivery). As it has already been stated, this section aims to target the defense-relevant issues in public procurement – therefore, we refer the reader to the primary source (Fazekas, Tóth, and King 2016) for the extensive detail on illicit procurement techniques in general.

We have already covered the various approaches to studying corruption that exist within the field. We find that objective corruption measurements based on specific red flags appearing in the procurement process are the best way to achieve this paper's aims. The paper by Fazekas, Tóth, and King (2016) represents a study of the kind. Our study, nonetheless, does not aim to build up a composite index or borrow a ready-made methodology from another paper. The issue with the defense sector primarily is that a lot of data is missing – likely due to secrecy and the irregularity of deals. In this light, building up or borrowing a more comprehensive evaluation tool that would take into view different bits of the procurement process at the same time might run into the data availability issue and become problematic for any meaningful analysis. We are also wary about data imputing, as the nature of the contracts may differ to the degrees which would forbid mathematical simulation of values. Our plan to move forward is therefore to select a single variable that would be sufficiently present in the databases at hand after filtering as well as descriptive of whether there is a risk of corruption.

2.2.3. The Focus on Single Bidding

Our research plan in this paper is to focus on single bidding as it suffices both the criterion of availability within data and the criterion of sufficient predictive power. Single bidding can be viewed as the one obvious and nasty indicator that something in a tender has most likely gone wrong, as there is just one company which competes with no one else (Amaral, Saussier, and Yvrande-Billon 2009; Mustafa et al. 2014; Pyman, Wilson, and Scott 2009).

Before developing this argument further, we should note that there are three reservations to be made about establishing a direct link between single bidding and outright corruption, and each of them deserves a further discussion in the defense industry settings. The first issue is that contracts with two or more suppliers might be as corrupt as those with a single bid if the suppliers have pre-entered into an agreement and control the playing field regardless of whether there is one bid or more. We find this "just bring two friends" argument (Fazekas, Tóth, and King 2016, 376) convincing and are cautious about it. Still, there are two factors which make it less relevant for our context: first, focusing on single bids is a more conservative way to estimate corruption as it is capable of "providing a lower bound estimate" (Fazekas, Tóth, and King 2016, 376); second, the cooperation within the defense sector specifically is limited by the structural features of the market, and that is why the collusions of the kind should be less likely to happen, both internally and internationally.

The other limitation of focusing on single bidding is the reasonable inference that a bidder actually has no incentive to give bribes if there is no competition (Fazekas, Tóth, and King

2016, 376). This refers us to the ‘chicken-and-egg’ nature of corruption mechanisms within the defense industry. On the large scale, we have no way of knowing for every individual deal whether the bidder is genuinely alone, or institutionalized corruption took place, abolishing any competition and encouraging single bidding. In the market sector that is fifteen, forty, or more per cent corrupt, we believe that the second explanation is on average closer to truth.

Finally, the contradiction most problematic for any counterclaims in our circumstances is the one regarding monopolistic situations within certain market segments (Fazekas, Tóth, and King 2016, 376). A company may have gained an advantage through a merger or R&D, which would explain why a tender for effectively monopolized goods or technology is most likely to go into the only hands that operate in that specific segment. Research suggests that “less than 5% of contracts were awarded on markets with three or fewer companies” (Fazekas, Tóth, and King 2016, 376), although we are not aware whether this is the case for Hungary, the country in question, or overall. This figure might be higher for military defense contracts, especially those with high value or contract specificity, although the consideration makes the issue less extant. Still, this is an important limitation of our research: by looking into single bidding, we are unable to tell corruption from monopolization – which itself might affect a company’s incentives to employ corruption. Our assumption is that the overall turnover of the arms trade is mostly sufficient to offer alternative suppliers, and therefore the problem persists but in a less acute form.

The benefits of looking directly at single bidding as the main corruption indicator outweigh the associated limitations. Due to the nature of the defense industry, contracts are likely to be unique and extremely detail-specific, take considerable time to be fulfilled, require additional research and cooperation. Therefore, one could expect issues with alternative variables such as contract requirements, technical details, delivery times, and so on. Single bidding in this view is a more universal indicator as it has less to do with what is being traded.

Single bids also hold considerable predictive power. Single bid is an explicit and easily measurable indicator – it tells quite easily that there is a potential for something illicit going on. Additionally, companies submit their offers at the first stage of tendering; it is more likely that illicit practices will happen as early as possible. By starting at the stage one, public officials will have extra time to tip the procedure during the following phases if something goes wrong. When we look at single bids, we have more chances to find sufficient data and detect a problem early.

2.2.4. Conclusion: Corruption in the Defense Industry

This section has attempted to outline the features that make corruption in the defense industry so pervasive: that is, the secrecy, the technical specificity of goods, political and economic concerns, market structure, and so on. We have also attempted to cover the menu of mechanisms and methods the actors have at their disposal both in terms of influencing other involved persons and modifying tendering procedures in ways that would shape the competition and enable corrupt deals to take place. These considerations enable us to model the variables based on the risk factors and causal links that we suspect to be true.

The outcome of this discussion is that we plan to use single bidding as the single most crucial and efficient indicator of corruption in the contracts we are going to review. The main advantages of looking into the number of bids submitted are data availability, the primary place of bidding in tendering stages, and the suitability in the defense industry context.

Earlier on we have argued that transparency is the way to combat corruption, including (or especially) in the very secretive and frequently corrupt arms trade. An additional goal of this paper is then to establish whether transparency by itself can shape the behavior of companies towards more optimal outcomes. One understands that claims for transparency are not equal to being transparent, and therefore research is needed to see the real situation.

CHAPTER 3 – EMPIRICAL STUDY

3.1. Preliminary Design

The section fleshes out the project research design that we had before consulting in detail with the available data. We consider this part necessary and suitable for starting out the discussion of the empirical findings, as the impediments that forced the design change are some of the crucial features of the field, and therefore could be viewed as the study's limitations and the field for future scientific work.

The preliminary research design was to compare the transparency and anti-corruption declarative statements of defense producers with their real behavior on tenders by regressing price changes from the first stage of tendering process to the final price on the company's DCI anti-corruption score (Linney, Dowson-Zeidan, and Paukovic 2021). Unfortunately, the lack of appropriate price data even in the Tenders Electronic Daily (TED), with as many as 87% of estimated and final prices missing on the bid level for relevant Common Procurement Vocabulary (CPV) codes, lead to a change of the study's design the exact details of which are to be discussed in the next subsection (digiwhist 2022; European Commission 2022). Before this discussion, we should first outline how pervasive the lack-of-data problem is in the field – a fact outlined by numerous researchers (see, for example, Fazekas 2019, 77).

Out of 25,754 bids submitted under defese-relevant CPV codes in 2009-2022, only 430 observations belonged to the large and renowned companies included in the Transparency International's 2020 listing – Lockheed Martin, Rolls Royce, and Rheinmetall among them. While the differences in entry frequencies are clearly influenced by sectoral market dominance and contract pricing, there is no obvious way to establish this in a straightforward manner. As many of the prices are undisclosed, we can only guess whether, for the sake of example, a single jet contract is worth more than twenty highly homogeneous small arms or military equipment deals. That is, while the TI-surveyed firms constitute less than 2% of the raw CPV-filtered TED data for 2009-2022, we have grounds to think that these companies' share in the overall expenses is much higher, as they are well-known large contractors with significant market shares and exclusive rights to specific technologies.

To make matters worse, the data is sometimes abstract to the level of not giving out which exact goods were purchased, with lot names missing in approximately 80% of cases. This confounds any suggestions on matters such as whether the purchase might have concerned a monopolized technology or instead was a suspicious single bid against the backdrop of alternative suppliers being available. Out of 25,754 bids, 14,176 have missing bid price, 14,619 do not disclose whether the contract was concluded with a single bid, and 1232 have missing or fuzzy tender procedure. The personal, economic, and technical tender requirements are missing in approximately 88-90% of observations, criteria count – in 80%, EU funding – 80%, supply type (supplies/service/etc.) – 70% (all rounded up). To reiterate, the prices as estimated by the clients are missing in the colossal 87% of the total cases (22,488 out of 25,754 bid-level observations), although the bid prices as supplied by the contractors are missing in only 45% of cases (11,578 out of 25,574 bid-level observations).

This subprime data accessibility may be pointing out the issues with both the way the EU collects data, and the way specific characteristics of the arms trade interfere with how we accumulate knowledge about it. For these reasons, we modified the design of the study in order to minimize the potential problems resulting from data omissions. As we will attempt to demonstrate further on, missing data points in place of concrete values might be no less telling.

3.2. Data Sources

In correspondence to what was stated above, we are using the TED (acquired through digiwhist 2022; for general information, see European Commission 2022) and the DCI datasets (Fish et al. 2015; Linney, Dowson-Zeidan, and Paukovic 2021; Pyman et al. 2012) which together represent the most comprehensive source of data on EU tenders that is complemented by transparency and anti-corruption indicators on the largest defense companies in the market. Even with the listed deficiencies in the data, the two sources offer a rich material which may be suitable for a study after some preparation and precautions.

The TED data covers the 2009-2022 tenders on the level of a bid across 138 variables ranging from the year, buyer and contractor IDs, their respective geographic identifiers, etc., to tender-specific objective features such as goods categories in the form of CPV codes, prices, procedure, criteria length, etc. The data additionally features indicators regarding both the tender-relevant company and the public institution in terms of anti-corruption, transparency, and administrative capacity.

The Transparency International's DCI, or Defence Companies Index on Anti-Corruption and Corporate Transparency in full, "assesses 134 of the world's largest defence companies, across 38 countries", based "entirely on publicly available information", for their "commitment to transparency and anti-corruption standards" in terms of "openness, policies and procedures" (Transparency International 2022). DCI studies are available for 2012, 2015, and 2020. Methodologies and the companies on the lists vary, with the authors claiming that the DCI 2020 is the most comprehensive and well-adjusted out of the three but not comparable to the previous editions due to the changes (Transparency International 2021, 1).

The DCI 2020 evaluation differentiates between ten "key risk categories": Leadership and Organisational Culture, Internal Controls, Support to Employees, Conflict of Interest, Customer Engagement, Supply Chain Management, Agents, Intermediaries and Joint Ventures, Offsets, High Risk Markets, and State-Owned Enterprises (Transparency International 2021, 3). Each of them receives a separate scoring, and the scorings are then grouped into two aggregate scores – a policy score which evaluates the policies and procedures the company has put in place to counter corruption, and a transparency score which evaluates the quality of the company's data disclosure. The two have cognate aims but different nature and are not necessarily correlated, making the separation meaningful.

According to the authors' claims, the idea behind the DCI is to inform the Transparency International's wider strategy for engaging stakeholders by serving as a basis for discussion and advocacy, and to work as a building block for the future research on the topics of corruption and transparency (Transparency International 2021, 2). We should stress here once again that it is not a measurement of corruption, compliance, good management, and so on, as the indicators in fact cover the declared procedures and policies rather than their application. The DCI can serve as a benchmark for how a good anti-corruption documented framework would look like, but is not sufficient *per se* for making claims about corruption risks. In this light, we believe that both the Index and the research area would benefit from a study comparing this "best practice" advocacy piece to tender tactics of respective companies.

3.3. The Hypothesis

The goal of the study is, therefore, to evaluate the relation between the Defence Companies Index on Anti-Corruption and Corporate Transparency and the defense tender data of the European Union. *The research question is whether DCI-listed companies behave differently on tenders than others.*

We cannot estimate how a company's *interval* DCI scores might influence its behavior: the relevant companies only make up just about 2% of the population data, there are only three scoring rounds each of which featured a divergent methodology making the figures incomparable, the scores are non-normally distributed and are constant for the durations of the between-scoring periods.

Still, we are able to look into whether *the presence or the absence on the list* has any meaningful effects on how the company behaves. That is, we need to find out whether the way by which the companies are selected (by researchers' discretion) or conditioned (by objective factors) for the listing has any impact on tenders which would make their behavior distinguishable from the behavior of the companies not scored with DCI. There are good reasons to believe that DCI-listed companies are different from the rest: they (a) are the largest in the world, (b) have publicly available scores that show how cleanly they conduct business, and (c) are likely to enjoy more public scrutiny because of their larger size and more intense exposure.

First, the answer to our research question would shed some light on how specific features of defense companies influence their tender strategies and engender or deter related corruption. Second, it would also show whether factual differences support the DCI study's claim to shaping company behavior. It is clear that corporate policies on transparency and anti-corruption do not necessarily guarantee transparency and anti-corruption just by themselves, and therefore it is crucial we study what effect integrity scorings might possibly have.

3.4. Variable Selection and Assumptions

To estimate how the presence on the DCI list changes company behavior, we had to preprocess the tender data and to adjoin the DCI 2020 figures to it. As TED covers all

European tenders in 2009-2022, not just defense-related ones, we filtered out the necessary deals via their CPV codes based on the comprehensive code summary from the paper by Czibik et al. (2020, 43-47). As the company names differed considerably between the two datasets, we searched for all the entries of the DCI-listed companies in TED, excluding subsidiary companies of the larger organizations in order to avoid possible overreach in assumptions. We also investigated closely the data for the companies with high similarity in names so as to avoid including irrelevant entries. The CPV-relevant TED dataset features 25,574 bid-level observation in total, 430 of which come from DCI companies.

The predictor we are mainly looking into is a binary variable that represents whether a company submitting a bid in a specific year was at the time present or absent on the DCI list. We take the most recent, 2020 DCI data as a baseline, with 33 out of 134 DCI companies having submitted at least one bid registered in TED. Non-DCI companies automatically receive a "0". Pre-2012 entries are all dropped since they precede the first TI publication. Cooperative bids that include two or more companies, however many of them DCI-evaluated, receive "0" to avoid making too extensive assumptions. Out of the 32 companies in 2020 (Linney, Dowson-Zeidan, and Paukovic 2021), four were absent in the 2015 DCI scoring (Fish et al. 2015), and five – in 2012 (Pyman et al. 2012). There are two companies which were scored in 2015, but not in 2020 – they respectively get "1" for bids in 2015-2019, but "0" for 2012-2014 and 2020. To summarize, the mechanism is that we code every bid submitted by a company with "1" if the company had a DCI evaluation in the study's year and the years up until the next edition of DCI, and "0" in all other cases, including the cases for the periods when the company was off the list. After leaving out the pre-2012 data, there remain 303 observations from DCI companies, with one-third of them single bids.

Table I. Thirty-two DCI Companies With At Least One Bid Present in the Tender Data.

1. Denel SOC	2. Patria Oyj
3. Airbus Group	4. Polish Defence Holding
5. Babcock International Group	6. QinetiQ Group
7. BAE Systems	8. Rheinmetall A.G
9. Chemring Group	10. Rolls Royce
11. Cobham Limited	12. RUAG Holding Ltd.
13. Diehl Stiftung & Co. KG	14. Saab AB
15. Excalibur Army	16. Safran S.A
17. Kongsberg Gruppen ASA	18. Thales Group
19. Krauss-Maffei Wegmann GmbH & Co.	20. Ultra Electronics Holdings PLC
21. Leonardo S.p.A	22. IMI Systems
23. MBDA Missile Systems	24. AAR Corporation
25. Nammo AS	26. General Dynamics Corporation
27. Navantia S.A	28. Honeywell International
29. Nexter Group	30. Lockheed Martin Corporation
31. OGMA – Indústria Aeronáutica de Portugal	32. Raytheon Technologies

The dependent variable is a binary indicator of whether single bidding occurred for that specific bi (and, consequently, for the whole relevant tender). There are 14,619 missing observations for single bidding, making up 57% of the dataset, and we have to drop them, leaving 10,165 observations for which we know whether single bidding occurred or not. While such pruning is a drastic measure, the missing 57% belong to a highly indicative variable and omitting them is nonetheless not as problematic as the alternative of leaving out from 70% to 90% of the entries missing for other comparably useful variables.

We then take one bid out of every tender at random, which cuts the data down to 7389 observations. Randomizing in this way ensures that the model does not overestimate the presence of non-single bids within the data. Some of the tenders have dozens of bids, so there are chances that we would take two or more alike bids from the same contract, muddling the coefficients and making them compete against single bids which are by definition singular per their tender. We then take a random 10% of the remaining bids for the model's sample. This provides us with a subset of 739 observations. Randomized sampling ensures that there is no bias in how the subset was put together.

The extant issue of the data is the small proportion of bids from DCI-evaluated companies – they make up just above 4% of the large dataset (303 non-unique, or 206 unique observations out of 7389). Accordingly, the same holds for the sample – there are only about 30 tenders in it after the randomized selection.

3.5. The Models

3.5.1. Binomial Logit Regressions, Unmatched

We use binary logistic regression to predict whether the presence on the Defence Companies Anti-Corruption Index changes the likelihood for a company to submit a single bid (the results are reported in Table II).

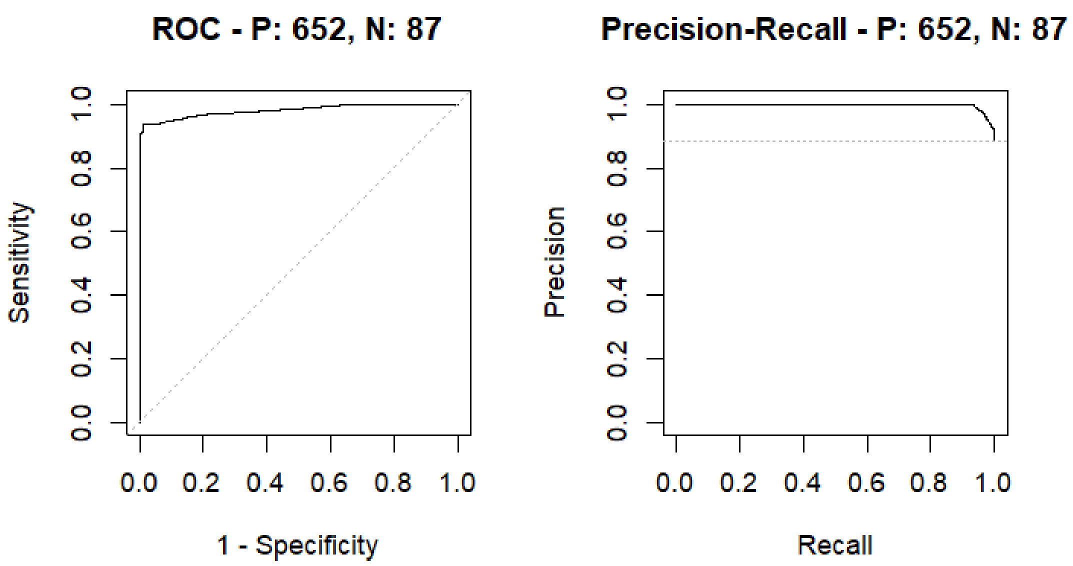
Table II. Logit Binomial Regression Results for Model I (with buyer country and type of procedure controls omitted here for brevity – see Table IIa in the Appendix for full results).

	Dependent variable:
	singleb
notDCI	-1.711**
	(0.823)
Observations	739
Log Likelihood	-72.504
Akaike Inf. Crit.	207.008
Note:	*p<0.1; **p<0.05; ***p<0.01

The results are challenging in that they contest the automatic assumption that companies in the spotlight of a large anti-corruption study are less likely to engage in one of the most notoriously corruption-prone practice – single bidding. The table demonstrates the opposite, i.e., that the companies not listed in the DCI have 82% *less odds* of engaging in single bidding. With a 95% confidence, we can say that based on the model the odds for them are 6% to 97% less than for the listed companies. We also estimate the average marginal effects (AME) of the models, which is -0.14 for the independent variable in Model I.

In this model, we control for the buyer country and the tender procedure type. The former variable encapsulates the expected differences in national legislation, corruption levels, common practices, etc. The latter absorbs the obvious effect of various tender procedures in affecting the number of bids submitted, based on an EU study's inferences (Fazekas 2019). We prefer to avoid excessively strong assumptions, and so treat the procedure variable as nominal but not ordinal, with open tenders serving as the baseline category in the models.

Graph I. Quality Control for Model I.



The issue with Model I (Table II) is that it is overfitted, even though there are only three independent variables present for 739 observations. We attribute this problem to the small share of cases where DCI listing is present – it is only 2% of the random sample.

Additionally, single bids are just 12% of the sample. The evidence for the problem is in the receiver operating characteristics (ROC) and Precision-Recall plots which demonstrate an almost perfect fit (see Graph I). According to our post-model evaluation, the area under the ROC curve (AUC) is 0.98, and the adjusted McFadden pseudo-R-squared is at the high figure of 0.7. This clearly does not signal the model's healthiness, and therefore we implement a number of measures to mitigate the issue.

After receiving the results for the regular logit regression, we perform ridge regularization on the coefficient (Table III). The ridge regularization penalizes coefficients for their magnitude, and reduces the complexity of the model (Kassambara 2018, 116-121). We perform it in order to remedy overfitting and, given that we do not have a lot of variance in the predictor variable, to improve on our findings in terms of DCI listing.

Table III. Ridge Regularization on Model I.

	Dependent variable:
	singleb
(Intercept)	-1.648
valuesisNA	-2.317
buyer_country	0.130
procedure	0.908

The revamped model has the same sign and a numerically comparable coefficient, although we cannot report standard deviations as ridge and lasso models do not have them. Regularizing is one way to fix the problems with the balance within the samples, and the updated model generally corroborates our findings that DCI companies are more likely to submit a single bid.

3.5.2. Matching

A more robust way to counteract the sample imbalance is to match observations on predictors, with DCI listing as the treatment. In order to find closer matches, we use the whole dataset from which in the previous subsection we took only a sample of ten per cent.

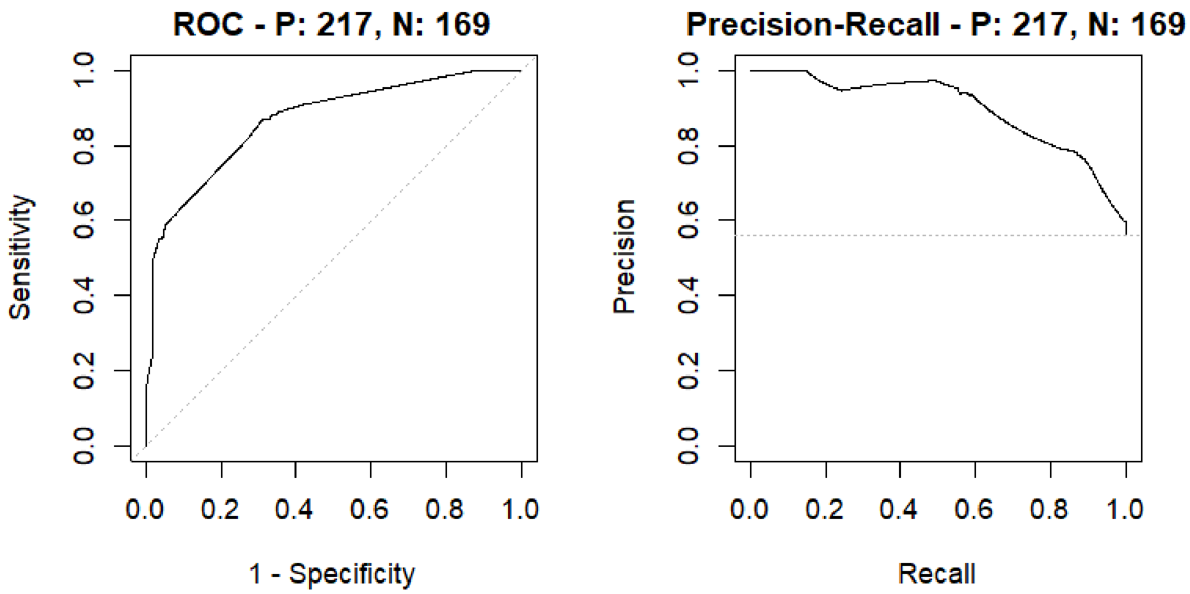
We perform exact matching on the same two control variables – the buyer country and the tendering procedure. This course of action ensures that we compare "apples to apples" – similar cases to similar cases. At the same time, we have to carefully choose among many relevant control variables, as using too many for the comparison limits the number of matched pairs we have in the final sample and therefore decreases the statistical power of the model.

Table IV. Logit Binomial Regression Results for Model II on Matched Data I (only the coefficient of DCI listing is reported, see Table IVa in the Appendix for full results with controls).

	Dependent variable:
	singleb
notDCI	-1.573^{***}
	(0.277)
Observations	386
Log Likelihood	-169.278
Akaike Inf. Crit.	388.555
Note:	*p < 0.1 **p < 0.05 ***p<0.01

Given that there is overall sufficient data, but one class is insufficiently present in order for us to straightforwardly employ generalized linear models, matching is a solid choice for providing concrete inferences. The matched data has 368 observations, or 184 pairs of DCI and non-DCI bids. On the matched sample with the same covariates, we find that the coefficient has the same size and comparable magnitude, and its standard deviation has significantly gone down compared to the first two models. The results suggest that the odds for a non-DCI bid to be a single bid are 80% less, with $p < .01$. The AME of the independent variable in Model II is -0.23. The model has its pseudo-R-squared at the level of 0.36, and its ROC and Precision-Recall graphs are more reasonable (see Graph II), although the AUC is nonetheless high at 0.87. We believe this model is more powerful compared to the previous two, more naïve, models, especially in the light of a more directed approach to sampling and healthier post-model evaluative indicators.

Graph II. Quality Control for Model II.



In order to explore alternative explanations and corroborate the findings, we use a different set of control variables that can also meaningfully cover some part of the yet-unobserved factors incurring or inhibiting single bidding. A more comprehensive model would have included all the relevant control variables, but in order to find a sufficient number of matches we are forced to keep the number of covariates within reasonable limits.

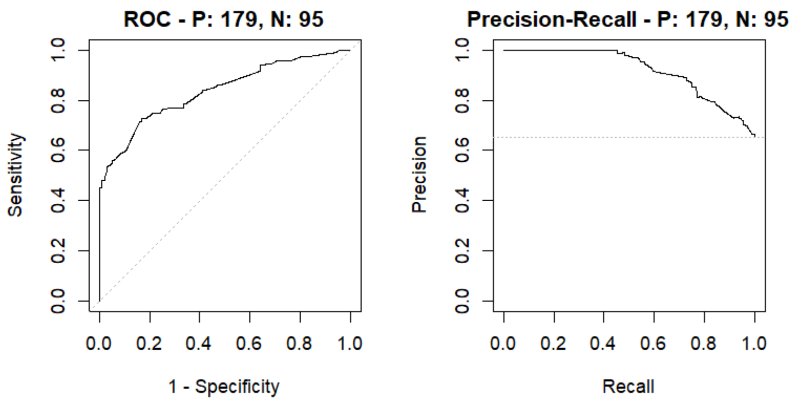
This alternative matched model focuses on suppliers rather than on buyers by matching and including in the regression two supplier-related variables: the decimal exponent of the bid price, and the CPV code of the tendered goods. The price level of bid helps with differentiating among smaller tenders that might have low corruption attractiveness and larger, more lucrative opportunities. The CPV coding is taken in the form of the first four digits in order to approximate the group of tendered goods without constraining the matching too excessively or, conversely, piling up categories that are essentially not close. These two control variables ensure that we look for the effect of the presence in the DCI dataset on single bidding within the pairs that include close types of goods tendered at close prices. We keep the procedure covariate as it is a strong predictor that does not constrain the matching too excessively and at the same time directly affects the number of bids and therefore muddles the causal effect of DCI listing when left unattended. The design allows for 278 observations, or 139 matched pairs. The results for the predictor of primary interest are shown in Table V, and Table Va in the Appendix covers all the categories within all control variables.

The alternative model for matched data, Model III, shows the coefficient of the *notDCI* variable resembling that of Model I and Model II. We again find evidence for the fact that the presence on the DCI list is positively associated with single bidding. The AME of the predictor is at -0.15, which is also consistent with our previous results of -0.14 and -0.23. The evaluation of the model shows a modest pseudo-R-squared of 0.29, and an AUC of 0.84 (please see Graph III).

Table V. Logit Binomial Regression Results for Model III on Matched Data II (only the coefficient of DCI listing is reported, see Table Va in the Appendix for full results with controls).

	Dependent variable:
	singleb
notDCI	-1.184^{***}
	(0.313)
Observations	278
Log Likelihood	-125.238
Akaike Inf. Crit.	294.475
Note:	*p **p ***p<0.01

Graph III. Quality Control for Model III.



3.5.3. Conclusion

All four of the models (Model I, ridge Model I, Model II, and Model III) we constructed suggest that DCI listing is associated with higher likelihood of single bidding. Non-DCI companies have 69% to 82% less odds to submit a single bid, depending on the model and without taking into account the associated standard deviations. This is reinforced by the AMEs of the models' independent variable estimated at -0.14, -0.23, and -0.15. The result has sufficient statistical power as demonstrated by the respective *p*-values, and we corroborate it by using different controls – buyer country, and procedure type, as well as the CPV code, and the tender price band. We also use matched data to compensate for deficiencies in the sampling, where bids from the primary (that is, excluding subsidiaries) DCI companies contribute to around 2% of the whole dataset. The next section discusses the discovered evidence for the influence of DCI listing on single bidding.

3.6. Discussion of the Results

3.6.1. Methodological Assumptions

We have found that the companies not listed within the Defence Companies Index have 69% to 82% *less* odds to engage in single bidding. This finding is supported by consistent statistical significance. By itself, the statistical significance does not mean a lot, therefore in this section we discuss the suspected causal mechanisms of how the companies from the Transparency International's anti-corruption study actually participate in the potentially corrupt single bidding more often than others.

To claim that the results of the models are truthful, we first need to demonstrate that the study has met the criteria of rigorous scientific methodology. A fuller discussion of this is to be found in the previous section where we cover in detail how we collected and refined the data and why we made the specific decisions that lead to finding the results at hand. In this part, we find it crucial to reiterate that we put in place the controls that would isolate the predictor from confounding effects and distill the previously unobserved variance. The control variables – the buyer country, tender procedure type, bid price, and product category – influence the potential range of bids in the ways which we covered above. If we assume that accounting for these variables clears out the noise in the data, we are one step closer to declaring that the coefficient we get on the predictor is truthful.

We also modelled on both unmatched and matched data. Matching the data exactly allowed us to compare the cases which are similar in all the highly relevant regards but one – the presence within the DCI study. Again, if we assume that matching was done in the way that isolates the effect of the predictor, we come closer to establishing the grounds for a mathematical connection between the predictor and the outcome variable.

3.6.2. The Causality and Explanations of the Discovered Effect

The main part of a causal mechanism is that it should make sense in terms of theory rather than just correlation. What this study has found is in a sense ambiguous: the companies present in an anti-corruption study from a renowned international organization are in fact more likely to commit the act of single bidding, which is a serious red flag of corruption. While we have found (given that the methodological assumptions were satisfied) the mathematical relationship between the two variables, the explanation for this is relationship is what matters. To support our explanation, we first need to refute or at least reiterate a number of alternative explanations. In this manner, we would establish why single bid is a sufficient indicator of corruption, what causes and effects the DCI listing has, and how these causes affect single bidding.

The companies that were included in TI's study are the largest defense contractors in the world. Because of this, single bidding may be an essential outcome – larger companies are likely to hold proprietary technological knowledge and/or have sufficient capacities to fulfill the largest of contracts, and therefore be the only contractor suitable for specific tenders. We concede that this may hold true for certain market segments of high technological complexity such as aircraft or electronic systems, and thus there is a possibility that some single bids occur naturally. Because of that, we might be overestimating how closely single bidding approximates corruption.

Our counterargument is, however, that – by a huge margin – the traded products are not extremely complex, rare, or monopolized; the bulk of the goods tendered is actually the opposite. These are rather mundane, similar across companies, and homogeneous products – like small arms, equipment, maintenance works, and so on. Therefore, the risks of using single bidding as a proxy are not exorbitant. A fuller discussion on this and other, less pressing, concerns about looking into single bidding can be found in the literature review.

Crucially, the results are not caused by any imbalance in the smaller sample, or the matched data – according to our plots, there is no significant overrepresentation of the DCI companies in the larger contract price levels. There is no significant correlation between the presence in the DCI and the price within the matched data, and in one of the models we additionally control for the price level to exclude the confounder effect, as one could suspect that the price level is a confounder in that it limits the number of possible bids and allows only for the largest (DCI) companies to participate.

The presence on the DCI list is also a complicated issue. We were unable to follow the initial research design and use the exact transparency and anti-corruption scores due to the data deficiencies. Instead, we worked with the binary "present/absent" variable. A company is present on the DCI list if it is large and has been selected by the researchers. We find close correspondence between the DCI and top rankings of military companies (see, e.g., Defense News 2022), therefore there are no grounds to suspect that the TI researchers had any selection criteria significantly different from the company size. What this means is that the presence on the DCI is a symbol that a company is big and visible.

Table VI. The Relationship Between DCI Listing and Bid Price, Data Matched on Price Level (linear regression on matched data, matching includes price level; NA prices not included in the model and coded as a separate category of the price level for matching).

	Dependent variable:
	bid_price_EUR
DCI	-2,554,669.000
	(13,423,090.000)
Constant	14,694,439.000
	(9,491,558.000)
Observations	128
Log Likelihood	-2,504.222
Akaike Inf. Crit.	5,012.443
Note:	*p<0.1**p<0.05***p<0.01

Table VII. The Relationship Between DCI Listing and Bid Price, Data NOT Matched on Price Level (linear regression; NA prices not included in the model and coded as a separate category of the price level for matching).

	Dependent variable:
	bid_price_EUR
DCI	24,174,617.000*
	(14,181,544.000)
Constant	7,935,682.000
	(9,058,002.000)
Observations	201
Log Likelihood	-3,985.355
Akaike Inf. Crit.	7,974.709
Note:	*p<0.1**p<0.05***p<0.01

If we believe that the assumptions we have made are truthful, the final relationship is then not just between the DCI companies and single bidding, but between the size of the company and corruption risk, which according to our results are positively related. The focus on the DCI is a deliberate choice – while we could have regressed just on company size, basing the research on a specific anti-corruption study adds an analytical edge, as the said study looks into the corruption and transparency policies of specific companies, and these companies are actually more likely to submit single bids than the average. We know now that whatever the claims about transparency and anti-corruption are made, on average they matter less for the one hundred of the largest companies when compared to everyone else in the defense market.

3.6.3. Limitations of the Study

The main limitation was the data accessibility. Although the featured datasets offer many observations for analysis, there are two-digit missing inputs for some of the crucial variables. Because of that, we had to take the conservative way and focus on single bidding only, which is a powerful yet not exhaustive indicator.

The DCI studies presented a challenge in that they were conducted three times – in 2012, 2015, and 2020. The periods are evidently not equal, and we suspect that this might omit the yearly variance. Each of the iterations had methodology modifications, therefore the data is less comparable. The observations from the DCI companies composed only 2-4% of the sample based on the methods used, which forced us to use matching to get plausible results.

Both the predictor and the outcome are dependent on strong assumptions. We use single bidding as a proxy of corruption (risk) which is an idea supported by a body of literature. The DCI listing is a reflection of a company's size and renown. We focus on the DCI rather than just the size in order to be able to make claims about the specific sample of companies within that study, and by extension about the study itself.

CHAPTER 4 – CONCLUSION

Defense is a crucial part of any state's responsibilities, and therefore corruption within the defense industry and public procurement is detrimental to a state's ability, sovereignty, and image. We do not view corrupt practices as something inevitable, notwithstanding necessary, and attempt to research the reasons behind them. Our focus is on company behavior rather than on behavior of public officials – that is, we are interested in the demand-side of corruption more that in the supply-side. Uncovering the reasons behind why companies lean towards corruption-prone practices might help researchers, policymakers, and law enforcement to address the roots of the problem more efficiently, which might bring crucial positive effects for national security of countries.

We performed binomial logit regressions on the EU tender data for 2012-2022, using the listing in the Transparency International's Defence Companies Index as the predictor of single bidding. All four models we employed found a highly statistically significant positive relationship between the listing and single bidding – non-DCI companies in our data had, according to various estimation techniques, 69% to 82% less odds to participate in single bidding compared to the companies listed by the DCI in the period of the study corresponding to the tender year. While the study had a number of limitations – most of all data accessibility, sample imbalances, and quite strong assumptions – we have done our best to mitigate this by using meaningful controls and matching. We controlled for the effects of the variables that may themselves influence the outcome –price, buyer country, procedure type, and product category – and did matching specifically in order to refute alternative explanations based on the results we have with the isolated relationship between the predictor and the outcome on highly comparable cases. Therefore, we believe our consistent estimates to be valid and telling at least a part of the story.

Additionally, we addressed the alternative theories regarding the causality of the relationship. It is our view that, due to the nature of the industry, larger companies are indeed more corrupt, and therefore more likely to submit single bids. There is clearly no evidence for the DCI listing's effect on single bidding *per se*; rather, the study includes most of the largest defense contractors in the world, which in turn do submit single bids more often. Such big companies are more likely to be approached by corrupt officials, and tend to commit more potentially illicit acts compared to their smaller counterparts, which explains why single bidding, a significant red flag of corruption, occurs with large companies more frequently.

We used the DCI sample for our purposes in order to have an additional angle on the transparency questions. It is perhaps ironic that the companies under the scope of an anti-corruption study are in fact more corrupt than the average. We were unable to establish any causal relationship between single bidding and the listing itself, but there is a different important implication: the authors of the DCI, if they would agree with the claims we have made throughout this paper, might consider modifying their methodological and negotiation strategies in light of what was found. Perhaps if we treat the large defense contractors differently from the rest, we might uncover some new insights into how they operate – both in terms of legal and illicit practices.

There is yet another implication: if we only target the large companies, we forego the smaller ones – the suppliers of smaller-scale volumes, maintenance works, mechanical components, non-essential services, flags and heraldry, and so on. While the focus on grand corruption and big firms is understandable, research should cover this more modest part of the industry as well, especially in light of our claim that this part is less corrupt – and therefore there might be valuable practices to unearth.

In terms of methodology, the field would benefit from more data accessibility. An objective composite indicator of corruption, built on this more accessible data, could serve as a consensual benchmark for firm-level and market-level integrity. This would improve comparability within the field and shift the established methodology towards more unified practices. From a non-academic point of view, more data availability and cleaner data collection methods are as important – they improve transparency, which is first and foremost practical as it influences how companies behave.

APPENDIX

Table IIa. Full Binomial Logit Regression for Model I with the Controls Reported (see Table II for the same output without controls; controls: buyer country and procedure type; baseline procedure = open tender).

	Dependent variable:
	singleb
notDCI	-1.711**
	(0.823)
buyer_countryBE	20.873
	(20,670.470)
buyer_countryBG	20.957
	(20,670.470)
buyer_countryCZ	1.659
	(35,802.290)
buyer_countryDE	20.247
	(20,670.470)
buyer_countryDK	44.791
	(35,802.290)
buyer_countryEE	23.654
	(20,670.470)
buyer_countryES	21.196
	(20,670.470)
buyer_countryFI	-0.052
	(35,802.290)
buyer_countryFR	21.519
	(20,670.470)
buyer_countryHU	42.364
	(25,416.060)
buyer_countryIT	19.915
	(20,670.470)
buyer_countryLT	0.00001
	(35,802.290)
buyer_countryLV	21.882
	(20,670.470)

buyer_countryMISSING	21.346
	(20,670.470)
buyer_countryNL	43.132
	(35,802.290)
buyer_countryNO	43.132
	(35,802.290)
buyer_countryPL	22.274
	(20,670.470)
buyer_countryPolska	45.648
	(25,316.050)
buyer_countryPT	21.584
	(20,670.470)
buyer_countryRO	38.654
	(22,142.340)
buyer_countryRomania	21.405
	(20,846.920)
buyer_countrySE	21.502
	(20,670.470)
buyer_countrySlovenija	45.648
	(35,802.290)
buyer_countryUK	20.704
	(20,670.470)
procedureNEGOTIATED_WITH_PUBLICATION	2.643^{*}
	(1.438)
procedureNEGOTIATED_WITHOUT_PUBLICATION	5.486^{***}
	(1.600)
procedureOPEN	2.516^{*}
	(1.366)
procedureOUTRIGHT_AWARD	24.243
	(2,309.450)
procedureRESTRICTED	0.857
	(1.519)
Constant	-22.371
	(20,670.470)
Observations	739
Log Likelihood	-72.504
Akaike Inf. Crit.	207.008
Note:	*p**p***p<0.01

Graph IV. Charts for Model I's Ridge Regression.

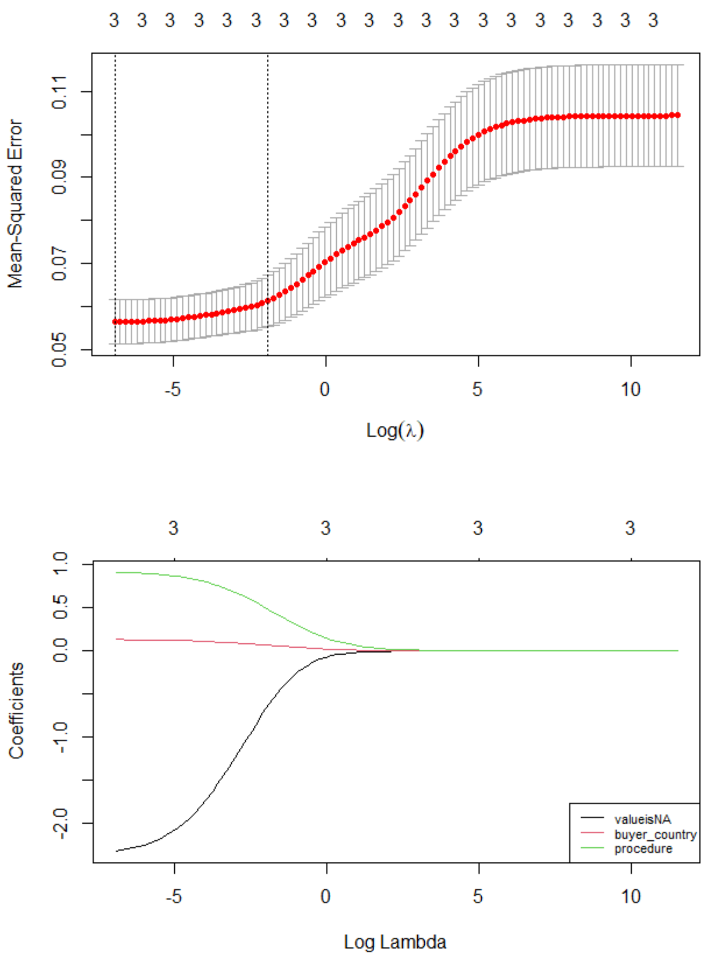


Table IVa. Full Binomial Logit Regression for Model II on Matched Data I with the Controls Reported (control variables: buyer country and procedure type; see Table IV for the same output without controls; baseline procedure = open tender).

	Dependent variable:
	singleb
notDCI	-1.573***
	(0.277)
buyer_countryAT	16.523
	(2,637.295)

buyer_countryBE	15.702
	(2,637.296)
buyer_countryCZ	18.383
	(2,637.296)
buyer_countryDE	17.089
	(2,637.295)
buyer_countryDK	31.497
	(3,729.699)
buyer_countryEE	-1.786
	(3,113.751)
buyer_countryES	18.549
	(2,637.295)
buyer_countryFI	35.007
	(3,038.946)
buyer_countryFR	16.139
	(2,637.295)
buyer_countryIE	0.653
	(3,729.699)
buyer_countryIT	18.317
	(2,637.295)
buyer_countryLV	18.179
	(2,637.295)
buyer_countryNL	13.767
	(2,637.296)
buyer_countryPL	18.383
	(2,637.296)
buyer_countryPT	31.497
	(3,045.286)
buyer_countrySE	16.585
	(2,637.295)
buyer_countrySI	31.497
	(3,230.014)
buyer_countryUK	16.972
	(2,637.295)
procedureRESTRICTED	-0.653
	(1.023)
procedureNEGOTIATED_WITH_PUBLICATION	0.093
	(0.554)

procedureNEGOTIATED_WITHOUT_PUBLICATION	3.962***
	(0.782)
procedureOUTRIGHT_AWARD	35.460
	(3,729.698)
procedureMISSING	2.642**
	(1.272)
Constant	-16.944
	(2,637.295)
Observations	386
Log Likelihood	-169.278
Akaike Inf. Crit.	388.555
Note:	*p < 0.1 **p < 0.05 ***p <0.01

Table Va. Full Logit Binomial Regression for Model III on Matched Data II, Alternative Controls (bidder country, CPV code, and procedure type).

	Dependent variable:
	singleb
notDCI	-1.184***
	(0.313)
price_cut2	-0.010
	(1.592)
price_cut3	-0.373
	(1.004)
price_cut4	0.334
	(0.445)
price_cut5	0.659
	(0.520)
price_cut6	14.449
	(1,205.572)
price_cut7	14.510
	(2,698.968)
CPV3534	15.215
	(2,698.968)
CPV3540	-0.068

	(0.527)
CPV3542	0.334
	(1.021)
CPV3581	18.000
	(2,698.968)
CPV5021	0.332
	(0.903)
CPV5063	0.791*
	(0.465)
CPV5064	2.002*
	(1.081)
CPV5065	0.665
	(0.793)
CPV8060	14.842
	(2,698.968)
procedureRESTRICTED	-1.361
	(0.855)
procedureNEGOTIATED_WITH_PUBLICATION	-0.600
	(0.700)
procedureNEGOTIATED_WITHOUT_PUBLICATION	2.809***
	(0.906)
procedureOUTRIGHT_AWARD	2.809
	(3,816.917)
procedureMISSING	0.025
	(1.223)
Constant	0.602
	(0.616)
Observations	278
Log Likelihood	-125.238
Akaike Inf. Crit.	294.475
Note:	*p<0.1**p<0.05 ***p<0.01

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