LUISS

Department of Economics and Finance

Chair of IO & Competition Theory

Fighting Collusion in Procurement Auctions: Evidence of Bid-Rigging in Technical Assistance Services Contracts

Supervisor:

Prof.

Gian Luigi Albano

Candidate:

Maria Grazia Santocchia

231391

Academic Year 2020/2021

TABLE OF CONTENTS

INTRODUCTION

Detection and deterrence of collusion are longstanding antitrust concerns. In any market, firms have the incentive to coordinate their actions and increase their collective profits by restricting output and raising market prices. Auction markets are no exception.

Bidder collusion, commonly referred to as bid-rigging, is an arrangement among a group of bidders designed to soften price competition between the participants and thus capture some of the rent that would otherwise be transferred to the auctioneer in the case of competitive bidding.

Bid-rigging in public procurement imperils the effort of contracting authorities in awarding a contract according to the rules of fair competition and distorts the efficiency of the final allocation. Since successful bidding rings increase the price paid by contracting authorities and reduce the quality of the goods or services procured, bid-rigging has detrimental repercussions on the overall economy. Government agencies are affected as they end up paying far more than they would have had under competitive bidding. This, in turn, causes a significant waste of money for the public sectors – money that could have been devolved to other activities of social interest. Additionally, the multiplier effect is perceivable in the economic impact of bid-rigging as the higher prices are inevitably passed onto citizens in the form of higher distortionary taxes. For these reasons, competition authorities have focused on prosecuting bidder collusion, but not without difficulties. Indeed, these arrangements are surreptitious because they are usually illegal under antitrust laws and because they are intended to be kept secret from the victims.

The objective of this paper is to outline the main competition problems that can be observed in public procurement procedures by throwing some light on the nature and characteristics of bid-rigging, the common structures used by bidding rings to sustain collusion as well as the presence of certain patterns that could serve as an indication for the presence of anti-competitive bidding. Additionally, this paper provides a survey of theoretical and empirical research on bidder collusion, with an eye on identifying structural factors that facilitate or inhibit collusive schemes and evaluating possible anti-collusive measures to prevent bid-rigging in auctions and procurements.

In particular, Chapter 1 provides an elementary, non-technical review of auction theory and a description of the typical auction formats. Procurement auctions are then introduced and presented as the most efficient and transparent mechanism to select the best contractor in a pool of competing firms and maximize buyer's savings.

Chapter 2 proposes an explanation of bid-rigging in tendering procedures and the harm it causes to the public sector and society as a whole. In studying the common types of ring organizations, I highlight how structural characteristics and conditions of the procurement market, such as the number

of competitors or the level of entry barriers, may facilitate the implementation of collusive schemes and enhance their sustainability. Moreover, the operational problems of cartels are considered.

Chapter 3 addresses the relative vulnerability of different auction formats to bidder collusion. The central message of this chapter is that the presence and characteristics of collusive mechanisms depend critically on the given auction rules and nature of the object being auctioned.

For the most part, industrial organization scholars have addressed the optimal design of antitrust policies against collusion. However, the strong tendency to emphasize public policy responses to collusion obscures the importance of successful anti-collusion precaution-taking efforts of sellers and procurers to forestall or inhibit successful coordination. Chapter 4 shows how good auction design complements antitrust enforcement, and both play a role in deterring bidder collusion. I analyze possible precautions that contracting authorities can take independently, without necessarily invoking public laws that condemn cartels, to deter or discourage bidder collusion. Understanding the mechanisms by which bidders coordinate on collusive agreements can be valuable for informing the choice of auction format and the details of institutional design. Indeed, some choices may make it more difficult for bidding rings to operate effectively in the first place, while others may make it easier to detect and prosecute collusion after the fact. Of course, optimal auction design cannot deter all bidder collusion. The ex-post fight to curtail cartel activity is also taken into consideration.

This paper describes tests developed by Porter and Zona (1993) and Bajari and Ye (2003) to detect collusive bid-rigging by firms competing in sealed-bid auctions. While no method for detecting collusion is likely to be infallible, and these tests have their limitations, I argue that the approaches described in this paper are a helpful first step to determine whether suspicious bidding has occurred and whether further investigation and analysis are warranted.

Finally, to lend some concreteness to the discussion, this paper includes the case study of a bidding ring put in place in 2015 by the Big Four in the procurement of technical assistance services contracts for the Italian public administrations.

1. A Brief Rundown on Auctions

An auction is a market mechanism defined by a set of rules which determine the allocation and the prices of goods on the basis of the offers submitted by the participants in the auction. Traditional models of competition that determine equilibrium prices given demand and supply characteristics (e.g., Cournot and Bertrand) do not explain the price-formation process in terms of buyer-seller interactions. In contrast, auction theory provides an explicit model that governs the formation of prices.

A typical auction consists of a single auctioneer responsible for selling an item and several bidders who wish to buy it. Oftentimes, the auctioneer may announce a reserve price – the lowest price she is willing to accept to sell the item. The economic literature analyzes four basic types of single-item auctions. These four types of auctions are characterized along two dimensions: whether bidding is dynamic or simultaneous and whether the winning bidder pays an amount equal to her bid (the highest bid) or the highest losing bid. Thus, the four types of auctions are: (i) the first-price sealed-bid auction, (ii) the second-price sealed-bid auction (also called Vickrey auction), (iii) the English auction (ascending-bid), and (iv) the Dutch auction (descending-bid).

In first-price and second-price sealed-bid auctions, sealed bids are submitted and considered simultaneously by the seller to determine the winning bidder. In a first-price sealed-bid auction, the highest bidder wins the item and pays an amount equal to the highest bid. It is obvious that in a first-price sealed-bid auction, a bidder will always bid below her valuation for the item. If she bids her valuation or above, then, if she wins the auction, her expected profit will be zero or negative. In a second-price sealed-bid auction, instead, the highest bidder wins the item and pays an amount equal to the second-highest bid. The second-price sealed-bid auction is a special case of a Vickrey auction. As in other Vickrey auctions, it is a dominant strategy for a bidder to bid their true value. The intuition is that in order to expect a positive profit, it is not necessary to shade one's bid – the bidder with the highest valuation wins the object and pays an amount equal to the second-highest valuation.

An English auction is an open-bid auction in which bidders sequentially raise the price until no bidder is willing to raise it further. English auctions are dynamic in the sense that they are carried out interactively in real-time. The auctioneer keeps raising the price while bidders gradually drop out until only one bidder remains. The economic literature on auctions, such as Milgrom and Weber (1982), usually approximates English auctions by Japanese auctions for the sake of analytical convenience. In a Japanese auction, bidders press and hold down a button while the price of the item is raised continuously. A bidder drops out of the auction by releasing her button when the price of the item exceeds her willingness to pay. The continuous increase in price simplifies the theoretical analysis and makes it clear that the winning bid in an English auction is approximately the second-highest valuation. This is why the English auction is sometimes referred to as an open second-price auction.

A Dutch auction is an open-bid auction that proceeds in the opposite direction. The auctioneer begins the auction at a particularly high price and lowers the price until a bidder is willing to purchase the item. The first bidder to accept the current price wins the object at that price. The set of strategies available to bidders in a Dutch auction is the same as the set of strategies available in a first-price

sealed-bid auction, and therefore the Bayesian-Nash equilibrium bid functions are the same. This is why the descending bid auction is sometimes referred to as an open first-price auction.

A fundamental result in auction theory is the revenue equivalence theorem for independent private values auctions. The revenue equivalence theorem essentially states that, under the assumptions of risk neutrality, all efficient, symmetric independent private values auctions yield the same expected revenue for the seller if they have the same announced reservation price. Thus, for independent private values auctions, the expected winning bid is the same whether the auction mechanism is English, Dutch, first-price sealed-bid, or second-price sealed-bid. This result was first obtained by Vickrey (1961) and later generalized by Riley and Samuelson (1981).

In many real-life situations, such as natural resources auctions, the assumption that the bidders' valuations are independent is improper. An alternative set of assumptions is that the value of the object is the same for all bidders, but each bidder has an unbiased estimate of the value drawn from an identical distribution. Milgrom and Weber (1982) prove, in a more general version of this common-value model, that when bidders are symmetric and risk-neutral, but the value estimates are "affiliated" (e.g., positively correlated), oral auctions yield the seller higher expected revenue than do second-price sealed-bid auctions, which, in turn, do better than first-price sealed-bid auctions.

1.1 Procurement Auctions

Traditional auctions, in which a seller puts an item up for sale and buyers bid on it, have been adopted for centuries and in a wide range of sectors. For instance, governments are particularly keen on using auctions to sell mobile-phone licenses, operate decentralized electricity markets, privatize companies, etc. In the late 1990s, with the Internet boom, a new kind of auctions started gaining popularity as more and more companies began using them for strategic sourcing: reverse auctions.

A reverse (or procurement) auction is a type of auction in which the buyer puts up a request for a good or service, and sellers place bids for the amount they are willing to be paid to supply the good or service. At the end of the auction, the seller with the lowest price offer wins. Competitive procurements are designed to select the most efficient contractor in a pool of competing firms and maximize buyer's savings. Public and private organizations often rely upon a competitive bidding process to obtain goods and services at the lowest possible price or, more generally, to attain the best value for money. It is important to note that procurement auctions work best when there are many sellers who offer similar goods and services, and that can ensure the integrity of a competitive process.

Bidding for government contracts is an example of procurement auctions. Public procurement is often related to the expenditure of public funding for the implementation of projects of key importance for economic development, such as the construction of infrastructures (e.g., highways), facilities in the

energy sector, or projects in the field of social policy, healthcare, and education. Additionally, public procurement has a wide impact on the market, both short-term and long-term, as it affects the level of investment and the degree of innovation in a specific industry as well as the overall level of competitiveness, with potential benefits for the whole economy.

Contracting authorities count on competition in public procurement to minimize costs and allocate resources in the most efficient way. Low prices and better quality are desirable because they allow for resources to either being saved or freed up for use on other goods and services. The bidding process can only work when competitors make their bids independently. That is why the contracting authorities' vigilance of public procurement should be directed to fighting against anti-competitive behavior. Even if vigorous competition among the market participants should be applied, it is not uncommon for restrictions of competition in public procurement to occur. The violation of the competition principle can be carried out by the contracting authorities themselves through the introduction of discriminatory requirements to the participants in opening a procedure. The economic literature refers to these conditions as public restrictions of competition, to be distinguished from the private restrictions of competition. The latter stem from the actions of bidders, which could lead to the restriction or distortion of competition in the awarding of public procurement procedures.

2. COLLUSION IN AUCTIONS: INTRODUCTION TO BID-RIGGING

The competitive process can achieve lower prices and better quality only when companies genuinely compete. Competition is not, however, firms' preferred scenario. Firms dislike cutthroat behavior and would rather coordinate their actions to soften price competition and raise joint profit.

Collusion belongs to the private restrictions of competition, and it has been defined as an illicit agreement between two or more undertakings – competitors in the relevant market – that aim at reproducing the market outcome induced by a single, dominant firm. Collusion depresses the revenue obtained by the seller (or the buyer in procurement) and distorts the efficiency of the final allocation. Indeed, to be awarded the tender at conditions that are most favorable for them, bidders, that would be expected to compete, are willing to secretly conspire to capture some of the rents that would otherwise be transferred to the auctioneer and close the market for potential competitors. At the same time, collusion considerably restricts the degree of innovation and the stimuli for the participating undertakings to invest in a specific industry sector.

Non-colluding bidders may be harmed by bidder collusion in two ways. First, auctioneers and procurers often combat cartels by being more aggressive in their use of reserve prices. Second, when the commodity is informationally complex, bidder collusion may create a better-informed bidder

relative to the non-colluding bidders. Non-colluding bidders will realize that winning against better-informed colluding bidders is "bad news." Consequently, timid bidding by non-cartel bidders implies they will lose items that they would have won in the absence of collusion.

Collusion can take many forms, including price-fixing, the allocation of production or sales quotas, and bid-rigging – the most common. Bid-rigging is a form of horizontal anti-competitive conduct of undertakings with the purpose of pre-arranging the outcome of the tender or, more specifically, pre-determining the contracting authority's choice of the winning bidder. Bid-rigging schemes often include mechanisms to apportion and distribute the collusive profit. For example, ring members who agree to refrain from bidding or to submit a losing bid may receive advantageous subcontracts or supply inputs to the designated winner. However, long-standing arrangements may employ much more elaborate methods of assigning contract winners, monitoring ring members, and splitting the gains over a period of months or years.

At first glance, the social harm from bidder collusion is not evident. If an auctioneer has a fixed supply to dispose of, then the effect of collusion is simply a transfer of surplus from the auctioneer to the collusive bidders. This analysis is too simplistic though. First, organizing a bidding ring and the costs of investigating and prosecuting collusion are obvious social losses. Second, if collusion depresses the revenue from an auction, then the number of auctioned items will fall, and output will be inefficiently restricted. Conversely, if collusion raises the expected cost of procurement, that will also inefficiently restrict output as the demand for procured products will fall. Third, the transfer of wealth away from a government auction deprives society of a relatively efficient source of revenue that may be replaced by a less efficient source. Similarly, increased procurement costs attributable to collusion increase the burden from higher taxation, which is intrinsically distortionary and results in a deadweight loss.

The latter is the most significant cost of collusion. Bid-rigging can be particularly harmful if it affects public procurement because when contracts are financed through distortionary taxation, as is realistically the case, then the collusive profits earned by the cartel cause a welfare loss. One reason for this is that public procurement is often a large part of a nation's economy. According to the Organization for Economic Cooperation and Development, OECD countries spend approximately 12% of their GDP on purchasing goods and services in the public sector, and in most developing countries, this percentage can be higher, between 15-20%.

Another adverse economic implication of bid-rigging is the diversion of money away from development programs. At times governments may allocate a huge amount of money to public projects in view of a particular set of socio-economic reforms. Bid-rigging affects these projects by pushing up prices and discouraging the flow of funds to other such projects. Resources thus lost are

an unacceptable drain on developmental effectiveness. Given the nature of the projects in question, bid-rigging impacts not only the poor, since many projects are conceptualized for their exclusive benefit, but also society at large.

2.1　The Various Forms of Bid-Rigging

Bid-rigging can take many forms, including: (i) cover bidding, (ii) identical bidding, (iii) bid rotation, (iv) bid suppression, (v) subcontracting agreement, and (vi) market allocation.

Cover bidding. Cover (also called complementary, courtesy, token, or phantom) bidding is the most frequent collusive scheme implemented by bidders. It occurs when a competitor agrees to submit a bid that is higher than the bid of the designated winner or that contains terms that are known to be unacceptable to the contracting authority. Usually, in a public procurement procedure, the participants in a bid-rigging agreement submit several cover bids with the aim of creating the impression of genuine competition and concealing secretly inflated prices. This collusive scheme requires the definition of a sharing rule according to which the winning bidder transfers some of the spoils to other cartel members.

If the buyer is uncertain about the true cost distribution, phantom bids may be useful to manipulate the buyer's expectation regarding the likely price of future jobs. To the extent that data on government engineers' prior estimates of the costs of various jobs depend on previous bidding patterns, such data should be regarded as potentially biased estimates of true costs. For example, a sequence of high winning bids, together with many phantom bids that exhibit little dispersion, may induce the buyer to anticipate too high costs for future lettings. Future reservation prices would then be higher, and so would future cartel profits.

Identical bidding. One possible collusive scheme is to have all bidders submit identical bids, preferably close to the reserve price, and let the seller randomly select the winner. If the cartel is inclusive, bidders should bid the reserve price. If not, they should optimize versus the other bidders. Identical bidding wastes a lot of the potential gains from collusion because the good is unlikely to go to the bidder with the highest valuation. This scheme is also difficult to enforce. First, when many identical bids are to be submitted and only the identity of the winning bidder, and not her bid, is announced, individual bidders have a strong incentive to slightly underbid the designated winner because the deviation will be difficult to detect. Second, since the identical-bids mechanism works by using the contracting authority as a randomizing device, the authority can easily disrupt the mechanism by refusing to randomize. Instead of awarding the item arbitrarily when the bids are tied, she could announce a deterministic tie-breaking rule (e.g., awarding the contract to the bidder whose name comes first in the alphabet). Then it would no longer be in the interest of discriminated bidders

to remain in the ring. Additionally, identical bidding results in each bidder winning with equal probability. Yet, cartels may seek a different division of the spoils. Mund (1960), among many others, argues that the submission of many identical bids is an unlikely Nash equilibrium, particularly when sellers' costs are heterogeneous.

With antitrust authorities raising awareness on identical bidding, this simple form of collusion has become much less common. Mund (1960) cites some instances of bidders switching from identical bidding to a rotating-bid mechanism after the competition authorities became suspicious about the identical bids.

Bid rotation. In a bid rotation scheme, firms agree to take turns being the lowest bidder. They arrange in advance who is going to submit the winning bid and who is going to submit a cover bid. Usually, the candidate whose turn it is to win the specific bid prepares the bids of the other candidates. A simple type of bid rotation scheme is the one in which each ring member is attributed a phase of the moon. The phase of the moon at the time of the auction determines which of the ring members has the right to bid, free from competition from other members of the ring. An example of the phases-of-the-moon system occurred in the 1950s when General Electric and Westinghouse assigned low bid privileges for electrical equipment contracts (Smith, 1961). Alternatively, cartelists might choose to allocate approximately equal monetary values from a given group of contracts to each firm or to allocate volumes that correspond to the size of each firm. Even more complex, bidders can use a tally sheet keeping track of each bidder's winnings to ensure the bidders' wins approximately balance out over time. The latter is more efficient than simple bid rotation schemes but requires more coordination and communication, thus it increases the likelihood that collusion is discovered and prosecuted by antitrust authorities.

Bid suppression. Bid-rigging may consist of agreements among competitors in which one or more firms agree not to bid or to withdraw a previously submitted bid so that the designated winning bid will be selected.

Subcontracting agreements. In some cases, ring members may agree to refrain from bidding, to submit a losing bid, or to withdraw a previously submitted bid in return for "loser fees," which may be disguised under lucrative subcontracting contracts. The winning bidder adds these costs to its bid.

Market allocation. Expected competitors may carve up the market and agree not to compete for certain customers or in certain geographic areas. Market allocation could also be based on criteria related to the characteristics of the purchaser (e.g., specific public organizations) or of the contract. Each cartel member, apart from the designated winner, then submits a cover bid or forgoes bidding.

These typical bid-rigging techniques are not mutually exclusive but complement one another. Thus, the cover bids are most often used in conjunction with a bid rotation scheme, and bid suppression is combined with market allocation.

Bid-rigging should be distinguished from some non-prohibited forms of cooperation between competitive undertakings which take part in public procurement procedures. Oftentimes, the undertakings enter into contractual agreements to establish a consortium or a joint venture and participate together in the tender in an effort to achieve compliance with some of the requirements set by the contracting authority, which are often related to the financial capacity, reliability, or experience on the part of the bidders. Economic benefits may arise as a consequence of these forms of cooperation, whose beneficial effects for the market surpass the potential anti-competitive effect achieved as a result of the coordinated behavior of the parties.

2.2   Factors Facilitating Bid-Rigging

Although bid-rigging can occur in any economic sector, there are some sectors in which the characteristics of the competitive structure of the relevant market support bidders' coordination efforts and make collusion more likely to occur. A factor facilitates collusion if (i) it increases the level of collusive profits, (ii) it helps firms solve the coordination problem by providing some simpler rule to "share the pie," or (iii) it reduces the short-run profits a firm can gain by deviating from the collusive agreement, or (iv) makes punishment swifter or more severe.

Small number of firms. The probability of bid-rigging is higher when there are only a few bidders. This is for at least two different reasons. First, the fewer the number of bidders, the easier it is for them to reach an agreement on the mechanism of the ring. Second, the higher the number of collusive firms, the smaller the share of the "pie" they get. This implies that as the size of the cartel increases, so does the gain obtained by deviating from the collusive agreement, undermining the stability of the ring.

High barriers to entry. When the barriers to entry are high (e.g., entry in a certain market is costly, hard, or time-consuming), incumbents are protected from the competitive pressure of potential new entrants, which may dismantle the collusive scheme. Furthermore, high barriers to entry strengthen the scope of retaliation, thus improving the sustainability of collusion.

Symmetries across firms. Asymmetry in market shares has an ambiguous effect on collusion. Asymmetry hinders collusion because smaller firms have high incentives to deviate from the scheme. At the same time, smaller firms are more financially fragile and, therefore, more easily deterred from cheating by the prospect of a bidding war. Asymmetry in market shares makes coordination more difficult, especially when the tender is divided into symmetric lots. That being said, the stability of

market shares (even if asymmetric) helps support bid-rigging efforts as usually collusive bidders allocate contracts among themselves in such a way as to ensure that the previously agreed balance of their market shares is maintained for a long period of time.

The difference in market shares depends on more fundamental asymmetries such as production costs, capacity, product range, or quality (see, e.g., Albano et al. 2006). Cost asymmetries make collusion more difficult because firms may find it difficult to agree on a common pricing policy. Even if firms are able to coordinate on a collusive price, it is nonetheless more difficult to discipline the most efficient firms since they can obtain higher gains from undercutting the cartel and the deterrent of a bidding war is less effective. Low-cost firms should then be allocated a bigger share of collusive profit to prevent them from undercutting the cartel. However, this increases weaker firms' incentives to deviate from the collusive agreement.

As for capacity constraints, their impact on collusion is often equivocal when firms are symmetric. On the one hand, because it can only satisfy demand up to its capacity, a capacity-constrained firm has less to gain from undercutting the cartel pricing. On the other hand, a capacity-constrained firm has limited reprisal power. Capacity asymmetries have less ambiguous effects. A firm with a larger capacity than other ring members has a strong incentive to undercut the designated winning bid since its rivals have little retaliatory power. Thereby, asymmetries in capacity constraints tend to reduce collusion.

Standardized or simple products or services. The chances of bid-rigging are greater if the products or services being purchased are standardized and do not change over time. Under these circumstances, it is easier for firms to reach an agreement and have it last a long time.

Absence of substitutes and innovation. When there are few, if any, valid alternative products or services the purchaser can substitute the procured products or services with, collusive firms' efforts to raise prices are more likely to be successful. In addition, little or no innovation helps firms reach an agreement and maintain that agreement over time.

Market conditions. Constant and predictable demand from the public sector tends to aggravate the risk of collusion. Significant changes in demand or supply conditions tend to destabilize ongoing bid-rigging agreements, yet the effect on future collusive schemes is unpredictable. During periods of economic upheaval or depression, incentives for competitors to collude increase as they seek to replace lost business with collusive gains. Yet, once an agreement is reached, deviating from it becomes captivating as it brings maximum gains while the potential cost of retaliation is at a minimum. Generally, collusion is easier to sustain in growing markets. Since future profits will be greater than current ones, the gains from adhering to the collusive agreement grow over time, so the temptation of deviating decreases. At the same time, growing markets usually attract new entrants

whose presence is disruptive for operating cartels. The impact of growing demand on collusion is thus unpredictable. The level of barriers to entry is then a crucial factor to assess the relative strength of the two opposite forces.

Industry associations. Industry associations can be used as legitimate mechanisms to promote standards, innovation, and competition within the relevant market. Conversely, when subverted to illegal, anti-competitive purposes, these associations have been used by firms' officials to meet and exchange sensitive trading information as well as discuss ways and means to reach and implement a bid-rigging agreement.

Market transparency. Market transparency facilitates retaliation because deviations from the collusive schemes become easier to detect and punish. When prices are clearly observable, collusion is easier to implement. This means that a disclosure policy hiding all information from bidders would hinder collusion since firms would not be able to predict competitors' behavior.

Repetitive tenders. The frequency of interaction helps members of a ring allocate contracts among themselves. When auctions are held at regular intervals, a bidding ring can more easily implement a bid rotation scheme and can credibly threaten to retaliate against ring members if they deviate from the mechanism. As discussed above, some bidding rings make monetary transfers among themselves after the auctions at which they collude. However, it is more common for firms to keep records of amounts owed and only infrequently make payments to clear the accounts, preferably balancing them out at future procurements. Such behavior is facilitated if the bidding ring knows there will be a regular stream of auctions in which they can participate.

In addition, if auctions are held frequently, the cartel can rely on threats of expulsion from the ring, promptly reversing to competitive bidding to sustain collusion. Then, short-run gains to cheating must be weighed against the discounted loss of further profits, adjusted by the probability of inducing punishing behavior. Instead, infrequent competition hinders collusion as deviations can be punished only in the distant future.

When considering the bidding frequency, one must look at the various markets in which competitors are active as multi-market contacts can facilitate collusion. Firms that meet in more markets interact more frequently and can, therefore, level the asymmetries that may arise in a single market.

2.3   The Hardships of Bid-Rigging

Most cartels encounter operational problems. First, the ring must reconcile the disparate interests of its members and devise some mechanism for dividing the spoils. In doing so, the ring must overcome the adverse-selection problem: each member has private information (e.g., willingness to pay or costs) that she can disguise to argue for a bigger share of the "pie." Second, an agreement is ineffective

without some way of enforcing it. Since collusive agreements are not legally binding, they must be designed to be self-enforcing. Third, collusion contains the seeds of its own destruction. The high profits earned in an industry prone to successful collusion attract new firms into the industry, and the competition from those new entrants then tends to disrupt the collusive arrangement. Last, the ways in which a cartel deals with these problems often facilitates the detection of the scheme by the antitrust agencies.

2.3.1 The Problem of Private Information

In order to collude, bidders must devise a mechanism to select the designated winner and the winning bid. A ring's problem is then to devise a mechanism to divide the spoils. The choice of such mechanisms depends on the nature of the ring and the characteristics of its members.

If the ring members are symmetric (e.g., their costs or valuation are drawn from the same distribution), a bidding ring's internal allocation problem is much simpler. The selection of the ring representative does not matter if all members value the item identically. In these situations, the ring may agree to allocate equal shares of the collusive surplus to each ring member. Given this sharing rule, ring members have no incentive to misrepresent their information. The problem with such agreements, however, is that the expected payment to ring members may not exceed the amount they can expect to earn (conditional on their information) by bidding alone in the seller's auction. A bidding ring in a common value auction may also face a moral hazard problem: each member has an incentive to free-ride on the information gathering efforts of other members. All these difficulties may explain why collusion appears to be less frequent in common value environments than in environments where bidders' intrinsic valuations differ.

When, instead, some members of the ring are economically stronger than others (e.g., have lower costs or higher valuations), as is most likely the case, the choice of the decision rule that assigns low-bidding privileges and loser transfers will not be as trivial. In this circumstance, ring members will face an additional adverse selection problem: they do not know each other's valuations, or, in the case of procurement, they cannot observe each other's production costs.

Theoretical studies have focused primarily on private information as a source of efficiency challenges for colluding bidders. The gains from collusion captured by the ring are maximized when the winning bid is submitted by the ring member with the highest valuation or lowest cost in a procurement setting. However, ring members are reluctant to disclose their true valuations because that undermines their ability to claim rents when the ring divides the collusive gain. Self-interest motivates cartel members to misreport information disclosure and causes cartels to make inefficient output decisions. To

overcome this adverse selection problem, the ring has to design an efficient and incentive-compatible mechanism to designate the winner and divide the collusive profits.

McAfee and McMillan (1992) analyze all-inclusive bidder cartels at first-price sealed-bid auctions and conclude that, given the asymmetry of information, identical bidding (e.g., bidding the reserve price) is the best a weak cartel, unable to make monetary transfers, can do. This is because, in the absence of side-payments, incentive compatibility requires that the good be awarded stochastically, with each member having an equal probability of winning. Any attempt to select the highest-value bidder generates incentives for the bidders to misreport their valuations.

The possibility of making side-payments can help bidders solve the problem of private information. Indeed, Graham and Marshall (1987) show how a strong all-inclusive cartel can typically solve this issue by holding a pre-auction knockout to induce members to reveal their private valuations. A pre-auction knockout is an illicit auction conducted among ring members before the official auction, in which the members bid for the right to be the sole bidder (or the only serious one) in the official auction. By holding a pre-auction knockout, cartels can achieve full efficiency: the bidder who bids the highest amount wins the right and makes monetary transfers to the other bidders based on the bids submitted by them.

2.3.2 *Internal Enforcement and Detection of Deviant Behavior*

Even if firms are able to agree on a mechanism to share the spoils, collusion still entails a second fundamental problem, that is, a collusive scheme cannot be sustained in the absence of an appropriate enforcement device. While bidders can increase their total surplus by agreeing to compress bidding, designated losers may find it in their private interest to deviate unilaterally from the coordinated strategy and reap a one-shot windfall profit. Obviously, due to the illegal nature of ring formation, collusive agreements are non-binding, thus firms cannot rely on the legal system to enforce their illegal agreement. Therefore, they are bound to use self-discipline, that is, a market mechanism that punishes defections.

In markets that last a single period or have a brief duration, the temptation to cheat is inexorable: unilateral deviation from non-Nash equilibrium actions is profitable, at least in the short-run. Repeated interaction is usually necessary to overcome the temptation to cheat because repetition gives ring members the chance to monitor each other's market conduct and punish secret price cutting.

When suppliers are long-run competitors, the enforcement needed to ensure that the members comply with the ring mechanism can come from one of two sources. First, the ring may hire an enforcer who punishes any deviating bidder – an organized-crime approach. The alternative avenue is to appeal to

a grim trigger strategy in an infinitely repeated auction context (Abreu et al., 1990). A deviating bidder can be threatened with non-cooperative bidding in all future auctions should she win the current auction when the mechanism dictated otherwise. Thus, if the present value of short-run gains from a deviation is lower than the present value of the long-run losses caused by the subsequent bidding war, each firm would find it rational to never deviate from the collusive scheme. This threat will be sufficient to deter deviations if discounting is sufficiently low.

The inability to detect deviant pricing by ring members is then a fundamental challenge to cartel stability.

2.3.3 *Threat of Entry and Detection by Antitrust Authorities*

If firms succeed in raising prices above competitive levels, thereby earning high profits, then they invite entry into the industry. As previously discussed, entry hinders the stability of collusive agreements. Additionally, if there is entry, and the entrants are not a party to the conclusive agreement, the non-inclusive nature of the ring may lead to evidence of its existence as outsiders can serve as a benchmark for comparison. Porter and Zona (1993) show how non-inclusive bidding rings can be easier to detect by comparing complementary bids by a ring from non-winning bids submitted by the competitive fringe. In the procurement of highway paving contracts in New York, a subset of firms participated in pre-auction meetings in order to assign low bidding privileges. The collusive scheme was supported by complementary bids above the low bid. Porter and Zona found that the ranking of the bids submitted by non-ring members was related to observable cost factors such as capacity and a measure of capacity utilization – the backlog of contracts recently won. In contrast, the order of the higher bids submitted by ring members was not correlated with the same cost measures.

The problem of detection is straightforward. A bidding ring wants to avoid the detection by antitrust authorities that, given the illegal nature of the agreement, will impose hefty sanctions on its members. At the same time, a ring wants to avoid the detection by the contracting authorities who can alter the selling mechanism in response (e.g., the auctioneer may raise the minimum bid in an auction, decrease the maximum price in procurement, and keep bids secret to make it harder for the ring to maintain discipline). If the ring is not all-inclusive, it may wish to keep its presence unknown to rival bidders that can suffer from the ring formation.

Rings must also keep in mind that the manner in which they decide to deal with the operational problems that arise from the implementation of the collusive mechanism may facilitate the detection

of the scheme by antitrust agencies. For instance, transfer payments immediately after the auction improve the stability of a cartel, yet they also increase the probability of detection.

3. COLLUSION AND THE TYPE OF AUCTION

Economic theory shows that the vulnerability of auctions to bidder collusion depends in part on the specific auction format adopted by the auctioneer.

Moreover, one auction format may be more or less susceptible to collusion depending on (i) the details of the auction rules (e.g., reserve price, information disclosure policy, bid improvement rule), (ii) the auction environment (e.g., whether communication and side-payments are available, the extent of asymmetry among members, and the heterogeneity of the objects being sold), and (iii) the cartel's ability to enforce its members' bids by adopting a bid coordination or bid submission mechanism and to collect payments from its members (weak or strong cartel).

3.1 Dynamic vs Sealed-Bid Auctions

Compared to sealed-bid auctions (including first- and second-price auction), dynamic auctions (including English and Dutch auctions) are more susceptible to collusion. A dynamic auction makes collusion more likely because a potential defector faces the threat of immediate retaliation by the designated winner.

Indeed, trigger strategies work better in dynamic auctions than in sealed-bid auctions because the opportunity for the ring to respond to deviant behavior comes immediately, while the auction is still in progress. Any member who is intended to offer a lower price, thus deviating from the collusive agreement, cannot do so without triggering an immediate response from the designated winner. This would, indeed, push the price down so that the defecting firm cannot gain from deviation. In a sealed-bid competitive tendering, once a bidding ring identifies the designated winner, all other bidders must refrain from bidding or submit phony bids, while the designated winner submits a bid above her costs. In this kind of format, a deviation is more likely to occur since the shading of the bid by the designated winner gives a hypothetical defector a higher chance to win by undercutting the cartel, as the winner cannot react immediately.

Another major area of concern of practical auction design is to attract bidders since an auction with only a few bidders runs the risk of being unprofitable for the auctioneer and potentially inefficient. Dynamics auctions are often particularly inadequate in this respect since they can allow some bidders to deter entry or depress the bidding of rivals. In a dynamic auction, there is a strong presumption that

the firm that values winning the most (the lowest-cost firm) will be the eventual winner because even if it is underbid at an early stage, it can eventually rebut any opposition. As a consequence, other firms have little incentive to enter the bidding and may not do so if they have even modest costs of bidding[1].

From the perspective of encouraging more entry, the merit of a sealed-bid auction is that the outcome is much less certain than in a dynamic auction. An advantaged bidder will probably win a sealed-bid auction, but it must make its single final offer in the face of uncertainty about its rivals' bids, and because it wants to make a profit, its sealed-bid will not be the maximum it could be pushed to at an ascending auction. So "weak" bidders have at least some chances of victory, even when they would surely lose a dynamic auction (Vickrey, 1961). For this reason, potential entrants are likely to be more willing to enter a sealed-bid auction than a dynamic auction.

3.1.1 "In-Auction" Collusion

Dynamic auctions for multiple contracts are particularly susceptible to the so-called "in-auction" collusion. When objects are marketed simultaneously, bidders can observe the tentative prices on all of the objects, thus understanding which aggregation is the best value. In order to improve efficiency, by allowing bidders to switch from lost object to a substitute or to stop bidding on a complement, and promote price discovery, auctioneers may rule out that the bidding procedure must remain open until no new bids arrive on any object (a simultaneous closing rule). Yet, it has been noticed that this kind of practice is significantly vulnerable to tacit collusion. Moreover, through this kind of format, bidders are enabled to observe each other's bids, coordinate the collusive scheme, and enforce punishments in case of defections. Some of the communication devices used by bidders used to signal their strategies include (i) code bidding, (ii) jump bidding, and (iii) bid withdrawals.

Code Bidding. Bidders can use trailing digits to encode messages in their bids and communicate their intentions. In different FCC simultaneous ascending auctions, some bidders used the last three digits to disclose their identities, to signal an object of special interest, or the object on which they were punishing competitors. Cramton and Schwartz (2000) and Klemperer (2002) give many

---

[1] Wighton (1995) provide as example Glaxo's takeover of the pharmaceutical company Wellcome in 1995. After Glaxo's first bid of 9 billion pounds, Zeneca considered an offer of around 10 billion pounds, while Roche expressed its willingness to offer 11 billion pounds. However, the cost of bidding was in the tens of millions of pounds and both Zeneca and Roche thought that Glaxo valued Wellcome' takeover a little more than them. Eventually, neither Roche nor Zeneca entered the bidding, and Wellcome was sold at the original bid of 9 billion pounds, a billion or two less than its shareholders might have received. Wellcome's CEO admitted that "there was money left on the table."

examples, including a multi-license US spectrum auction in 1996. During the auction, US West was competing vigorously with McLeod for a license in Rochester, Minnesota, identified by the FCC as lot number 378D. Although most bids in the auction had been in exact thousands of dollars, US West bid $313,378 and $62,378 for two licenses in Iowa in which it had earlier shown no interest, overbidding McLeod, the uncontested high-bidder for those licenses. McLeod understood that it was being punished for competing in Rochester and dropped out of that market.

Jump Bidding. A bidder can use jump bids as a signal of a low cost (or high valuation), causing other bidders to drop out earlier. This may depress the buyer's savings.

Bid Withdrawals. Bid withdrawals can be used as warnings or as part of retaliation or cooperative strategies, where bidders attempt to split objects among themselves.

3.2   Lowest vs Second-Lowest Auctions

A key to understanding the difference between auction formats is the presence or absence of shading by the bidder representing the bidding ring. At a first-price sealed-bid auction, the payoff from winning equals the gap between a bidder's valuation of winning and her bid. The bidder gets no profit unless she shades her bid below her valuation. But when the highest-valuing cartel member lowers her bid, the opportunity is created for deviant behavior by other non-highest-valuing cartel members. The need to shade the winning bid at a first-price auction makes it more difficult for a ring to detect and punish defectors, thus jeopardizing the stability of a cartel. To secure a collusive gain at a second-price auction, the highest-valuation bidder acts exactly as he would have noncooperatively. The gain comes from the suppression of bids by all members except the bidder with the highest value. Outbidding the designated winner in a second-price auction means facing a loss. In a second-price auction, there is no opportunity for profitable deviant behavior by ring members, thus it follows that collusive mechanisms are more stable.

Turning to procurement, in a lowest-price competitive tendering, the collusive agreement would call the most efficient firm (lowest-cost firm) in the ring to submit a price offer equal to the reserve price while other ring members do not participate. Alternatively, the most efficient firm may submit a bid marginally below the reserve price while other ring members submit cover bids equal to the reserve price. In a lowest-price competitive tendering, the most efficient firm bids an amount equal to or marginally below the reserve price, so it is still possible that a defector slightly undercuts the collusive price and makes a positive profit. A hypothetical defector still has the possibility of making positive profits since the price set for the auction is equal or marginally below the reserve price.

In a second-lowest price competitive tendering, instead, the most efficient firm would submit a price offer equal to its production cost while other members submit offers equal to the reserve price. In this

context, it is not profitable for a ring member to defect from the collusive strategy since this would require undercutting the most efficient firm and would result in negative profits since the awarding price coincides with the marginal cost of the most efficient firm. Hence, a second-lowest price competitive tendering is highly exposed to the risk of collusion.

Despite these properties, there is empirical evidence for collusive agreements also in first-price sealed-bid procurement (see, e.g., Pesendorfer 2002, who investigates bid-rigging in the school milk market in Florida and Texas during the 1980s).

3.3 Simultaneous vs Sequential Auctions

In the case of a sealed-bid auction, a sequential format is more likely to enhance collusion than a simultaneous one, and it does so in two different manners. In order to describe these, it is assumed that, after each object has been awarded, there is a perfect disclosure of information. This assumption is realistic, considering that it happens in many real-world sequential competitive tendering. The first setback of a sequential tendering procedure is linked to the ability of ring members to identify defections and retaliate faster within the same sequence. This clearly limits the incentives and the short-term gains bidders have when undercutting the cartel, enhancing the sustainability of the collusive scheme in the case of a simultaneous format. If firms are asymmetric, a sequential procurement improves the viability of collusion because a ring can minimize the maverick's (that is, the firm with the highest bargaining power) incentive to defect by allocating to her the last object in the sequence.

In the simultaneous format, multiple contracts (or lots) are procured at the same time, with the price determined on each of them independently. When it comes to dynamic auctions, it has already been discussed above how a simultaneous format is prone to "in-auction" collusion as bidders can use communication devices to signal their intentions and tacitly agree on the allocation of contracts[2].

---

[2] Jehiel and Moldovanu (2001) analyze a case of "in-auction" tacit collusion. In 1999, Germany sold ten blocks of spectrum by a simultaneous ascending auction with the rule that any new bid had to exceed the previous high bid by at least 10 percent. Only two credible bidders participated in the offer, Mannesman and T-Mobil. Mannesman's first bids were 18.18 million deutschmarks per megahertz on blocks 1-5 and 20 million deutschmarks per megahertz on blocks 6-10. Note that 18.18 plus a 10 percent raise equals approximately 20. T-Mobil interpreted Mannesman's first bid as an offer. It understood that if it bid 20 million deutschmarks per megahertz on blocks 1-5 but did not bid on blocks 6-10, the two companies would then live and let live with neither company challenging the other on the other's half. And this is exactly what happened. The auction closed after just two rounds with each of the company acquiring half the blocks for the same low price.

3.4   One-Shot vs Repeated Auctions

A fundamental matter in the theoretical analysis of bid-rigging is stability. A collusive agreement cannot be sustained in the absence of an appropriate enforcement device, such as side-payments or punishments. Short of such a device, bidders have an incentive to lie about their valuations or deviate from the collusive scheme.

In a sealed-bid auction, the extent of collusion is tied to the availability of side-payments and monetary transfers. It is well known that, in the one-shot auction, if the cartel members can administer side-payments, then they can achieve efficient collusion and pay reserve price to the seller (see, e.g., Marshall & Marx 2012, Che et al. 2018). In the absence of side-payments, collusion at a one-shot sealed-bid auction is difficult to sustain, as defection is difficult to detect and punish.

The requirements for successful collusion are that bidders should believe that the auction will be repeated regularly, be patient, they should plan to participate in the cartel for some time into the future, and they should be patient enough. At an oral auction, these requirements are less relevant because collusion can be sustained even though some bidders are short-term and impatient.

A frequently repeated auction market is particularly vulnerable to collusion because the repeated interaction among bidders expands the set of signaling and retaliation strategies available to them.

Repetition setting ensures the existence of many collusive equilibria even without monetary side-payments because strategies in which current losers are rewarded in future auctions can provide sufficient incentives for bidders to cooperate. Continuation payoffs can play the role of side-payments. The bidders have incentives for truth-telling through a proper choice of continuation payoffs, and thus appropriate adjustment of continuation payoffs is essential for the enforcement of the collusion scheme.

The alternative avenue to ensure that the members comply with the cartel mechanism is to appeal to retaliatory strategies (grim trigger strategies) in an infinitely repeated auction context. A deviating bidder can be threatened with non-cooperative profit levels in all future auctions should he win the current auction when the collusive mechanism dictated otherwise. This threat will be sufficient to deter deviations if the discount factor is sufficiently low.

Fudenberg, Levine, and Maskin (1994) draw a famous result known as the Folk Theorem, which establishes the link between repetition and collusion. The Folk Theorem (so named because it was known to many economists before being formally stated) holds that if bidders at an auction are sufficiently patient, if auctions are repeated indefinitely, and if enough information is revealed to bidders at the end of each auction, then collusion is an equilibrium. The value of repetition is that it discourages cheating. A potential cheater can earn a short-run gain from cheating until her cheating is detected. Detection leads to punishment by the cartel and the loss of the long-term benefits from

collusion. For a sufficiently patient bidder, the long-term gains of collusion will outweigh the short-term gains from cheating, and cheating is deterred.

3.5 Common Value vs Independent Private Value Auctions

Understanding the information environment of the underlying market supports the tender design process as different environments can have different implications for bidding and collusion.

The economic literature on auctions typically distinguishes two types of information environments: independent private values (IPV) and common value. In an IPV auction, each bidder knows her own value but not those of other bidders. In a common value auction, the bidders share the same valuation of the item up for auction, but that valuation is unknown to the bidders before the auction. Prior to bidding, bidders receive disparate private signals about the true value of the object. For example, similarly-situated oil exploration companies would share common values for rights to explore for oil on a particular tract, but they would receive different private signals about the value of the tract from their geologists.

The existence of the "winner's curse" in common value auctions is a notable strategic difference between the two information environments. The label "winner's curse" arose because unsophisticated bidders were cursed by winning at common value auctions if they failed to adjust their bid downward to account for the "bad news" of winning. Winning is bad news in the sense that the winning bidder has received the most favorable signal about the value of the auctioned item. A sophisticated bidder avoids the winner's curse by recognizing that winning means all other bidders received less favorable signals and adjusting her expected valuation and bid accordingly. In contrast, winning does not reveal information in the IPV environment because valuations are independent; therefore, there is no winner's curse.

In the context of common value auctions, the winner's curse depresses bidding and auctioneer's profits more at sealed-bid auctions – as it will cause everyone to bid cautiously – than at dynamic auctions, where bidders are able to extract information from the rivals' bids, mitigating the effects of the winner's curse. Weaker firms must be especially cautious at common value sealed-bid auctions since they must recognize that they are only likely to win when they have overestimated the value. An advantaged firm, instead, can be less cautious since beating very cautious opponents need not imply one has overestimated the object's value. Because the winner's curse affects weak firms much more than strong ones, the advantaged bidder wins most of the time, and because its rivals bid extremely cautiously, it also generally pays a low price when it does win.

Unfortunately, neither theoretical nor empirical research on bidder collusion points to strong distinctions between common and independent private values. Nevertheless, one can present some

useful insights into the nature of bidder collusion that hinge on the distinction between the two information environments.

As already stated, the nature and feasibility of collusion depend, among other things, on the private information held by cartel members. Bids and within-ring transfers will often depend on the valuations reported by ring members to the ring. An efficient bidding ring typically extracts private information from ring members to assure that the winning bidder has the highest value for an auctioned item or the lowest production cost in a procurement setting. If cartel members truthfully reveal their private information to each other, this greatly aids the cartel's ability to maximize the gains from collusion. But the desire of cartel members to maximize their individual profit discourages truthful revelation and causes cartels to make inefficient output decisions. Information gathering necessary for efficient collusion is harder to achieve in common value settings than in private value settings.

In IPV auctions, the problem of having ring members reveal their true valuation can be solved by holding an illicit auction within the ring. McAfee and McMillian (1992) show that where side-payments are feasible and ring members are ex-ante symmetric, the optimal ring mechanism can be implemented using a first-price sealed-bid knockout auction prior to the official auction. The winner in the knockout gets the right to bid in the auction, and the revenue raised is shared equally among the ring members.

In a common value auction, a single bidder with better information than other bidders enjoys an informational rent. This rent provides an incentive to invest in information gathering. Of course, a well-informed bidder may be reluctant to share her advantage by colluding with a poorly informed bidder but may be eager to collude with another well-informed bidder. If two bidders both have access to the same information, then they will dissipate all of their informational rent if they bid against each other at the auction; they can potentially preserve their rents by colluding.

At the other extreme, the winner's curse may be so severe that poorly informed bidders get zero expected profit, and they are discouraged from participating in the auction. Collusion by poorly informed bidders can thus provide social benefits. If poorly informed bidders can improve the quality of their information by bidding jointly, then they can mitigate the winner's curse, which is a particular problem for poorly informed bidders. The main social benefit is more aggressive bidding, which increases revenue to the auctioneer. The revenue gain is likely greatest when the bidders would not have participated in the auction without the joint bid.

Hendricks et al. (2008) point out that, in common value auctions, the ring can increase aggregate surplus by providing a way to aggregate bidders' signals of the value of the object. However, some bidders may prefer a non-cooperative auction, as the efficiency of collusion works to the advantage

of bidders with low signals, but against a bidder with high signals and, as a result, the latter may refuse to join the ring. More precisely, bidders who have received a high signal may have an incentive to deviate from collusion because the cost of making payments to fellow ring members outweighs the benefit of a smaller payment to the auctioneer. The intuition is that in an efficient ring mechanism, a buyer with a low signal does not have to worry about the winner's curse and is, therefore, more aggressive in demanding payment for revealing her private signal. As a result, a buyer with a high signal ends up paying less to the seller but more to the other bidders. The trading inefficiency caused by the winner's curse can be an important obstacle to collusion in common value auctions. As a result, it may be more difficult to collude at common value auctions than at IPV auctions.

4. FIGHTING BID-RIGGING IN PUBLIC PROCUREMENT

Contracting authorities in public procurement rely on competition to ensure that their budgets will be spent in the most effective and efficient way. In public procurement, competition promotes efficiency, ensuring that goods and services offered to public entities more closely match their preferences. Competition produces benefits such as lower prices, improved quality – more generally, better "value for money" – increased innovation, and higher productivity to the benefit of end consumers, users of public services, and taxpayers. However, the formal rules that govern procurement, the design of the tender itself, and the way in which a tender is carried out can hinder competition and sustain collusive arrangements or bid-rigging conspiracies between competitors.

Collusion in public procurement is among the most serious violations of competition law that injures the public purchaser by raising prices and restricting supply, thus making goods and services unavailable to some purchasers and unnecessarily expensive for others, to the detriment of end-users and taxpayers. Careful consideration of the rules that govern the public procurement process and their impact on the likelihood of collusion may contribute significantly to the fight against anti-competitive behavior.

In 2012, the OECD Council formally recognized that some public procurement practices might inadvertently promote collusion even when they are not intended to lessen competition. The Recommendation on Fighting Bid Rigging in Public Procurement calls for governments to assess their public procurement practices at all levels of government in order to promote more effective procurement and reduce the risk of bid-rigging in public tenders

4.1   Ex-Ante Tender Design

The strong tendency to emphasize public policy responses to collusion overshadows the importance of precaution-taking efforts of sellers and procurers to forestall or inhibit successful coordination. Deterring bid-rigging and making its occurrence less likely by putting in place preventive measures is essential for procurers to deal with the practice.

4.1.1   The Choice of the Auction Format

Good auction design complements antitrust enforcement. Yet, as we have seen in the previous chapter, good auction design is not "one size fits all," but rather, it must be sensitive to the characteristics of the context.

A private sector auctioneer will typically design an auction to maximize expected revenue. Discouraging collusion aids revenue maximization but an optimal auction sometimes tolerates an increased risk of collusion to encourage more aggressive bidding. For example, an English auction may be preferred over a sealed-bid auction in a common value environment because the winner's curse depresses revenue more at a sealed-bid auction than at an English auction. An auctioneer might reasonably conclude that the greater risk of collusion from the use of the English auction would have a smaller expected impact on revenue than the expected impact of the winner's course (Milgrom & Weber, A Theory of Auctions and Competitive Bidding, 1982).

The government instead should be conscious of the welfare losses from taxation and, therefore, should strive to maximize expected social welfare, maximizing revenue at auctions and minimizing costs at procurements. But the government should also aim for efficiency, allocating items to the highest valuation bidders and awarding contracts to the most efficient supplier. Sometimes, allocative or productive efficiency clashes with revenue maximization or cost minimization. For example, in an asymmetric IPV auction, certain bidders draw their valuations from more favorable distributions than other bidders. The strong bidders tend to shade their bids more than the weak bidders, so it is possible for a weak bidder with a lower valuation to win a sealed-bid auction. In contrast, the bidder with the highest valuation always wins at an oral auction; therefore, the oral auction achieves greater allocative efficiency. Nevertheless, the sealed-bid auction may yield greater expected revenue.

In most situations, the choice of the auction format is likely to involve an important trade-off among revenue, efficiency, transparency, and other concerns. A first major set of concerns for public auction design involves the risk that participants may explicitly or tacitly collude to avoid bidding up prices. The conclusion of the literature surveyed in this paper is that auction designers who are especially worried about collusion should adopt the first-price sealed-bid format rather than the English format.

Recall that bid-rigging agreements are stable in English auctions since no ring member has an incentive to deviate from the scheme as the highest-valuation bidder remains available to rebid up to his valuation. In contrast, in first-price sealed-bid auctions, the ring must reduce its bid below the highest valuation of its members in order to earn a positive expected profit. This reduction in the bid gives ring members the incentive to deviate from the agreement by outbidding the cartel. Additionally, tacit collusion is particularly difficult at sealed-bid auctions since firms are unable to use the bidding to signal their intentions; "in-auction" collusion, instead, is common in dynamic auctions.

The dominance of the first-price sealed-bid auction over the English auction, however, is unwarranted and mainly based on analyses of private value, single-object auctions. In common value auctions or simultaneous auctions, the lack of transparency of the sealed-bid format can lead to inefficient allocations and lower revenues. An English auction is most likely to achieve allocation efficiency since a bidder with a higher value always has the opportunity to rebid to top a lower-value bidder who may initially have bid more aggressively. In common value auctions, an English auction may be preferred over a first-price sealed-bid auction because, by allowing price discovery, it mitigates the effects of the winner's curse and promotes more aggressive bidding. Bidders will be more comfortable with their own assessments and less cautious, often raising the auctioneer's revenues. Of course, a similar effect could also be achieved in sealed-bid auctions if the contracting authorities produce and disseminate information about the value of the item at stake. In simultaneous auctions, if there are complementarities between the objects for sale, an English auction makes it more likely that bidders will win efficient bundles as they can learn about their opponents' intentions.

A number of methods to impair signaling devices and make dynamic auctions more robust are clear enough. For instance, code bidding and jump bidding become ineffective if bidders are forced to bid round numbers, and the exact increment or an upper bound to the bid increase is specified. In order to reduce the use of bid withdrawals, the auctioneer may either limit their number or make them costly. Keeping secret the number of bidders remaining in the auction also makes collusion harder.

While these measures can be useful, they do not eliminate the risks of collusion or of too few bidders. An alternative is to choose a different type of auction. A solution to the dilemma of choosing between the English and first-price sealed-bid auctions is to combine the two into a hybrid, the Anglo-Dutch auction, which was first described by Klemperer (1998). In an Anglo-Dutch auction, the auctioneer begins by running an ascending auction in which the price is raised continuously until all but two bidders drop out. The two remaining bidders are then required to make a final sealed-bid offer not

lower than the current asking price, and the winner pays the winning bid[3]. Weak bidders might be unwilling to enter a pure ascending auction against a strong bidder, who would be perceived as an indisputable winner, but the sealed bid at the final stage induces some uncertainty. Thus, weak bidders will be willing to take part in the auction knowing that they have a chance to make it to this final stage. Because of the increase in the number of participants, the price may easily be higher even by the end of the first ascending stage of the Anglo-Dutch auction than if a pure ascending auction were used. The Anglo-Dutch auction also captures the other advantages of a sealed-bid auction. Collusion will be discouraged because the final sealed-bid round allows potential ring members to cheat without fear of retaliation and because the Anglo-Dutch auction eliminates the stage of the ascending auction when just two bidder remains, at which point the rules against collusion and predation may not be credible. But the Anglo-Dutch auction also captures much of the benefit of an ascending auction. It will be more likely to achieve allocation efficiency than a pure sealed-bid auction, both because it directly reduces the number of bidders allowed into the sealed-bid stage and also because the two finalists can learn something about each other's and the remaining bidders' information about the value of the object by scrutinizing their behavior during the ascending stage.

LOTS DESIGN

Contracting authorities must consider whether to divide the procurement into smaller lots. On the one hand, dividing a large procurement contract into smaller, local contracts may be optimal for procurement agencies because of the transportation costs linked to geographical dispersion. Additionally, smaller lots are palatable even for small and medium-sized enterprises (SMEs), increasing competition. On the other hand, often, certain parts of a contract cannot be efficiently split because complementarities would suggest advantages from bundling them.

But the division into lots has other important effects. The division into lots also determines how a procurement contract can be split among potential competitors, hence how easy it is for bidders to achieve and sustain tacit or explicit collusive agreements. It is for procurement officials to understand the market structure so as to design lots to minimize the risk of collusion.

For a given contract value, the higher the number of lots, the easier the firms' attempt at sharing the collusive profit. When it comes to deciding the number of lots into which a supply contract should be divided, Krishna (2002) and Milgrom (2004) advise that the number of lots should be lower than the

---

[3] The Anglo-Dutch auction shares some similarities with eBay auctions. eBay uses ascending auctions, but with a fixed ending time so that many bidders often bid only in the last few seconds in essentially sealed-bid style. eBay attracts far more bidders than its rival, Yahoo, which runs a standard ascending auction with a traditional procedure that does not close the auction until there have been no bids for 10 minutes.

number of potential participants. This rule is indeed useful but is not unconstrained. Collusive agreements may be implemented through rotation schemes or multi-market sharing agreements even if the number of lots falls short of the number of bidders. Not to forget that collusive gains can also be shared through side transfers and profitable subcontracting. Klemperer (2004) adds that the number of lots should be at least one more than the number of incumbents. This provision may encourage the participation of new bidders and thus foster competition, particularly so if the most valuable lot is reserved for new participants[4].

The lot size is another important variable for fighting collusion in procurement. A cartel aims at allocating lots among its members so as to match each member's bargaining power in the collusive agreement, which, in turn, depends upon the level of profit each firm would yield in a purely competitive scenario. If colluding firms' are quite symmetric, then they will seek to allocate fairly similar "slices" of the contract among themselves – the opposite is true for asymmetric firms. As a general rule, lot sizes should not reflect the suppliers' market structure (Engelmann & Grimm, 2009). If potential bidders have asymmetric market shares, costs, or capacity, a division of the contract in homogeneous lots may constitute an anti-collusive device. Conversely, if potential bidders have symmetric market shares, costs, or capacity, a division of the contract in heterogeneous lots may discourage collusion as coordination for agreeing on specific "pie-sharing" becomes too complex.

4.1.2   Be Informed about the Relevant Market

Before designing the tender process, public procurers at all levels of government should understand, in co-operation with sector regulators, the general features of the relevant market to determine whether it is particularly prone to collusion. It is important for procurement officials to collect information on the range of goods and services available in the market that would suit the requirements of the purchaser, as well as information on the potential suppliers and their costs. Procurers should also be aware of recent price changes, prices in different geographic areas, and prices of substitute products, and they should be informed on past tenders for the same or similar products or services.

---

[4] For example, Grimm et al. (2009) analyses the British UMTS auction held in 2000. At the beginning only four licences were envisaged; however, the market was shared by exactly four incumbents. Weaker competitors would have been inevitably deterred from entering the auction, and a non-competitive one-lot-each outcome was likely. Therefore, the number of licences was increased from four to five and each bidder was allowed to win only one licence. Moreover, the most valuable licence was reserved to new participants to encourage the entry of weaker bidders. The tender was a success and government raise around 23 billion pounds.

4.1.3 Maximize the Potential Participation of Genuinely Competing Bidders

Effective competition can be enhanced if a sufficient number of credible bidders are able to take part in the tender and have an incentive to compete for the contract. To ensure a sufficient number of reliable participants, the contracting authority should avoid unnecessary restrictions that may be discriminatory and pose unreasonable obstacles to participation. While bid qualifications can help eliminate those firms that are unqualified for the task, careful judgment should be exercised so as not to discourage qualified bidders. Unnecessary restrictions on size, composition, or nature can reduce the number of bidders. For instance, the tender specification may provide for minimum requirements that are proportional to the size of the procurement contract. Additionally, to create conditions for smaller firms to take part in the procedure, contracting authorities may allow bids on certain lots or objects within the same procurement, rather than bids on the whole contract only.

To maximize the pool of participants, procurements should reduce constraints on foreign participation, allowing undertakings that implement the economic activity in other geographic regions to participate in the procedure. Tender specifications and terms of reference should avoid a specific description of the products or services to be procured, but rather should be designed with a focus on functional performance – what is to be achieved rather than how it is to be done – in order to attract the highest number of bidders, including suppliers of substitute products, as alternative sources of supply make collusive practices more difficult.

BIDDING CONSORTIA

In competitive procurement, there is the possibility for two or more undertakings, that are actual or potential competitors, to come together and jointly submit a bid. This contractual relationship is generally referred to as bidding consortium and has an ambiguous effect on collusion. On the one hand, bidding consortia serve purposes that enhance efficiency and hinder collusion, fostering competition by allowing participation of firms that would otherwise be excluded and promoting more aggressive bidding by certain participants. For instance, they may provide a mechanism for entrants to pair with firms with prior experience and may also facilitate entry into the industry by allowing small firms to overcome capital constraints. Consequently, per se illegality of joint bidding may be unwarranted. On the other hand, bidding consortia may be instrumental to anti-competitive agreements as they provide a way to disguise the distribution of the collusive profits that would otherwise be easily detected by competition authorities. In general, consortia of bidders may form for many legitimate reasons (e.g., qualification constraints, risk avoidance, capital pooling, and information sharing), and it may not be easy to discriminate between collusive and legitimate motives. The complex task of a procurer is then to devise rules on the admissibility of such contracts.

First, bidding consortia that are arranged very close to the date of the auction should be discouraged since they give no time for new entrants to emerge to threaten the new coalition. One view is that auction participants should generally be restricted to entities that exist when the auction is first announced, although exceptions would clearly be necessary.

Albano et al. (2006) provide an analysis of possible rules on the admissibility of a bidding consortium. They conclude that a bidding consortium might not be considered admissible if it is composed of firms having the economic capabilities and the resources necessary to individually supply the procured contract. They observe, however, that this condition is sufficient but not necessary. A bidding consortium can increase the efficiency of the procurement process even if its members have the capacity to participate in the tender by themselves because, by joining efforts, some firms may represent a more effective competitor. Thus, a bidding consortium should not be considered admissible when it does not improve the efficiency of less efficient participants. The implementation of this second condition might prove extremely difficult as it requires the demanding task of assessing the efficiency of a bidding consortium. A simpler rule, for instance, could bar a bidding consortium when its participants are the incumbent operators, the market leaders, or the winner of similar past procurements.

4.1.4 Tender Specifications

Drafting the tender specifications and terms of reference is a stage of the public procurement cycle particularly vulnerable to bias, fraud, and corruption. How requirements are written influences the number and type of suppliers that are prone to participate in the tender and, therefore, affects the success of the selection process. They should be drafted in a way to avoid bias (e.g., requirements that favor the incumbents or over-emphasize the importance of performance records) and should be clear and comprehensive but not discriminatory. The clearer the requirements, the easier it will be for potential bidders to understand them, and the more confidence they will have when preparing and submitting bids. However, clarity should not be confused with predictability. More predictable schedules and unchanging quantities sold or bought can facilitate bid-rigging schemes. It is therefore important to vary the scope and size of successive contracts by aggregating or disaggregating contracts as well as to vary the timing of tenders.

4.1.5 The Level of Disclosure

Transparency in procurement auctions for multiple contracts concerns mainly the amount of information disclosed to bidders across the different phases of the same tendering process.

Transparency requirements are essential for a sound procurement procedure to aid in the fight against corruption. Yet, they should be complied with by the contracting authority in a balanced manner in order to avoid the unfavorable effect of encouraging bid-rigging by disseminating more information than what is required. Indeed, collusion is more effective when the market is more transparent since a cartel can monitor its members' behaviors and punish defecting firms. Namely, dynamic auctions, where bidders learn about the participation and bids of their rivals in real-time, are more prone to bid-rigging than sealed-bid auctions. But, even in sealed-bid auctions, the seller can choose how much information to report before and after the auction. The less information the seller makes public, the harder it is for the ring to collude. A completely opaque disclosure policy that hides all information to bidders would make collusion difficult to sustain as each firm will be unable to observe its competitors' strategies. If the risk of collusion is high, the only effective disclosure policy is no disclosure, that is, keeping all information on winning bids and the identity of winners on each lot secret to all bidders. However, since public procurement agencies cannot afford a fully opaque disclosure policy owing to the risk of corruption, among all possible partial disclosure policies, publicly disclosing only the selling price may negatively affect the cartel's ability to detect and punish unilateral deviations. Again, in the context of public procurement, a partial disclosure policy that reveals only the selling price would be considered too opaque in terms of the risk of corruption it may generate. In this case, a buyer could still make collusion harder by postponing the disclosure. Nevertheless, the divulgation of sensitive trading information when announcing the results of a given procedure should always be avoided, as it could lead to future bid-rigging schemes.

A transparent procurement process also to the impact that facilitated communication among bidders has on the feasibility of bid-rigging. Whenever the formal rules governing public procurement make communication among competitors easy, there is an increased potential for collusion. It is, therefore, necessary for the auctioneer or procurement official to design the tender process in such a way as to reduce the opportunities for communication among bidders and make it difficult for a ring to achieve first-best profits. For example, collusive schemes can be discouraged by ensuring the anonymity of bidders during the course of the procedure (e.g., withholding the identity of bidders by using numbers, rather than names, to identify them), concealing their number and observing strict confidentiality with regard to the content of their bids.

Additionally, the use of pre-bid clarification meetings or in-person bid submission, which provides an opportunity for last-minute communication and deal-making among firms, should be limited, where possible, in favor of remote methods that guarantee the confidentiality of bidders' identities, such as electronic communications or telephone bidding.

4.1.6 *Scoring Rules and Selection Criteria*

The criteria for evaluating and awarding the tender, which often capture the value of the trade-off between quality and price, affect the intensity and effectiveness of competition. The choice of what selection criteria to use is not only important for the current contract but also in maintaining a pool of potential credible bidders interested in bidding on future contracts. It is, therefore, necessary to ensure that awarding criteria are chosen in such a way that credible bidders, including small and medium-sized enterprises, are not deterred unnecessarily.

The most elementary selection criteria evaluate bidders on the price offers submitted and award the contract to the lowest bidder. In this context, coordination on bidding strategies is less burdensome, but collusion is easier to detect. Moreover, the implementation of interdependent scoring rules such as bid average methods may further support collusive efforts. A bid average method may provide that the winner is the one whose bid is closest to and lower than the simple average of all submitted and valid bids. Alternatively, the geometric average may replace the simple average. In this case, the winning firm is the one whose bid minimizes the distance from the geometric average of all submitted and valid bids. Bid average methods facilitate collusion because the bigger the cartel, the lower the incentive of each member to deviate from the collusive agreement as each bid influences the average only marginally.

Whenever evaluating bidders on criteria other than price (e.g., the most economically advantageous tender criterion analyzed in the case study proposed in this paper), such criteria need to be described and weighted adequately in advance in order to avoid post-award challenges and reduce the risk of corruption. In this case, collusive outcomes may be uncertain if quality scores are partially unpredictable because of subjective quality dimensions. At the same time, under such criteria, it is difficult to distinguish truly competitive bidding strategies from collusive ones.

The extent to which the selection criteria are disclosed in advance of the tender closing can affect the ability of the bidders to collude. Transparent scoring rules are those that allow participants to compute their score before submitting their bids and coordinate their strategies on that basis.

Contracting authorities should make inquiries if the prices or bids do not make sense and reserve the right not to award the contract if they suspect that the bidding outcome is not competitive. For instance, contracting authorities should avoid splitting contracts between suppliers when faced with identical bids as they are a plausible indicator of bid-rigging.

4.1.7   Procurement Officials' Awareness About the Risks of Bid-Rigging

Professional training on bid-rigging is important to strengthen procurement officials' awareness of competition issues in public procurement. Bid-rigging may not be revealed by the results of a single tender. Often a collusive scheme is only noticeable when examining the results from a number of tenders over a period of time. Efforts to fight bid-rigging more effectively can be supported by storing information about the characteristics and bidding behaviors of past tenders and periodically reviewing them on the lookout for suspicious patterns.

Public procurers or competition authorities should also establish a complaint mechanism for firms and their employees to convey competition concerns and make use of mechanisms, such as a whistleblower system, to collect information on bid-rigging. Competitors are potentially good candidates to be effective private attorneys general in the anti-collusion realm because they are likely to have good information about collusion. Yet, antitrust law is cautious because competitors' incentives to bring suit may not align very closely with the social incentives to bring suit. To incentivize the deliberate self-report, competition authorities may grant immunity by means of leniency programs. Leniency programs award immunity or lower fines to individuals or corporations taking part in a cartel that spontaneously report timely information needed to prosecute competition law violations.

4.2   Ex-Post Screening

Despite the precaution-taking efforts of tender designers, bidders are often able to devise and put in place collusive schemes to limit competition. They do so when the expected gain from ring formation exceeds the expected loss caused by an antitrust conviction. Hence, the threat of severe sanctions (e.g., fines or debarments) may discourage bidders from forming colluding in the first place. The dissuasive effect of a sanction depends on its absolute level and the probability of being exposed to it. While procurers cannot affect the level of the public sanctions, they can affect the ring members' expected losses increasing the probability that a ring is discovered and convicted. Therefore, procurers should always be on the lookout for suspicious behavior.

The secrecy with which bid-rigging is conducted renders it difficult to discover its practice. There are certain indicators, however, which may at least create suspicion that the relevant undertakings took part in anti-competitive bid-rigging arrangements. The indicators of possible bid-rigging described below identify numerous suspicious bid and pricing patterns as well as suspicious statements and behaviors. The presence of one or more of these circumstances should not, on its own, be regarded as evidence of actual bid-rigging as, for many of the described situations, there might be a reasonable

explanation not related to the engagement of the undertakings in bid-rigging. Nonetheless, when suspicious bidding and pricing patterns are detected or when procurement agents hear odd statements or observe peculiar behavior, further investigation is required. Additionally, it is important to carefully record all information so that a pattern of behavior can be established over time.

4.2.1 Bids

In the case of bid-rigging, bids are often submitted by a smaller number of bidders than expected, or bids are submitted by bidders who are known to be unable to execute the work being procured. With a view to implementing the agreement for bid-rigging, usually, all participants in the cartel request the tender documentation from the contracting authority, but only a small number of them ends up submitting bids. In most cases, the bidders that submit cover bids either do not request the technical specifications of the project from the contracting authority or their bids do not include information that should have been provided.

Oftentimes, the cover bids are submitted by the bidder who represents the ring in front of the contracting authority. It is common practice for all the bids of the participants in bid-rigging agreements to be prepared by the same person or to be prepared jointly. In comparing such bids, contracting authorities should look out for certain similarities that could give rise to the suspicion of non-competitive bidding as the same typeface, stationery, terminology, spelling errors, miscalculations, and estimates of the cost[5].

4.2.2 Proposed Trading Conditions

To conceal bid-rigging, cartels usually implement cover bidding schemes that can result in a striking difference between the price offer of the lowest-bidder and those of the other bidders. On the other hand, however, bid-rigging may be manifested in submitting identical tenders or in offering prices that differ from one another by the same margins observed in other similar procedures partaken by the same undertakings.

---

[5] A collusive agreement between three firms in the procurement for medical equipments for the Safdarjung Hospital in New Delhi was discovered because of common typographical errors in the offers submitted by the firms. All three competitors miss-typed the word "of" as "o" and misspelled the word "overlapping" as "overelapping." Additionally, all the items under price schedule XIA (used for domestic goods) were wrongly included under price schedule XIB (used for foreign currency items). The font used for typing bids was also the same.

If for a relatively long period of time, the prices of goods and services purchased under similar public procurement procedures remain relatively stable, this may be an indication that a non-competitive level has been maintained manipulatively. The same conclusion could be drawn if a new participant in the market submits a bid that is drastically lower compared to the offers submitted by the traditional bidders for similar projects.

Additionally, suspicion could arise if bidders who implement their economic activity in the same geographic region where the work is to be carried out submit price offers which are higher than those of bidders operating in more remote regions. Other suspicious situations include sudden and identical increases in price by bidders that cannot be explained by cost increases, differences in the level of a certain supplier's bids on similar contracts, significant reductions from past price levels after a bid from a new supplier that may have disrupted an existing bidding cartel, and, in the case of public bids, offers including unusual numbers where one would expect a rounded number. This may indicate that bidders are using the bids themselves as a vehicle to collude by signaling preferences.

4.2.3   Cost Evaluation and Price Formation

In order to detect bid-rigging, the contracting authority may have hired experts to calculate in advance an estimate of the cost-oriented price offers which could be received for the service being procured. If the lowest submitted bid is considerably higher than the calculated cost price, this may raise suspicion of a collusive scheme. That being said, comparisons of winning bids and engineers' estimates of costs may be unreliable as the estimates may be unduly influenced by historical bid patterns, and so they may be an inflated measure of true costs.

The fact that some of the bidders hired the same consultants to prepare their price offers could also be interpreted as an indication of bid-rigging. Another possible sign of bid-rigging may be found in cases in which a firm has information on the price formation of another firm, or cases in which a firm provides in its offer a comparative analysis with "industry suggested prices," or "standard market prices," or a comparison with the price formation practices that are "industry price schedules."

4.2.4   Contacts Between the Participants in the Tender Procedure

Bidders seeking to enter into an agreement need to communicate among themselves and, in-so-doing may leave a trail of evidence behind. Such communication may be carried out on the phone, by e-mail, or more frequently during face-to-face meetings. These meetings occur most often at, or in association with, industry association meetings or other professional or social events. In some cases, after the award of the tender, bidders may attempt to split the extra profit that is earned through bid-

rigging. Sometimes the winning firm may pay the other bidders directly; however, most often, the collusive profit can also be passed on through lucrative subcontracts to do some of the work or to supply inputs to the project.

There is suspicion of bid-rigging if a firm unexpectedly withdraws from bidding and later appears as a subcontractor, or if the winner refuses to sign the contract and it is later to be found as a subcontractor of another bidder in the same public procurement procedure. Such subcontracting, however, needs to be distinguished from the cases in which the winning bid was submitted by undertakings that participated in the tender as a consortium or through establishing a joint undertaking, not prohibited by the law. Still, one must be aware of joint bidding, especially if one of the firms could have bid on its own, as joint bids can also be used to split profits. Sometimes procurement agents can infer that bidders are communicating if, for example, suppliers meet privately before submitting bids, regularly socialize together or appear to hold regular meetings, or if a company requests a bid package for itself and a competitor or submits both its own and a competitor's bid and bidding documents.

4.2.5 Suspicious Patterns in Consecutive Tenders

Some of the bid-rigging schemes devised by the undertakings may reveal themselves as a pattern over the course of many bids. A regular pattern of suspicious behavior over time is often a better indicator of possible bid-rigging than evidence from a single bid. It is, therefore, necessary to keep record of all the bids so that a pattern of behavior can be established over time.

For example, patterns could be observed when consecutive tenders are won by the same bidders or firms seem to take turns being the winning bidder. It is possible that one winning bidder stands out in relation to certain types and sizes of tenders, or it could be noticed a geographic allocation of winning tenders for which some bidders only win in certain geographic areas. Other patterns in consecutive tenders can be ascertained when given participants never win but keep participating, or when a certain participant rarely takes part in a tender but when it does, it always wins, or when the winning bidder repeatedly subcontracts the work to unsuccessful bidders.

While an established pattern may be more informative than a single bid, it is still far from constituting undisputable evidence of anti-competitive conduct. For instance, bid rotation or incumbency advantages, while consistent with a collusive agreement, are not in and of themselves evidence of collusion. Bid rotation may be the efficient outcome of a competitive bidding process when capacity constraints or decreasing returns matter. An extreme example of this would be binding capacity constraints. Firm cost heterogeneities then arise from backlogs of jobs in process. Zona (1986) that,

in repeated auction games where bidder's cost functions exhibit decreasing returns to scale, optimal Nash equilibria entail an alternating pattern of winners. Auctions tend to be won by firms with little or no backlog. Any inclination to view bid rotation patterns as per se evidence of collusive behavior is therefore unwarranted. Firms with idle capacity are more likely to win a contract, but having won the contract, they are less likely to win another until some existing contracts are terminated. Likewise, patterns reflecting incumbent advantage can reflect unobserved asymmetries among firms. Those who won contracts in the past may have done so because of location or other advantages that persist through time.

4.3   Econometric Methods to Detect Collusion

Detecting collusion and cartels have long been a primary concern of industrial organization economists. Concomitant with an increased focus on price-fixing and bid-rigging by antitrust authorities, economists began paying greater attention and worked to develop methods to identify collusive behavior in auctions. During recent years, econometric methods with the aim to detect collusive behavior in the bidding process have been developed. The statistical detection of bidding rings proceeds by constructing a model of the suspected ring and then comparing the observed bidding pattern with that of the modeled ring and a non-cooperative benchmark.

For instance, the Federal Trade Commission in Korea uses a Bid Rigging Indicator Analysis System (BRIAS) that automatically analyzes the bids received during all public procurement procedures, speeding up the process for identifying a cartel. BRIAS looks at data, including bidding prices as a ratio of the reference price, the number of participants, and the competition format, and applies a formula that generates a potential bid-rigging score. If above a certain threshold, this then suggests the need to collect more information, and an investigation is opened in cases where it is warranted.

Porter and Zona (1993) propose an econometric test to examine bid-rigging in procurements for New York highway paving contracts in the early 1980s. Their methodology is to detect differences in behavior between (known) ring members and non-ring members, taking full advantage of limited participation in the collusive scheme. The authors statistically detect the existence of cartel bidding in two ways. First, a Chow test reveals that the estimated bid functions of cartel bidders are statistically different from those of non-cartel bidders. Not only are the OLS coefficients different, but many of the coefficients in the estimated bid regression of cartel firms also do not have the expected sign. Second, a multinomial logit model of bid rankings reveals statistical differences among low and high-ranking bids among cartel bids but not among competitive bids. Comparing the rank distribution of bids submitted by the known ring and non-ring bidders, they find that the order of the less competitive ring bids is not explained by cost measures (e.g., capacity utilization), whereas the

order of less competitive non-ring bids is explained by the respective firms' cost measures. They conclude that the discrepancy between bid rankings and cost rankings is consistent with a cover bidding mechanism.

Bajari and Ye (2003) propose a similar scheme to detect collusive behavior and empirically analyzed data on highway seal-coating contracts in Minnesota and North and South Dakota. They apply the theory of competitive bidding with asymmetric bidders to distinguish between competitive and collusive bidding[6]. They then derive a series of necessary and sufficient conditions for a bids' distribution to be consistent with bids generated by a model of competitive bidding. They refer to these conditions as conditional independence and exchangeability. If these conditions hold, an analysis of bidding data cannot reject the hypothesis that firms in question behaved competitively. Conversely, bidding that does not satisfy these conditions was not generated by the fully competitive process modeled by Bajari and Ye, indicating the possibility of collusion.

The first condition implied by competitive bidding is conditional independence. Conditional independence means that, after we have adjusted for or conditioned on all of the information about the project and firms' costs that is publicly available to the bidders, the bids should not be correlated. Before submitting a bid, firms take into account all of the public information expected to affect their own costs and those of other firms. In addition, the firm takes into account private information about its own costs that only it has and that can affect only its own bid. If there is no collusion, each firm independently arrives at its cost estimate and bid. Since the cost estimates were arrived at independently, the bids should be independent after taking account of the publicly observable information. If the cartel members have coordinated on how to bid before the auction, their bids will typically be correlated, and this can be detected through the careful application of econometric methods.

Bajari and Ye start by regressing firms' bids on several explanatory variables (e.g., distance from a firm's location to the job site, the minimal distance of its rivals to the job site, the firm's capacity, and the maximum free capacity of its rivals) to estimate how the bids of each firm change as each of these factors varies from firm to firm and project to project. The residuals capture the variation in

---

[6] Bajari and Ye (2003) begin their analysis with a model of competitive bidding that specifies the rules of the auction and the resulting bidding strategies of competing firms. First, the Bajari and Ye model assumes that firms submit sealed bids for a procurement contract and that the contract is awarded to the lowest bidder. Second, Bajari and Ye assume that each firm has private information about its costs. Third, Bajari and Ye assume that the firms' bidding strategies are a Bayes-Nash equilibrium. In equilibrium, firms are rational and submit bids that maximize their expected profits, taking into account all possible information about themselves and their rival firms. Fourth, Bajari and Ye assume that firms have asymmetric costs.

bids not explained by the factors included in the regression. Some of this unexplained variation in bids is due to private cost information not observable to either the econometrician or other firms. To test for conditional independence, Bajari and Ye test whether the correlation between the residuals of the bid functions for different firms is zero. As described above, if firms are conditionally independent, there should be no persistent pattern or correlation in the divergence between the actual and predicted bids of different firms.

The second condition implied by competitive bidding is exchangeability. All competing firms behave in the same way when faced with identical cost structures. If the publicly observed factors affecting costs or other information that firms use to compute their bids are exchanged or permuted among the firms, then the bids should permute among the firms in the same way when exchangeability holds.

To test for exchangeability, Bajari and Ye test the hypothesis that firms' estimated coefficients for any given explanatory variable in the bid regression are statistically the same. This test reveals whether firms respond in the same way to changes in variables that affect their bidding strategies.

No econometric method for detecting collusion is likely to be infallible, and these tests have their limitations, one being that a sufficiently sophisticated cartel could disguise its collusive behavior by tailoring its complementary bids so that the overall bid pattern passed the test. Furthermore, while these tests can help to detect departures from competitive behavior, they do not directly establish that a departure is the result of an illegal agreement, rather than a form of tacit collusion arising from firms acting independently while aware of their interdependence. For instance, suppose that two firms, located in different countries, manage to tacitly coordinate their bidding without directly communicating so that neither bids aggressively for jobs in the rival's home country. Nonetheless, these methods can be used as a first step to determine whether bid-rigging has occurred and whether further investigation and analysis are warranted.

4.4   Debarments

Collusion is a pervasive phenomenon in public procurement auctions. In order to prevent wasteful use of taxpayer money, governments and international organizations devote substantial resources to the fight against collusion using different remedies. One of the most important sanctions used in reaction to collusion and other types of anti-competitive practices in procurement auctions is debarment. Debarment denotes the exclusion of bidders convicted of bid-rigging from future procurement auctions for a specified period.

The answer to whether debarments effectively deter collusion is far from obvious. On the one hand, the availability and selective use of debarment can have high deterrence effects. On the other hand,

this sanction must be applied cautiously to avoid the unwarranted costs of distorting future competition by reducing the size of procurement markets and facilitating collusion.

Cerrone et al. (2018) present an experimental study on the impact of debarments on collusion and bidding behavior in procurement auctions. They explore whether debarment deters collusion by comparing it with the benchmark case of no sanction. To explore how the deterrent effect of debarment varies with its length, they vary the length of bidder exclusion. Moreover, they explore whether and how the exclusion of colluding bidders affects the bids of non-debarred bidders. They find that debarments significantly reduce the frequency of collusion relative to the no-sanction baseline and decrease bids towards the competitive level. This deterrent effect increases with the length of the debarment. However, under the short debarment regime, the exclusion of colluding bidders increases the bids of non-debarred bidders. This suggests that the reduced size of the auction market generated by the exclusion of colluding bidders may facilitate tacit collusion among the remaining bidders in the market. Interestingly, they do not observe this effect under the long debarment. Moreover, short debarments reduce efficiency because the exclusion of bidders is more frequent, and the bidder with the lowest cost is less likely to win the auction.

CONCLUSION

In conclusion, bid-rigging in public procurement or lease auctions is a widespread phenomenon and may result in substantial additional expenditures or revenue losses, respectively. Moreover, procurement auctions that allocate orders to inefficient sellers, or lease auctions that distort exploratory incentives, can also result in nontrivial welfare losses. It follows that the essential features of an auction are its robustness against collusion and its attractiveness to potential bidders. This paper showed how the vulnerability to collusion strongly depends on the way in which sellers conduct auctions and buyers conduct procurements. However, while modern experience in prosecuting cartels has generated a valuable body of information that can inform the choice of auction format and the design of collusion countermeasures, auction design is not "one size fits all," and anyone setting up an auction would be foolish to follow past successful designs blindly. Indeed, practical tender design must take into consideration the nature of the object being procured (or sold) and the characteristics of the underlying market. For instance, I have shown that while sealed-bid auctions are ideal in some contexts, and Anglo-Dutch auctions perform well in other contexts, ascending auctions can also be used successfully – and with outcomes superior to sealed-bid auctions – when proper measures are taken to fight against "in-auction" collusion.

In any case, economic theory, together with empirical analysis, suggests that collusion is more likely to occur in a stable and predictable environment. Thus, besides being aware of the factors affecting collusion and deciding which format and specifications to adopt to hinder collusion, contracting authorities have the fundamental task of not letting the tender design stagnate over time. Indeed, the creation of uncertainty by changing the tendering procedure is a powerful tool to discourage bidders from entering into collusive agreements.

A crucial step towards the limitation of collusive behaviors is the identification of suspicious bidding patterns that could indicate the presence of potential cartels during their actual implementation. It follows that professional training is solicited for contracting authorities in order for them to be aware and constantly updated on competition issues in public procurement.

Finally, while the econometric tests reviewed in this paper are poor substitutes for a disclosure by a dissident ring member or a a wiretap, I argue that these procedures may be preferable to the view that patterns of relatively constant market shares, or bid rotation, constitute indisputable evidence of collusion, and may prove useful first steps to determine whether bid-rigging has occurred and whether further investigation and analysis are warranted.

CASE STUDY: BID-RIGGING IN TECHNICAL ASSISTANCE SERVICES

Introduction

On the 15th of March 2016, the Italian Competition Authority (ICA) [7] launched an investigation into Deloitte & Touche S.p.A. (Deloitte & Touche), Meridiana Italia S.r.l. (Meridiana), KPMG S.p.A. (KPMG), PricewaterhouseCoopers S.p.A. (PwC), PricewaterhouseCoopers Advisory S.p.A. (PwC Advisory), and Reconta Ernst & Young S.p.A. (EY) to ascertain alleged infringements of Article 101 of the Treaty on the Functioning of the European Union (TFEU). On the 4th of August 2016, the investigation was extended to KPMG Advisory S.p.A. (KPMG Advisory), Deloitte Consulting S.r.l. (Deloitte Consulting), and Ernst & Young Financial Business Advisory S.p.A. (EYFBA). The consulting and auditing companies involved, except for Meridiana, belong to the Deloitte, KPMG, EY, and PwC networks (the so-called Big Four).

The alleged concerted practices investigated by the ICA concerned technical assistance services for the use of structural funds set up by the European Union. Indeed, EU Regulation No 1303/20131 rules that, to ensure the proper use of the funds, the Member States shall carry out a series of activities to control and verify how they are spent. Namely, the Member States must designate a Managing Authority, responsible for managing the operational program in accordance with the principle of sound financial management[8], and a Certifying Authority, responsible for drawing up and submitting payment applications to the Commission, and certifying that they result from reliable accounting systems, are based on verifiable supporting documents and have been subject to verifications by the Managing Authority[9]. The Member States shall also appoint an Audit Authority, independent from the Managing Authority and the Certifying Authority, to ensure that audits are carried out on the proper functioning of the management and control system of the operational program and on an appropriate sample of operations based on the declared expenditure[10]. To carry out the abovementioned activities, commonly referred to as "technical assistance," public administrations avail themselves of experienced professionals in the field.

---

[7] Autorità Garante della Concorrenza e del Mercato (AGCM).

[8] See Article 125 of the EU Regulation No 1303/2013.

[9] See Article 126 of the EU Regulation No 1303/2013.

[10] See Article 127 of the EU Regulation No 1303/2013.

In 2015, Consip S.p.A (Consip)[11], on behalf of the Italian Ministry of Economy and Finance, launched two Community tendering procedure for technical assistance services, one for the assistance to the Audit Authority (hereinafter AA tender) – the investigated matter – and the other for the assistance to the Managing Authority and the Certifying Authority (hereinafter MA-CA tender).

The Tender Design

On the 19th of March 2015, Consip launched a Community tender for the procurement of technical assistance services to the Audit Authority for the monitoring and audit of the programs co-funded by the European Union.

As shown in Table I, the tender was divided into nine lots, amounting to a total reserve value of approximately 66,5 million euros, differently allocated among each lot[12]. The first seven lots were defined according to a geographical criterion, while the last two were dedicated to central administrations.

Table I: Lots of the AA tender (Source: ICA's decision I796)

Lot	Object	Maximum Value
1	Regione Liguria, Regione Lombardia, Regione Piemonte, Regione Valle d'Aosta	3,980,375 euro
2	Regione Friuli Venezia Giulia, Provincia Autonoma di Bolzano, Provincia Autonoma di Trento	4,016,115 euro
3	Regione Emilia Romagna, Regione Toscana, Regione Veneto	5,682,059 euro
4	Regione Lazio, Regione Sardegna	7,139,760 euro
5	Regione Abruzzo, Regione Basilicata, Regione Marche, Regione Molise	4,291,004 euro
6	Regione Campania, Regione Puglia	8,532,013 euro
7	Regione Calabria, Regione Sicilia	9,698,174 euro
8	Agenzia per la Coesione Territoriale, NUVEC e Ministero del Lavoro	11,304.620 euro
9	Presidio di coordinamento Nazionale presso il Ministero dell'Economia e delle Finanze	11,899,600 euro

To ensure maximum participation, Consip did not place any constraints on registration in professional registers, thus allowing both consultancy and auditing firms to take part in the tender. Firms instead

---

[11] Consip S.p.A. operates as a joint-stock company held by the Italian Ministry of Economy and Finance (MEF), which is the sole shareholder. It carries out activities in consulting, assistance, and support in procuring goods and services for public administrations.

[12] The reserve prices were obtained from an analysis carried out by Consip on previous tenders having the same or similar object.

were expected to meet a minimum global turnover as well as a minimum specific turnover for technical assistance services to the Managing Authority, the Certifying Authority, or the Audit Authority. These minimum turnover requirements were specified for each lot. Additionally, the specification provided, for each competitor, a double limit for the award of lots. The first limit in value, equal to 27 million euros of allotment; the second in maximum number of lots to be awarded, equal to three. In the event of exceeding these limits, the lots to be awarded to a bidder would have been identified starting from the lot of greater economic importance among the lots for which it resulted first in the provisional ranking. The remaining lots in which the bidder ranked first would have been awarded to the competitor that followed in the ranking.

The award of the various lots was simultaneous, and the criterion adopted was the most economically advantageous tender (MEAT). The maximum score associated with the technical offer was 70 points, while the maximum score achieved through the economic offer amounted to 30 points. Relevant to this analysis, more than the technical score is the economic score. Indeed, the economic score depended on the discounts offered by the participants on the reserve price for the daily rates of each professional figure (i.e., manager, senior consultant, and junior consultant). The economic score of each offer was determined by a mathematical formula that, as the level of the average discount decreased, reduced the advantage obtainable over the other participants through a particularly competitive discount. In other words, when the average discount decreased, formulating a more aggressive offer than those of the other bidders became less and less decisive for the award of the lot. For the purpose of this analysis, it is also important to refer to the issue of incompatibility since, for the great part, the arguments put forward by the parties relied on it, as we will see below. The issue of incompatibility must be read with reference to the subsequent MA-CA tender[13]. The *lex specialis* of that tender had provided that a firm carrying out tasks in favor of the Audit Authority in certain regions would have been precluded from submitting an offer for the lot that included such regions in the procurement of technical assistance services to the Managing Authority and the Certifying Authority. To exemplify, the bidder who was awarded one or more of the regional lots (from 1 to 7) in the AA tender could not have won the same regional lots in the MA-CA tender, the latter being divided according to the same geographical criterion of the former.

The Anomalies in the Results

The lots were awarded on the 5th of May 2016. Table II shows the tender results, while Table III shows the weighted average discounts offered by the Big Four on every lot.

---

[13] The MA-CA tender was launched by Consip on the 21st of December 2015.

Table II: AA tender results (Source: ICA's decision I796)

LOT 1	3,980,375		TS	ES	Total Score	Weighted Average Discount
1	KPMG S.p.A.		68,565	27,690	96,255	30.0%
2	TJV Deloitte & Touche S.p.A.-Meridiana Italia S.r.l.		70,000	10,231	80,231	10.1%
3	Reconta Ernst & Young S.p.A.		58,521	11,397	69,918	11.2%
4	TJV IZI S.p.A.-Baker Tilly Revisa S.p.A-MBS S.r.l.-Selene Audit S.r.l.		45,043	30,000	75,043	41.5%
5	TJV Ria Grant Thornton-Ria Research Innovation Analysis S.r.l		28,086	29,696	57,782	40.0%

LOT 2	4,016,115		TS	ES	Total Score	Weighted Average Discount
1	KPMG S.p.A.		68,967	27,455	96,422	30.0%
2	TJV Deloitte & Touche S.p.A.-Meridiana Italia S.r.l.		70,000	10,617	80,617	10.9%
3	TJV PricewaterhouseCoopers Advisory S.p.A.-PricewaterhouseCoopers S.p.A.		67,711	13,195	80,906	13.6%
4	TJV IZI S.p.A.-Baker Tilly Revisa S.p.A-MBS S.r.l.-Selene Audit S.r.l.		45,679	29,764	75,443	41.5%
5	Lattanzio Advisory S.p.A.		67,128	30,000	97,128	42.7%

LOT 3	5,682,059		TS	ES	Total Score	Weighted Average Discount
1	KPMG S.p.A.		68,951	10,763	79,714	10.0%
2	TJV Deloitte & Touche S.p.A.-Meridiana Italia S.r.l.		70,000	14,216	84,216	13.2%
3	Reconta Ernst & Young S.p.A.		58,515	28,079	86,594	31.4%
4	TJV PricewaterhouseCoopers Advisory S.p.A.-PricewaterhouseCoopers S.p.A.		67,675	14,193	81,868	13.2%
5	TJV Ria Grant Thornton-Ria Research Innovation Analysis S.r.l		27,708	29,542	57,250	40.0%
6	Lattanzio Advisory S.p.A.		67,083	30,000	97,083	42.7%

LOT 4	7,139,760		TS	ES	Total Score	Weighted Average Discount
1	KPMG S.p.A.		68,532	13,010	81,542	14.0%
2	TJV Deloitte & Touche S.p.A.-Meridiana Italia S.r.l.		70,000	27,282	97,282	31.3%
3	Reconta Ernst & Young S.p.A.		58,348	10,733	69,081	11.5%
4	TJV PricewaterhouseCoopers Advisory S.p.A.-PricewaterhouseCoopers S.p.A.		67,731	10,809	78,540	11.6%
5	TJV IZI S.p.A.-Baker Tilly Revisa S.p.A-MBS S.r.l.-Selene Audit S.r.l.		45,540	28,538	74,078	41.5%
6	TJV Ria Grant Thornton-Ria Research Innovation Analysis S.r.l		27,839	28,351	56,190	40.0%
7	IT-AUDIT S.c.a.r.l. (Archidata, Consedin, Exit one, Gruppo clas, Sercam srl)		58,837	30,000	88,837	53.3%

LOT 5	4,291,004		TS	ES	Total Score	Weighted Average Discount
1	KPMG S.p.A.		68,951	11,652	80,603	11.0%
2	TJV Deloitte & Touche S.p.A.-Meridiana Italia S.r.l.		70,000	12,816	82,816	12.1%
3	Reconta Ernst & Young S.p.A.		68,515	14,036	72,551	13.2%
4	TJV PricewaterhouseCoopers Advisory S.p.A.-PricewaterhouseCoopers S.p.A.		67,675	28,201	95,876	32.4%
5	TJV IZI S.p.A.-Baker Tilly Revisa S.p.A-MBS S.r.l.-Selene Audit S.r.l.		45,846	29,794	75,640	41.5%
6	Lattanzio Advisory S.p.A.		67,083	30,000	97,083	42.7%

LOT 6	8,532,013		TS	ES	Total Score	Weighted Average Discount
1	KPMG S.p.A.		68,565	12,227	80,792	14.0%
2	TJV Deloitte & Touche S.p.A.-Meridiana Italia S.r.l.		70,000	8,789	78,789	10.1%
3	Reconta Ernst & Young S.p.A.		58,521	27,089	85,610	31.4%
4	TJV IZI S.p.A.-Baker Tilly Revisa S.p.A-MBS S.r.l.-Selene Audit S.r.l.		45,043	28,810	73,853	41.5%
5	IT-AUDIT S.c.a.r.l. (Archidata, Consedin, Exit one, Gruppo clas, Sercam srl)		58,826	30,000	88,826	48.5%
6	TJV Ria Grant Thornton-Ria Research Innovation Analysis S.r.l		28,086	28,552	56,638	40.0%

LOT 7	9,698,174		TS	ES	Total Score	Weighted Average Discount
1	KPMG S.p.A.		70,000	9,852	79,852	10.0%
2	Reconta Ernst & Young S.p.A.		59,708	27,873	87,581	31.5%
3	TJV IZI S.p.A.-Baker Tilly Revisa S.p.A-MBS S.r.l.-Selene Audit S.r.l.		45,779	30,000	75,779	41.5%
4	Cogea S.r.l.		66,717	13,793	80,510	14.0%
5	TJV Ria Grant Thornton-Ria Research Innovation Analysis S.r.l		28,212	29,678	57,890	40.0%

LOT 8	11,304,620		TS	ES	Total Score	Weighted Average Discount
1	KPMG S.p.A.		68,936	15,907	84,843	15.0%
2	TJV Deloitte & Touche S.p.A.-Meridiana Italia S.r.l.		70,000	28,024	98,024	31.3%
3	Reconta Ernst & Young S.p.A.		58,256	11,888	70,144	11.2%
4	Cogea S.r.l.		65,561	11,666	77,227	11.0%
5	TJV IZI S.p.A.-Baker Tilly Revisa S.p.A-MBS S.r.l.-Selene Audit S.r.l.		45,495	29,795	75,290	41.5%
6	Lattanzio Advisory S.p.A.		67,040	30,000	97,040	42.7%

LOT 9	11,899,600		TS	ES	Total Score	Weighted Average Discount
1	KPMG S.p.A.		70,000	30,000	100,000	30.0%
2	TJV Deloitte & Touche S.p.A.-Meridiana Italia S.r.l.		65,682	22,075	87,757	14.0%
3	TJV PricewaterhouseCoopers Advisory S.p.A.-PricewaterhouseCoopers S.p.A.		60,748	19,919	80,667	12.7%
4	Cogea S.r.l.		57,400	18,858	76,258	12.0%

Table III: Big Four's bids in the AA tender (Source: ICA's decision I796)

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6	Lot 7	Lot 8	Lot 9
KPMG	30%	30%	10%	14%	11%	14%	10%	14.999%	30%
EY	11.21%		31.42%	11.55%	13.25%	31.44%	31.51%	11.21%	
PwC		13.553%	13.186%	11.632%	32.274%				12.676%
Deloitte	10.064%	10.905%	13.207%	31.342%	12.098%	10.064%		31.342%	14.048%

Five out of nine lots (1,4,7, 8, and 9) were awarded to KPMG, EY, and the temporary joint venture formed by Deloitte & Touche and Meridiana (TJV Deloitte & Touche-Meridiana) – all firms belonging to the Big Four networks, apart from Meridiana. Besides PwC Advisory, which participated in the tender together with PwC (TJV PwC-PwC Advisory), the other firms carrying out consultancy activities in their respective networks (KPMG Advisory, Deloitte Consulting, and EYFBA) did not submit an offer.

Through a meticulous screening of the results, the ICA detected certain anomalous bidding patterns that could be indicative of an anti-competitive behavior: (i) the chessboard design of the bids; (ii) two specific discount ranges; and (iii) the cover bids.

Chessboard Design. The ICA found that the offers of the parties, although each having participated in several lots, are articulated in such a way that the most substantial discounts presented by each of them – all ranging between 30% and 32% – never overlap on all the nine lots. This is anomalous and suggests a collusive partition of the tender. As Table II shows, in five out of nine lots (1,4,7,8 and 9), the winner designated by the cartel – the one offering a discount above 30% – ended up being awarded the lot. In the other four cases, the designated winner lost to the unexpectedly more economically advantageous tenders of the competitors not part of the cartel. Thus, KPMG won lots 1 and 9 but lost lot 2; EY won lot 7 but lost lots 3 and 6; and TJV PwC-PwC Advisory did not win any lot, while they lost their designated lot 5. Finally, TJV Deloitte & Touche-Meridiana won both their allocated lots, 4 and 8.

Discount Ranges. As it can be inferred from Table III, the common bidding scheme also covered the level of discounts, as all Big Four offers are positioned around two recurring, and particularly spaced out, percentage ranges. Indeed, all the firms belonging to the Big Four networks submitted, for some lots, competitive bids with discounts ranging between 30% and 32% (without ever overlapping), and for the others (where there was overlapping), un-competitive offers with discounts ranging between 10% and 15%. This constitutes a further anomaly, expected that it is implausible for four bidders, allegedly competing against each other, to present the same level of discount both on the lots they are interested in (30-32%) and on the lots where they claim to have no interest (10-15%).

Cover Bids. As well as agreeing on which lots the undertakings would have submitted their best offer, the allocation mechanism was supported by the formulation of cover bids aimed at

concealing the cartel, giving the impression of competition among the parties, and leveraging the economic scoring mechanism. The formula used by the contracting authority for the award of the economic score rewarded the increase in discount with a linear increase in economic score. However, the proportionality was lower for price reductions above the mean than those below the mean[14]. This means that thanks to the phony bids (i.e., price reductions of 10-15%), the designated winner could have offered a lower discount with respect to a potentially more aggressive outsider. The cartelists were well aware that an auction base discount below 15% was ineligible to win the lot; despite this, they submitted their bids to improve the economic score of the designated winner.

Except for a few isolated cases related to the different scores obtained in lot 9, each bidder presented a substantially equivalent technical offer and obtained a very similar technical score on all the lots where it submitted a bid. However, while the competitors outside of the cartel did not differentiate, or did so only marginally, their economic offers depending on the lot they tendered for, the Big Four differentiated their discounts according to the abovementioned symmetrical scheme (30-32% and 10-15%). Moreover, the weighted average discounts offered by the other participants were always significant (equal to or higher than 40%), with the only exception of one bidder (Cogea), which offered meager discounts on all lots.

According to the ICA, the anomalies in the results and the bidding patterns could not have been explained if not in the light of a collusive cartel implemented by the incumbents to alter the outcome of the AA tender through the elimination of competition and the allocation of the different lots among themselves. Additionally, the fact that the collusive arrangement was solely based on the discount and not on technical specification is in no way called into question by the fact that the award criterion laid down in the tender specification was that of the most economically advantageous offer. Indeed, the parties were convinced of obtaining a technical score close to the maximum on every lot, which would have allowed them to recover the minimum gap of two or three points – devised through the cover bidding mechanism – possibly suffered in the assessment of the economic offer on the lots that had been assigned to them by the cartel. Therefore, confident of obtaining a high technical score, the cartel's goal was to share the lots trying to win them with a maximum 30-32% discount. To protect the collusive scheme against aggressive offers from potential competitors outside the cartel, the parties submitted particularly low supporting bids on the lots not allocated to them. From this

---

[14] This reasoning is reflected in a document found in the EY offices that consists in a simulation of the economic assessment, assuming an aggressive offer (called alpha), an average offer of EY (20%), and two supporting offers of KPMG and PWC (10% and 8%). Thanks to the economic score formula, due to the effect of particularly low supporting offers, the economic score achieved by the EY simulated offer is less than three points from the maximum score attributed to the aggressive outsider alpha.

perspective, it would have been useless and inefficient to coordinate on the technical offer, presenting differentiated offers on the lots according to the shared distribution scheme. This, also given the reputational aspect linked to the submission of insufficient technical offers.

The envisaged mechanism would have perfectly worked according to the agreed allocation scheme if it were not for two unexpected and unforeseeable factors that changed the scenario: the inadequate assessment of EY's technical offer and the good evaluation of Lattanzio's technical offer.

Table IV: Big Four's bids in the MA-CA tender (Source: ICA's decision I796)

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6	Lot 7	Lot 8	Lot 9	Lot 10
KPMG	34.85%	42.2%	45.3%	45.3%	40.6%	47.3%	40.0%		47.6%	47.3%
EY	32.2%			51.5%	51.5%		36.6%	51.48%	51.48%	51.5%
PwC			48.0%	48.0%	48.0%		48.0%		48.0%	48.0%
Deloitte			52.5%	52.5%			56.1%			56.1%

The intrinsic oddity of the parties' behavior emerges even more when compared to that adopted in the MA-CA tender. As shown in Table IV, the discounts submitted by the parties were much higher than those of the AA tender, and the Big Four's highest price reductions overlapped in several lots and, in some cases, also exceeded the allotment limit (4 lots) provided for in the disciplinary. It should also be noted that, in the MA-CA tender, there was no evidence of the clear parallelism of the AA tender. The companies adopted different bidding strategies – some presented the same discount in all the lots (PwC), while others differentiated their offers (KPMG, EY, and Deloitte) – and the discounts were evenly distributed from a minimum of 32% up to over 55% without being possible, therefore, to identify the two ranges of the AA tender. Thus, it seems that the collusive balance reached in the AA tender broke in the subsequent MA-CA tender, probably because of the unsettling results of the former that led the participants to the cartel not to replicate the concerted strategy previously adopted.

Exogenous Evidence of the Alleged Conducts

In addition to the collusive bidding strategy that can be inferred from the screening of the AA tender results, the investigation carried out by the ICA revealed a series of documents, proof of the horizontal contacts and meetings between KPMG, KPMG Advisory, PwC, PwC Advisory, Deloitte & Touche, Deloitte Consulting, EY, and EYFBA. Among the documents collected on the premises, of substantial relevance were the various email exchanges that took place between the start of the market consultation procedure by Consip and the launch of the tender. In these exchanges, the parties decided to meet with each other to "open a table" and "share an action" with reference to the AA tender (referred to in the emails' subjects as "EU funding meeting"). During the meeting, which took place on the 10th of December 2014, and which involved both the consulting and the auditing firms belonging to the Big Four networks, the parties allegedly compared each other's positions in the

market and intentions in the upcoming tender. Some other emails instead date to after the award of the lots and express the utter bafflement at the unexpected results and disruption of the bidding ring. Additionally, a series of documents emerged from which it is clear that the Big Four had frequent contact opportunities within the meetings organized by the Italian Association of Auditors (Assirevi) in the timeframe close to the submission of bids. It should also be noted that all the undertakings belonging to the Big Four networks share a single department dealing with tenders. Thus, the decision to participate in a tender is taken at the network level, considering the respective expertise and interests and possible conflict of interests between audit and consultancy activities.

Furthermore, the ICA found a document at EY offices titled "Preliminary simulations of the tender for assistance to the Audit Authority"," which, during the inspection, was dated by EY between November and December 2014. In the document (recreated in Table V), alongside the nine lots and their value, there are two columns headed *Competence* and *Interest*, indicating for each lot the acronym of a Big Four. Comparing these simulations with the bids submitted, it emerges that the results of the column *Interest* match the outcome of the tender – considering as winning bids those with a discount over 30% – in six cases out of nine (lots 2 and 5 to 9).

Table V: EY simulation of the AA tender (Source: ICA's decision I796)

Lot	Competence	Interest	Highest Discount
1	KPMG	DT	KPMG
2	KPMG	KPMG	KPMG
3	DT	KPMG	EY
4	EY	EY	DT
5	DT	PwC	PwC
6	EY	EY	EY
7	EY	EY	EY
8	PwC+DT	DT	DT
9	KPMG	KPMG	KPMG

Justifications of The Parties

The Big Four justified the concerted practices on the basis of historical positioning and regional presence, the allotment limits provided for in the tender specifications, transfer costs, and the incompatibility issue concerning the subsequent MA-CA tender. Overall, none of the justifications put forward by the partiers proved reliable as they were contradictory and illogical and represented at most an attempt to provide ex-post justifications for their conduct in the tender.

Concerning the historical positioning, the argument is not understandable from the perspective of firms belonging to global networks and with offices widely spread throughout Italy. It should also be

noted that some of the parties submitted winning offers in territories where they had little presence (or no presence at all) and refused to submit competitive offers in territories where they had greater presence, which is inconsistent with the regional presence argument[15].

As for the allotment limits, the tender specifications expressly provided for a system which allowed the bidder who, pending the award of a contract, ranked first for a number or value of lots exceeding the limits, to be awarded the lots starting from those of greater economic importance. In this context, differentiating the economic offers between interesting and non-interesting lots to allow for the allotment limits would not have been necessary for a profit-maximizing strategy.

Regarding the alleged significant cost differences between the lots, none of the undertakings involved provided any justification indicating a real difference in cost structure or other rational logic behind the bids with low discounts. It should also be noted that this difference, assuming it existed, could not have been so significant as to justify the discount differences presented in the tender. This is even more true when referring to firms that are widespread throughout the Italian territory and that can easily contract external practitioners to meet any arisen workloads. Indeed, in the documents collected during the inspection and containing a detailed analysis of the costs of service, there were either no references to transfer costs, or they were only limited to a paltry 5% of the value of the contract. Instead, there were references to external professional profiles.

As per the various contacts, the meeting of the 10th of December was confirmed by the parties during the hearings. During the hearings, all the parties stated that the discussed matter was the incompatibilities that the award of the AA tender could have generated on the technical assistance services that would have been the object of the subsequent MA-CA tender. However, the ICA deemed the parties' statements unreliable since the emails did not include any references to the issue of incompatibility, but only to "strategies" and "alliances". It is also remarkable that, although all the parties had doubts on the issue of incompatibility, none of them, after the publication of the AA tender, had then formulated a specific request for clarification on the issue to Consip[16]. This confirms,

---

[15] For example, KPMG presented a winning bid (30.0%) on lot 2, despite having only one consultant working in Bolzano, but presented an offer ineligible to win (14.0%) on lot 6, despite having eleven consultants in its Naples office and despite it being more than double the value of lot 2. Or even, EY presented a winning bid (31.4%) on lot 3, despite having no resources in Bologna, yet it offered a low discount (11.5%) on lot 4, even though, in Rome, it could have counted on fifteen resources having the professional profiles required by the AA tender.

[16] It should be noted that the Council of State had already discussed the issue of incompatibility on services offered by firms belonging to the same network. The Council had specified that the impairment of the independence requirement must result from legal, financial, organizational, and managerial elements that attest the existence of a substantial link between controller and controlled. In the absence of these indicators, there is no evidence that there is a single center of interest between two separate legal entities which would allow an exchange of information.

therefore, the assumption that at the meeting, the parties agreed on the allocation of the lots then merged into the simulation referred to in Table V.

To demonstrate the absence of the effects, PWC, Deloitte, and EY developed some counterfactual scenarios which supported the argument that different participatory modalities would have led to a less satisfactory outcome for the procuring agency[17]. As a matter of fact, the parties, focusing on the cover bids, failed to highlight a rather more critical factor of the agreement, namely the annihilation of competition among the Big Four. They consistently offered discounts of between 30 and 32%, trusting the absence of more aggressive offers from the other firms in the ring and the neutralization of more aggressive offers outside the cartel thanks to the supporting bid mechanism. In their simulations, the parties disregarded the fact that their discounts were also the result of the cartel and, for that reason, certainly lower than those expected in a market not distorted by the cartel. The ICA, instead, found that replacing the offers of the parties with a discount equal to that offered in the same lot by an averagely aggressive competitor that reached a technical score comparable to that of the Big Four (e.g., Lattanzio) would have led to a saving in expenditure for Consip of over 4,5 million euros, together with a quality increase of around 10 points.

The ICA's Decision

The preliminary investigation carried out by the ICA uncovered, on the one hand, the intrinsic oddity of the parties' conducts in their participation in the tender and, on the other, the presence of exogenous elements – simulations of participation in the tender and contacts and exchanges of information prior to and following the tender.

The conduct surfaced thanks to a thorough screening of both the tender results and the exogenous elements in the proceedings and was not justified in the light of the arguments advanced by the parties, which were wholly deficient and inconsistent with the documents acquired. All the justifications set out by the Big Four did not provide a reasonable explanation for the adopted behavior alternative to bid-rigging. Therefore, the ICA claimed that all the probative elements demonstrated, in an incontrovertible way, the existence of an illegal agreement between the Big Four aimed at public

---

[17] In particular, the parties proposed three different counterfactual scenarios. In the first scenario, the parties eliminated the alleged cover bids on all the lots to show that such bidding scheme would have determined a saving for Consip of "only" 700,000 euro. The second alternative scenario, which provided that each party to the cartel submitted, in each lot in which it participated, a discount equal to the highest discount submitted by a Big Four in that lot, would have led to the same outcome. Finally, the third scenario, which replaced the cover bids with the highest bid submitted by the Big Four, taking into consideration all the lots in which it participated, would have led instead to a minimal increase in cost for the contracting authority.

contract allocation. The undertakings involved had the joint goal of sharing the lots, eliminating reciprocal competition, and securing the contracts with a maximum 30-32% discount. To neutralize potentially aggressive outsiders from undermining the stability of the cartel, the ring implemented a cover bidding scheme.

The offense was to be attributed to all the parties to the proceedings, regardless of the modalities chosen to participate in the tender (i.e., participation of only one of the firms in the network, participation of both in TJV, subcontracting, etc.), except for Meridiana, for which the investigation did not bring to light sufficient evidence of its participation in the infringement. In particular, the ICA found Deloitte Consulting, EYFBA, and KPMG Advisory, that inside of the respective networks carry out the consulting activity, and that did not take part in the AA tender – despite being eligible to do so – to be part of the collusive agreement. According to the ICA, the decision to participate in the AA tender was taken at the network level following the logic of profit maximization.

Sanctions

In light of the above, the ICA found that the behavior at issue constituted an infringement of Article 101 of the Treaty on the Functioning of the European Union (TFEU). To fall within the scope of Article 101 of the TFEU, a concerted practice must have as its object the prevention, the restriction, or the distortion of competition within the underlying market. In this regard, the European Court of Justice ruled that certain forms of coordination between undertakings reveal a sufficient degree of harm to competition that examining their effects would be superfluous. Indeed, certain collusive behaviors, such as horizontal price-fixing, market sharing, or customer allocation agreements resulting from a cartel, have such a negative impact on the price, quantity, or quality of products and services that it may be deemed useless for the application of Article 101 to demonstrate that such behaviors have a tangible effect on the market, resulting in a misallocation of resources to the detriment of consumers[18].

In the Big Four case, the object of the concerted practices was found to be anti-competitive per se, since the major market players, with experience and economic capacity far superior to others operating in the field, intended to affect the outcome of the tender through the allocation of the lots. Moreover, the agreement was fully implemented with the submission of coordinated bids, influencing the procedure's outcome with respect to all nine lots. It follows that to establish its unlawfulness, it would have been unnecessary to show it had any restrictive effects. Nevertheless, the ICA found that

---

[18] *Dole Food and Dole Fresh Fruit Europe v Commission*, C-286/13P (Court of Justice Mar. 19, 2015); *CB v. Commission*, C-67/13, (Court of Justice Sept. 11, 2014).

the grave distortion of competition resulting from the behavior of the undertakings involved did, in fact, undermine the process of selecting the best contractual counterparty to provide the services envisaged by the call for tender, causing the tender to be awarded on terms less favorable than in the event of a fully competitive scenario.

Article 15, paragraph 1, of Italian Law No 287/90 provides that to evaluate the seriousness of an infringement, various factors must be considered and weighed depending on the nature of the breach and its circumstances. Importance should be given to the nature of the competition restriction and the role and market position of the undertakings involved. The concerted practices in the Big Four case consisted of a secret horizontal agreement aimed at conditioning the dynamics of the tender at issue to avoid competition in the award of the contracts. The agreement led to the allocation of the lots, as planned by the parties, in five lots out of nine, but it influenced the outcome of the tender with respect to all nine lots. The distortion of competition was aggravated by the fact that the cartelists were the major player in the game – totaling an appalling 96% of the underlying market[19].

To determine the penalties, legal references are the "Guidelines on how to apply the criteria for quantifying monetary financial sanctions imposed by the Authority pursuant to Article 15, paragraph 1 of Law No 287/90" (hereinafter Guidelines). According to the Guidelines, the basic amount of the fine is calculated by multiplying the allotment amount directly or indirectly derived from the illegal behavior by a percentage of between 15% and 30%, according to the gravity of the infringement and the duration of each undertakings' participation in the infringement[20]. In the present case, the allotment amount was calculated as the value of the bid made by the firm to which the lot had been awarded by the ring, according to the allocation scheme identified. Since the behavior led to a severe breach of Article 101 TFEU, the initial allotment amounts had been multiplied by 30% for all participants. Furthermore, the Guidelines states that to confer to the sanctions the necessary deterrent effect, with respect to the most severe restrictions of competition, the ICA shall consider adding to the basic amount of the fine an additional entry fee of between 15% and 25%[21]. In this context, the sale value had been multiplied by 25%.

Finally, the Guidelines provide that the basic amount of the fine may be reduced to take into account specific attenuating circumstances. In the present case, the ICA evaluated the adoption by all parties

---

[19] With specific reference to the technical assistance services to the Audit Authority Deloitte & Touche estimated that, in Italy, out of 17 tenders awarded by the PA at central and regional level in the period 2008-2014, the Ernst & Young network had a share of 55%, the KPMG network of 24%, the Deloitte network of 9%, the PwC network of 7%, and other competitors of 4%.

[20] See point 7 and 11 of the Guidelines.

[21] See point 17 of the Guidelines.

of specific antitrust compliance programs[22]. The ICA found that only the EY, Deloitte, and PwC policies were in line with the provisions of the Guidelines; therefore, the ICA granted them a reduction of 5% of the fine. The ICA did not recognize any attenuating circumstance to KPMG.

Given that the undertakings involved in the proceedings were part of four global networks, the ICA decided to impose a single fine on each network. As shown in Table VI, the ICA imposed administrative fines amounting to a total of more than 23 million euros divided as follows: 7,659,966 euro to KPMG and KPMG Advisory, 5,955,011 euro to Deloitte & Touche and Deloitte Consulting, 8,563,021 euro to EY and EYFBA, and 1,516,218 to PwC and PwC Advisory.

Table VI: Calculation of the fines (Source: ICA's decision I796)

	Lot	Lot Value	Total Value	Gravity Coefficient	Entry Fee	Basic Amount	Compliance Discount	Total Fine
KPMG	1	2,786,264	13,927,211	30%	25%	7,659,966	0%	7,659,966
	2	2,811,267						
	9	8,329,680						
Deloitte	4	4,902,000	11,397,150 (*)	30%	25%	6,268,433	5%	5,955,011
	8	7,761,500						
PwC	5	2,901,852	2,901,852	30%	25%	1,596,019	5%	1,516,218
EY	3	3,896,750	16,388,558	30%	25%	9,013,707	5%	8,563,022
	6	5,849,522						
	7	6,642,286						
(*) Deloitte participated in TJV with Meridiana. The total value of sales is considered to be 90% (share in the TJV) of the value awarded.								23,694,216

Conclusion

This case study shows how tender design, though it can help to deter collusion, must be complemented by the constant monitoring of bidding activities and ex-post screening of tender results to detect bid-rigging. Indeed, the AA tender was devised so that, at least in principle, it would have made it difficult to reach and maintain a collusive agreement. First, the extent of the commercial opportunity and the tender specifications encouraged broad participation, which favored competition from other subjects. Moreover, because of the heterogeneity of the Big Four and the lots, it would have been extremely complex to find a coordination mechanism. Additionally, the high value of the lots and the long duration of the procurement contracts provided high incentives to deviate from a potential agreement. Finally, as the tender was a simultaneous award, there was no possibility of punishment in the event of deviation. Despite all these anti-collusion characteristics, the Big Four were still able to put in place a sophisticated collusive mechanism that the ICA uncovered through a careful analysis of both endogenous and exogenous elements.

---

[22] See point 23 of the Guidelines.

BIBLIOGRAPHY

Abreu, D., Pearce, D., & Stacchetti, E. (1990). Toward a Theory of Discounted Repeated Games with Imperfect Monitoring. *Econometrica, 58*(5), 1041-1063.

Albano, G., Buccirossi, P., Spagnolo, G., & Zanza , M. (2006). Preventing Collusion in Procurement. In *Handbook of Procurement* (pp. 347-380). Cambridge University Press.

Autorità Garante della Concorrenza e del Mercato. Guidelines on Antitrust Compliance.

Autorità Garante della Concorrenza e del Mercato (2017, October 18). Provvedimento No I796.

Bajari, P., & Summers, G. (2002). Detecting Collusion in Procurement Auctions. *Antitrust Law Journal, 70*(1), 143-170.

Bajari, P., & Ye, L. (2003). Deciding between Competition and Collusion. *The Review of Economics and Statistics, 85*(4), 971-989.

Barrus, D., & Scott, F. (2020). Single Bidders and Tacit Collusion in Highway Procurement Auctions. *The Journal of Industrial Economics, 68*(3), 483-522.

Brosig-Koch, J., Güth, W., & Weiland, T. (2016). Comparing the Effectiveness of Collusion Devices in First-Price Procurement: an Auction Experiment . *Evolutionary and Institutional Economics Review, 13*(2), 269-295.

Cerrone, C., Hermstrüwer, Y., & Robalo, P. (2018). Debarment and Collusion in Procurement Auctions. *Discussion Papers of the Max Planck Institute for Research on Collective Goods No. 2018/5*.

Che, Y.-K., Condorelli, D., & Kim, J. (2018). Weak Cartels and Collusion-Proof Auctions. *Journal of Economic Theory, 178*, 398-435.

Consip S.p.A. (2015, March 19). Documentazione Gara Servizi di Assistenza Tecnica per le Autorità di Audit dei Programmi Cofinanziati dall'UE.

Cramton, P., & Schwartz , J. (2000). Collusive Bidding: Lessons from the FCC Spectrum Auctions. *Journal of Regulatory Economics, 17*, 229–252.

Engelmann, D., & Grimm, V. (2009). Bidding Behaviour in Multi-Unit Auctions - An Experimental Investigation. *Economic Journal, 119*(537), 855-882.

Fudenberg, D., Levine, D., & Maskin, E. (1994). The Folk Theorem with Imperfect Public Information. *Econometrica, 62*(5), 997-1039.

Graham, D., & Marshall, R. (1987). Collusive Bidder Behavior at Single-Object Second-Price and English Auctions . *Journal of Political Economy, 95*(6), 1217-1239.

Grimm, V., Pacini, R., Spagnolo, G., & Zanza, M. (2006). Division into Lots and Competition in Procurement. In *Handbook of Procurement* (pp. 168-192). Cambridge University Press.

Hendricks, K., & Porter, R. (1989). Collusion in Auctions. *Annales D'Économie Et De Statistique, 15*, 217-230.

Hendricks, K., Porter, R., & Tan, G. (2008). Bidding Rings and the Winner's Curse. *The Rand Journal of Economics, 39*(4), 1018-1041.

Jehiel, P., & Moldovanu, B. (n.d.). Efficient Design with Interdependent Valuations. *Econometrica, 69*(5), 1237-1259.

Klemperer, P. (1998). Auctions with Almost Common Values: The "Wallet Game" and its Applications. *European Economic Review, 42*(3), 757-769.

Klemperer, P. (2002). What Really Matters in Auction Design. *The Journal of Economic Perspectives, 16*(1), 169-189.

Klemperer, P. (2004). *Auctions: Theory and Practice.* Oxford Economics Papers.

Krishna, V. (2002). *Auction Theory.* Academic Press.

Marshall, R., & Marx, L. (2012). *The Economics of Collusion: Cartels and Bidding Rings.* The MIT Press.

Marshall, R., & Meurer, M. (2004). Bidder Collusion and Antitrust Law: Refining the Analysis of Price Fixing to Account for the Special Features of Auction Markets. *Antitrust Law Journal, 72*(1), 83-118.

McAfee, P., & McMillan, J. (1992). Bidding Rings . *The American Economic Review, 82*(3), 579-599.

McAfee, P., Williams, M., & Hendricks, K. (2014). Auctions and Bid Rigging. In *The Oxford Handbook of International Antitrust Economics.* Oxford Economics Papers.

Milgrom, P. (2004). *Putting Auction Theory to Work.* Cambridge University Press.

Milgrom, P., & Weber, R. (1982). A Theory of Auctions and Competitive Bidding. *Econometrica, 50*(5), 1089-1122.

Mund, V. (1960). Identical Bid Prices. *Journal of Political Economy, 68*(2), 150-169.

OECD (2009). Guidelines for Fighting Bid Rigging in Public Procurement.

OECD (2012). Recommendation on Fighting Bid Rigging in Public Procurement.

Pesendorfer, M. (2000). A Study of Collusion in First-Price Auctions. *The Review of Economic Studies, 67*, 381-411.

Porter, R. (2005). Detecting Collusion. *Review of Industrial Organization, 26*(2), 147-167.

Porter, R., & Douglas, J. (1993). Detection of Bid Rigging in Procurement Auctions. *Journal of Political Economy, 101*(3), 518-538.

Porter, R., & Zona, J. (1993). Detection of Bid Rigging in Procurement Auctions. *Journal of Political Economy, 101*(3), 518-538.

Riley, J., & Samuelson, W. (1981). Optimal Auctions. *The American Economic Review, 71*(3), 381-392.

Robinson, M. (1985). Collusion and the Choice of Auction. *The Rand Journal of Economics, 16*(1), 141-145.

Smith, R. (1961). The Incredible Electrical Conspiracy. *Fortune*, 132-180.

Vickrey, W. (1961). Counterspeculation, Auctions, and Competitive Sealed Tenders. *The Journal of Finance, 16*(1), 8-37.

Wang, H., & Chen, H. (2016). Deterring Bidder Collusion: Auction Design Complements Antitrust Policy. *Journal of Competition Law and Economics, 12*(1), 31-68.

Wighton, D. (1995, March 8). Wellcome Still Smarting Over Handling of Trust's Stake. *Financial Times*, p. 27.

Zona, J. (1986). Bid-Rigging and the Competitive Bidding Process: Theory and Evidence. *Ph.D dissertation*. State Univ. New York Stony Brook.