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An Empirical Study of Competition and Bidding Behaviors of Small and Large Firms in Public Procurement

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Abstract: The number of firms participating in public procurement in Sweden has declined since 2012, worrying policymakers since competition is seen as a driver of value-for-money. However, previous research suggests that efforts to increase participation in procurement do not necessarily result in a desirable, competitive effect, due to the auction format of the practice. Using a novel dataset of manually collected observations of bid prices placed in procurements, this thesis empirically studies the effects of increased competition on public procurement in the Swedish setting. Efforts currently in place aimed at increasing participation predominantly target smaller companies, therefore, the bidding behavior of these firms in comparison to their larger counterparts is investigated. We find that more competition results in relatively lower bid prices, moreover, that the participation of smaller firms contributes to a larger reduction in prices. This could in part be due to their more erratic bidding behavior in general, however, there are fragments of evidence suggesting small firms practice more aggressive bidding than large firms on average.

Keywords: Public procurement, Procurement, Competition, Bid price, Auction

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1 Introduction

The value of public procurement in a given EU member state amounts to, on average, one-fifth of the country's GDP. In Sweden, the exact figure is 706 billion SEK (The National Agency for Public Procurement, 2019), making it a substantial expense to the country's economy. Procurement of goods and services from the private sector allows the public sector to harness the competitive forces of private markets and achieve cost efficiency, which is of substantial importance since procurements are financed entirely using taxpayer funds. Procured goods and services are meant to benefit citizens and society at large, making procurement an eternally sensitive affair. To ensure it is practiced carefully, public contracts are auctioned to suppliers in a highly regulated manner.

Competition is a known catalyst for lowering prices while at the same time increasing the quality of goods and services on a market, making its presence desirable for achieving effective use of taxpayer funds. Additionally, the existence of a competitive effect has been acknowledged in auction theoretic studies of specifically procurements (See Schmidt, M. 2015 for example). The Swedish procurement market is currently experiencing a decrease in the number of bidders per contract, a sign that the level of competition is low. Policymakers are concerned by this development, much of which can be credited to the high transaction costs of entry (See, for example, European Commission, 2008). Firms aiming to compete for public contracts are required to produce tender offer documents, a process that can be cumbersome, costly, and often require some expertise. Smaller firms tend to find the costs of entry burdensome in proportion to their size, granting them a disproportionately small mandate on the market. Ongoing efforts aimed at increasing competition on the Swedish public procurement market therefore predominantly target this group (Tukiainen & Halonen, 2020).

Meanwhile, a body of research in auction theory suggests that increasing competition in public procurement will not result in aggressive bidding or prompt a competitive effect, rather, the opposite, due to the nature of the procurement practice. Hong and Shum (2001) find that information asymmetries between bidders, measured in a common-values component, induce conservative bidding or a so-called 'common-values effect', and Pinkse and Tan (2004) propose the existence of a similar effect in affiliated values auctions. Furthermore, Li and Zheng (2007) stipulate that an overestimation of entry intensity among bidders decreases their will to participate in the first place, suggesting that efforts to include more bidders might be counterproductive.

In the ongoing analysis of the competitive landscape of procurements by the Swedish Competition Authority (2020a, 2020b), the bidding behavior of firms has not been investigated in-depth to determine whether the competitive effect in fact is prevalent as competition increases. This mostly due to the lack of aggregated data available, a problem that has been identified by the Swedish Procurement Authority, however, not fully addressed. In this study, data has been manually collected from over 200 procurement auctions to fill the gap of empirical research on bid prices and firms' bidding behaviors in Sweden. The dataset is especially unique in the sense that it has documented all bid prices placed in a given procurement auction, not solely the winning or projected bid price, enabling more thorough analysis of bid prices across auctions.

Our study aims to investigate the bidding behavior of firms in procurement auctions as the number of bidders, or the competition, increases. The purpose is to understand whether the

competitive effect prevails or if it is dwarfed by the other effects specified in auction theory. It is also of our interest to specifically study the bidding behavior of small firms in public procurement. We want to understand whether their behavior significantly differs from the pool of bidders and discuss possible reasons why.

Research Questions:

(1) Does an increase in competition result in a competitive effect in public procurement?

(2) Does the bidding behavior exhibited by small firms differ from the bidding behavior of large firms?

The chosen research questions have, to our knowledge, not previously been investigated within Swedish public procurement. This is most likely due to the lack of accessible data concerning bid prices placed in individual procurements, which is what makes our manually acquired dataset unique. Since our data enables comparability between different procurements, we are also able to make more general trend observations. We have additionally chosen to specifically investigate the difference in bidding behaviors of small and large firms. There is a lot of research on the positive externalities of including small firms in public procurement, for example, their contribution to technical innovation, social integration, and employment (Edler et. al., 2014), however, few have probed whether they also contribute positively to the practice itself, by inducing more competitive price setting. Since several of the directives in place regulating the market specifically address the entry barriers facing small firms, the outcome of this study could be of importance in determining the resources that need be devoted to helping these firms (European Commission, 2008).

2 Background

2.1 Competition in Swedish Public Procurement

The legal framework regulating public procurement has been subject to numerous modifications since the Swedish Competition Authority overtook the responsibility of overseeing the market and its practices in 2009, all in theory contributing to improving the competitive landscape. Measures thus far have targeted transparency, governance problems and anti-trust practices (Spagnolo, 2009). The key issue facing Swedish public procurement today is the large decline in participation; the average number of bidders per procurement contract has decreased since the year 2012, from 4.8 to 4.3 in 2018. The median number of bidders competing for a contract today is 2 (The National Agency for Public Procurement, 2019).

The Swedish Competition Authority published a report in 2020 analyzing the competitive landscape in Sweden and suggesting courses of action in light of the trending decrease, as well as the high number of objections made by suppliers in finalized procurements. Both of these factors contribute to an inadequate competitive environment; the will to avoid objections may cause procuring agencies to limit the number and selection of competitors invited to the procurement to avoid costs associated with a retrial. The report mentions that one underlying reason for scarce competition is the common conception among smaller firms that participating in public procurement is too burdensome, resulting in their avoidance of submitting bids (Tukiainen & Halonen, 2020).

The report gives a comprehensive overview of firms' sentiments towards the procurement practice. For instance, it unveils the results from a survey conducted by Visma AB, where 92% of respondents agreed there are challenges embedded in the public procurement system that hinder them from placing a bid. Many of these challenges were deemed to be related to substantial procedural requirements, as well as procurers' extensive focus on price (Tukiainen & Halonen, 2020). In another survey analyzing the price-setting strategy among suppliers, 55% admit they place bids where the expected profit is very low or non-existent at times to win, and 16% of suppliers admit they use this strategy often. This penetrative price setting is motivated by suppliers' will to acquire experience of delivering goods and/or services to the public sector to better understand what is expected of them (Himmelstrand et. al., 2020).

The actors in the public procurement market are disproportionately represented by large firms. Albeit constituting 99.9% of all companies in Sweden (Statistics Sweden, 2020), small-to-medium sized companies generate only 71% of bids in public procurement. Large companies are significantly more active as bidders, on average producing 24.2 tender offers each, while the corresponding figure for micro, small and medium-sized enterprises is 1.9, 3.3, and 6.9 respectively[1] (The National Agency for Public Procurement, 2019). The high activity of large firms can be explained by their ability to channel economies of scale to reduce the size of transaction costs related to producing tender offers (see, for example, Strömbäck, 2015 and Schmidt, 2015).

[1] See Appendix A for a detailed table of market share by company size.

3 Literature Review

This section is dedicated to presenting the body of literature upon which our empirical study has been founded.

3.1 Auction Theory

The majority of public sector contracts are awarded through procurement auctions. These auctions vary in format, the most common kind being the reverse, sealed-bid auction. In these auctions, the roles of seller and buyer are reversed; suppliers thus compete in to win the right to provide a good or service to the public sector. The bids placed by firms represent the price they are willing to charge for providing the service or supplying the goods specified in the contract. The bidding is not dynamic, meaning that all bids are placed simultaneously and that the suppliers have no knowledge of what price their competitors will set. These factors fundamentally set the public procurement market apart from other markets, and auction theory has served as a useful tool for understanding the forces at play (Klemperer, 1999).

The selected body of auction theory in this literature review is primarily applicable to the contracts awarded in Sweden using open, simplified, and at times, direct procedures that adopt the reverse, sealed-bid format.[2] Therefore, this thesis limits itself to investigating these procurement procedures, practiced in approximately 94% of Swedish procurements (The National Agency for Public Procurement, 2019).

3.1.1 The Competitive Effect

The market for public procurement is more similar to financial markets, or more accurately, Walrasian financial markets, than to regular commodity markets. Suppliers compete to win a contract with the public sector by trying to undercut each other's bids; all bids are then grouped and evaluated by the procurer at the same time. The Walrasian analogy of auctions stipulates that a higher number of bidders should result in more aggressive bidding, forcing the prices down towards a new competitive equilibrium. Schmidt's (2015) game-theoretic model of bid price determination in procurement supports the Walrasian concept of a competitive effect, by demonstrating how an increasing number of bidders is negatively correlated with bid prices. The expected profit of a firm i is expressed as: $\Pi_e = (B_i - C_i) * p(B_i < B_2 \wedge \dots \wedge B_i < B_n)$, where B_i denotes the bid price and C_i the individual cost for the supplier. Schmidt's model abstracts from the notion that procurements can be evaluated on criteria other than the bid price. Therefore, as the number of bids, n, increases, the probability p of winning decreases. Thus, firms aiming to maximize their expected profit will maximize the following bid price: $B_i^* = \frac{\beta + C_i(n-1)}{n}$. This fraction will decline when the number, n, of competing bids increases, resulting in aggressive bidding behavior from suppliers.

Underdeveloped in Schmidt's model rendering the competitive effect is the notion that suppliers are unaware of the exact number of firms they are competing against, or whether this number is increasing. Supposedly, suppliers have an intuition of the number of potential participants, perhaps based on previous data or their experience of procurements, however,

[2] See Appendix D for detailed information about procurement procedures practiced in Sweden.

there is still a component of uncertainty. This potentially allows for other effects to dominate the competitive effect, contradicting the common knowledge that more competition is better (Hong & Shum, 2001, Pinkse & Tan, 2004, Li & Zheng, 2007 and Fugger et. al., 2014). These effects will be discussed in the following sections.

3.1.2 Effects That Thwart the Competitive Effect

There are studies of public procurement within the realms of auction theory that challenge the presumption that increasing competition would result in more competitive price setting, for example, in the *common-values effect* presented by Hong and Shum (2001), the *affiliation effect* proposed by Pinkse and Tan (2004), and the *entry effect* presented by Li and Zheng (2007). These theories take into consideration the characteristics of public procurement auctions to a higher degree.

The *common-value effect* investigates the information asymmetries that exist between suppliers in public procurement and impact their cost estimation, and thus bid price determination. In an auction where a bidder is independently, accurately able to estimate the costs related to a contract, taking their own capabilities into account, they can estimate what the lowest bid they are willing to place is. The ability to estimate one's private costs has been termed the private-value paradigm in auctions. In public procurement, pure private-value signals are common in auctions of a more uniform nature, where the suppliers have more or less perfect information about their private cost of completing the contract. The existence of solely a private-value component in auctions should generate aggressive bidding and drive down the average bid price. Competitors benefit from being aggressive in this scenario since they increase their probability of winning when they place a low bid (Hong & Shum, 2001 and Pinkse & Tan, 2004).

The common-value signal is, contrarily, uniform across all suppliers. It embodies the inability to fully evaluate costs related to the contract. This inability is considered a product of information asymmetries between suppliers, caused by ambiguity or uncertainty in the information communicated by the procuring entity, or the exogenous uncertainty of the costs related to the contract. Hong and Shum (2001) assume that a contractor's costs can be broken down into two components: $c_i = a_i * v$. The supplier i's private cost of completing a contract, based on their individual ability and efficiency, is captured by the term a_i. Consequently, v captures the unknown cost component associated with the contract.

Common-value auctions also gravitate towards aggressive bidding, a result of naïve cost estimations by suppliers. However, understanding that this naïve bidding behavior potentially may result in negative or very low profits will induce a rational bidder to place a less aggressive bid in equilibrium. Whether the costs exceed the profit is not known until the actual contract commences, therefore, a rational bidder will internalize this information and avoid underestimating their costs. Two forces are at play here as competition increases; the competitive effect which reduces the price of the bid, and the *common-values effect* that induces a rational bidder to place conservative bids. In auctions with a common-values component, the competitive effect has been coined the winner's curse; despite winning the auction if placing a low, competitive bid, the supplier may end up in a position where their profit is very low or where they do not make any profit at all.

If the *common-values effect* exceeds that of the competitive effect and the winner's curse, prices may increase as the competition does. Hence, asymmetric information, measured by the

common-values component, can invalidate the assumption that more competition is better in public procurement. Hong and Shum (2001) investigate the impact of an increase in competition on the aggressiveness of bidding, as well as the level of the winning bid, in public procurement contracts at the New Jersey Department of Transportation. They find that the result varies between different contract types, where private and common-value components are of different importance. The common-values component is here measured as the standard deviation between the competing firms' expected costs. For example, heterogeneous highway work and bridge construction/maintenance contracts exhibit both a private- and common-value component, while the homogenous, relatively uniform road paving contracts are dominated by the private-value component. The former two industries present a *common-values effect* that thwarts the competitive effect as competition increases.

While the *common-values effect* and winner's curse only occur in common-value models, there are other effects which may cause prices to increase as competition does, unrelated to information asymmetries. The *affiliation effect*, for example, prompts the winning bidder to believe that the intensity of competition is less than previously expected, leading them to set a price higher than the value of the contract (Pinkse & Tan, 2004). This is somewhat related to what Schmidt (2015) presents in his model, namely that a low level of competition will induce the bidder to make a calculated choice and place a high bid, expecting the other bidders to make the same decision. The bidders' coordinated thinking will increase the expected profit for both. In the common-values model, this overestimation of the contract value instead occurs due to uncertainty regarding costs and to hedge oneself from potentially incurring a profit loss from aggressive bidding.

In addition to the *affiliation effect,* Li and Zheng (2007) find that the overestimation of entry intensity induces bidders to refrain from participating; this is called the *entry effect*. As the number of potential bidders increases, the bidders' equilibrium probability of winning and the equilibrium price decrease, holding everything else constant. It does then not make sense for the bidders to pay the entry costs of participating, opposing the conception that inviting more bidders to the auction would have a positive effect on the efficacy of procurement.

Our investigation of the competitive effect is founded upon the aforementioned body of research of paradoxical nature. We aim to see which of the theories reflects the Swedish competitive environment best. In examining if prices become more competitive, we will look at two industries that differ in contract homogeneity, namely the consulting and cleaning industry. The cleaning industry is more heterogeneous in contract format, thus presumably resulting in larger information asymmetries between the bidders. This will be measured using standard deviations between bid prices placed in auctions. To investigate whether larger information asymmetries lead to increasing bid prices, a so-called *common-values effect*, or if they induce more competitive pricing and prompt a winner's curse, we will compare the results from the cleaning industry with the consulting industry. This way, we benefit from a more comprehensive understanding of the competitive effect in procurements.

3.2 Economies of Scale

Being able to channel economies of scale as a supplier in public procurement is important for many reasons. The extensive legal requirements for producing a tender offer result in transaction costs for each supplier in public procurement. Schmidt (2015) interprets these transaction costs as a direct entry barrier to the procurement market, stipulating that the condition of entry for a firm is their expected profit less their transaction costs. Since transaction

costs differ between suppliers, those with relatively smaller transaction costs will participate to a higher degree, and the remaining suppliers will likely refrain from participating. This is one aspect of external economies of scale that typically benefits suppliers of a larger size.

Spagnolo (2009) discusses how economies of scale in public procurement allow companies pursuing larger contracts to exploit complementaries when setting their prices, allowing them to place the lowest bid. Using internal economies of scale, larger firms can thus increase their probability of winning a contract. This fact persists even in Swedish split-contract awards, as larger firms are then able to internalize synergies of internal economies of scale between contracts in the same project (Strömbäck, 2015). Strömbäck also finds some evidence that large firms self-select into contracts of a larger size and vice versa for small firms. Likewise, economies of scale could explain why the public procurement sector is overrepresented by large firms. This phenomenon is highly related to Li and Zheng's (2007) *entry effect*, where suppliers who are not able to increase their probability of winning by setting a lower price, and at the same are not able to carry the transaction costs of entering the market, will not participate.

To account for the firms' differing ability to make use of economies of scale, our analysis will take into account both the size of the bidding firm and the size of the contract where the bid has been placed in investigating the competitive effect. Furthermore, considering economies of scale are one of the key characteristics that set large and small firms apart, we expect the bidding behavior to differ between these firm types.

3.3 Evaluation Criteria

In Sweden, bids are evaluated by procuring authorities either using price as the sole selection criteria (57% of all procurements in 2018) or the best ratio between price and quality (43% of all procurements in 2018).[3] These criteria are disclosed in the tender documents, meaning that suppliers take them into account in forming their offers (The National Agency for Public Procurement, 2019). Schmidt's (2015) model of bid price determination, as previously mentioned, assumes that bids are evaluated only using price criteria. Consequently, the competitive effect in the model is closely tied to the existence of these evaluation criteria. In parallel, Fugger et. al. (2013) find that suppliers are more enthusiastic to collude and set non-competitive prices when bids are evaluated using both quality and price. Therefore, the evaluation method used in our observed dataset will be analyzed to determine if price setting differs depending on which evaluation criteria is used.

[3] There is one more evaluation model that can be practiced: cost. However, it is almost never used.

4 Data

Data on bid prices has been collected from one of the largest contract-notice databases in Sweden: Visma Opic, which records both past and current public procurements. Most importantly for this study, the database contains award documents disclosing all bid prices placed by firms participating in a given procurement. This is important because, while award documents are public documents required by law to be accessible, there is no efficient way of acquiring these other than emailing each procuring authority and requesting the award documents tied to each procurement. (Offentlighets- och sekretesslag (2009:400)) Today, there is no publicly available database exhibiting data on bid prices in a table format. The data used in this thesis has been collected manually by reading the aforementioned award documents.

4.1 Criteria

The procurement auction observations all fulfill the below criteria:[4]

i. The observations are procurements from 2019.
ii. The procurements observed are all completed procurements with an award document available for download.
iii. The award document must disclose the bid price each evaluated bidder placed in an auction. Procurements only detailing the price data of the winning bid or none at all are therefore not included in the data.
iv. The award document must contain the bid prices from each evaluated participant before any potential reductions according to the evaluation model of the procurement. This means that procurements where the award document only disclosed some sort of relative bid price, a score, or the bid price after potential reductions, were not observed.
v. We did not observe framework agreements. This is because framework agreements can look very different, regardless of if the procurement procedure is the same. An analysis of bidding behaviors in procurements where framework agreements are included is therefore very complicated, as there is no general way of applying the auction theory reviewed in this thesis on these agreements.

4.1.2 Company Size Categories

Each bid price has been sorted into two groups, depending on the size of the company placing the bid. The European Commission's guidelines (European Commission, 2003) for defining enterprise size-classes has been adopted to some extent for this classification. An enterprise is thus defined as any entity engaged in economic activity; the legal formation of the entity will not be considered. Companies will be categorized into two different size classes: *small* and *large* companies. Our small company category includes enterprises defined as both micro- and small-sized according to the Commissions definition guidelines shown in **Table 1**. Consequently, our large company category will include all companies defined as medium-sized or larger.

[4] See Appendix D for details about the specific Visma Opic search filters used.

Table 1
Enterprise size-class definitions - Commission Recommendation 2003/361/EC

Size class	Employee Number	Annual Sales (EUR)	*OR Balance Sheet Total (EUR*
Micro	<10	2 million	2 million
Small	<50	10 million	10 million
Medium	<250	50 million	43 million
Large	>250		

Source: EUR-lex

Note: The above table depicts the parameters used for classifying companies into different size categories, as recommended by the European Commission.

The size-class definition recommended by the European Commission stipulates that the companies should be evaluated on (a) the number of employees and (b) the lowest value of either their annual sales or balance sheet total.

Splitting companies into the categories *small* and *large* is motivated firstly by the notable difference in the Commissions size-class definitions of small and medium-sized companies. It is likely that a company of medium size, according to this classification, will be able to experience the benefits of economies of scale. Economies of scale are a factor we believe sets companies of large and small size apart (See **section 3.2**), affecting them in their ability to pursue contracts of a certain size. It is to account for the effect of economies of scale that companies have been categorized accordingly. Secondly, in collecting the data, it proved difficult to find auctions where the largest firm types (>250 employees) participated alongside the smaller firms (< 50 employees), thus limiting the possibility to conduct a statistically valid analysis without making this interpretation of company size.

Some of the literature presented in the background and literature review of this thesis will differ in its definition of company size classes, however, we believe that this will have no significant impact on the discussion and analysis of our results since our data has been categorized and sorted independently. However, the classification may affect the comparability of our thesis with the broader body of research of competition in public procurement, which mainly adopts the category class small-to middle-sized.

4.1.3 Procurement Size Categories

There are three threshold levels for public procurement contracts; they are determined by the EU and the Swedish Procurement Authority respectively, and updated every other year. Regulations typically become stricter as the value of the procurement increases. Procurements below the lowest threshold are procured directly, which exempts them from numerous legal requirements (The National Agency for Public Procurement, 2020). Procurements above this level are regulated by a similar legal framework since the laws concerning public procurement have been harmonized in the EU, however, they are set apart by annunciation requirements. Contracts above the EU-threshold in economic size, following the EU principles on equal treatment, transparency, non- discrimination, proportionality, and mutual recognition, must be announced on the EU-wide notice database TED (https://ted.europa.eu/). Worth mentioning is that we have not found any foreign bids in our dataset, meaning all the bids in our dataset were placed by domestic firms.

4.1.4 Selection of Industries

The investigated industries, namely cleaning and consulting, have been chosen to test the presumption Hong and Shum (2001) made regarding contract heterogeneity's impact on the common-values effect and the winner's curse. When collecting the data, we specifically looked for two industries where contracts differed in contract layout. We found that contracts in the consulting industry were more standardized than those in the cleaning industry, as here the bid prices were often given as an hourly wage for the procured consultancy service. Contrarily, in cleaning contracts, the participating suppliers are often required to estimate their total costs of performing the contract per the contract terms regarding cleaning frequency, the area subject to cleaning, etc. The variance in bid prices between the industries could have explanatory value for the bidding behavior in the datasets.

4.1.5 Evaluation Criteria

The procurement contracts which firms compete for in each auction are evaluated based on different criteria; some bids are evaluated solely on price, and others on the best price-quality ratio. The evaluation method is stipulated before the auction of the contract, and in the latter case may include non-mandatory evaluation requirements that can benefit the supplier in the evaluation of their bid. The companies competing for the contract may choose to bid differently depending on what signal they receive regarding evaluation criteria; therefore, we control for this variable.

4.2 The Construction of Three Datasets

Table 2
Data table format

Observation	1	2	…	n
Bid prices from small companies	SB11	SB21	…	SBn1
	SB12	SB22	…	SBn2
	…	…	…	…
	SB1a	SB2a	…	SBna
Bid prices from large companies	LB11	LB21	…	LBn1
	LB12	LB22	…	LBn2
	…	…	…	…
	LB1b	LB2b	…	LBnb
Controls	C1	C2	…	Cn

Note: The above table depicts the structure of the dataset of procurement observations. SB11 -> SB1a denotes all the bid prices left by small firms on auction 1, LB11 -> LB1b denotes all the bid prices left by large firms on auction 1, and so on. C_i is the set of control variables for procurement *i.*

The observed bid prices were fed into an Excel table of the above format. Each observation is one procurement auction with the set of control variables C_i and includes prices from all the evaluated bids placed in that auction. Since the raw data consists of bid prices from different auctions, prices have been normalized to enable analysis between contracts. The above table was replicated two times, where bid prices were normalized using auction bid price mean and median respectively, using the following formulas:

$$B_{rij}^{Normbymean} = \frac{B_{ij}}{\mu_{Bi}}, \qquad B_{rij}^{Normbymedian} = \frac{B_{ij}}{M_{Bi}}$$

B_{rij} expresses the normalized bid price placed by company j in procurement auction *i,* μ_{Bi} expresses the average bid price on procurement *i,* and M_{Bi} expresses the median bid price on procurement *i.* Normalizing by both the mean and the median enables more robust analysis, as the effects of bid price outliers will differ between the two datasets.

4.3 Creating Aggregated Data

Having normalized the bid prices in procurements, the construction of a dataset with aggregated bid price data was enabled, whilst keeping the information about what type of procurement the bid was placed in. Thus, two more datasets were created using the bid prices normalized by mean and median. The table below illustrates this aggregation.

Table 3

Aggregate data table format

Observation	Bid price	Controls
1	SB11	C1
1	SB12	C1
…	…	…
1	SB1a	C1
1	LB11	C1
1	LB12	C1
…	…	…
1	LB1b	C1
2	SB21	C2
2	SB22	C2
…	…	…
2	SB2a	C2
2	LB21	C2
2	LB22	C2
…	…	…
2	LB2b	C2
…	…	…
n	SBn1	Cn
n	SBn2	Cn
…	…	…
n	SBna	Cn
n	LBn1	Cn
n	LBn2	Cn
…	…	…
n	LBnb	Cn

Note: The above table describes the structure of the dataset of aggregated bid prices. The leftmost column indicates what procurement auction observation each bid price observation is tied to; the middle one is the bid price, with SB representing bids from small firms and LB representing bids from large firms. C_i is the set of control variables connected to the procurement observation the bid prices are from.

This enables analysis of differences between all the bid prices in the dataset grouped by the set of control variables C_i tied to each procurement auction observation, as well as differences in the aggregated bid prices of large and small companies.

5 Method

This section will describe the statistical tests and regressions performed on the datasets in the pursuit of answering the research questions.

5.1 Regressions

Regression 1, where the normalized, lowest bid price is set as the dependent variable, will indicate whether the competitive effect increases as the number of bids in an auction increase. The participating firms have been categorized according to their size to see whether an increase in small firms impacts the bid prices differently than an increase in large firms. **Table 4** summarizes the control variables included in the regression, as described in the previous chapter.

Table 4
List of control variables and their expected effects

Definition	Notation	Comment
Number of firms	*NFirms*	The number of firms is a control variable that captures the number of bids that have been evaluated by the procuring authority in each auction. This variable will be used to measure the impact of competition on bid prices, as well as bid price standard deviation. We expect that a higher number of bids will result in more competitive prices. By splitting up the variable in size categories, we can see if there is any difference in the effects of an increase in the number of firms between firm size categories.
Number of small firms	*NSmallFirms*	
Number of large firms	*NLargeFirms*	
Procurement size	*PPSize*	The effects of procurement size are controlled for using a dummy variable. The contracts have been split into the size classes: EU level and non-EU level, the first including contracts of a larger size.
Industry	*Industry*	The two investigated industries, cleaning and consulting, are controlled for using a dummy variable. We expect that the cleaning industry will exhibit higher bid price standard deviation since contracts are of a more heterogeneous nature.
Evaluation criteria	*Eval*	The evaluation model used by the procuring agency is controlled for using a dummy variable.

Note: The above table is a summary of the control variables in the dataset, as well as a comment about what their respective expected effects are.

Regression 1

$$LowestBid_i = \beta_0 + \beta_1 NSmallFirms_i + \beta_2 NLargeFirms_i + \beta_3 PPSize_i + \beta_4 Industry + \beta_5 Eval_i + \varepsilon_i$$

In addition to testing the pattern of the lowest bid prices, it is in our interest to see how the bid price standard deviation is affected as the $NSmallFirms$ and $NLargeFirms$ variables increase. Regardless of the trend exhibited in the lowest bid price regression, the remaining bids might exhibit contrasting behavior as competition increases. To control for the spread in bids, both the standard deviation of bid prices and the interval between the lowest and highest bid

price in each observation will be regressed. The same control variables will be included in these regressions.

Regression 2

$$\sigma_{Bi} = \beta_0 + \beta_1 NSmallFirms_i + \beta_2 NLargeFirms_i + \beta_3 PPSize_i + \beta_4 Industry + \beta_5 Eval_i + \varepsilon_i$$

Regression 3[5]

$$B_{i(Interval)} = \beta_0 + \beta_1 NSmallFirms_i + \beta_2 NLargeFirms_i + \beta_3 PPSize_i + \beta_4 Industry + \beta_5 Eval_i + \varepsilon_i$$

5.2 Tests on Aggregated Data

Hong and Shum (2001) perceive the increasing standard deviation of bids as a product of information asymmetries between bidders and their ability to estimate costs adequately. As the number of bidders increases in an auction where information asymmetries are present, the standard deviation should be larger than in auctions where asymmetries are not prevalent, i.e., vastly differing cost estimation prompts firms to place differing bids. We expect the standard deviation to be higher in the cleaning industry since the contracts more heterogeneous than in the consulting industry, which should result in larger information asymmetries regarding the value of the contract. To test this hypothesis, the following test will be conducted.

$$H_0: \sigma_{Cleaning} \leq \sigma_{Consulting}$$
$$H_1: \sigma_{Cleaning} > \sigma_{Consulting}$$

To investigate whether small firms exhibit a larger bid price standard deviation than large firms, the following test will be conducted on the aggregated data in all groups. It is in our interest to see whether this is true, to determine whether their bidding behavior varies more than the bidding behavior of large firms.

$$H_0: \sigma_{Small} \leq \sigma_{Large}$$
$$H_1: \sigma_{Small} > \sigma_{Large}$$

Moreover, whether auctioned contract's size impacts the standard deviation of bids will also be tested. It is plausible that contracts of a larger size have more precise requirements and specific instructions concerning what is expected from the supplier, due to their economic significance. This could lead to a smaller information asymmetry between suppliers regarding the value of the contract, presumably resulting in a consolidation of bid prices.

$$H_0: \sigma_{LargeContracts} \geq \sigma_{SmallContracts}$$
$$H_1: \sigma_{LargeContracts} < \sigma_{SmallContracts}$$

The bid evaluation method is expected to have some impact on the standard deviation of bids. For example, Fugger et. al. expects increasingly non-competitive prices as the number of bidders increases in auctions evaluated on quality. Therefore, we can expect that prices might be more consolidated in this category than in auctions where contracts are evaluated on price.

[5]Where the bid interval is defined as: $B_{i(Interval)} = B_{i(Max)} - B_{i(Min)}$

However, it is also plausible that auctions evaluated solely using price have a larger consolidation in prices, due to the competitiveness of bidders.

$$H_0: \sigma_{Quality} \geq \sigma_{Price}$$
$$H_1: \sigma_{Quality} < \sigma_{Price}$$

All tests testing the standard deviation of bid prices between groups will be performed using a standard variance ratio F-test for homogeneity of variances.

The discrepancy in bidding aggressiveness between small and large firms is investigated additionally using a t-test on the aggregated data of normalized bid prices. The test outcome is confirmed by additionally checking its validity within the industry categories. Since we expect that the variance between groups will differ, the t-tests will be performed using Welch's t-test.

$$H_0: \mu_{Small} \geq \mu_{Large}$$
$$H_1: \mu_{Small} < \mu_{Large}$$

6 Results

This section will present the results from the regressions and tests described in the previous chapter, as well as descriptive statistics from both the procurement observation data and the aggregated bid price data.

6.1 Descriptive Statistics

Table 5a:
Descriptive statistics, median normalization values in parentheses
All procurements

	N	Mean		St.Dev		Median	
Lowest bid price	203	.803	(.826)	.157	(.147)	.826	(.854)
Highest bid price	203	1.249	(1.316)	.261	(.443)	1.175	(1.178)
Bid price interval	203	.446	(.49)	.399	(.518)	.343	(.341)
Standard deviation	203	.167	(.185)	.144	(.201)	.137	(.137)
Number of evaluated bidders	203	4.734	(4.734)	3.242	(3.242)	4	(4)
Number of large bidders	203	2.803	(2.803)	2.28	(2.28)	2	(2)
Number of small bidders	203	1.931	(1.931)	2.06	(2.06)	1	(1)
Average bid price by large firms	178	1.025	(1.065)	.139	(.179)	1	(1.012)
Average bid price by small firms	149	.978	(1.023)	.145	(.311)	.994	(1)

Note: The table reports descriptive statistics for our dataset of 203 procurement auctions. The values in parentheses are the same descriptives calculated using the bid price median normalized dataset.

Table 5a shows that the average (4.7) and median (4) number of bidders in each procurement are quite similar, however, the median number of bidders is also twice the size of the median of all procurements in Sweden (2), as measured by the Swedish Competition Authority in 2019. This means that our dataset is overrepresented by contracts that on average exhibit slightly higher bidding activity than the country-wide average. Additionally, we find that the average and the median number of large firms in each auction is slightly higher than the equivalent figures for small firms in our dataset. Small firms on average have placed lower bids in the procurements in our dataset.

Table 5b
Consulting industry

	N	Mean		St.Dev		Median	
Lowest bid price	95	.846	(.854)	.167	(.166)	.888	(.903)
Highest bid price	95	1.169	(1.191)	.209	(.283)	1.109	(1.094)
Bid price interval	95	.323	(.337)	.366	(.406)	.226	(.234)
Standard deviation	95	.123	(.129)	.126	(.146)	.094	(.096)
Number of evaluated bidders	95	4.2	(4.2)	3.487	(3.487)	3	(3)
Number of large bidders	95	2.021	(2.021)	2.264	(2.264)	2	(2)
Number of small bidders	95	2.179	(2.179)	2.26	(2.26)	1	(1)
Average bid price by large firms	70	1.026	(1.044)	.122	(.169)	1.004	(1.003)
Average bid price by small firms	76	.976	(.99)	.086	(.107)	1	(1)
Cleaning industry							
Lowest bid price	108	.766	(.802)	.139	(.125)	.767	(.816)
Highest bid price	108	1.32	(1.427)	.282	(.523)	1.237	(1.256)
Bid price interval	108	.554	(.625)	.397	(.567)	.491	(.489)
Standard deviation	108	.206	(.235)	.149	(.228)	.176	(.175)
Number of evaluated bidders	108	5.204	(5.204)	2.947	(2.947)	4	(4)
Number of large bidders	108	3.491	(3.491)	2.071	(2.071)	3	(3)
Number of small bidders	108	1.713	(1.713)	1.85	(1.85)	1	(1)
Average bid price by large firms	108	1.024	(1.079)	.15	(.185)	1	(1.021)
Average bid price by small firms	73	.981	(1.058)	.188	(.43)	.982	(.99)

Note: The table reports descriptive statistics for our dataset of 203 procurement auctions, where the top half containing descriptive statistics for the 95 procurement auctions from the consulting industry, and the bottom containing descriptive statistics for the 108 procurement auctions from the cleaning industry. The values in parentheses are the same descriptives calculated using the bid price median normalized dataset.

In **Table 5b** we see that that the lowest bid price is lower on average in procurements in the cleaning industry. The highest bid price is likewise much higher in this category, with a quite large discrepancy between mean and median values, indicating that the highest bid price is often an outlier. Consequently, the bid price interval and standard deviation is larger in the cleaning industry. Small firms are on average more represented in the consulting industry. The difference in bid price averages is consistent between the two contract size categories.

Table 5c
Below EU-Thresholds

	N	Mean		St.Dev		Median	
Lowest bid price	84	.795	(.815)	.187	(.178)	.848	(.872)
Highest bid price	84	1.244	(1.314)	.27	(.497)	1.15	(1.143)
Bid price interval	84	.449	(.5)	.443	(.592)	.303	(.3)
Standard deviation	84	.173	(.195)	.159	(.237)	.127	(.127)
Number of evaluated bidders	84	4.262	(4.262)	3.355	(3.355)	3	(3)
Number of large bidders	84	1.869	(1.869)	1.734	(1.734)	2	(2)
Number of small bidders	84	2.393	(2.393)	2.282	(2.282)	2	(2)
Average bid price by large firms	70	1.027	(1.063)	.16	(.19)	1.015	(1.017)
Average bid price by small firms	73	.979	(1.037)	.175	(.419)	.994	(1)
Above EU Thresholds							
Lowest bid price	119	.809	(.834)	.133	(.122)	.81	(.845)
Highest bid price	119	1.253	(1.318)	.256	(.403)	1.184	(1.202)
Bid price interval	119	.444	(.483)	.367	(.461)	.385	(.398)
Standard deviation	119	.163	(.178)	.133	(.172)	.15	(.144)
Number of evaluated bidders	119	5.067	(5.067)	3.132	(3.132)	4	(4)
Number of large bidders	119	3.462	(3.462)	2.393	(2.393)	3	(3)
Number of small bidders	119	1.605	(1.605)	1.828	(1.828)	1	(1)
Average bid price by large firms	108	1.023	(1.067)	.125	(.173)	1	(1.009)
Average bid price by small firms	76	.977	(1.01)	.109	(.148)	.994	(1)

Note: The table reports descriptive statistics for our dataset of 203 procurement auctions, where the top half containing descriptive statistics for the 84 observations conducted using a below EU-threshold procedure, and the bottom containing descriptive statistics for the 119 procurement auctions conducted using the above EU-threshold open procedure. The values in parentheses are the same descriptives calculated using the bid price median normalized dataset.

In **Table 5c** we observe no significant difference in lowest bid price, highest bid price, or bid price interval between the contract size categories. As expected, large bidders are more prevalent in the above EU threshold contracts, and small firms likewise represent most of the bidders in below EU-level contracts. The median number of bidders above the EU threshold is higher than the median number below EU-level. The difference in bid price averages is consistent between the two contract size categories.

6.2 Regression Results

Table 6
Regression results

	(1)		(2)		(3)	
Regression	Lowest bid price		Bid price std. dev.		Bid price interval	
Normalization	Mean	Median	Mean	Median	Mean	Median
# Small bidders	-0.025***	-0.024***	0.012***	0.012***	0.045***	0.045***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.010)	(0.010)
# Large bidders	-0.013***	-0.014***	0.006	0.007*	0.031***	0.032***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.009)	(0.009)
Procurement size	0.048**	0.044**	-0.044**	-0.042**	-0.083*	-0.066
	(0.021)	(0.020)	(0.019)	(0.019)	(0.047)	(0.046)
Industry	-0.100***	-0.078***	0.085***	0.082***	0.215***	0.195***
	(0.021)	(0.020)	(0.018)	(0.019)	(0.046)	(0.045)
Evaluation model	0.011	0.011	-0.001	0.002	-0.033	-0.027
	(0.018)	(0.017)	(0.016)	(0.017)	(0.040)	(0.040)
Constant	0.924***	0.936***	0.083***	0.080***	0.148***	0.136***
	(0.023)	(0.022)	(0.021)	(0.021)	(0.051)	(0.051)
Obs.	203	203	203	203	203	203
R-squared	0.295	0.288	0.172	0.161	0.274	0.268

Note: The table reports the regression results from the three regression models described in the method chapter, run on our dataset of 203 procurement auctions. The mean and median columns indicate what type of bid price normalization dataset that is used for the regression. Robust standard errors in parentheses. **** p<0.01, ** p<0.05, * p<0.1*

In part 1 of **Table 6**, we find that an increase in the number of bidders correlates with a significant decrease in the lowest bid price, regardless of the size of the bidding company. The coefficient is more negative for small firms, indicating that their participation is associated with a larger price reduction. Furthermore, we find that the lowest bid price relative to the procurement bid price mean or median is significantly lower in the cleaning industry and for contracts of a smaller size.

The bid price standard deviation increases significantly as the number of small firms increases and is higher for contracts of a smaller size as well as for contracts in the cleaning industry. The bid price interval increases significantly as the number of bidders increases, regardless of the size of the firm placing the bid. The interval does not differ significantly between large and small contracts. However, the bid price interval is a lot larger in the cleaning industry than the consulting industry on average, with high statistical significance. These results are consistent between datasets of different normalizations. Another observation is that the evaluation method used by the procurer has no significant impact on the dependent variables.

6.3 Results from Tests on Aggregated Data

Table 7a
Sample descriptives using variance ratio tests for equality of standard deviations between industries

	Consulting = 0			Cleaning = 1			Statistic		
	Std. Dev			Std. Dev			sd(0)/sd(1)	*p*-value	
Group/Norm.	Mean	Median	N	Mean	Median	N	Ha	Mean	Median
All bid prices	0.2107	0.2450	399	0.2474	0.3259	562	Ratio < 1	0.0003***	0.0000***
Small firm bids	0.2342	0.2662	207	0.2702	0.4010	185	Ratio < 1	0.0232*	0.0000***
Large firm bids	0.1813	0.2199	192	0.2350	0.2822	377	Ratio < 1	0.0000***	0.0001***
Small contracts	0.2414	0.2839	267	0.3178	0.4852	91	Ratio < 1	0.0004***	0.0000***
Large contracts	0.1286	0.1366	132	0.2317	0.2853	471	Ratio < 1	0.0000***	0.0000***
Quality evaluation	0.2095	0.2532	280	0.2340	0.3409	194	Ratio < 1	0.0458*	0.0000***
Price evaluation	0.2144	0.2255	119	0.2544	0.3182	368	Ratio < 1	0.0142*	0.0000***

Note: The above table reports variance ratio F-tests for the equality of bid price standard deviations between the consulting and cleaning industries respectively, using the data of aggregated bid prices. The mean and median columns indicate what type of bid price normalization dataset that is used. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

When performing tests on the aggregated data between industries, our results show that the bid price variance is significantly larger in the cleaning industry consistently throughout all the test groups and between datasets. This piece of information complements our regression of procurement bid price standard deviations and procurement bid price intervals, reinforcing that bidding behavior is more erratic for cleaning contracts.

Table 7b
Sample descriptives using variance ratio tests for equality of standard deviations between firm sizes

	Large firms = 0			Small firms = 1			Statistic		
	Std. Dev			Std. Dev			sd(0)/sd(1)	*p*-value	
Group/Norm.	Mean	Median	N	Mean	Median	N	Ha	Mean	Median
All bid prices	0.2183	0.2630	569	0.2515	0.3365	392	Ratio < 1	0.0010**	0.0000***
Consulting contracts	0.1813	0.2199	192	0.2342	0.2662	207	Ratio < 1	0.0002***	0.0038**
Cleaning contracts	0.2350	0.2822	377	0.2702	0.4010	185	Ratio < 1	0.0128*	0.0000***
Small contracts	0.2490	0.2921	157	0.2724	0.3846	201	Ratio < 1	0.1198	0.0002***
Large contracts	0.2057	0.2513	412	0.2282	0.2776	191	Ratio < 1	0.0436*	0.0514
Quality evaluation	0.2073	0.2456	276	0.2362	0.3483	198	Ratio < 1	0.0232*	0.0000***
Price evaluation	0.2282	0.2782	293	0.2663	0.3243	194	Ratio < 1	0.0086**	0.0090**

Note: The above table reports variance ratio F-tests for the equality of bid price standard deviations between the large firms and small firms respectively, using the data of aggregated bid prices. The mean and median columns indicate what type of bid price normalization dataset that is used. * p < 0.05, ** p < 0.01, *** p < 0.001

Running the same test on small versus large firms, we confirm that the standard deviation in bid prices is significantly larger for small firms in all test groups and between datasets. This complements the results from our regression, providing solid evidence that the bid price variance is, in fact, higher among small firms than large firms in our dataset.

Table 7c
Sample descriptives using variance ratio tests for equality of standard deviations between contract sizes

	Small contracts = 0			Large contracts = 1			Statistic		
	Std. Dev			Std. Dev			sd(0)/sd(1)	*p*-value	
Group/Norm.	Mean	Median	N	Mean	Median	N	Ha	Mean	Median
All bid prices	0.2625	0.3468	358	0.2134	0.2603	603	Ratio > 1	0.0000***	0.0000***
Consulting contracts	0.2414	0.2839	267	0.1286	0.1366	132	Ratio > 1	0.0000***	0.0000***
Cleaning contracts	0.3178	0.4852	91	0.2317	0.2853	471	Ratio > 1	0.0000***	0.0000***
Small firms	0.2724	0.3846	201	0.2282	0.2776	191	Ratio > 1	0.0070**	0.0000***
Large firms	0.2490	0.2921	157	0.2057	0.2514	412	Ratio > 1	0.0015**	0.0100*
Quality evaluation	0.2720	0.3822	224	0.1593	0.1770	250	Ratio > 1	0.0000***	0.0000***
Price evaluation	0.2467	0.2782	134	0.2448	0.3056	353	Ratio > 1	0.4479	0.8974

Note: The above table reports variance ratio F-tests for the equality of bid price standard deviations between the small contracts and large contracts respectively, using the data of aggregated bid prices. The mean and median columns indicate what type of bid price normalization dataset that is used. * p < 0.05, ** p < 0.01, *** p < 0.001

The test results exhibited in **Table 7c** confirm that contracts of smaller size have a significantly larger bid price standard deviation than contracts of a larger size, on average. The only anomalous result is the test result for small and large contracts only using price criteria in their evaluation. This provides solid evidence that bid price standard deviation is higher in small contracts than in large contracts on average, regardless of if it is a cleaning contract or

consulting contract, or the size of the participant bidders. That the bid price standard deviation difference between contract sizes is consistent for both small and large-sized firms also tells us that this difference is not only due to the higher participation of smaller firms in smaller contracts. These results are consistent between datasets of different normalizations.

Table 7d
Sample descriptives using variance ratio tests for equality of standard deviations between evaluation methods

	Price evaluation = 0			Quality evaluation = 1			Statistic		
	Std. Dev			Std. Dev			sd(0) / sd(1)	*p*-value	
Group/Norm.	Mean	Median	N	Mean	Median	N	Ha	Mean	Median
All bid prices	0.2450	0.2983	487	0.2196	0.2925	474	Ratio > 1	0.0084**	0.3345
Consulting contracts	0.2144	0.2255	119	0.2095	0.2532	280	Ratio > 1	0.3751	0.9257
Cleaning contracts	0.2544	0.3182	368	0.2340	0.3409	194	Ratio > 1	0.0963	0.8681
Small firms	0.2663	0.3243	194	0.2362	0.3483	198	Ratio > 1	0.0470*	0.8668
Large firms	0.2282	0.2782	293	0.2073	0.2456	276	Ratio > 1	0.0537	0.0184*
Small contracts	0.2467	0.2782	134	0.2720	0.3822	224	Ratio > 1	0.8915	1.0000
Large contracts	0.2448	0.3056	353	0.1593	0.1770	250	Ratio > 1	0.0000***	0.0000***

Note: The above table reports variance ratio F-tests for the equality of bid price standard deviations between the contracts where bids are evaluated using a mix of price and quality criteria, and contracts where bids are evaluated using only price criteria, respectively, using the data of aggregated bid prices. The mean and median columns indicate what type of bid price normalization dataset that is used. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

When testing for the impact of the evaluation criteria on the bid price standard deviation, we find few significant results. Contracts of a larger size are significantly impacted by the evaluation criteria and exhibit larger standard deviation when evaluated on price, however, the result is the opposite for small contracts. This would explain the anomalous result in the previously discussed test, where there was no significant difference in standard deviation between large and small contracts evaluated solely on price. There are significant differences in bid price standard deviation between small firms when examining the results from the dataset with mean normalized values, however, performing the same test using median normalized values, the result indicates the opposite. We are thence reluctant to draw any general conclusions about bid price standard deviation differences between these groups using the test results. In the case of large firms, the results could be interpreted as significant, since the test result using mean normalized values is close to a *p*-value of 0.05 and the test with median normalized values is significant. We can then speculate whether large firms bid more uniformly on contracts evaluated on both quality and price due to their individual behavior rather than through the influence of external factors. This could, for example, indicate that large firms have internalized knowledge of other firms' expected behavior to a larger extent. Coincidentally, these firms are overrepresented in the large contract category, where the evaluation criteria indeed have a significant impact. Altogether, we cannot conclude that the bid price standard deviation is impacted by which evaluation criteria are used.

Table 8
Sample descriptives using Welch's t-tests for equality of bid price means between firm sizes

	Large firms = 0			Small firms = 1			Statistic		
	Mean			Mean			mean(0)-mean(1)	*p*-value	
Group	Mean	Median	N	Mean	Median	N	Ha	Mean	Median
All bid prices	1.0119	1.0486	569	0.9827	1.0194	392	Diff > 0	0.0315*	0.0749
Consulting contracts	1.0153	1.0296	192	0.9858	1.0060	207	Diff > 0	0.0798	0.1666
Cleaning contracts	1.0102	1.0583	377	0.9793	1.0345	185	Diff > 0	0.0926	0.2344
Small contracts	1.0170	1.0504	157	0.9867	1.0279	201	Diff > 0	0.1370	0.2645
Large contracts	1.0010	1.0479	412	0.9786	1.0105	191	Diff > 0	0.0532	0.0569
Quality evaluation	1.0036	1.0347	276	0.9949	1.0330	198	Diff > 0	0.3391	0.4759
Price evaluation	1.0197	1.0617	293	0.9703	1.0056	194	Diff > 0	0.0174*	0.0244*

Note: The above table reports t-test results for the equality of bid price means between bids placed by small firms and bids placed by large firms, respectively, using the data of aggregated bid prices. The tests are conducted using Welch's t-test formula, as the variance between groups is expected to be unequal. The mean and median columns indicate what type of bid price normalization dataset that is used. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In testing the difference in mean prices between large and small firms, we observe that small firms bid more aggressively on average if looking at the whole dataset and the mean normalized values, with a close to significant result using median normalized values. However, this result is not consistent in all test groups. Therefore, the test results are not very conclusive, although indicative. Smaller firms account for more of both the lower bids and the higher bids, meaning that any normalization using the median bid price could be affected by very high bid prices and thus skewed to a higher normalized value than when using the mean bid price.

7 Analysis

After performing our tests, we can indeed confirm that the competitive effect prevails as the number of bids increases. The cleaning industry exhibits a significantly larger competitive effect, as the lowest bid price is significantly lower in this industry than in the consulting industry. At the same time, we find evidence of higher levels of information asymmetries, measured in a larger bid price standard deviation and the interval between the lowest and the highest bid, in the cleaning industry. In other words, both the lowest bid is lower and the highest bid is higher in this industry. This signifies there is a larger spread of bids, meaning it is plausible that some suppliers have internalized the information asymmetries and adopted a conservative bidding style, a product of the common-value effect, while others practice naïve bidding and potentially suffer from the winner's curse. This naïve bidding may benefit the procurer in the sense that the good or service acquired will have a low price, which is the chief objective of the competitive effect; however, awarding the contract to the lowest bidder in this situation may also cause troubles later on with the contract should the supplier's costs exceed the agreed price. For example, it could impact the quality of the procured object, or add on costs later on in the process. The competitive effect is also prevalent in the more homogeneous consulting industry; however, it is significantly lower, confirming our hypothesis that standardized, homogeneous contracts result in less bid price discrepancies.

In analyzing the bidding practiced on contracts of a larger size, we find that this category exhibits both a higher level of conservative bidding, as well as lower standard deviation and spread in bid prices. This could be an indication that requirements placed on suppliers in contracts on the EU-level are more specific and leave less room for interpretation, hence consolidating the bidding behavior of firms through a higher level of transparency. This is supported by our result showing that this difference persists albeit the existing self-selection of large firms into larger contracts. Hence, the behavior of large firms is probably not the only underlying reason for the consolidation of bid prices in this category. Likewise, the spread in bid prices in the small contract category is likely not only due to the higher participation of small firms and their more erratic bidding behavior.

In our regression, we find that as the number of small firms increases, the lowest bid decreases significantly. This decrease is larger for an increase of small firm bidders. This could be interpreted as an indication of more aggressive bidding behavior from small firms. We additionally find an indication of this in our test of average bid prices of small versus large firms. Their more aggressive bidding suggests that small firms are worse at estimating the true value of the contract, or that they practice penetrative price setting to a greater extent than large firms. It is evident that the size of firms and the contract size are intertwined in terms of their effect on bidding behavior, which is quite intuitive, considering the observed self-selection. Therefore, it is hard to draw any conclusions about causality between the variables.

Which evaluation criteria are used by the procuring authority in the auction, intriguingly, do not seem to have a very significant effect on the lowest bid, standard deviation in bid prices, or the bid price interval. However, we do find some evidence that large firms bid more conservatively on contracts evaluated on both price and quality. This could be interpreted as evidence of Fugger et. al.'s (2014) theory stipulating that procurements evaluated on both price and quality are fertile soil for non-competitive price setting and collusion, in the sense that the prices are more consolidated in this group. However, we will refrain from drawing any conclusions, and merely suggest that this ought to be investigated further in future research.

8 Conclusion

Our study confirms that an increase in the number of bids in public procurement results in a competitive effect. This effect is stronger in industries exhibiting a common-value component and may to some extent be a result of naïve cost estimations. Furthermore, we find that the bidding behavior of small and large firms differs in the following ways: firstly, our tests indicate that small firms may practice slightly more aggressive bidding behavior than large firms, although we have no conclusive evidence that this is the case and more testing need be conducted on a larger data sample to confirm this. However, we can conclude that small firms are more erratic in their bidding behavior overall, attributing a large share of the lower bids to them. Secondly, small firms and large firms respectively self-select into contracts of a small and large size. This makes it increasingly difficult to conclude whether the bidding patterns of these firms could be credited to exogenous factors, rather than their individual bidding behavior. There are, for example, indications that the contract size categories could have an equally important explanatory value as the size of the bidding firms.

More conclusive answers could surely be drawn if the dataset was larger. The very persistent problem of a lack of data availability surfaces in this study just as in the work of many others researching public procurement. In the future, an interesting course of research would be delving into the exogenous and endogenous factors that impact the bidding behavior of different firms, to determine how the competitive environment in procurement could be improved in a way that benefits all parties. Improving the collection, standardization, and availability of data would surely benefit such an endeavor, as well as research conducted in the field of public procurement overall.

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Appendices

Appendix A – Procurement Market Share Data

This appendix provides public procurement market share data for the public procurement market in Sweden.

Table 1:
The number and share of tender offers sorted by company size, 2018

Company size	# of tenders	% of total tenders	# of bids	% of total bids	Average # of bids per tenderer
Micro-size companies	5922	39%	11229	19%	1.9
Small companies	5511	37%	18120	31%	3.3
Middle-size companies	1778	12%	12194	21%	6.9
Large companies	609	4%	14740	25%	24.2
Other	1276	8%	2703	4%	2.1
Total	15096	100%	58986	100%	3.9

Note: This table presents data from 2018 on the number and share of tender offers by company size, where the companies are categorized in size categories according to the European Commission Recommendation 2003/361/EC. The companies categorized as "other" are lacking information needed to determine their size.

Appendix B – Public Procurement Threshold Values in the EU and Sweden

This appendix is dedicated to presenting the current threshold values in public procurement at the time this thesis was written.

EU threshold values (SEK) as of 1 january 2020

	Goods & Services	Public works	Social services & other specific services
LOU			
State authorities	1 427 377	54 938 615	7 701 675
Other authorities	2 197 545	54 938 615	7 701 675
Direct awards	615 312	615 312	615 312
LUF			
Contracting authorities	4 395 089	54 938 615	10 268 900
Direct awards	1 142 723	1 142 723	1 142 723
LUFS			
Contracting authorities	4 395 089	54 938 615	4 395 089
Direct awards	1 142 723	1 142 723	1 142 723
LUK			
Contracting authorities	54 938 615	54 938 615	54 938 615
Direct awards	2 746 930	2 746 930	2 746 930

Source: The National Agency for Public Procurement

Note: This table displays the current threshold values for public procurement as of January 1, 2020. The leftmost column tells what legal framework the values following to the right are applied to, as well as what type of contracting authority. Public procurements with an economic value projected to exceed these threshold values must follow an EU-level procurement procedure. The values are revised every other year by the European Commission.

Appendix C – The Public Procurement Principles

This appendix is dedicated to presenting the five principles that the EU-directives regulating public procurement are built on.

The five EU-procurement principles

Principle	Description
I. The principle of non-discrimination	It is prohibited to discriminate suppliers directly or indirectly. This goes for all of the EU, meaning that contracting authorities can't include requirements in a procurement that only a domestic company can fulfil, or preference local companies over foreign or distant ones.
II. The principle of equal treatment	All suppliers should be treated equally and have access to the same information about the ongoing procurement at the same time.
III. The principle of transparency	The contracting authority is obliged to be transparent about the procurement process towards all suppliers to the same extent. In practice, it means that the procurement documents have to be clear and comprehensive; there should be no room for interpretations about what is expected in the procurement of the supplier.
IV. The principle of proportionality	This principle stipulates that the requirements that need to be fulfilled by suppliers must have an obvious link to the procurement and what it aims to achieve, meaning the procurement cannot contain unnecessary requirements or requirements that can be seen as out of place.
V. The principle of mutual recognition	This principle states that certificates or diplomas issued in an EU member state shall also be recognised by other member states.

Source: The National Agency for Public Procurement

Note: The above table details the five principles that the procurement laws of the European Union are built upon.

Appendix D – Public Procurement Procedures

This appendix describes the main procedure types when conducting public procurement in Sweden, used in >99% of procurements in Sweden (Upphandlingsstatistik 2019). Some of the procedures described in this appendix have subtypes of procedures. For an exhaustive list of procurement procedures, the reader is referred to the website of The National Agency for Public Procurement, https://www.upphandlingsmyndigheten.se/.

Main procedure types

	Description
Above EU-thresholds	
Open procedure	A one step, sealed bid reverse auction where the qualification of bidders, evaluation of bids and determination of winner(s) is performed at the same time.
Negotiated procedure	A procedure where the contracting authority select potential bidders that it then invites to place bids. Can consist of several steps where the contracting authority negotiates the design of the good or service procured, as well as the contract terms. Can only be used when the good or service procured mandates some special adaptation.
Competetive dialogue	This procedure is always conducted in more than one step. The contracting authority will negotiate and design the good/service procured in several steps, as well as contract terms. Can only be used in the same situations as negotiated procedure, the difference being that everyone is free to place bids in the first round.
Restricted procedure	A procedure performed in two steps, where suppliers first apply for being able to bid, then the suppliers determined to fulfil the preliminary requirements can place a full bid for the contract.
Below EU-thresholds	
Simplified procedure	A one step, sealed bid reverse auction where the qualification of bidders, evaluation of bids and determination of winner(s) is performed at the same time.
Selective procedure	A procedure very similar to negotiated procedure performed in two steps, where bidders first apply for being able to place bids, and where specifics of the good/service as well as contract terms can be negotiated.
Below threshold for direct award	
Direct award	No specific rules regarding the procurement process, but should follow the five principles. Subject to national legal framework. Many direct award contracts are still performed in the same way as simplified procedures.

Source: The National Agency for Public Procurement

Note: The above table names the main procedures used in >99% of public procurement procedures in Sweden. The leftmost column indicates what procedures are used in what range of threshold values.

Appendix E – Visma Opic Search Filter

This appendix describes the search filter applied to the search engine in Visma Opic's contract notice database. Results sorted by publication date in descending order.

Cleaning

Keywords:	N/A
CPV-codes:	9090000-6 Cleaning and sanitation services
Last call for tender:	2019-12-31
Document type:	Award documents

Consulting

Keywords:	Konsult, konsulttjänster
CPV-codes:	N/A
Last call for tender:	2019-12-31
Document type:	Award documents

Note 1:
As it is the procuring agency's own responsibility to title procurements and label them with CPV-codes, some procurements are wrongly labelled and/or are very broadly defined. PPs where it is apparent that the service procured cannot be placed in one of this thesis' categories have therefore been excluded. See section 4.1 for selection and collection details.

Note 2:
The viewing of award documents is a premium function of Visma Opic tied to the subscription "Opic Upphandlingskoll Plus".[6] An account with the subscription "Opic Analys", an even more premium service, was provided by the Swedish company Tendium AB, however, Opic Upphandlingskoll Plus is the minimum subscription needed to view award documents, and should suffice to conduct data collection in the same way we did. The price for this service is at the writing of this thesis 16,300 SEK/year for full geographical coverage. A much slower and incredibly more burdensome way of collecting the data, although possible, would be to request each award document from its respective procuring authority in turn. The contracts observed in this thesis can be identified in the dataset by the meta-data fields "Procurement name" and "Reference number".

[6] English translation (by author): Opic Procurementcheck Plus

Appendix F – Descriptive Data Tables

Descriptive Statistics for procurement observations, median normalized dataset

Variable	Description	Obs	Mean	Std.Dev.	Min	Max
avg_large	The average bid price for large companies.	178	1.065	.179	.428	2.059
avg_small	The average bid price for small companies.	149	1.023	.311	.58	4.332
avg_all	The average bid price for all companies	203	1.038	.118	.88	2.018
winning_bid	The winning bid price	203	.839	.175	.127	1.287
lowest_bid	The lowest bid price	203	.826	.147	.137	1
highest_bid	The highest bid price	203	1.316	.443	1	4.332
lowest_small_firm_bid	The lowest bid price by a small firm	149	.887	.331	.137	4.332
highest_small_firm_bid	The highest bid price by a small firm	149	1.182	.453	.58	4.332
lowest_large_firm_bid	The lowest bid price by a large firm	178	.918	.205	.422	2.059
highest_large_firm_bid	The highest bid price by a large firm	178	1.25	.343	.428	2.844
interval	The bid price interval between the highest and lowest bid	203	.49	.518	0	3.61
small_interval	The bid price interval between the highest and lowest bid by small firms	149	.296	.438	0	3.004
large_interval	The bid price interval between the highest and lowest bid by large firms	178	.332	.392	0	2.171
std_dev	The bid price standard deviation	203	.185	.201	0	1.64
std_dev_small	The small firm bid price standard deviation	149	.123	.178	0	1.227
std_dev_large	The large firm bid price standard deviation	178	.136	.166	0	.956
next_lowest_bid	The next lowest bid	188	.924	.159	.417	1.42
min_bid_diff	The difference between the lowest bid and the next lowest bid.	188	.112	.166	-.297	.841
avg_diff	The difference in average bid prices between large and small firms	124	-.05	.424	-1.177	3.471
median_bid	The median bid price	203	1	0	1	1
nfirms	The number of evaluated bidders	203	4.734	3.242	1	21

Descriptive Statistics for procurement observations, median normalized dataset

Variable	Description	Obs	Mean	Std.Dev.	Min	Max
nsmall	The number of evaluated small firm bidders	203	1.931	2.06	0	12
nlarge	The number of evaluated large firm bidders	203	2.803	2.28	0	12
Winner_size	The size of the firm placing the winning bid (String)	203	-	-	-	-
winner_dummy	Dummy indicating size of winning firm	203	.468	.5	0	1
Line_of_business	The industry for this observation	203	-	-	-	-
industry	Dummy indicating industry	203	.532	.5	0	1
Procurement_name	The name of the notice in Visma Opic	203	-	-	-	-
Reference_number	The reference number of the notice in Visma Opic	203	-	-	-	-
Date_collected	The date collected	203	-	-	-	-
ppsize	Dummy indicating procurement size	203	.586	.494	0	1
eval	Dummy indicating evaluation method	203	.547	.499	0	1
lowest_bidder	Dummy indicating firm size of lowest bidder	203	.488	.501	0	1
only_large	Dummy equals 1 if only large firms participated	203	.266	.443	0	1
only_small	Dummy equals 1 if only small firms participated	203	.123	.329	0	1

Note: The above table presents the descriptive statistics for all the variables in the Excel-sheet of procurement auction observations, where the bid price has been normalized using the bid price median for each procurement.

Descriptive Statistics for procurement observations, mean normalized dataset

Variable	Description	Obs	Mean	Std.Dev.	Min	Max
avg_large	The average bid price for large companies.	178	1.025	.139	.417	1.751
avg_small	The average bid price for small companies.	149	.978	.145	.58	2.147
avg_all	The average bid price for all companies	203	1	0	1	1
winning_bid	The winning bid price	203	.839	.175	.127	1.287
lowest_bid	The lowest bid price	203	.803	.157	.127	1
highest_bid	The highest bid price	203	1.249	.261	1	2.897
lowest_small_firm_bid	The lowest bid price by a small firm	149	.85	.201	.127	2.147
highest_small_firm_bid	The highest bid price by a small firm	149	1.124	.284	.58	2.897
lowest_large_firm_bid	The lowest bid price by a large firm	178	.887	.2	.358	1.751
highest_large_firm_bid	The highest bid price by a large firm	178	1.193	.234	.417	1.998
interval	The bid price interval between the highest and lowest bid	203	.446	.399	0	2.343
small_interval	The bid price interval between the highest and lowest bid by small firms	149	.273	.374	0	2.329
large_interval	The bid price interval between the highest and lowest bid by large firms	178	.305	.324	0	1.451
std_dev	The bid price standard deviation	203	.167	.144	0	.813
std_dev_small	The small firm bid price standard deviation	149	.113	.147	0	.951
std_dev_large	The large firm bid price standard deviation	178	.124	.132	0	.635
next_lowest_bid	The next lowest bid	188	.924	.159	.417	1.42
min_bid_diff	The difference between the lowest bid and the next lowest bid.	188	.137	.142	0	.841
avg_diff	The difference in average bid prices between large and small firms	124	-.061	.3	-1.001	1.72
nfirms	The number of evaluated bidders	203	4.734	3.242	1	21
nsmall	The number of evaluated small firm bidders	203	1.931	2.06	0	12
nlarge	The number of evaluated large firm bidders	203	2.803	2.28	0	12

Descriptive Statistics for procurement observations, mean normalized dataset

Variable	Description	Obs	Mean	Std.Dev.	Min	Max
Winner_size	The size of the firm placing the winning bid (String)	203	-	-	-	-
winner_dummy	Dummy indicating size of winning firm	203	.468	.5	0	1
Line_of_business	The industry for this observation. (String)	203	-	-	-	-
industry	Dummy indicating industry	203	.532	.5	0	1
Procurement_name	The name of the notice in Visma Opic	203	-	-	-	-
Reference_number	The reference number of the notice in Visma Opic	203	-	-	-	-
Date_collected	The date collected	203	-	-	-	-
ppsize	Dummy indicating procurement size	203	.586	.494	0	1
eval	Dummy indicating evaluation method	203	.547	.499	0	1
lowest_bidder	Dummy indicating firm size of lowest bidder	203	.488	.501	0	1
only_large	Dummy equals 1 if only large firms participated	203	.266	.443	0	1
only_small	Dummy equals 1 if only small firms participated	203	.123	.329	0	1

Note: The above table presents the descriptive statistics for all the variables in the Excel-sheet of procurement auction observations, where the bid price has been normalized using the bid price mean for each procurement.

Descriptive Statistics for aggregated data, median normalized dataset

Variable	Description	Obs	Mean	Std.Dev.	Min	Max
winner_dummy	Dummy indicating size of winning firm	961	.501	.5	0	1
industry	Dummy indicating industry	961	.585	.493	0	1
ppsize	Dummy indicating procurement size	961	.627	.484	0	1
eval	Dummy indicating evaluation method	961	.493	.5	0	1
lowest_dummy	Dummy indicating firm size of lowest bidder	961	.497	.5	0	1
small_firm~d	Dummy indicating size of bidder	961	.408	.492	0	1
bid_price	The normalized bid price	961	1.037	.295	.137	4.332

Note: The above table presents the descriptive statistics for all the variables in the Excel-sheet of aggregated bid prices, where the bid price has been normalized using the bid price median for each procurement. The dataset consists of 961 individual bid prices.

Descriptive Statistics for aggregated data, mean normalized dataset

Variable	Description	Obs	Mean	Std.Dev.	Min	Max
winner_dummy	Dummy indicating size of winning firm	961	.501	.5	0	1
industry	Dummy indicating industry	961	.585	.493	0	1
ppsize	Dummy indicating procurement size	961	.627	.484	0	1
eval	Dummy indicating evaluation method	961	.493	.5	0	1
lowest_dummy	Dummy indicating firm size of lowest bidder	961	.497	.5	0	1
small_firm~d	Dummy indicating size of bidder	961	.408	.492	0	1
bid_price	The normalized bid price	961	1	.233	.127	2.897

Note: The above table presents the descriptive statistics for all the variables in the Excel-sheet of aggregated bid prices, where the bid price has been normalized using the bid price mean for each procurement. The dataset consists of 961 individual bid prices.