Bidding for Complex Projects: Evidence From the Acquisitions of IT Services

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Summary

Competitive bidding (as auctions) is commonly used to procure goods and services. Public buyers are often mandated by law to adopt competitive procedures to ensure transparency and promote full competition. Recent theoretical literature, however, suggests that open competition can perform poorly in allocating complex projects. In exploring the determinants of suppliers' bidding behavior in procurement auctions for complex IT services, we find results that are consistent with theory. We find that price and quality do not exhibit the classical tradeoff one would expect: quite surprisingly, high quality is associated to low prices. Furthermore, while quality is mainly driven by suppliers' experience, price is affected more by the scoring rule and by the level of expected competition. These results might suggest that (scoring) auctions fail to appropriately incorporate buyers' complex price/quality preferences in the tender design.

Keywords: Procurement Auctions, Scoring Rules, IT Contracts, Price/Quality Ratio

JEL Classification: D44, D86, H51, H57

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1. Introduction

Contracting authorities often use competitive bidding[1] to select providers of IT services. Competitive bidding was already popular among private procurers, and today is a central principle for public procurement regulations worldwide (in particular in Europe and in the U.S.).[2] Competition in fact allows buyers to achieve cost minimization and to ensure transparency.

When projects are complex, however, economic theory suggests that competition may not be the best allocation mechanism. Goldberg (1977) argued that using auctions for complex transactions may prevent the parties to exchange important pre-contractual information. More recently, Manelli and Vincent (1995) show that bargaining dominates competition when the buyer is unsure about the quality the supplier will deliver (quality is unobservable). Empirical evidence on construction procurement highlights the potential limits of sealed-bidding. These stem from unexploited useful communication between buyer and supplier (Bajari, McMillan and Tadelis, 2006) and to the difficulties in capturing post-contract adaptation costs (Bajari and Tadelis, 2001).[3]

The critical point for the buyer in designing competitive bidding for complex projects is to precisely describe (many) quality dimensions that are often unverifiable and that can sometimes be only partially known at the bidding stage. Talks with practitioners, for instance, suggest that the outcome of an new software for a large organization (e.g., payroll management) typically depends on the ability of the project managers to set up a "working and flexible team" and that of single developers/programmers to transform the buyer's requirements in a good software. Although ability may be inferred by some measure of quality (e.g., errors during running) the real functioning of the software can be learnt only at the end of the job, when it is rather costly to recover development mistakes.

[1] The open procedure is one of the procedures provided for by EU Directive 18/2004. Other procedure are the "negotiated procedure" and the "restricted procedure".

[2] See the EU Directive 2004/18 and the U.S. Federal Acquisition Regulation, 2005. The FAR 2005 (Part 6) explicitly recommends to adopt full and open competition, with certain limited exceptions.

[3] Although the topic of the paper is contract design, both economic and construction management literature suggest a strong link between cost reimbursement contracts and the use of negotiations, whereas fixed price contracts seem to be awarded by competitive bidding. The link is also present in the U.S. FAR.

The task of course becomes even more complicated when the buyer adopts a scoring auction to award the contract.[4] Scoring auctions are rather common in the practice of public procurement and their use is supported by many procurement regulations. The scoring auction is particularly appropriate for commercial/standardized items (as PC and printers), i.e., when quality is verifiable and thus the buyer's price/quality preferences can be well represented by a scoring rule (see Che, 1993).[5] Scoring auctions instead do not appear suitable for complex projects, as they "force" the buyer to give a precise shape (the scoring rule) to complex, often unknown, price/quality preferences.[6] In these cases, problems may also arise for suppliers in setting their bidding strategies. When competing to provide a commercial item, any supplier easily computes the monetary cost of improving his score on the basis of his internal cost/efficiency. In bidding for the provision of a laptop, for instance, if increasing the score of 1 point implies lowering price of $500 or, alternatively, offering X additional power (e.g. RAM) at the cost of $400, the supplier will for sure opt for the latter to save $100.[7] In the case of complex, custom tailored projects (such as IT solutions/services to be provided to a large buyer) it is not clear how this trade-off, at least at the margin, could work. For instance, a reliable cost estimate of developing new SW applications requires the supplier to know *ex-ante* the types and number of functionalities (complexity of SW) and what are existing IT infrastructures (e.g., servers) new applications must be compatible with. Lacking precise information, it is of course hard for the supplier to estimate how many consultants (money) will be necessary to develop the SW, and thus how the price bid could be traded-off with quality dimensions (e.g., completion time, days of ex-post training for users, more advanced programming languages or developing technologies).

[4] In public procurement, scoring auctions are known as the awarding criteria of the most economically advantageous tender (MEAT).

[5] The rule assesses whether one proposal's technical superiority is worth the higher price, and it allows the buyer to select the best "value for money" supplier (highest score supplier).

[6] Following this point, Che (forthcoming) discusses the issue of non-contractible quality and possible solutions, as option contracts and reputation mechanisms. Also notice that the recent theoretical developments produced by Asker and Cantillon (2008) on the properties of scoring auctions pass inevitably through the assumption of perfectly verifiable (and thus contractible) quality.

[7] This is true when the scoring rules governing the price/quality tension have certain properties (e.g., linearity in the price dimension). Dini, Pacini and Valletti (2006) analyze in more detail the properties of linear and non-linear scoring rules.

In Italy, the Ministry of Economy and Finance (MEF) selects IT services contractors through scoring auctions. Consip[8] acts in the behalf of the MEF, being in charge to organize the tenders and to award the contracts. IT services contracts are often "general purpose", or "framework contracts", i.e., include a large variety of activities – from simple maintenance to developments of new applications, from IT consultancy to integration of complex systems. Quality proposals consist in providing effective and flexible teams of professionals and technological solutions to best fit the various needs of the MEF. The selected supplier is required to adapt its initial organizational set-up to development tasks that will be more clearly specified during the procurement relationship.

In this paper we aim at moving one first step in understanding suppliers' behavior in bidding for complex projects. The general issue we address is what happens when competitive mechanisms are used in settings for which the theory suggests that other mechanisms (e.g., negotiation) could be preferable. More precisely, our research questions are: can observed bids tell us something about how well the awarding mechanism captures the buyer's price/quality trade-offs in complex projects? Is there a relationship between price and quality emerging from bids? What are the most important factors explaining bidding behavior, i.e., submitted price/quality ratios? How do bidders respond to the incentives generated by different scoring rules?

To answer these questions we exploit a unique dataset of contracts for IT development and consultancy that Consip (the Italian Public Procurement Agency) awarded on behalf of the MEF. In particular, we use the complete set of 20 contracts awarded by Consip in the period 1999–2007 in the sector of IT development and consultancy.

We find no evidence of a tension between price and quality in submitted price/technical bids: data exhibit a puzzling negative correlation between quality and price bids, such that higher quality is associated to lower prices. These results put at least some doubts on the possibility for scoring auctions to appropriate capture complex price/quality trade-offs.

Regression analysis also shows that the nature of the scoring rule and past experience are important determinants of submitted quality/price ratios. However, while quality is mainly driven by suppliers' experience, price is influenced by the scoring rule and by

[8] Since 1997 Consip S.p.A. (the Italian Public Procurement Agency) is mandated to select suppliers and manage IT contracts on behalf of the MEF.

the level of expected competition. This provides some support to the conjecture that quality and price bidding may respond to rather different elements.

Finally, we find that the distribution of scores for technical proposals is significantly less dispersed when evaluation committees are composed of "outsiders" (mainly non-IT persons) rather than "insiders", suggesting that in the former case competition shifted more towards the economic aspect of the contract. Results offer several insights for policy considerations on IT services scoring auction design.

The rest of the paper is organized as follows. Section 2 surveys the related empirical literature. Section 3 describes the procurement environment, the characteristics of contracts and the role of Consip and the MEF. It also provides a description of the dataset and some basic descriptive statistics. Section 4 illustrates the results from regression analysis testing for price/quality trade-off in observed bids. Section 5 explores the determinants of price/quality ratios, while section 6 investigates the role of committees in explaining the variability of technical scores. Section 7 concludes the paper and summarizes some policy indications.

2. Related Literature

This paper is related to the empirical literature on bidding in procurement auctions. Important results have been achieved in the field of structural approach to auctions. Several authors estimated structural auction models addressing the issue of common value vs. private value (e.g. Athey, Susan and Haile 2006, Paarsch 1992, Guerre, Perrigne and Vuong 2000), often finalized to find evidence of the *winner's curse* in both one dimensional and multidimensional procurement auctions (Hong and Shum 2002). This field of research exploits repeated auctions data (e.g., timber auctions), and relies on frameworks where bidders' behavior can be well enough incorporated in a structural model. A structural approach allows the researcher to identify the distribution of bidders' values and thus to investigate important issues such as the optimality of reserve prices or the mark ups realized by bidders.

The cross-section nature of our data, as well as the complexity of the environment prevent the use of structural approach and suggest the adoption of reduced form models. In their recent paper, Asker and Cantillon (2008) highlight serious difficulties

from the standpoint of identification[9] that in our settings would be even more complicated as observed scores do not reflect precise quality/technical characteristics – verifiable quality is one key assumption in their model – rather they arise from discretional evaluation of projects (unverifiable quality).

However, the nature of data allows us to address issues that others have not yet been able to address. To some extent these issues are closer to the ones investigated by the literature on the bidding behavior for complex/incomplete contracts. There are several papers exploring renegotiation and adaptation costs – most of them bounded to the field of public works and construction industry. For instance, Bajari, Houghton and Tadelis (2007) and Bajari and Tadelis (2001) try to measure such costs in the procurement of highways paving works in the U.S.. The limitations to use auctions, when projects are complex and contractual design is incomplete, suggest that negotiations may be more attractive than auctions. By the way, Bajari, McMillan and Tadelis (2008) compare auctions with negotiations by examining a comprehensive data set of private sector building contracts in the U.S.. Crocker and Reynolds (1993) use Air Force engine procurement contracts to show how the degree of observed contractual completeness reflects the desire of the parties to minimize the economic costs associated with ex-post contractual exchange. Several other papers have studied bidding for construction and highway contracts (e.g., Porter and Zona 1993) with the goal to isolate transaction costs due to ex-post renegotiation.

Our perception is that there is a lack (of valuable data and hence) of understanding of several other important issues in procurement. While theoretical works advanced the research on the properties of multidimensional procurements (Dagupta and Spulberg 1989, Che 1993, Branko 1997, Asker and Cantillon 2008), and studied the conditions under which scoring auctions can do better than other mechanisms (Asker and Cantillon 2006), empirical investigations on the role of scoring rules on bidding behavior are completely absent. In particular, how bidders effectively trade-off price and quality? What is the role of critical elements of the tender design, such as the *nature* of the scoring rules or bidders' experience, in the bidding behavior? Attempts to investigate the role of competitive tender design and scoring rules on bidders' behavior are in Lundberg (2005), although in a completely different setting. In a framework where suppliers bid to supply cleaning services to local public administrations, the

[9] For instance, "the observed information (the scores) is one dimensional while the information to be inferred is multidimensional" (Asker and Cantillon, 2008, p. 81).

author's most important result is no evidence of differences in winning bids depending on the auction format (simultaneous multiple lots vs. single lots). Zhong (2007) is the work most related to ours. The author explores some key issues in online procurement auctions for manufacturing goods from a large buyer in the high-tech industry. He characterizes the suppliers' bidding behavior to examine the effect of incumbency on bidding. His most interesting findings are: i) the buyer bias towards the incumbent suppliers, the buyer, however, is not committed to the final tender ranking; ii) incumbent has a price premium; iii) incumbent winners quality is higher, on average, than the quality buyer had before the auction, while non-incumbent winner's quality is lower; iv) using field data of procurement auctions for legal services, he shows that prices are on average reduced after dynamic bidding events.

3. The Institutional context

3.1. What is Consip

Consip S.p.A. is one of the first European Central purchasing bodies to raise the challenge of rationalization of public spending for the procurement of goods and services. It was created in 1997 to provide the MEF with ICT solutions, technologies and services, and to promote IT change management within its Departments and peripheral offices. So, one important task of Consip was (and still is) to manage ICT acquisitions to maintain the whole IT infrastructure supporting the MEF activities. The Italian Financial Law (December 23, 1999 n. 488) laid down the foundations for the "Rationalization Program for Public Spending on Goods and Services", charging Consip with the additional task of implementing the program and working as central procurement agency for all the public administrations.[7]

A specific three-year based agreement regulates the afore-mentioned outsourcing relationship. The agreement mandates Consip to perform several activities: from demand analysis and identification of key IT solutions to suppliers selection, but also contract management and monitoring. With regard to suppliers selection, Consip is mandated to: define needs/solutions, organize the tender, appoint the evaluating

[7] The program is currently carried out through two main tools: framework contracts and the Italian Government's e-Platform (MEPA), an online e-platform for low-value purchases. Framework contracts are stipulated for higher–volume acquisitions from suppliers who are awarded the contract as a result of an open competitive procedure. The online marketplace (MEPA), instead, allows public administrations to procure low-value items with fast and "slim" procedures (request for quotation and one-stop orders).

committee, evaluate the suppliers' proposals, award and manage the contract and monitor suppliers' performance.

Contracts either refer to specific/small activities (e.g., development services for a single MEF Department or over a specific MEF architecture - "vertical projects"), or to larger projects involving many activities merged into a big cross-Departments contract. Some of the most important contracts are of the second type, that is "framework contracts" or "general purpose", including a large variety of activities, such as IT consultancy, development and maintenance of IT applications, databases, internet and intranet websites. Our dataset is essentially based on these general purpose contracts.

In compliance with the EU Directive 2004/18 all these contracts are awarded through open competitive tendering. The Italian law incorporates the EU rules, establishing the most economically advantageous tender (MEAT) and the lowest price as the main criteria to award contracts for services. However, IT contracts are usually awarded by the MEF with the MEAT.

Quality is crucial for every IT services contract. Very often the weight of the technical side is equal or above 50% and evaluation of proposals is always based on a significant discretional component.

The "typical" contract requires the contractor to set up an adequate team of professionals, resources, IT equipments and technological solutions to achieve both high quality standards and sufficient flexibility to manage heterogeneous activities. The three milestones of evaluation criteria are the organizational proposal (teams), technological solutions and improvements over key performance indicators. To each milestone is assigned a weight (score/points). Within each single milestone, points are allocated to several sub-criteria. Basically, the milestones are:

- **Organization**, e.g., how resources are organized and deployed to best perform tasks; solutions to maintain stability and provide flexibility to working teams; how activities are split among partners in case of joint bidding or subcontracting;
- **Solutions**, e.g., software, methodologies and tests for development activities, best practices for the implementation of big projects involving many "Function Points";[10]

[10] Function Points are a software metrics to quantify estimating software development. Function Point Analysis is considered a reliable method for measuring the size of computer software. In addition to

- **Quality**, e.g., quality plans, documents released, improvements over Key Performance Indicators (KPI), skills of professionals and consultants, etc.

Contracts are fixed-price, providing for some performance incentives based on the achievement of certain KPI thresholds.

As anticipated above, the contracts provide for a large variety of activities, e.g.:

- evolutionary and corrective maintenance of applications;
- development over existing applications;
- development of new applications;
- consultancy on IT services and data monitoring;
- management of websites (development of new accessible websites, publishing, etc.);
- management of data warehouse and databases;
- help-desk and end-user assistance/support levels;
- corporate assistance/support/consultancy (Ministry of Economy and his Cabinet).

To best manage all activities, contracts usually require the contractor to deploy different types of professionals: the Chief of the project, a list of selected senior consultants, and teams composed of several other professionals, such as junior consultants, function analysts, programmers, product/technology specialists, data warehouse designers and enterprise data administrators.

Depending on the size of the contract and the number of departments/users involved, supplier's team may be composed of even more than 100 professionals. The contractor's team operate in harness with dedicated people from the MEF and Consip project managers and monitoring unit.

3.2. Bids' evaluation: role of committees

Contracts for services are usually awarded with the most economically advantageous tender criterion (MEAT). This configures a sealed-bid first score procurement auction. Technical and price bids are simultaneously submitted by each supplier.

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measuring output, Function Point Analysis is useful in estimating projects, measuring productivity, and communicating functional requirements.

Submitted bids are evaluated by *ad-hoc* committees. The committee checks whether competing suppliers have the minimum technical/economic requirements indicated in the solicitation documents. All suppliers fulfilling the minimum requirements are admitted to the subsequent phase. In this phase, the committee evaluates the technical bids of all the admitted suppliers. As mentioned before, in the case of IT contracts, the technical bid consists in an organizational proposal of teams and resources which are (discretionally) evaluated by committee. The committee judges how the organizational setting and proposed solutions are able to perform the various activities established in the contract. At the end of the evaluation process, the committee draws the final technical scores. These scores are disclosed in a *public* session with the suppliers. In the same public session the committee opens the sealed envelopes containing the price bids and publicly announces the submitted prices.[11]

The committee only evaluates technical proposals. Despite discretion powers it on assigning the score within the sub-criteria indicated in section 3.1, the committee is *committed* to the maximum score for each macro-criterion, as well as to the specific scoring rule for price bids indicated in the solicitation documents.[12]

Submitted price bids are not known during this evaluation process and are discovered by the committee and the bidding suppliers in the same time during the public session. After announcing the technical scores and prices, the committee computes the financial scores, by inserting the submitted prices in the scoring rule.[13] The total score (and thus the final ranking) is computed by summing the technical and the financial scores for each supplier.

The composition of the committees is regulated by the law. Until 2006 the legislation established members to be selected among both public administration's employees ("insiders") and external professionals, such as university professors or recognized experts ("outsiders"). Since 2007 committees are of all insiders. The number of members can be either 3 or 5 depending on the complexity of the supply.[14]

Our dataset enables us to make some comparisons between the two regimes and to see whether, other things being equal, there is a difference in evaluating technical

[11] In this phase suppliers are able to compute their own total scores and the score of competing suppliers, and thus to find out the winner's identity.

[12] For instance, if the solicitation document provides for up to 5 points for "organization" the committee is free to assign between 0 and 5 depending on the quality of the supplier's proposal over that aspect, but is not allowed to assign more than 5 points. This, of course, holds for each technical criterion.

[13] The scoring rule, as well as the score of each technical evaluation criteria, are public information as they must be disclosed in the solicitation documents.

[14] The rules on committees apply to Consip as well as to all other public administrations.

proposals. The first contracts (1999-2002) and than the latest ones (2007) were evaluated by insiders committees, while all the others by mixed committees (insiders and outsiders). Our conjecture is that, being in depth with the details of the contract, internal committees are likely to evaluate technical proposals with more accuracy than mixed committees. As we will see, some patterns arise in the analysis of technical scores distribution.

4. Overview of the dataset

Our analysis is based on a unique set of 20 contracts[13] that Consip awarded in the period 1998–2007. The total value of the contracts analyzed amounts to €428,7 millions, 4,6% of total Italian expenditure on IT services in 2006 (private and public sectors amount to €9,3 billions).

Economic value is only one aspect characterizing the importance of such data of contracts. First, we are able to address issues not yet empirically explored. One is the impact of scoring rules on bidding behavior. Second, these contracts are for performing strategic activities, as they often relate to critical (IT) MEF infrastructures, such as the ones supporting the Public Balance Sheet and the definition of Budget Laws. Moreover, despite the set of 20 contracts yields a limited number of observations, namely 132 price/technical pairs, these are the whole set of procurement auctions on IT services run by Consip in behalf of MEF since its creation in 1997. In other words, we do not deal with observations "drawn" from a sample of contracts, rather with *the whole* set of existing contracts.

One last element worth highlighting is the number and the importance of bidding suppliers. Bidders include the major worldwide players in IT, such as Accenture, Almaviva, Enterprise Digital Architects (EDA), EDS, Engineering, IBM, Siemens. These are the most important suppliers in the IT sector, covering almost the entire market share in Italy and Europe, as reported in Figure 1 and Figure 2. Figure 3 reports the number of times these suppliers submitted a bid in the set of contracts we

[13] In some circumstances the competitive tender is split in different lots. Each lot is a different contract and thus considered as separated competitive framework. See Grimm, Pacini, Spagnolo and Zanza (2006) for an in-depth discussion on lots division and competition in procurement.

considered. As the reader can note, the most important IT services provision companies compete to provide IT services to the MEF.

Figure 1-2 – Revenues from main IT services suppliers operating in Italy (2006)

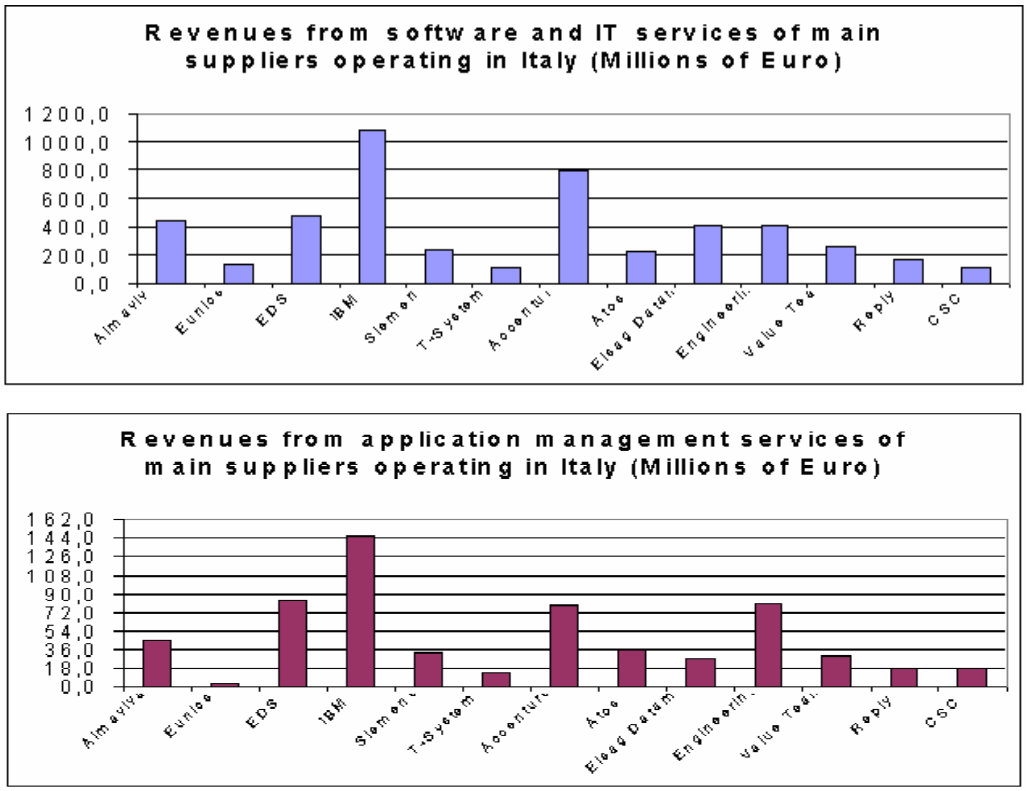
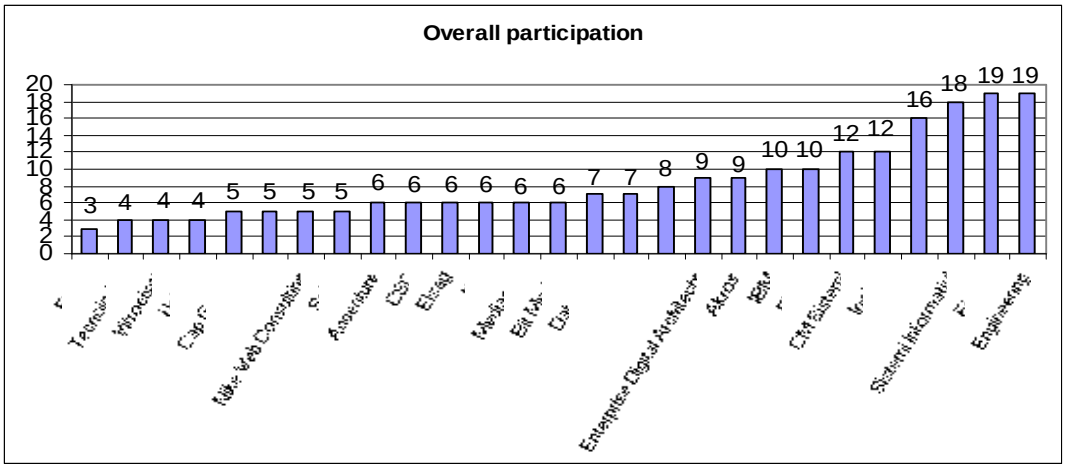


Figure 3 – Overall tender participation from main IT services suppliers operating in Italy.



4.1. Some statistics

Many issues analyzed below are widely discussed in the common practice of procurement. However, even at level of simple descriptive statistics, there is no systematic evidence about the direction of the effects that practitioners and economists

have been suggesting by years. For instance, while many procurers are aware about the potential adverse effects of large contract value (high reserve price) on participation of (especially small) firms, to our knowledge there is no study attempting to test this relationship.[15] Similar considerations can be made about contract value and joint bidding, as well as the effects of supplier's experience/learning on the chances to win future competitions.

4.1.1 Bids and scores

The simple ranking of contracts by technical scores[16] raffled off shows that quality is very important. We note that 60% of contracts are skewed on technical side. In the majority of lots quality weights at least 60%. Contracts in which quality is at least 50% are 85% of total contracts.

Table 1 – Frequency distribution of available Technical Score				
α	<50	50-59	60-69	≥70
N.	3	5	8	4
%	0.15	0.25	0.40	0.20
Table 2 – Frequency distribution of available Financial Score				
β	≤30	31-40	41-50	>50
N.	4	8	5	3
%	0.20	0.40	0.25	0.15

Symmetrically, the frequency distribution of financial scores shows that 60% of lots has been faced with scores until 40 points, or 85% under 50 financial score.

Table 3 and 4 show the frequency distribution of observed relative scores effectively achieved by the competitors. Relative score equals actual score/maximum score. The cumulated distribution is plotted in Figure 4. The central technical score ranges (51-60 and 61-70) represents the 50% of technical proposals, whereas 62% of technical proposals obtained scores over 60. Overall average technical score is 66.17, median is 65. Standard deviation is 14.67, showing a significant dispersion if we consider the

[15] In the U.S., the importance of the issue was recognized by the creation of the Small Business Administration (SBA, www.sba.gov) already in 1953. The SBA is an independent agency of the Federal Government in charge to provide support to small business. The role of SBA is critical in public procurement since it monitors that contracting agencies fulfil the "set-aside" goals provided by FAR (2005, Subpart 19.5 — Set-Asides for Small Business). The goal was established to protect small (and disadvantaged) business in the market for public procurement contracts.

[16] Henceforth, we will use score(s) and points(s) interchangeably. This holds also for lot(s) and contract(s).

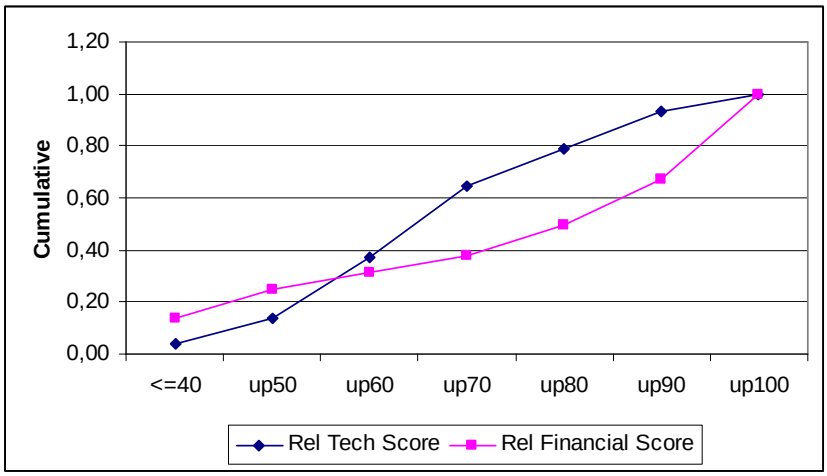
best and the worst technical proposals. But statistics also highlight the low number of bidders (9 out of 132) achieving the highest score range (91-100).

Table 3 – Frequency distribution of relative technical score							
rank	<=40	41-50	51-60	61-70	71-80	81-90	91-100
N.	5	13	31	36	19	19	9
%	0.04	0.10	0.23	0.27	0.14	0.14	0.07
Summary Statistics							
Mean			*Median*		*St. Deviation*		
66.17			65.00		14.67		

Table 4 – Frequency distribution of relative financial score							
rank	<=40	41-50	51-60	61-70	71-80	81-90	91-100
N.	18	15	8	9	15	24	43
%	0.14	0.11	0.06	0.07	0.11	0.18	0.33
Summary Statistics							
Mean			*Median*		*St. Deviation*		
72.60			80.81		25.43		

Things are quite different if we analyze the frequency distribution of relative financial scores. The first two higher ranks (81-90 and 91-100) together account for the 51% of proposals, while the 75% are over 50. Furthermore, both the mean and the standard deviation (72.60 and 25.43 respectively) are greater with respect to the technical scores. This might also be due to a sort of "bias" in the mapping from price to score when using "interdependent" scoring (see paragraph 4.1.3 for more details on scoring rules). For instance, although one supplier's bid is slightly above the average, the score differential between her bid and the average bid can be very large when using "average scoring". Anyway, data show clearly that bidders seem to achieve higher ranks of financial scores more easily rather than analogous levels of technical scores.

Figure 4 – Cumulative function of relative technical and financial scores



A noteworthy finding is that suppliers do not win submitting outstanding financial proposals. The score matrix below shows that the winner obtains the highest technical score in 16 cases out of 20, whereas only in 7 cases out of 20 she gets the highest financial score. This suggests that suppliers mainly win contracts by promising relatively more (ex-ante) quality rather than low price, so much so they win 11 times thanks to the best technical score, but not to achieve the best financial ones.

Score Matrix

Winners' Financial Score	**Winners' Technical Score**		
		Best score	*Not best*
	Best score	5	2
	Not best	11	2

4.2. Participation

(a) Participation and contract value[17]

As the contract value increases, the economic and technical requirements become more binding for suppliers.[17] This may adversely affects participation of smaller firms and encourage joint bidding, as we will see in more detail in the next paragraph.

We have run a simple OLS estimation in order to test for a negative correlation between the number of actual bidders and the reserve price/contract value, controlling for some other factors likely to affect participation (e.g., type of scoring rule, discretional technical scores). Regression analysis confirms the intuition: negative relationship is statistically significant (t-statistic = -2.92), as well as the negative correlation is relevant enough (-0.57).

[17] The contract value is also the reserve price. Therefore, we will use these interchangeably.

[17] Italian public procurement laws and the Antitrust Authority indicate that participation requirements, namely revenues and financial capacity, should be proportional to the contract value. Larger contracts require suppliers to satisfy higher revenue/financial capacity for bidding in that procurement competition.

Figure 5 – Smoother of number of actual bidders on contract values[18]

Figure 5 shows that starting from low values, an increase in the reserve price is associated with lower participation. Instead, above a certain threshold (€40 millions) participation slightly increases with the reserve price. This could be explained by assuming that the participation of the biggest and most experienced suppliers is, to some extent, "value independent". In particular, the two outlier tenders have been competed by 4 and 5 bidders respectively, 3 and 4 of which are joint bidders including the largest and more experienced players of the IT sector (Accenture, Almaviva, EDS, IBM, Engineering, Siemens).

(b) Participation and joint bidding

Partnership is a common form of participation to tenders when contracts are "big". Joint bidding can be an appropriate strategy for small as well as for big firms. The latter might be skeptic about bidding autonomously: especially at their first bidding, they may prefer sharing risks with other (possibly more expert) bidding firms. The former do not always have enough economical/technical capacity for individual bidding, so participation necessarily requires partnership. Figure 6-7 support this hypothesis: joint participation is more frequent for large contracts – indeed, the correlation with the contract value of share of joint bids over the number of bids in each lot is relevant and statistically significant. On the other hand, the absolute number of joint bids also increases over time, as shown in fig. 6 (tenders are time graded). Notice the effect of extreme values in Figure 7. As the contract value increases, the

[18] We computed a Locally Weighted Scatter Plot Smoothing with a bandwidth = 0.8.

relationship tends to be less steep since the overall participation becomes lower due to more stringent economic requirements and joint participation proportion tends to 1.

Figure 6 – Individual and joint bidding patterns

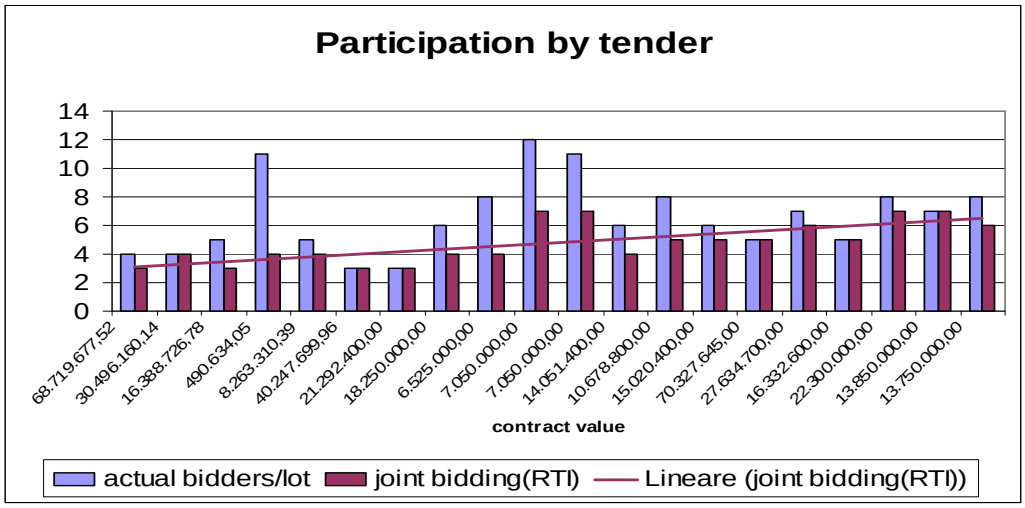
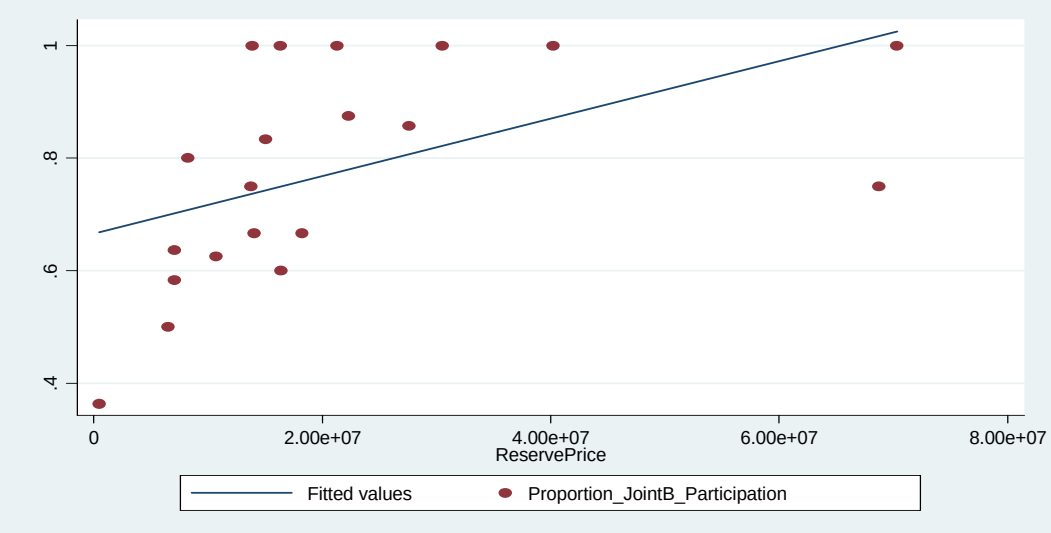


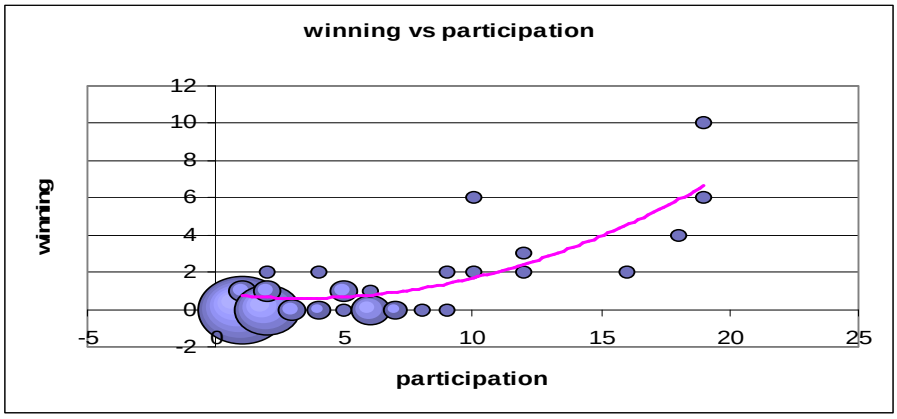
Figure 7 – Correlation between proportion (joint bids/number of bids) and contract value



(c) Awarding rates and participation

Figure 8 shows the correlation between awarding rates and participation. The number of participations for each supplier is the number of contracts for which she has submitted an offer.

Figure 8 – Awarding rates and participation



The size of the ball in the graph represents the number of suppliers with a given pair participations-wins. On the one hand, we observe that most of the suppliers never won a contract: 26 suppliers bid once and were awarded no contract; 15 firms bid twice without winning any contract. There are even suppliers facing with 9 bids and still facing with 0 contracts awarded. On the other hand, there is a smaller number of suppliers winning quite frequently. The relationship between participations and number of contracts won seems to be exponential. The number of contracts awarded, and the probability of winning a contract (number of wins/number of bids) seems to increase with the participation. The more frequently any supplier bids, the greater her chances to win a contract.[19]

Data show some learning effect. After winning and supplying a contract bidders acquire an informational advantage over potential competitors. Such an advantage is then exploited in subsequent tenders, allowing experienced suppliers to become more efficient and so increase (more-than proportionally) their probability to win a contract. The regression analysis presented in Section 5 illustrates how experience/learning plays an effective role in suppliers' bidding behavior, also when controlling for important elements of the procurement tender design.

4.3. Scoring rules

Contracts for IT services always contain various aspects of quality. Such a multidimensional problem is treated with MEATs. As well known, MEATs are usually performed by scoring rules that transform price (and/or other quality aspects) into a

[19] The relation between winning and participation is well fitted by a polynomial graph of 2nd order which shows a more than proportional increase in winning with respect to the number of bids submitted.

score. The highest score wins the contract.[20] As a preliminary analysis, Figure 9 shows how rebates of winners increase on average when the scoring rule is "linear" with respect to other rules.[21] A scoring rule is said to be linear if score increases linearly/proportionally as the price declines. This type of scoring rule belongs to the family that we may call *independent scoring rules*. Independent scoring *rules* are such that one bidder's score depends on her bid *only*. *Interdependent* scoring rules, instead, are such that the score of any bidder also depends on some (or all) other bids (e.g. the lowest bid, the highest bid, the average bid, etc.).

We will see below that the former type of rule leads to lower submitted prices on average. The difficulty or the impossibility to fully infer the buyer's preferences in terms of price-quality trade-off in the case of interdependent rule may be at the root of such a difference. With linear scoring rules, at the contrary, computing the score associated to any possible price bid and thus defining the appropriate price/quality strategy is much more easy for suppliers. Simplicity of the rule and predictability of the score might then stimulate price competition, as Figure 9 seem to suggest.

Interdependent scoring rules tend to yield significant lower rebates on average – about 27% with respect to 46% – than independent scoring rules.[22] In particular, "lowest and/or average price-based" scoring rules induce suppliers to submit bids as close as possible to what they expect the best or average price will be. The more precise this estimate is, the more chances the supplier will have in achieving an high score. The uncertainty, however, may trigger a precautionary or not aggressive bidders' behavior on the price side.

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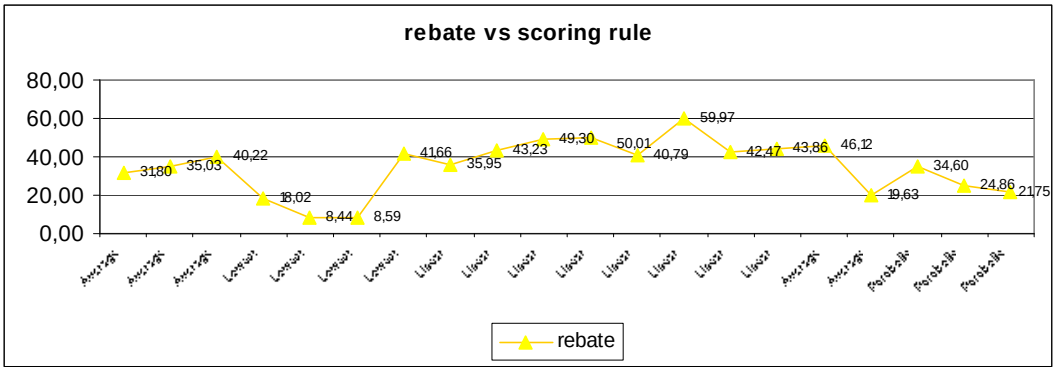
[20] See Che (1993) and Asker and Cantillon (2008-2006) for theoretical implications and properties of scoring auctions. See also Dini, Pacini and Valletti (2006) for an in-depth analysis on the design of scoring rules.

[21] "The linear scoring rule is a very simple way to transform price bids into a score. This rule is described by […]": $PriceScore = nn * \frac{(ReservePrice - PriceBid)}{(ReservePrice - PriceThreshold)}$, where the price threshold is a percentage of the reserve price that the procurer may want to introduce in order to stimulate competition on price." See Chapter 12, N. Dimitri, G. Piga, G. Spagnolo (2006), "*Handbook of Procurement*", Cambridge University Press.

[22] Data also show that price bids tend to be more concentrated under interdependent scoring rules than under independent scoring rules. The effects of interdependent scoring rules has not been studied by the theoretical literature. However, first indications from Albano *et al*. (2007) suggest that interdependent scoring rules might facilitate some form of coordination among bidders. Lower dispersion found in submitted bids when scoring mechanisms are of the interdependent type might not conflict with the authors' findings.

Figure 9 – Rebates of winning bidders and scoring Rules



5. Empirical analysis

In this section we use the dataset to explore the main factors explaining suppliers' bidding behavior.

Our estimates are based on a non-structural (or reduced form) regression approach. As mentioned in the literature section we do not wish – and our data do not allow us – to address issues implying the derivation of a structural model, such as the optimality of reserve price, checking common value vs. private value paradigm, or estimating suppliers' mark-up. Our environment does not appear appropriate for structural modeling. Buyer's and suppliers' behavior would be very hard to describe in multidimensional procurement environments where, among others, contracts are highly incomplete, quality is non-contractible and bids are discretionally evaluated by the committee.[23] Optimization should also account for several factors, often unobservable to the econometrician (or observable at prohibitive costs) or hard to be modeled. These are for instance the description of a large set of law-driven auctions rules,[24] and the multiplicity of buyers' needs "dispersed" – and often only roughly described – in the contract.

The reduced form approach allows us to focus more on the *directions rather than magnitude effects*. A standard reduced form regression model is the following:

[23] One issue of our data is that sometimes explanatory variables cannot be considered fully exogenous. Endogeneity may affect for instance the scoring rule or the reserve price. Sometimes their setting at time *t* depends on the outcome of the tender at time *t-1*. Despite we look at data cross-sectionally, some endogeneity may be still present.

[24] These include participation requirements, antitrust regulation for joint bidding, contractor's payment rules, etc..

$$[\text{dependent variable}_i] = \text{constant} + \beta_k\,[\text{independent variable}_{ik}] + \varepsilon_i$$

and $k = 1, \ldots K$ indexes all our explanatory variables, while $i = 1, \ldots N$ indexes our observation units. A cross-section estimate is carried out on 132 observations-bids. We estimate equations using standard OLS.

The analysis of bidding behavior is split in 3 main parts. In the first we test for the existence of a relationship between price and quality in submitted bids. We do this running two regressions on quality (technical bids) and price separately, controlling for some other variable incorporating key aspects of the tender design and the bidding behavior. Note that regressing quality on price is not exactly the same that regressing price on quality. For instance, technical bids might be less sensitive to the reserve price than price bids. But price bids (and scores) are completely independent of the composition of the evaluating committees, that on the contrary can impact technical scores.

In the second part we address the issue of what are the main determinants of the price/quality ratio offered by suppliers. In the third one we investigate the determinants of the dispersion of technical scores in relation with the composition of the evaluating committee.

List of variables included in regressions:

Number of bids. The number of bids is a proxy of the level of ex-ante expected participation/competition to the tender. In mature markets, as IT market is, bidding suppliers are likely to know each other. This variable can therefore provide information about what suppliers know about the level of competition in the tender. In general, this variable can be an important determinant explaining bidding behavior. Standard theory suggests that in a setting of independent private value model, prices increase with participation (in procurement, the price decreases with participation).

Scoring rules. This is a binary variable, 1 for independent and 0 for interdependent scoring rules, respectively. Our conjecture is that independent scoring rules should stimulate competition on the economic side, since suppliers are able to compute ex-ante the incremental score associated to additional price reductions. Predictability of the score may provide suppliers with incentives to bid more aggressively on price. Interdependent scoring, instead, complicates bidding and the conjectures suppliers make about other competitors' bidding behavior. In "average scoring

rules", for instance, suppliers should be induced to estimate the average price in order to bid as close as possible to that level. This "game of expectations" may push submitted prices around the (estimated) average level rather than the lowest possible level, and makes price distribution more concentrated towards higher prices.

Experience. This is measured by the number of previously won contracts for any bid *i* at any given time *t*. We expect more experienced suppliers to better know the procurement environment and thus *ceteris paribus* to offer proposals that better fit the various needs of the buyer. Expert suppliers are expected to be better informed about the real needs of the buyer and how to put this knowledge into more comprehensive technical offers. This should yield higher technical scores with respect to less (or non-) experienced suppliers.

Committees. This is a binary variable, equal to 1 for insiders committees and 0 for mixed committees (insiders + outsiders). This is a control variable capturing the fraction of technical score variability due to a different evaluation approach of the two types of committee.

Bids and scores. We use technical score as a proxy of the ex-ante quality offered by suppliers. Rebates, financial scores and the price/reserve price ratios are alternative measures of economic effort.

The number of explanatory variables is kept low. Such parsimony is used to focus more on those factors that are more likely to explain the dependent variable and, more important, to avoid losing degrees of freedom given the not very large number of observations.

Table 5 – Summary Statistics of variables

Variable	*Mean*	*St. Deviation*	*Min*	*Max*	*Obs*
N. of Bids	*7.56*	*2.63*	*3*	*12*	*132*
Experience	*1.73*	*2.29*	*0*	*10*	*136*
Tech. Score (relative)	*66.17*	*14.72*	*29.17*	*96.82*	*132*
Financial Score (relative)	*72.60*	*25.53*	*0*	*100*	*132*
Rebates	*33.15*	*13.78*	*0.37*	*59.97*	*132*
Reserve Price	*2.14e+07*	*1.88e+07*	*490,634*	*7.03e+07*	*20*

5.1 Testing for price/quality trade-off

5.1.1. Technical score regression

In this section we investigate the main aspects affecting bidding on quality. In particular, *we investigate whether quality is explained by price*, controlling for the type

of scoring rule, the number of bidders, the type of committee and the bidders' experience. The type of scoring rule represents one key element of the tender design. Expected participation/competition and experience are important factors potentially affecting bidding behavior. We measure quality with the technical score the suppliers are assigned by the committee at the end of the evaluation process. Quality we consider is of the *ex-ante* type, i.e., what the suppliers *commit* to provide in terms of organization, quality standards and technological solutions. The equation we estimate is the following:

$$Tech\_Score_i = const + \beta_1 Financial\_Score_i\ [Rebate_i;\ Bid\_Price/Res\_Price_i]$$
$$+\beta_2 \sum_t Winning_{it} + \beta_3 N\_Bids_i + \beta_4 Scoring\_Rule_i + \beta_5 Committee\_dummy_i + \varepsilon_i \qquad (5.1)$$

Does price explain ex-ante quality? We performed 5 regressions with alternative measures of the price bid: financial score, rebate and relative price (price bid/reserve price). All regressions suggest that price explains quality, all the coefficients being statistically significant. However, the relationship between ex-ante quality and economical aspects is *positive*: higher quality is associated to lower prices and vice versa. The sign in this relation seems to contradict the paradigm of a "price-quality trade-off" in submitted bids. Nevertheless, this could be not so surprising, because of some arguments already mentioned above. One first explanation is that it is hard for the buyer to incorporate complex price/quality preferences in the tender design. If the awarding mechanism (the scoring rule) does not adequately reflect these preferences, price and quality may clearly exhibit perverse relationships as the ones observed in the data.

Table 6 – Technical proposals Regression[25]					
		OLS			
$Tech\_Score_i$	I.	II.	III.	IV.	V.
$Financial\_Score_i$	0.156*** (3.24)	-	-	-	-
$Rebate_i$	-	0.389*** (3.72)	0.364*** (3.47)	0.244** (2.44)	-
Bid_Price/Res_Price_i	-	-	-	-	-38.91*** (-3.72)
$\sum_t Winning_{it}$	3.07*** (6.55)	3.414*** (7.15)	3.55*** (7.44)	3.01*** (6.23)	3.414*** (7.15)
N_Bids_i	-1.41*** (-2.86)	-0.854** (-1.97)	-	-1.266*** (-2.91)	-0.854** (-1.97)
$Scoring\_Rule_i$	-5.12** (-2.00)	-9.625*** (-3.49)	-11.11*** (-4.14)	-	-9.625*** (-3.49)
Committee_dummy	-8.964*** (-3.76)	-2.676 (-1.03)	-2.857 (-1.09)	-1.739 (-0.65)	-2.676 (-1.03)
Constant term	67.202*** (16.27)	61.092*** (12.62)	56.252*** (13.34)	63.158*** (12.60)	100.00*** (12.08)
Adj. R^2	0.33	0.35	0.33	0.29	0.35
F-test	14.09	15.06	17.46	14.51	15.06
N. Obs.	132	132	132	132	132
t-Statistic shown in parentheses; significant levels at *0.10, **0.05, ***0.01.					

The results might also be driven by non-contractible quality considerations. Since many quality dimensions are hard/costly to monitor ex-post, suppliers may anticipate this at the bidding stage and offer low prices for the "promise" of outstanding quality (yielding high technical scores), but lower ex-post effective quality.[26] A similar effect is studied in theory by Kim (1998), who builds up a procurement model where the buyer wishes to acquire a high-quality project by the use of a sealed-bid tendering. Non-contractible quality of projects implies transaction costs for contract enforcement and difficulties to ensure that the project is of the desired high quality. In this framework the author points out that if the buyer commits himself to a firm fixed price contract,[27] the contractor may provide low quality in order to cut down on production costs.[28]

[25] Tests indicate that the estimated model is not affected by multi-collinearity for independent variables. F-test indicate that all variables should be included in the regression. Goodness of estimation appears good: despite parsimony the model is able to explain up 30%-35% of total variance. Further testing rejects the hypothesis of non-normality in estimated residuals, therefore supporting the choice of a linear model for our data. These considerations hold also for the price regressions.

[26] This is the case of the procurement environment we considered. Monitoring is difficult being quality widely non-contractible. Moreover, several public procurement legislations (among these we include Italian procurement laws), provide for limits to the use of customer satisfaction or other subjective measures of performance to judge contractors' performance. In this context, it is rather difficult for public procurers to achieve a full contract enforcement but also to use effective reputational forces. In our dataset therefore we cannot control for the ex-post quality.

[27] Instead of re-tendering in case of undesired outcome.

[28] Also note that project complexity can make the estimation of the organizational efforts actually required (and thus their monetary cost) a very hard task for the suppliers. This affects their ability to appropriately trade-off price and quality and may produce "optimistically" too low estimates of the project's costs.

The role of other variables

1) Estimates suggest that *independent scoring* (linear and concave)[29] reduces technical score increases (the sign of coefficients is always negative as reported in Table 6).

Independent rules allow each supplier to determine his financial score unloosed from his competitors' behaviour. This provide him with a clear incentive to improve the price offer. It is worth noting, on the contrary, that interdependent rules (lowest bid and average scoring) introduce uncertainty also on the price side. Scores become unpredictable because of the simultaneous presence of both discretional evaluation of technical proposals and interdependent price scoring. In this context, incentives for the suppliers to shift effort from quality towards price improvements are expected to be weaker since the shift can pay for only with a *known* "rate of return" in terms of financial score.[30]

2) The variable $\sum_t Winning_{it}$ summarizes the number of past contracts awarded to each bidding supplier. Experience/learning is what the supplier has learnt during the contract execution period. Learning can be important in complex procurement like the ones we are considering. Experience improves the supplier's understanding of what are today (and could be in the future) the technological evolutions and the developments most fitting buyer's needs, as well as the most important/critical activities among the ones indicated in the contract. In other words, the contractor learns to make a "custom tailored suite" and how to exploit this (private) information in subsequent procurement tenders.

Any single observation, i.e., any single pair of price-quality bid, is associated to a measure of experience given by the number of contracts previously awarded to the supplier. Technical scores appear to be *positively and significantly correlated* with this variable. Covariates statistical significance is robust to alternative regressions specifications, with estimated coefficients maintaining stability. Winning one

[29] Concave scoring is such that the score increases less than proportionally as price declines. A standard concave scoring can be as follows: $S_i = [1 - (P_i/P_b)^{\alpha}] * PE$. Where S_i is the score obtained by bidder "i", P_i is the price submitted by bidder "i", P_b is the reserve price, α measures the slope of the curve and PE is the weight of price in the tender. Concave scoring clearly discourages bidders to bid aggressively, as soon as the incremental score is made negligible (depending on α) for marginal reductions of P_i. This rule is sometimes used in procurements where quality plays a significant role and the procurer wishes to avoid that very low price favours ex-post opportunism from the contractor.

[30] With independent scoring rules such a shift can indeed pay: rather than offering X additional consultants at a cost of say €250.000, to get an uncertain incremental technical score, the supplier can easily compute the (certain!) incremental score associated to a price reduction of the same amount.

additional contract allows the supplier to improve the relative technical score by roughly 3.1-3.6 points, about 6% of relative technical score on average.

3) The *number of bids submitted* has a negative impact on the technical score suggesting that the larger the number of bidders the lower the "promised" quality. A first possible explanation is that more participation shifts the players' efforts towards price-competition rather than technical-competition. Again, the expectation that quality improvements may not be appropriately rewarded (or will do less than price improvements) may induce suppliers to shift effort from quality to price when expecting higher participation.
Scoring rule and expected participation appear to interact, and to operate in the same direction. In point sub 1) we have seen how independent scoring rules encourage competitors to shift effort toward price. Here we have found that higher participation *in general* encourages them to shift effort toward price competition.

4) Despite statistical significance is achieved only when using the financial score as covariate, the composition of committees seems to affect technical scores in the conjectured direction. Internal commissions are associated to a lower average technical score. Insiders tend to discriminate quality proposals more than outsiders, providing support for the results of the analysis of technical score distributions presented in section 6.

5.1.2. The determinants of price bids

Symmetrically to the previous regressions, we test whether price bids are explained by quality, controlling for other variables. We also control for the contract value (reserve price) since this may effect more directly price bids, in particular the magnitude of rebates. We measure price bid with the % of rebate. Price bid regression is also performed as a "check" for results obtained in technical regressions.
The estimated equation is:

$$Rebate_i\,[Financial\_Score_i] = const + \beta_1\, Tech\_Score_i + \\ + \beta_2\, Scoring\_Rule_i + \beta_3 \sum_t Winning_{it} + \beta_4\, N\_Bids_i + \beta_5\, Reserve\_Price_i + \varepsilon_i \qquad (5.2)$$

Table 7 – Financial proposals Regression

	$Tech\_Score_i$	$Scoring\_Rule_i$	$\sum_t Winning_{it}$	N_Bids_i	$Reserve\_Price_i$	Constant term	Adj. R^2	F-test	N. Obs
$Rebate_i^{OLS(E)}$	0.33*** (4.50)	15.78*** (7.49)	-2.025*** (-4.35)	1.05** (2.22)	7.30e-08 (1.02)	-4.55 (-0.73)	0.42	19.97	132
$Rebate_i^{WLS(1)}$	0.076 (1.46)	21.10*** (9.78)	-0.45 (-0.69)	1.481** (2.34)	3.28e-07* (1.86)	-1.59 (-0.21)	0.53	31.04	132

*t-Statistic shown in parentheses; significant levels at *0.10, **0.05, ***0.01.*
(E) Heteroscedastic affliction; (1) weight: Reserve_Price;

As expected, price and quality are still positively correlated. Estimated coefficients also show that:

i) experience reduces rebates, i.e., increases prices;

ii) higher expected competition lowers the price (increases rebate). This point is worth stressing. The level of expected competition does not impact quality as it does for price, although the directions of effects are unequivocal on both quality and price bid, as shown until now. If the ex-ante quality goes down, the opportunistic decision of decreasing price bid may be the relative cause in so far as either effects are in response of expected competition. But we demonstrate below that this first clue of price-quality trade-off is not confirmed because of the ex-ante quality unstable sensitivity to expected competition (see results in table 8). This indirectly supports the idea that quality and price bidding may be set independently rather than in a (very) coordinated manner by the supplier. Quality appears to respond more to factors related to the suppliers' experience. Price, instead, reflects information on expected competition and the nature of the scoring rule.

iii) the reserve price seems to play no role in the regression as a control variable for the dimension of the contract.

iv) Notice that independent scoring rules induce to lower prices (higher rebate). This suggests again that simplicity of the rule and predictability of the score make suppliers' life easier when bidding on price and induce them to bid more aggressively. Independent scoring affects financial proposals by decreasing submitted relative prices (increasing rebates) by 16%-21% on average.

6. The determinants of price/quality ratio

In this section we look at bidding behaviour under a different perspective. We investigate the main elements driving the submitted price/quality ratios. We identify the main determinants of price/quality ratio by using a price/quality index.[31] The index may be interpreted as a measure of the *elasticity* of the price with respect to quality. The *price/quality index* is as follows:[32]

$$R^{p}\!/_{Q_i} = \frac{Bid\ \mathrm{Pr}ice_i \,/\, \mathrm{Re}serve\ \mathrm{Pr}ice_c}{Tech.Score_i \,/\, MaxTech.Score_c} \qquad (6.1)$$

The index displays the following properties.

1. $\mathrm{Re}serve\ \mathrm{Pr}ice_c \geq Bid\ \mathrm{Pr}ice_i$;
2. $Tech.Score_i \leq MaxTech.Score_c$.
3. $0 \leq \left(Bid\ \mathrm{Pr}ice_i \,/\, \mathrm{Re}serve\ \mathrm{Pr}ice_c \right) \leq 1,$

and

4. $0 \leq \left(Tech.Score_i \,/\, MaxTech.Score_c \right) \leq 1.$

where subscripts "c" and "i" identify contracts and bidders, respectively. As a consequence, it will also be:

5. $R^{p}\!/_{Q_i} \in [0; +\infty].$

The price/quality ratio improves when the index decreases. When the price declines, Price_bid/Reserve_price declines (the rebate increases). This in turn lowers the index, i.e., improves the price/quality index. At the same time, as the technical score increases the denominator also increases; this pushes the ratio down, again improving the

[31] This is the natural way to measure a price/quality ratio. Alternatively, we could have considered the total score (sum of technical and price scores). However, this indicator would suffer from the fact that the effects on price and quality are milked and made indiscernible.

[32] Where the reserve price and the upper bound of technical scores are indexed for *c = 1…C*, the number of awarded contracts.

price/quality index. Therefore, higher quality and lower prices are associated to $R\,p/Q_i$ closer to 0.[33] With the following equation we estimate the effect of a set of explanatory variables:

$$R\,p/Q_i = const + \beta_1 Scoring\_Rule_i + \beta_2 N\_Bids_i + \beta_3 \sum_t Winning + \beta_4 \mathrm{Re}serve\_\mathrm{Pr}ice_i + \varepsilon_i \qquad (6.2)$$

Tab. 8 – Price/Quality Index Regression

	I.	II.	III.	IV.	V.	VI.	VII.
	$R\,p/Q_{i\ OLS}$ (E)	$R\,p/Q_{i\ WLS}$ (1)	Num_ $R\,p/Q_{i\ OLS}$	Num_ $R\,p/Q_{i\ WLS}$ (1)	Den_ $R\,p/Q_{i\ OLS}$	Den_ $R\,p/Q_{i\ WLS}$ (1)	Den_ $R\,p/Q_{i\ WLS}$ (2)
$Scoring\_Rule_i$	-0.267*** (-3.77)	-0.331*** (-3.30)	-0.148*** (-6.56)	-0.21*** (-9.66)	-0.031 (-1.24)	-0.026 (-0.71)	-0.027 (-1.03)
N_Bids_i	-0.015 (-0.96)	-0.033 (-1.12)	-0.011** (-2.10)	-0.015** (-2.34)	0.0004 (0.08)	0.001 (0.11)	-0.003 (-0.46)
$\sum_t Winning_{it}$	-0.036*** (-2.63)	-0.086*** (-3.03)	0.010** (2.31)	0.001 (0.16)	0.031*** (6.21)	0.046*** (4.40)	0.031*** (6.30)
$Reserve\_Price_i$	-5.81e-09** (-2.44)	-1.04e-08 (-1.27)	-1.29e-09* (-1.70)	-3.35e-09* (-1.89)	1.69e-09** (1.98)	8.93e-10 (0.30)	1.51e-09** (2.08)
Constant term	1.50*** (10.11)	1.84*** (5. 65)	0.8498*** (18.00)	0.97*** (13.81)	0.60*** (11.21)	0.57*** (4.77)	0.62*** (12.80)
Adj. R^2	0.19	0.24	0.33	0.53	0.26	0.13	0.26
F-test	8.50	11.59	17.28	37.93	12.29	5.93	12.77
N. Obs.	132	132	132	132	132	132	132

*t-Statistic shown in parentheses; significant levels at *0.10, **0.05, ***0.01.*
(E) Heteroscedastic affliction; (1) weight: Reserve_Price; (2) weight: N_Bids

The first two columns report the results of standard estimation with OLS and robust regressions (WLS). Weighted Least Squares regression is used to deal with heteroscedasticity.[34] The remaining columns instead report the estimations considering either the numerator or the denominator, again controlling for heteroscedasticity.

[33] Notice that when the submitted price is equal to the reserve price (zero rebate) and the actual technical score equals the maximum, $R\,p/Q_i = 1$, however, this cannot be considered the worst price/quality ratio. In other words, the index is not defined for extreme values. This also occurs when technical score is closer to zero and thus the index explodes to infinity although price approaches zero. However, we have not extreme cases in our dataset.

[34] Tests identify the variable(s) source of the heteroscedasticity. We use these variables to weight observation when running WLS regressions. In the second and last column of Table 8, regressions are weighted for the reserve price and number of bids according to the results of the test.

Estimates indicate that both scoring rule and past experience play an important role in explaining the price/quality ratios. Negative correlations implies overall improvements in the price/quality index. Scoring rules and experience clearly go towards this direction, confirming the effects showed in previous regressions. Independent scoring positively impacts the price/quality ratio achieved by the buyer: about 25%-31% of improvement in the index (made base for computation the mean value of the index)[35] is associated with the use of independent scoring rules instead of interdependent scoring rules. However, the largest impact occurs on the economic side of competition (the numerator of the index captures the effect on price side). This is shown by regressions 3 and 4.

Table 8 reports regressions 5-7 that capture the impact on quality side of competition (denominator of the index). Experience is quite relevant. One additional contract awarded improves the price/quality index by 3.4%-8.2%, if referring to its mean value. Decomposing the estimation, bidder experience has still the strongest impact on quality as found in the previous regressions (5 to 7). Reserve price variable here is used as a control variable, in order to account for the variability of the contract value. In the second column the reserve price is used as instrument to control for heteroscedasticity.

Finally, notice again the role of expected level of competition (number of submitted bids). Signs and significance of coefficients confirm the reasoning proposed in section 5.1.2, point ii). Technical proposals (the denominator of the index) are not influenced by the number of expected bidders (coefficient is not significant), while price does. So, the price/quality ratio doesn't show a clear overall improvement when competition gets fiercer, despite a competition effect is well-rendered on price bids.

7. Evaluating committees

Evaluation of quality proposals may vary significantly, depending on how deeply people involved in the evaluation process know the procurement environment, the needs of the buyer and the various details of the contract. Insiders, i.e., Consip IT experts, know these things much better than any outsider expert. Filling this

[35] The mean value of price/quality ratio, as computed on the 132 observations of dataset, amounts to 1.05 (min: 0.55, max: 2.78) and variance to 0.15.

information gap can be very costly and time consuming for outsiders. Outsiders in the committee were provided for, by law, to increase transparency in the awarding/evaluation procedures. However, such a transparency may not be costless. Lack of familiarity with the specific procurement context may limit the ability of committees to correctly distinguish among proposals with respect to insiders. A lower dispersion in technical scores, and higher average technical scores may could be interpreted as the fear of outsiders components of the committees for potential appeals of suppliers. On their part, day-to-day direct work on projects put insiders in a better position to fully understand the procurement tender context and to better evaluate quality proposals. This also enables insiders to better defend their choices in case of dispute with suppliers.

These conjectures seem to find some support in the data. Table 9 summarizes some simple statistics on technical scores distinguishing between insiders (committee = 1) and mixed (insiders + outsiders) committee (committee = 0). Two things are worth noting:

1) The variability of technical scores with all-insider committees is greater than with mixed committees. Mean variance is 0.083 vs. 0.058, i.e., 43% greater than in mixed committees. Mean standard deviation is 0.136 vs. 0.11, 23% greater than in mixed committees. Dispersion of technical scores is clearly higher with insider committees. Regression analysis reported in table 9.2 shows that such differences are statistically more significant, if a zero-intercept regression is run.[36]

2) Mixed committees are also more generous in rewarding quality with respect to insiders. Mean technical score is 68.63 and 62.55, respectively, 10% higher with mixed commissions. The maximum score is 96.82 of outsiders and 93.33 from insiders.

Tab. 9.1 – Summary Statistic on Committee

Statistics	*Committee = 0*	*Committee = 1*
Mean of Technical Score St. Deviation	*0.11*	*0.136*
Mean of Technical Score Variance	*0.058*	*0.083*
Observations (by group)	*79*	*56*
Mean of Technical Score	*68.63*	*62.55*
St. Deviation (by group)	*13.88*	*15.15*
Minimum	*29.17*	*32.29*
Maximum	*96.82*	*93.33*

[36] Imposing the model with a zero-intercept should be reasonable. When number of valid bids is zero (no participant) there is no reason because dispersion of financial score is different from zero, the same is for dispersion in technical score.

Table 9.2 – Evaluation Committees Regression[37]				
		OLS		
	St.Dev_ TechScore$_t$	St.Dev_ TechScore$_t$	Var_ TechScore$_t$	Var_ TechScore$_t$
St.Dev_FinScore$_t$	0.242** (2.72)	0.278*** (4.10)	-	-
Var_ FinScore$_t$	-	-	0.112* (1.91)	0.115** (2.33)
N_Bids$_t$	0.008** (2.14)	0.01*** (5.43)	0.006 (1.50)	0.006*** (3.80)
Committee$_t$	0.032* (1.89)	0.036** (2.34)	0.03 (1.60)	0.030* (1.84)
Constant term	0.021 (0.63)	-	0.003 (0.10)	-
Adj. R^2	0.31	0.92	0.15	0.77
F-test	3.85	78.53	2.14	23.18
N. Obs.	20	20	20	20

*t-Statistic shown in parentheses; significant levels at *0.10, **0.05, ***0.01.*

8. Conclusions

In this paper we explored the determinants of suppliers' bidding behaviour, using a unique dataset of contracts for IT services that Consip awarded on behalf of the Italian Ministry of Economy and Finance.

One first finding is the absence of a tension between price and quality in observed bids. Price and quality appear inversely related: higher quality is associated to lower prices. This results may be due to the difficulty for the buyer to adequately describe/incorporate her price/quality preferences into the tender design (the scoring rule). Consistently with Kim (1998), also non-contractible quality considerations might play a role, as these can shape the suppliers' incentives towards submitting low prices for ex-post lower-than-promised quality.

Another finding is that the nature of the scoring rule and past experience appear to be among the most important determinants of submitted price/quality ratios. Experience plays a primary role in bidding, positively affecting the level of ex-ante quality and in general price/quality ratios. Superior information on the procurement environment can significantly increase the contractor's probabilities to award future contracts.

Independent scoring rules facilitate bidding and encourage suppliers to be more aggressive on the price side of the tender. This suggests that interdependent scoring

[37] Explanatory variables are indexed to $t = 1…20$, where t is the contract number. In this field the observations available are only 20, such that the number of all treated contracts we analyze. In our estimations we use the dispersion measures of financial scores simply as a control variable. The number of bidders by lot (contract) is useful in order to control for tender participation that may affect the expectation of each bidder on quality proposals from competitors, and so the actual distribution of technical proposals.

rules are only an obstacle to bidding in already complex procurement environments. The result has some connections with Lundberg (2005), who shows how bidding strategies are complicated when the buyer's trade-off between price and quality is not announced to bidders. Interdependent scoring rules make in fact buyers' preferences rather opaque.

Finally, we find that the distribution of scores for technical proposals is significantly less dispersed when evaluation committees are composed of "outsiders" (mainly non-IT-Consip experts) rather than "insiders", suggesting that in the former case competition is shifted more towards price. Also, outsiders tend to be more generous than insiders. Risk aversion for appeals may explain this pattern.

Results allow us to give some indications for IT services tender designers:

1. **Price and quality.** Since scoring auctions may not well incorporate buyer's price/quality preferences, other mechanisms such as negotiations or restricted procedures, could be preferable to award complex IT projects.
2. **Scoring rules**. Independent scoring rules tend to improve the price/quality ratio of the buyer with respect to interdependent scoring rules. Improvements are mainly driven by price reductions, and are likely to be due to the simplicity of the rule and predictability of the score. This suggests to use independent scoring, such as a linear scoring rules. This finding seem to go in the direction indicated in a seminal paper by Che (1993) who shows that when the buyer has commitment power over, a scoring rule that is linear can implement the optimal scheme.

3. **Committees**. We have shown a potential trade-off between transparency and the effectiveness of bid evaluation process. With all-insider committee the awarding process might appear less transparent to the market. However, with respect to non-fully insiders, fully insider committees are more likely to guarantee fair project evaluation.

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