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Reputation and Entry[1]

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ABSTRACT

This paper reports results from a laboratory experiment exploring the relationship between reputation and entry in procurement. There is widespread concern among regulators that favoring suppliers with good past performance, a standard practice in private procurement, may hinder entry by new (smaller or foreign) firms in public procurement markets. Our results suggest that while some reputational mechanisms indeed reduce the frequency of entry, so that the concern is warranted, appropriately designed reputation mechanisms actually stimulate entry. Since quality increases but not prices, our data also suggest that the introduction of reputation may generate large welfare gains for the buyer.

Key-words: Entry, Feedback mechanisms, Governance, Incomplete contracts, Limited enforcement, Incumbency, Multidimensional competition, Participation, Past performance, Procurement, Quality, Reputation, Vendor rating

JEL Codes: H57, L14, L15

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1. Introduction

Does reputation deter entry? If buyers are allowed to use reputational indicators based on past performance in selecting among sellers, does this necessarily reduce the ability of new sellers—i.e., sellers with no history of past performance—to enter the market? The US Senate's concern that past performance-based selection criteria could hinder small businesses' ability to enter and successfully compete for public contracts recently led to an intriguing but inconclusive report by the General Accountability Office.[3] European regulators appear to have always been convinced that allowing the use of reputational indicators as criteria for selecting among contractors leads to manipulations in favor of local incumbents, hindering cross-border procurement and common market integration. For this reason EU Procurement Directives prohibit taking suppliers' track records into account when comparing their bids and EU regulators continue to resist requests from most public buyers to allow for such a practice.[4]

One major reason why European public buyers are pushing to permit the use of past-performance indicators in selecting among contractors is that they consider reputational indicators essential to obtain good value for money for the taxpayer.[5] If, however, these indicators deter entry, there may be a trade-off between the improved price/quality ratios buyers can secure using reputational indicators and the decreased ability of new suppliers to enter the market. If the use of past-performance indicators does not deter entry, there is little reason to forbid their use outright. In that case the decision whether to implement reputational mechanisms should only depend on whether the resulting increase in quality provision justifies any additional associated welfare costs borne by buyers and sellers.

In this paper we build a simple model of repeated procurement, with limited enforcement and potential entry, and implement it in the laboratory to shed some light on the questions raised above. We focus on reputation as an incentive system to limit moral hazard in the quality dimension as well as on the effect

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[3] See *Prior Experience and Past Performance as Evaluation Criteria in the Award of Federal Construction Contracts*, Oct. 2011, available at http://www.gao.gov/products/GAO-12-102R.. The inquiry had a qualitative nature and in our reading did not reach clear conclusions.
[4] See the EU Green Book for the *Consultation on the Modernisation of EU Public Procurement Policy,* 2011, and the *Replies to the Consultation* available at http://ec.europa.eu/internal_market/publicprocurement/modernising_rules/consultations/index_en.htm.
[5] Again, see the *Replies to the Consultation*. .

of reputation on selection through entry. Toward these ends, we assume that some costly-to-produce quality dimension of supply is observable for directly involved parties but, at the same time, is too costly to verify for a court to be governed through explicit contracting and is therefore left to reputational governance.

We make the additional assumption that there is a potential entrant firm that is more efficient than all incumbent firms. In this context, we study how quality, price, entry and welfare change when a simple and transparent reputational mechanism is introduced that rewards incumbent firms that provide costly high quality with a bid subsidy in the subsequent procurement auction and that may also award a bid subsidy (of varying size) to an entrant with no history of production.

Reputational mechanisms that reward past performance are an important governance mechanism for private transactions (Bannejee and Duflo 2000). Court-enforced contracts are often not sufficient to achieve a satisfactory governance of the exchange, and since procurement is rarely occasional, reputational forces may complement and improve substantially on what formal contracting can achieve. Private buyers, however, are typically only concerned about the price and quality of the goods they buy. Regulators in charge of public procurement are instead often interested also in objectives other than the price/quality ratio of publicly purchased goods. For example, they are also usually concerned that the public procurement process is transparent and open for obvious accountability reasons. The need to prevent favoritism and corruption has led lawmakers around the world to ensure that open and transparent auctions where bidders are treated equally—even when in some crucial dimensions they have very different track records—are used as often as possible.

In public procurement open, equal-footing competition is seen not only as an instrument to achieve efficiency and value for taxpayer money, but also as a way to keep public buyers accountable by limiting their discretion in the allocation of public funds. Kelman (1990), who pushed for a deep reform of the US system when he was the head of public procurement during the Clinton administration, stressed the fact that limiting discretion to ensure public buyers' accountability could come at the possibly large cost of not allowing reputational forces to complement incomplete procurement contracts. The reform pointed at reducing the rigidity of procurement rules in the Federal Acquisition Regulations and allowing public buyers to adopt more flexible purchasing practices common in the private sector, including giving more weight to suppliers' past performance.[6] Since the Federal Acquisitions Streamlining Act in 1994, US Federal Departments and Agencies are expected to record past contractors' performance evaluations and share them through common platforms for use in future contractor selection.[7]

The European Union has instead been moving in the opposite direction. An important concern driving procurement regulation in Europe is helping the process of common market integration by increasing cross-border procurement, i.e., the amount of goods and services each EU state buys from contractors based in other states. The EU Procurement Directives that coordinate public procurement regulation in the various European states considerably limit the use of past-performance information in the process of selecting among offers—a feature that came under broad attack during the 2011 consultation for the revision of the EU Directives.[8]

However, regulators would also like to ensure that small businesses are not excluded from public procurement, a concern that in the US led to large programs like the Small Business Act, with its rules limiting bundling and the establishment of the Small Business Agency and the 'set aside' common in many procurement markets (see e.g. Athey and Levine 2011; Krasnokutskaya, forthcoming). This brings us back to our main research question. It is natural to think that if past performance is important, incumbent firms are likely to have an advantage that might deter new entrants. However, in the case of public procurement and of firms' vendor rating systems, we are talking about reputational mechanisms based on public rules known and accepted by suppliers. Formal mechanisms and rules give commitment power to the buyer and can be designed in quite different ways. A common mistake is to assume that reputational mechanisms must be designed along the line of the eBay feedback system in which new sellers start with "zero reputation"—i.e., on equal footing with an incumbent seller with the

[6]As in the case of independent central banks, maintaining accountability after an increase in public buyers' ex-ante discretion (independence) requires more stringent ex-post controls in terms of performance measurement and evaluation. A real or perceived lack of stronger ex-post performance controls may be at the root of recent concerns that this process may have led to excessive discretion and poor accountability in US public procurement (e.g. Yukins 2008).

[7] Effective July 1, 2009, the Federal Acquisition Regulation requires federal agencies to post all contractor performance evaluations in the Past Performance Information Retrieval System (PPIRS). .

[8] See the summary of the Replies to the Consultation on the 2011 EU Green Book on Public Procurement regulation. Curiously enough, current European regulation acknowledges the importance of reputation for some types of procurement. For example, the European Research Council (ERC) funds top researchers in Europe, selected through peer review, and the track record of the researchers is then the main awarding criterion. ERC funding is distributed almost only on reputation criteria in order to reach the best and the brightest. Other European instruments for the procurement of research, such as the FET-OPEN program, are based on a completely anonymous evaluation instead. On the dedicated homepage of these programs one reads that: "The anonymity policy applied to short proposals has changed and is strictly applied. The part B of a short STREP proposal may not include the name of any organization involved in the consortium nor any other information that could identify an applicant. Furthermore, strictly no bibliographic references are permitted."

worst possible track record. However, a buyer with some commitment power on its rules for information aggregation and diffusion and for selecting suppliers may well award a positive rating to new entrants—e.g. the maximum possible rating, or the average rating in the market, putting entrants at less of a disadvantage—and ensure that this is taken into account by the scoring rule that selects the contractor, even if the contractor has never before interacted with the buyer. Indeed, private corporations often have vendor rating systems in which all suppliers start off with the same maximal reputational capital—a given number of points—and then lose points when performing poorly. Suppliers are then suspended for some time if their reputational capital falls below a certain low threshold. In many of these systems points may also be recovered by performing well, but exceeding the initial level of points is typically impossible. A similar system is adopted by many countries for their point-based driver licences. In such quality assurance systems incumbents that have already served the buyer may have lost some of the initial reputational capital while any new entrant would start off with the full initial reputational capital. This type of vendor rating system creates an advantage for new suppliers, stimulating rather than hindering entry, suggesting that it is possible to design a reputational mechanism in public procurement that simultaneously sustains quality and entry.

To verify this conjecture we develop here a simple three-period model of competitive procurement with non-contractible quality provision/investment that incorporates the possibility of entry by a more efficient competitor in the third and final period and implement it in the lab. We model the reputation mechanism by adding a simple and transparent past-performance based mechanism in the spirit of the vendor rating systems discussed above: past provision of high quality yields an advantage in the current auction. Rather than a point scheme, we implement an advantage directly in the form of a bid subsidy. The potential entrant in the third period also has a bid subsidy in some of the treatments. Across treatments, we vary both the existence of a reputational mechanism and, when a reputational mechanism is present, the relative size of the bid subsidy potential entrants enjoy. We use this framework, first and foremost, to ask whether reputation-based procurement must necessarily deter entry. We then dig deeper to investigate precisely how the relative size of the entrant's reputational disadvantage (bid subsidy) affects both the quality level produced by sellers and the total costs paid by the buyer/procurer.

We find that in the absence of a reputational mechanism quality provided is low in all periods, prices are significantly and constantly higher than production costs and entry occurs frequently. When a "standard" reputation mechanism is introduced that rewards an incumbent firm for producing high quality in the previous period with a bid subsidy (but assigns the lowest possible reputation to new entrants) quality is substantially higher, entry declines, but the total costs paid by buyers does not change much relative to the no-reputational-mechanism baseline. This result lends credence to concerns about the use of reputational criteria increasing quality but hindering entry. However, we also find that when the reputational mechanism is designed so that entrants, as well as incumbents, are awarded a strictly positive bid subsidy, quality *and* entry increase relative to the case without a reputational mechanism. Moreover, our data suggest that the introduction of a reputational mechanism intensifies competition: contrary to what happens to quality and entry, the total cost paid by the buyer does not increase. These results suggest that well designed reputational mechanisms may generate very large gains for the buyer while, at the same time, maintaining or increasing the rate of entry.

Considered together, our findings suggest there need not be a trade-off between reputation and entry. While our study is admittedly confined to a stylized laboratory setting, if confirmed by further empirical and experimental evidence our results imply that the dual goals of providing incentives for quality provision and increasing entry are not mutually exclusive as they are both achievable through an appropriately designed reputational mechanism. Moreover, since the reaction that we observe of prices to the presence of bid subsidies is relatively weak, the increase in quality and in entry may come at little cost for the buyer/taxpayer.

The remainder of the paper proceeds as follows. In the next section, we outline closely related literature. In Section 3, we discuss our simple theoretical model and, in the following section, present our experimental design. In Section 5, we present the results from our experiment. Section 6 provides some concluding remarks.

2. Related literature

Our study is related to a large literature investigating reputation using laboratory or field experiments. One prominent strand of this literature implements games mirroring closely Kreps and Wilson's (1982) imperfect information version of Selten's chain store paradox game in the lab: a sequence of distinct short-run players interacts with one long-run player, whose preferences are his or her private information; the history of interactions between short- and long-run players is observable, allowing each short-run player to form beliefs about the long-run player's preferences. In this setting, the short run players' equilibrium beliefs *are* the long-run player's reputation. Such beliefs-based reputation can have a beneficial effect for the long-run player, allowing her to earn higher equilibrium payoffs than possible without reputation. Early studies show that experimental participants' behaviour fits reasonably well with theoretical predictions, lending credence to the importance and potential benefit of beliefs-based reputation (Camerer and Weigelt, 1988). Subsequent studies investigate more finely both the fit between observed behaviour and theoretical predictions as well as the precise mechanisms generating this fit. The results have been somewhat mixed (Neral and Ochs 1992; Brandts and Figueras 2003). For example, Bolton, Katok and Ockenfels (2004) show that reputation can be beneficial for the long-run player even absent uncertainty about her preferences, calling into question the mechanism through which reputation operates. More recently, Grosskopf and Sarin (2010) investigate one alternative mechanism and show that beliefs-based reputational effects are weaker than theory predicts and that when reputational forces conflict with other-regarding preferences the latter tend to dominate. We sidestep the debate about the source and strength of reputation by, differently from this strand of the literature, considering a procurement game with complete and perfect information (similar to Dufwenberg and Gneezy 2000, 2002, discussed below) extended to multiple periods and entry, and by implementing a formal reputation mechanism in the form of a bid multiplier based on past quality provision similar to those public buyers are bound to adopt for transparency/accountability reasons.

Brown, Falk and Fehr (2004, 2012) and Bartling, Fehr and Schmidt (2012) also study reputational incentives in the laboratory, highlighting strong complementarities between them and social preferences. They also find that competition may reinforce the effects of reputation and its interaction with social preferences. Their focus is on labour markets and their subjects have discretion in how to use past performance information. Our experiment is very different, as it is framed in terms of business to business (or government to business) transactions, and because the effect of past performance on future trade is pre-determined by a formal reputation mechanism awarding a precise bid preference to a supplier that performed well in the past.

A more closely related strand of the experimental literature investigates beliefs-based reputation in the context of games with complete information. Particularly related are the studies by Dufwenberg and Gneezy (2000, 2002), who implement in the lab 10 repetitions (with re-matching each round) of a one-shot game that can be alternatively be interpreted as homogeneous Bertrand competition with discrete prices or as a first-price sealed bid auction with known common value. In the first study they vary the number of competitors finding that with only two competitors the price remains consistently above the

Bertrand solution, while increasing the number of competitors leads to a rapid convergence to that equilibrium. In the second study they vary whether the history of losing bids is observable finding that when previous losing bids are observable winning bids are higher (i.e., competitive forces are weaker), suggesting reputation between bidders affects efficiency. Although our benchmark game without reputation is already quite different from theirs (it is dynamic and has the possibility of entry), our finding that the price is consistently above the Bertrand solution in that treatment can be seen as consistent with their results. Their findings therefore suggest that with more competitors our benchmark treatment would possibly lead to lower prices. On the other hand, our finding that competition increases with the introduction of a reputation system that generates asymmetry and complexity (leading to higher quality but not higher prices) suggests that the latter may have a similar effect as an increase in the number of competitors.

More recently, Brosig and Heinrich (2011) implement two types of procurement games differing in their stage game rules:, one where the stage game is a standard first-price, lowest bidder wins, auction; another one in which in each period the buyer observes offers and sellers' past histories of quality provision and has complete discretion in choosing the winning seller. They find that when buyers have discretion to choose among sellers, the latter invest in reputation by providing high quality. In contrast, when buyers lack discretion sellers do not invest in reputation. Consequently, buyer discretion increases market efficiency with the benefits accruing entirely to buyers. A paper in this vein that features entry is Morgan, Orzen, Sefton and Sisak (2010), which investigates how strategic risk and luck affect entrepreneurs' market entry decisions in a setting with repeated competition among persistent six-member groups. This study explicitly minimizes the role of reputation by making entry decisions anonymous—in each competition, each entrepreneur observes only how many other group members enter, not which ones. The authors find that when success depends on luck, there is excess entry. Differently from this strand of literature, we implement a formal, transparent, reputational mechanism lacking buyer discretion in auctions with complete and perfect information and the possibility of entry.

Reputation has also been studied in the context of exchange platforms where buyers and sellers can leave public feedback about previous interactions. Familiar examples include many popular on-line trading platforms: eBay, Amazon, Cnet, etc. Results have been mixed as to whether this type of reputation mechanism induces more honest behavior or more trade. Bolton et al. (2004) study how such feedback influences honesty and trade in experimental auctions where agents interact repeatedly. They find reputational feedback provides weaker incentives for honest behavior than traditional markets with long-lasting relationships among agents. They argue that this is because reputational feedback mechanisms generate a public goods problem: benefits from honest behavior are not fully internalized by the agents. Bolton, et al., (2007) conduct online market games to test how competition and reputation in social networks interact. On the competition dimension they consider three cases: i) no competition (buyers cannot choose with whom they are matched); ii) matching competition (buyers choose sellers on the basis of reputation information); and iii) price competition (buyers choose sellers on the basis of reputation information and price offers by sellers). They consider two types of networks: partners networks (buyer-seller pairs persist) vs. strangers networks (a particular buyer seller interacting at most once). They find that competition in strangers networks increases total gains from trade: with competition and reputation, buyers can discriminate between sellers, creating incentives for seller honesty. Finally, Bolton, et al., (2011) provide experimental evidence on how reciprocity in feedback affects reputation exchange platforms. Modifying the standard feedback system by making conventional feedback blind (simultaneous feedback) and by adding a detailed seller rating system, they find that both of these modifications increase the informational content of feedback but that reciprocity in feedback tends to decrease efficiency. Our paper differs from Bolton et al (2004, 2007, 2011) in that we focus on reputation based on effectively delivered quality rather than (possibly false) messages about past performance, and considers the role of entry..

Dulleck et al (2009) study the determinants of efficiency in markets for credence goods varying liability, verifiability, reputation building and competition. Differently from our approach, but similar to much of the literature, reputation in their experimental framework is beliefs-based. They find liability has a crucial effect on efficiency relative to verifiability whereas allowing sellers to build up reputation has little influence. Moreover, competition—consumers' ability to choose among sellers—yields lower prices and maximal trade but not higher efficiency when liability is limited.

On the theoretical side, our work is closely related to the first formal analyses of reputation for quality in the 1980s, including Klein and Leffler (1981), Shapiro (1983), Allen (1984) and Stiglitz (1987), that were directly concerned with the relationship between the ability of reputational forces to curb moral hazard and the competitive conditions prevailing in the market. A central question this literature tried to address is precisely how reputational forces, which require a future rent as reward for good behaviour, could be compatible with free entry. Recent analyses in this direction include Kranton (2003), Bar-Isaac (2005) and Calzolari and Spagnolo (2009), which suggest that when important dimensions of the exchange are not contractible and there are many competing suppliers, limiting entry and competition may indeed be beneficial for the buyer. Hoerner (2002) shows that if prices can be used as signals of quality there are also equilibria in which competition strengthens reputational forces, but this would not be possible in public procurement in which prices are a dimension of the scoring rule selecting the winner and cannot therefore be used to signal quality.

Our work is also related to the literature on the efficient design of "feedback mechanisms" sparked by the emergence of eBay and its well known reputation system, surveyed in Dellarocas (2006). To our knowledge, however, the relationship between the design of the reputation system and entry in a market has not been analysed in this literature.

More indirectly related are theories describing how an incumbent's reputation can be used to deter entry, like the classic studies by Kreps and Wilson (1982) and Milgrom and Roberts (1982), and the recent literature on when reputation may have permanent effects and under which condition it has stronger effects, which is well summarized in Bar-Isaac and Tadelis (2008) and Mailath and Samuelsson (2006).

3. Theoretical framework

The game

We develop a simple dynamic game consisting of a sequence of three stages of homogeneous goods price competition on a discrete price grid, with each static stage similar—if we abstract from the reputation mechanism, the repetition, and the possibility of entry—to the game studied experimentally by Dufwenberg and Gneezy (2000, 2002). As is the case for their static game, each stage comprising our 3-stage dynamic game can be interpreted as a first-price simultaneous-bid procurement auction for a contract with known common value.[9]

[9] We adopt Dufwenberg and Gneezy's (2000, 2002) assumption that firms are fully informed because it simplifies the environment allowing us and the subjects to better focus on the *per se* complex dynamic choices of price, quality provision and entry under different reputational regimes. However, the assumption may not be far from reality in the procurement environments we are focusing on, where reputation/past performance may be important. These are typically characterized by a more or less stable group of firms regularly competing to win contracts from several common buyers. Such a frequent and prolonged interaction offers ample opportunities for learning about each other even if we abstract from the effects of the natural turnover of employees between firms in the same industry.

There are three players: two Incumbents and an Entrant firm. Incumbent firms participate in all three auctions, while Entrant firms may participate in at most the third auction. Entrant firms are more efficient: as detailed below, Entrant firms have a lower cost of production.

We chose to use a *three*-auction sequence to make the theory and experiment as simple as possible while still allowing for the features we are primarily interested in. In particular, three is the minimum number of sequential auctions allowing for investing in reputation (Auction 1) and potentially reaping the gains from such investment (Auction 2) before a new, more efficient, firm has the option of entering the market (Auction 3).

In each of the three procurement auctions comprising the sequence, bids are discrete and submitted simultaneously with the lowest bid winning. Ties are broken by selecting a winner (uniformly) randomly from among the firms submitting the lowest bid. The winning firm must produce the good, but can choose whether to produce a high quality good at a relatively high cost, or to produce a low quality good at a lower cost. The Entrant firm has a cost advantage in producing low quality: it can produce low quality at cost $c_L^e = c_L - k$, where c_L is the Incumbent firms' (common) cost of producing low quality, and $k > 0$ is a constant capturing the Entrant firms' higher efficiency. Both Incumbent firms and the Entrant firm face a cost of $c_H > c_L$ to produce a high quality good or service.

While producing high quality is relatively costly, it may yield reputational benefits. The essential characteristic of a reputational benefit is that, holding bids constant, it puts firms with "good reputation" at an advantage, and firms with "bad reputation" at a disadvantage in the subsequent auction. We introduce a reputational benefit in a simple, transparent, way by instituting a direct bid multiplier that applies for the immediately subsequent auction only. Specifically, for $t \in \{2,3\}$, if an Incumbent firm won auction t-1 and produced high quality in that auction, and then the same firm wins auction t, that firm is paid a multiple B of its auction t bid, with $B \geq 1$. In this way, Incumbent firms that choose to produce high quality today enjoy an advantage in tomorrow's auction, since the minimum bid required to ensure a positive profit is lower for such firms.

Entrant firms cannot participate in the first two auctions but do observe all bids and outcomes—as do Incumbent firms. The Entrant firm may, however, participate in Auction 3 if it so chooses. For every auction that the Entrant firm does not participate in, it earns a fixed per-auction "reservation wage," w. Before Auction 3 begins, the Entrant firm decides whether to participate, and forgo w, or to stay out (and earn *w)*. The Entrant firm's participation decision is made known to both Incumbent firms before Auction 3 begins.

To investigate the effects of a reputational mechanism on Entrant firms' behavior while incorporating the idea that such a mechanism may well assign a positive reputational score to a new firm or potential entrant, we assign a bid multiplier, $\beta \geq 1$, to the Entrant firm. We consider three main cases: i) an Entrant firm bid multiplier equal to the maximum possible for an Incumbent firm ($\beta = B$); ii) an Entrant firm bid multiplier equal to half of that of an incumbent that produced high quality in the previous period ($\beta = \frac{B+1}{2}$), corresponding to the average market reputation when one of the incumbents has high reputation; and finally, iii) an Entrant firm bid multiplier equal to the minimum possible for an Incumbent firm, i.e. no reputaton at all ($\beta = 1$). The first case is analogous to supplier qualification and quality assurance systems common in the private sector where all qualified suppliers start with a fixed maximum number of points, lose points for bad performance and may regain them through good performance but only up to the initial, maximal level. Point-based drivers licence incentive systems are also designed this way in many countries. The last case corresponds to a more standard reputational system such as that on eBay, where new firms start out with "zero" reputation. The second case represents a compromise between these two extremes. These rules are common knowledge among all players.

Finally, as a baseline case we also consider the above sequential three-auction game with no reputational mechanism at all. That is to say, in this baseline case we set both the Incumbent firms' and the Entrant firm's bid multipliers equal to 1 ($B = \beta = 1$).

Equilibria of the game

Without a reputational mechanism (Baseline)

In the case where no reputational mechanism exists, equilibrium predictions are straightforward. This is simply a case of repeated homogeneous good Bertrand competition with discrete prices, augmented by the possible entry in the third and last round (symmetric in the first rounds, possibly asymmetric in the last two because of bid preferences and the more efficient entrant). High quality production yields no future advantage to any firm and is consequently never produced. Winning bids are driven down to the Incumbent firms' marginal cost of producing low quality (c_L) in each of the first two repetitions. In the third round the Entrant firm enters and bids c_L only if its efficiency advantage is high enough relative to its reservation wage (k ≥ w).[10]

With a reputational mechanism

When a reputational mechanism is implemented, equilibrium predictions become slightly more complicated. For simplicity, we restrict attention to two particular pure strategy subgame perfect Nash equilibria which seem particularly intuitive.[11] In the first equilibrium—"entry-accommodation"—the Incumbent firm winning the first auction provides high quality in the first stage, then it exploits the reputational advantage by winning the second auction, receiving its (multiplied) winning bid and then producing low quality. In doing so, the incumbent firm accommodates entry in the third and last auction since it arrives there without a reputational bid preference. The more efficient Entrant firm will optimally enter and win the last auction, producing low quality. In the second equilibrium— "entry deterrence"—the Incumbent firm that wins Auction 1 also wins Auction 2, but here it keeps its reputational advantage by producing high quality also in this second stage. Since this Incumbent firm now has a pricing advantage in Auction 3, the Entrant firm finds it optimal not to enter. Obviously, the existence of this latter equilibrium depends on both the Entrant firm's bid multiplier, *β,* and its efficiency advantage, *k*.

We solve the model and find parameter values simple enough to incorporate into our experimental design which, at the same time, ensure that equilibrium predictions vary across the three broad levels of reputation assigned to Entrant firms under consideration: $\beta = B$; $\beta = \frac{B+1}{2}$, an $\beta = 1$.

Details are provided in the Appendix, Section C, but in a nutshell we find that provided Incumbent firms' bid multiplier is neither too high nor too low relative to the costs of production ($B \in \left[\frac{3c_H - c_L}{2c_L}, \frac{c_H + 3c_L}{2c_L}\right]$):

- when the Entrant firm is given maximal reputation (bid multiplier *β=B),* if $k > w$ only the "entry-accommodation" equilibrium exists*;*

[10] The Entrant firm's profit from winning must be at least as large as its reservation wage in order to justify entry: c_L - (c_L - k) ≥ w.

[11] The data from the experiment turn out to be consistent with subjects mainly focussing on these two pure strategy equilibria.

- when the Entrant firm is given minimal/no reputation (bid multiplier *β=1),* if $k < w + c_L - \frac{c_L}{B}$ only the "entry-deterrence" equilibrium exists;
- when the Entrant firm is given an intermediate reputation (bid multiplier $\beta = \frac{B+1}{2}$), if $k = w + c_L - c_L \frac{\beta}{B}$ it is indifferent between entering or not and both the "entry-deterrence" and the "entry-accommodation" equilibria exist.

Given these conditions, for our experiment we chose the following parameter values: $B = 2$; $c_L = 1.5$; $c_H = 2$; $w = 1$; and $k = 1.375$. Together, these values imply that entry deterrence is the unique equilibrium when *β=1*; that either entry accommodation or deterrence is possible when $\beta = \frac{B+1}{2}$; and that entry accommodation is the unique equilibrium when $\beta = B$.

4. Experimental Design

The basic structure

The experiment consisted of four different treatments, which we describe below. In all of the treatments participants played multiple rounds of the game described above, where a complete three-auction sequence constitutes a round. Before each round, participants were randomly and anonymously (re-)divided into groups of three and then randomly assigned one of two roles: two participants in each three-person group were assigned the role of "Incumbent firm," while the third person in each group was assigned the role of "Entrant firm."[12] Within each three-person group, in each round, participants played the sequence of three first-price sealed-bid auctions described above.

Each treatment consisted of 12 to 15 rounds of the three first-price sealed-bid auctions, with groups being randomly and anonymously re-formed between each round. Participants were instructed that at the end of the experiment one round would be randomly chosen to count toward their experimental earnings.

[12] We use the terms "Incumbent" and "Entrant" here for clarity of exposition. Neutral language was used in the experiment. Specifically, roles were referred to as "Firm A" "Firm B" and "Firm C," with the first two being incumbents and the latter the entrant.

Within each round and each group of three, play proceeded as follows. Incumbent firms participated in all three auctions of a round. By contrast, Entrant firms did not participate in the first two auctions, but instead earned a fixed outside wage of $w = 1$ euro and observed all bids and outcomes of the first two auctions within their 3-person group. Before the third auction of the round began, Entrant firms decided whether to participate in this last auction and forgo their outside wage, w, or to stay out of even this last auction and earn w. Incumbent firms never earned an outside wage in any period.

Within each auction, bids were submitted simultaneously with the lowest bid winning the auction. Ties were broken by randomly choosing among the firms submitting the lowest bid. The winning firm then decided to produce either a low quality good at cost c_L ($c_L^e = c_L - k$ for Entrant firms), or a high quality good at cost $c_H > c_L$. Losing firms earned nothing, while the earnings of winning firms varied by treatment (detailed below). At the end of each auction, participants learned the bids of the other firm(s), and the production decision of the winning firm, in their own three-person groups. Before the third auction began participants were informed of the entry decision of the Entrant firm in their group. Participants were not informed about choices in groups other than their own.

Four treatments

The basic structure outlined above was common to all sessions. Three treatments involved a formal reputational mechanism. In the fourth, "Baseline," treatment no formal reputational mechanism was implemented. Let us first consider the treatments with a reputational mechanism.

The reputational mechanism we implemented took the form of the simple bid multiplier described earlier. Incumbent firms' bid multiplier, B, was the same in all treatments involving reputation. In these treatments we set B = 2: an incumbent firm that wins Auction $t \geq 1$, produces high quality and then subsequently wins Auction $t+1$ with winning bid b is paid $2b$ by the buyer, resulting in Auction t+1 profits of $2b - c$, where $c \in \{c_H, c_L\}$ according to the firm's quality production decision in Auction t+1. In Auction 1, no firm received any bid multiplier.

What varied across the three treatments involving a reputational mechanism was the bid multiplier for Entrant firms: β. In the High Bonus (HB) treatment, we set $\beta = B = 2$; in the Medium Bonus (MB) treatment $\beta = 1.5$; and in the Low Bonus (LB) treatment Entrant firms enjoyed no strict bid subsidy, i.e. $\beta = 1$. Since Entrant firms participated in (at most) the third auction, their bid multiplier was not contingent on previous production decisions. Specifically, an Entrant firm winning Auction 3 with bid *b* earned $\beta * b - c$, where $c \in \{c_H, c_L^e\}$ according to the Entrant firm's quality production decision.

Baseline treatment

In our baseline treatment, we omitted the bid multiplier for both Incumbent firms and Entrant firms (i.e., we set $\beta = B = 1$). Hence, this baseline treatment involved no (formal) reputational mechanism. Otherwise, the design was identical to the three treatments (HB, MB, LB) detailed above. Winning Incumbent (Entrant) firms earned their bid minus the cost of production, $b - c$, where $c \in \{c_H, c_L\}$ ($c \in \{c_H, c_L^e\}$) depending on the firm's production decision.

Implementation

All sessions of the experiment were conducted in the laboratory facilities at the Einaudi Institute for Economics and Finance in Rome, Italy, using the software z-tree (Fischbacher, 2007). Twelve sessions were conducted involving a total of 243 participants. Average earnings in the experiment were approximately 12 euro, including payment for a risk elicitation task conducted after all rounds of the auction game were completed but *before* participants knew which round would be chosen to determine their earnings.[13] Each session lasted about two hours. Information on all four treatments is summarized in Table 1.

[Insert Table 1 about here]

5. Results

Our experimental outcomes of interest are the proportion of winning firms producing high quality, the cost to the buyer—which we call the "buyer's (total) transfer" to avoid confusion with the sellers' costs

[13] The risk elicitation task involved a sequence of choices between a sure payment of €5 and a lottery involving a 50% chance of a low payoff (€2.50) and a 50% chance of a high payoff, which increased over the sequence from €7.50 to €17 in steps of €0.50. More risk averse individuals should switch from preferring the sure payment to the lottery later in the sequence, so we take this switch point as an index of each participant's risk aversion. If there were multiple switch points, we follow much of the literature using related mechanisms and only consider the first switch point. One choice in the sequence was randomly chosen to count, with uncertainty being resolved, if necessary, by flipping a coin.

of producing—as well as the proportion of Entrant firms choosing to enter. We consider first each of these outcomes in isolation and then consider buyers' welfare, which may incorporate some or all of these outcomes simultaneously.

Quality provision

Let us first examine quality provision, as encouraging high quality goods provision is one primary reason buyers might prefer to implement some form of reputational mechanism. In Table 2, we report the average proportion of winning firms providing high quality. We observe a remarkably large increase in high quality provision in the first two auctions in all treatments involving a reputational mechanism relative to the baseline treatment which lacks such a mechanism. For example, in Auction 1 about 80% of winning firms provide high quality whenever there is a reputational mechanism, whereas in the baseline treatment only 18% of winning firms provide high quality – a 340 percent increase in the likelihood of high quality provision! Moreover, pooling over all three auctions, we observe an approximately four-fold increase in high quality provision in any of the treatments involving a reputational mechanism, relative to the baseline treatment. In the Appendix (Table A1), we report a battery of pairwise non-parametric Mann-Whitney tests confirming the statistical significance of many of the large differences observed in the raw numbers: in Auctions 1 and 2, Mann-Whitney tests reveal that quality provision in the baseline treatment is significantly different from all other treatments; differences among the non-baseline treatments themselves are generally not significant.

[Insert Table 2 about here]

A bit more formally, in Table 3 we estimate probit models of the binary decision to provide high quality in each of the auctions separately (columns 1-3). In column 4, we pool observations from all three auctions and estimate a Tobit model using, as the dependent variable, the proportion of the three auctions in which the winning firm provided high quality. In each of these estimates we control for dynamic effects (such as learning) in a simple way by including the round of the observation as a control. Additionally, in these and all subsequent model estimates—unless otherwise noted—we cluster standard errors by session to allow for arbitrary within-session correlation of behavior. We find that high quality provision is strongly significantly higher in all of our reputational mechanism treatments relative to the baseline treatment (the excluded category).[14]

Result 1. *The introduction of a reputation mechanism significantly increases supplied quality.*

Finally, notice that in all treatments except the baseline treatment quality provision declines precipitously from the second auction to the third auction. This suggests that participants generally understood the strategic incentives inherent in each three-auction sequence, as there is no reputational incentive to produce high quality in Auction 3 while there may be in the second auction. At the same time, even in the Auction 3 quality provision is significantly lower in the baseline treatment than in any other treatment. One plausible explanation that would provide a further unintended benefit of implementing a reputational mechanism is that participants acquired a "habit" of quality provision in the first two auctions which carried over to the third auction. Other possible explanations include "framing" or symbolic effects generated by the reputational mechanism. In any event, the effect is relatively small in magnitude so we do not focus on it here.

[Insert Table 3 about here]

Entry

Having seen that introducing a reputational mechanism tends to significantly increase costly quality provision, the question remains whether there is necessarily a trade-off between reputation and entry. In Table 4 we report the proportion of Entrant firms choosing to enter Auction 3. As can already be seen from these raw data, our results suggest that a reputational mechanism which assigns no bid subsidy to the Entrant firm (LB) may hinder entry. However, at the same time the data suggest that a

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[14] In the Appendix (Table B1), we allow for more flexible dynamic effects by introducing a full set of round dummies into our model estimates. Nothing changes either qualitatively or in terms of statistical significance.

properly calibrated reputational mechanism which assigns positive reputation to the Entrant firm (MB, HB) tends to increase entry.[15]

[Insert Table 4 about here]

To get a more formal sense of the significance of the effect of a reputational mechanism on entry, in Table 5 we report marginal effects from an estimated probit model using as the dependent variable an indicator taking the value one if the Entrant firm decided to enter Auction 3 and zero otherwise. On the right hand side, we include a set of treatment dummy variables with the baseline treatment as the excluded category. To account for dynamic patterns in a simple way we control for the round of the observation. We find that entry is economically and statistically significantly higher when the Entrant firm is assigned positive reputation (MB, HB) relative to the baseline treatment. In treatments MB and HB the estimated marginal effect of a reputational mechanism is to increase entry by 8 to 10 percentage points. On the other hand, we also find that the decline in entry observed in the raw data when the Entrant firm is not assigned positive reputation (LB)—i.e., enjoys no strict bid subsidy—is not statistically significant. As before, we report a specification allowing for more flexible dynamic effects in the Appendix (Table B2), finding similar results.

[Insert Table 5 about here]

Result 2. *The introduction of a reputational mechanism that assignes no reputation to an entrant reduces the frequency of entry - although the effect is not statistically significant. The introduction of an appropriately designed reputation mechanism that assigns a positive reputation score to an entrant significamtly* ***increases*** *the frequency of entry relative to the benchmark treatment without reputation.*

[15] As a first pass, a battery of pairwise non-parametric tests of entry by treatment is reported in the Appendix (Table A2) supporting the notion that the introduction of a reputational mechanism can either significantly increase or decrease entry, depending on the relative reputational score assigned the Entrant firm.

Buyer's transfer

Because our results suggest that the effect of reputation on entry depends on the relative level of the Entrant firm's bid subsidy, a natural question to ask is whether the most desirable outcome of high quality coupled with high entry comes at a significant increase in costs to the buyer. To avoid confusion with firms' costs of production, in the discussion that follows we refer to the total amount the buyer pays to the winning seller, accounting for any relevant bid subsidy, the "buyer's transfer."

In Table 6 we report average buyers' transfers by treatment and auction, as well as the average buyer's transfer across all three auctions. Our data suggest there is only a mild effect of even large bid subsidies on buyers' transfers. Buyers' transfers are generally lower in the first auction when there is a reputational mechanism than when there is not, reflecting competition for the bid advantage that reputation entails in the subsequent auction. This competition is apparently fierce. Considering the average buyer's transfer across all three auctions, there is a surprisingly mild effect of our reputational mechanism on buyers' transfers suggesting that sellers fully and correctly incorporate future reputational advantages when constructing their Auction 1 bids.

[Insert Table 6 about here]

To confirm this appearance, in Table 7 we present OLS estimates of buyers' transfers across treatments and auctions. As usual, we control for dynamic effects in a simple manner here and report in the Appendix (Table B3) estimates allowing for more flexible dynamic patterns. In both specifications we find that introducing a reputational mechanism significantly lowers buyers' transfers in Auction 1 and has little impact on buyers' transfers in Auctions 2 and 3. Considering buyers' transfers averaged over all three auctions, we again find no significant impact of our reputational mechanism, reinforcing the interpretation that the potential profit opportunities provided by bid subsidies are competed away.

[Insert Table 7 about here]

Result 3. *The introduction of a reputational mechanism does not increase the transfer paid by the buyer (even though it increases costly quality provision).*

Firms' profits

Taking stock of our results so far, we have seen that our formal reputational system yields the possibility of simultaneously increasing entry and the provision of high quality goods and services without substantially increasing the cost paid by the buyer. Thus, from the buyer's perspective, introducing a reputational mechanism seems to be a panacea. Before investigating this appearance more formally by constructing and estimating a simple welfare function for buyers, let us first briefly consider reputation from a firm's perspective. In particular, what remains to be seen is whether firms fare as well with a reputational mechanism as without in terms of profits, a standard measure of firm welfare. Following our (by now) familiar format, we first present a table of raw data on firms' profits followed by a table of OLS estimates.

In Table 8, we present average firms' profits, where this average includes both Entrant and Incumbent firms' profits. Because Entrant firms earn a "reservation wage," w, of one euro in Auctions 1 and 2, and in Auction 3 if they do not enter, we present profits in two ways: including w into our profit calculations (left panel); and excluding w from the calculations (right panel). Both panels present a similar story: firms' profits are lower in Auction 1 when there is a reputational mechanism than when there is no such mechanism, but higher in subsequent auctions. The patterns in profits are again consistent with firms' competing on prices in the first auction for the bid advantage offered by the reputational mechanism in later auctions. Participants in our experiment appear to be quite skilled in exactly offsetting lower current profit with higher later profits: averaging over all three auctions (columns 4 and 8) the impact of reputation on firms' profits appears to be mild.

We confirm the appearances in the raw data in Table 9 with OLS estimates using firms' profits on the left hand side and our standard set of controls on the right hand side. Estimates permitting more flexible dynamic effects appear, as usual, in the appendix (Table B4). Profits are significantly lower in the first auctions in all treatments, relative to the no-reputation baseline (the excluded category). In Auctions 2 and 3, profits are typically higher but only significantly so in Auction 3 of the High Bonus treatment. Considering the average profit over all three auctions, the data reveal no significant impact of our reputational mechanism on firms' profits. In summary, both the raw data and our OLS estimates suggest that firms are, on average, no worse off with a reputational mechanism than without.

Buyer's preferences: theoretical and empirical welfare functions

As a final exercise before concluding, in this section we construct a welfare function for buyers and examine how buyer's welfare varies, both theoretically and empirically, over our treatments.[16] In particular, we suppose that the buyer derives utility from three additively separable components: buyer's transfer (negatively), quality and entry. We model this in a flexible manner by assuming buyer's welfare is a simple weighted average of these three components. We then compare the welfare generated by each of our treatments—both theoretically, using equilibrium predictions, and empirically, using the experimental data—in two cases: i) buyers place equal weight on entry, quality and buyer's transfer (which may be close to the EU case, where increasing cross-border entry *per se* is a main political objective); and ii) the buyer does not care directly about entry, but rather divides all weight equally between the remaining two components (which may be close to the US case, where entry is valued in so far it increases efficiency and value-for-money for the tax-payer).

The welfare function we consider is $W = \alpha\mathcal{D} + \gamma Q + \delta Pr(E)$, where $\alpha + \delta + \gamma \leq 1$; and $\mathcal{D} = \frac{4.5 - \frac{\sum_{t=1}^{3} T_t^*}{3}}{4.5}$. To make sense of this last expression, notice that T_t is the transfer from buyer to seller (i.e., [winning bid]*[relevant bid multiplier]) in Auction *t*, while 4.5 is the maximum allowable bid in the experiment, so that $\mathcal{D}$ is a measure of the "discount" below the maximum possible price buyers could pay excluding bid subsidies. This serves as a convenient normalization of the buyer's transfer component of welfare on a 0-1 scale. The other two components of the welfare function are straightforward: $Q = \frac{\sum_{t=1}^{3} \mathrm{I}[q_H]}{3}$ is the proportion of the three auctions in which high quality is produced; and $Pr(E) = Pr[\mathbb{E}\pi^{entrant} \geq 1]$ is the probability (the frequency, in the empirical part) that entry occurs in the third auction. Weights are also normalized so that $\delta = (1 - \alpha - \gamma)$.[17]

Using the parameters chosen for the experiment, we calculate the buyer's theoretical welfare by computing the equilibrium values of $\mathcal{D}, Q$ and $Pr(E)$ for each treatment and then evaluating buyer's welfare in each treatment by for the welfare function weights implied by the two cases mentioned

[16] We are greatfull to Gary Charness for suggesting this last exercise.
[17] In the MB [B = 2; β = 1.5] and baseline [B = β = 1] treatments, both the entry accommodation equilibrium and the entry deterrence equilibria are possible. In these treatments, we calculate the average expected welfare as W = $\mathbb{E}(W) = \frac{w(acc)+w(det)}{2}$, where $w(acc)$ is the welfare generated from the entry accommodation equilibrium and $w(det)$ is the welfare generated from the entry deterrence equilibrium. In the other treatments, because we are assuming bids are discrete with bid increment $\varepsilon > 0$, there are (essentially) unique equilibrium predictions.

above: case i) $\alpha = \gamma = \frac{1}{3}$; and case ii) $\alpha = \gamma = \frac{1}{2}$. We report buyer's theoretical welfare levels in these two cases in Table 10.

[Insert Table 10 about here]

In case i) where buyers care about entry, quality and transfers equally we find the highest buyer welfare in the HB treatment (when B= β =2, W = 0.710) where the theoretical equilibrium probability of entry is largest. On the other hand, in case ii) where buyers do not care about entry directly—but rather, only about quality and transfers—buyer's welfare is maximized in the LB treatment (when B=2 and β =1, W = 0.73) where even though entry does not occur in equilibrium its spectre constrains bids and increases quality. Importantly, in both cases we consider, having a reputational mechanism in place increases buyer's welfare.

Empirically we find a similar result. To calculate empirical welfare we measure quality, Q, by the average proportion of winning firms providing high quality across all three auctions. We measure entry probability, $Pr(E)$, as the average proportion of Entrant firms entering in Auction 3. Finally, as our measure of buyer's transfers we calculate $\mathcal{D}$ according to the formula described above. Table 11 reports our empirical estimates of buyer's welfare.

[Insert Table 11 about here]

As with theoretical welfare, for both sets of welfare functions weights we consider buyers can always achieve higher welfare with a reputational mechanism than without. Slightly differently from our theoretical analysis, however, buyer's welfare is always maximized in the MB treatment, where Entrant firms are given neither the highest nor lowest possible reputation score. This difference is likely due to Entrant firms basing their entry decisions to a lesser extent on the bid subsidy than theory predicts. For example, entering Auction 3 with probability less than one when their bid-subsidy is relatively high

(HB), as we observe in the data, reduces the empirical welfare advantage of HB over MB when buyers care about entry directly.

Result 4. *Introducing a reputation mechanism increases buyer's welfare, whether or not he cares for the rate of entry per se.*

6. Concluding remarks

In this paper we ask whether the use of reputational indicators based on past performance, while stimulating quality provision, necessarily also hinders entry by new sellers. This is an open, timely and policy-relevant question. In the US, where reputational mechanisms are currently allowed in public procurement, the Senate recently expressed concerns that such past-performance based selection criteria could hinder small businesses' ability to enter and successfully compete for public contracts. On the other hand, in Europe where regulators were sufficiently convinced that allowing the use of reputational indicators as criteria for selecting contractors would discriminate against cross-border entrants to prohibit it, public buyers and their national representatives are now pushing to change the rules and allow the use of past-performance indicators in selecting contractors.

We investigated this question experimentally, developing a simple model of repeated procurement competition with limited enforcement on quality and potential entry by a more efficient supplier and implementing it in the laboratory. Treatments differed by the presence and design of a past-performance based reputational mechanism.

First, our results show that concerns about reputation hindering entry are justified: naively introducing a "standard" reputational mechanism in which only good past performance is rewarded with a bid subsidy in the following procurement auction increases quality provision but may indeed reduce entry, although the effect we measure is not very strong.

In contrast to this first result, we go on to show that properly designed reputational mechanisms in which new entrants, with no history of past performance, are awarded a moderate or high reputation score—as is often done in the private sector, or with point systems for driving licenses—actually *fosters entry* while, at the same time, delivering a substantial increase in high quality goods provision.

Our third result is that the total cost to buyers (buyer's transfer) does not increase when a reputational mechanism is introduced, even though (costly) quality provision increases. The introduction of bid subsidies for good past performance appears to benefit the buyer/tax payer by increasing competition for incumbency, driving winning bids down sufficiently to offset the potential increase in procurement costs due to bid subsidies and the costly quality provision they generate.

Taken together, our results suggest that there may not be a trade-off between the use of appropriately designed past-performance based reputational mechanisms and entry by new firms into a market. In our experiment a well-calibrated reputational mechanism may increase entry and quality provision simultaneously, without increasing the cost for the procurer. If confirmed in further studies, our results suggest that the emphasis placed on past performance by the revised Federal Acquisition Regulation is fully justified. They also suggest that European regulators may be imposing large unjustified deadweight losses on their citizens by not allowing well structured past performance indicators among selection criteria in public procurement. Policy makers should probably stop quarrelling about whether a generic past-performance based reputational mechanism should be introduced, and focus instead on *how* such a mechanism should be designed in different contexts.

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Tables and Figures

Table 1: Summary of Treatments

Treatment	Incumbent			Entrant			Participants	Sessions
	Bonus	c_H	c_L	Bonus	c_H	c_L		
HB	2	2	1.5	2	2	0.125	51	3
MB	2	2	1.5	1.5	2	0.125	60	3
LB	2	2	1.5	1	2	0.125	42	2
Baseline	1	2	1.5	1	2	0.125	90	4

Table 2: proportion of winning firms producing high quality

	Auction 1	Auction 2	Auction 3	All Auctions
Baseline	0.18	0.09	0.06	0.11
	(0.047)	(0.034)	(0.035)	(0.037)
Low Bonus (LB)	0.82	0.57	0.14	0.51
	(0.018)	(0.048)	(0.024)	(0.018)
Medium Bonus (MB)	0.77	0.49	0.17	0.48
	(0.010)	(0.075)	(0.026)	(0.031)
High Bonus (HB)	0.78	0.60	0.09	0.49
	(0.04)	(0.025)	(0.040)	(0.018)
Observations	1,011	1,011	1,011	1,011

Notes: [1] Robust standard errors, clustered by session, appear in parentheses. [2] "All Auctions" column reports the n. of times high quality has been produced by the winning firm standardized by the n. of auctions.

Table 3: Quality provision, by auction and treatment

	Auction 1	Auction 2	Auction 3	All Auctions
Low Bonus (LB)	0.51***	0.55***	0.10*	0.73***
	(0.043)	(0.063)	(0.061)	(0.110)
Medium Bonus (MB)	0.53***	0.50***	0.14**	0.69***
	(0.050)	(0.075)	(0.060)	(0.116)
High Bonus (HB)	0.52***	0.58***	0.04	0.69***
	(0.049)	(0.059)	(0.067)	(0.111)
Round	-0.01*	-0.01**	-0.01**	-0.02***
	(0.006)	(0.006)	(0.003)	(0.005)
Observations	1,011	1,011	1,011	1,011

Notes: [1] Columns 1-3 present marginal effects estimates from a (separate) probit model, using as a dependent variable a dummy taking the value one whenever the winning firm produced high quality in the relevant auction (column heading). [2] The fourth column presents results of a tobit regression in which the dependent variable is the n. of times high quality has been produced by the winning firm standardized by the n. of auctions. [3] Robust standard errors, clustered by session, appear in parentheses. [4] *** p<0.01, ** p<0.05, * p<0.1

Table 4: Entry propensity

	Auction 3
Baseline	0.61
	(0.019)
Low Bonus (LB)	0.42
	(0.161)
Medium Bonus (MB)	0.69
	(0.046)
High Bonus (HB)	0.67
	(0.033)
Observations	1,011

Notes: Robust standard errors, clustered by session, appear in parentheses.

Table 5: Entry, by treatment

Low Bonus (LB)	-0.19
	(0.125)
Medium Bonus (MB)	0.10**
	(0.040)
High Bonus (HB)	0.08**
	(0.031)
Round	-0.02***
	(0.006)
Observations	1,011

Notes: [1] Reported values are marginal effects from a probit model, using as a dependent variable a dummy taking the value one whenever the Entrant firm entered Auction 3 rather than staying out. [2] Robust standard errors, clustered by session, appear in parentheses. [3] *** p<0.01, ** p<0.05, * p<0.1

Table 6: Buyer's transfer, by auction and treatments

	Auction 1	Auction 2	Auction 3	Average Over Auctions 1 to 3
Baseline	2.14	1.97	1.57	1.90
	(0.071)	(0.083)	(0.093)	(0.081)
Low Bonus (LB)	1.87	2.02	1.75	1.88
	(0.085)	(0.080)	(0.113)	(0.017)
Medium Bonus (MB)	1.67	1.92	1.62	1.74
	(0.067)	(0.066)	(0.091)	(0.073)
High Bonus (HB)	1.91	1.95	1.82	1.90
	(0.073)	(0.092)	(0.084)	(0.082)
Observations	1,011	1,011	1,011	1,011

Notes: Robust standard errors, clustered by session, appear in parentheses.

Table 7: Average buyer's transfer, by auction and treatment

	Auction 1	Auction 2	Auction 3	Average Over Auctions 1 to 3
Low Bonus (LB)	-0.28**	0.05	0.18	-0.02
	(0.111)	(0.116)	(0.147)	(0.083)
Medium Bonus (MB)	-0.46***	-0.03	0.07	-0.14
	(0.103)	(0.114)	(0.141)	(0.117)
High Bonus (HB)	-0.22**	0.00	0.27*	0.02
	(0.101)	(0.120)	(0.123)	(0.113)
Round	-0.02***	-0.04***	-0.04***	-0.03***
	(0.006)	(0.008)	(0.007)	(0.006)
Constant	2.27***	2.21***	1.80***	2.09***
	(0.084)	(0.104)	(0.114)	(0.096)
Observations	1,011	1,011	1,011	1,011
R-squared	0.191	0.040	0.060	0.087

Notes: [1] Each column presents a simple OLS regression using as the dependent variable winning bids in the relevant auction (column heading). [2] Robust standard errors, clustered by session, appear in parentheses. [3] ***p<0.01, **p<0.05, *p<0.1.[4] The dependent variable in this table is the average buyer costs (transfers) over the tree auctions.

Table 8: Firms' profits by auction and treatments, pooling over roles

	Including w				Excluding w			
	Auction 1	Auction 2	Auction 3	All Auctions	Auction 1	Auction 2	Auction 3	All Auctions
Baseline	0.52	0.47	0.31	0.43	0.19	0.14	0.18	0.17
	(0.033)	(0.036)	(0.048)	(0.039)	(0.033)	(0.036)	(0.049)	(0.039)
Low Bonus (LB)	0.32	0.53	0.41	0.42	-0.01	0.20	0.21	0.13
	(0.035)	(0.051)	(0.071)	(0.005)	(0.035)	(0.051)	(0.017)	(0.023)
Medium Bonus (MB)	0.26	0.53	0.34	0.38	-0.07	0.19	0.24	0.12
	(0.028)	(0.029)	(0.038)	(0.029)	(0.028)	(0.029)	(0.034)	(0.028)
High Bonus (HB)	0.34	0.53	0.44	0.43	0.01	0.20	0.33	0.18
	(0.031)	(0.021)	(0.032)	(0.023)	(0.031)	(0.021)	(0.024)	(0.020)

Notes: Robust standard errors, clustered by session, appear in parentheses.

Table 9: Firms' profits by auction and treatment, pooling over roles

	Including w				Excluding w			
	Auction 1	Auction 2	Auction 3	All Auctions	Auction 1	Auction 2	Auction 3	All Auctions
Low Bonus (LB)	-0.20***	0.06	0.10	-0.02	-0.20***	0.06	0.04	-0.04
	(0.040)	(0.050)	(0.068)	(0.035)	(0.040)	(0.050)	(0.046)	(0.039)
Medium Bonus (MB)	-0.25***	0.06	0.03	-0.05	-0.25***	0.06	0.07	-0.04
	(0.039)	(0.042)	(0.055)	(0.044)	(0.039)	(0.042)	(0.056)	(0.044)
High Bonus (HB)	-0.18***	0.06	0.13**	0.00	-0.18***	0.06	0.15**	0.01
	(0.040)	(0.037)	(0.052)	(0.040)	(0.040)	(0.037)	(0.051)	(0.039)
Round	-0.01*	-0.01*	-0.01	-0.01**	-0.01*	-0.01*	-0.01***	-0.01**
	(0.002)	(0.004)	(0.004)	(0.003)	(0.002)	(0.004)	(0.004)	(0.003)
Constant	0.55***	0.52***	0.34***	0.47***	0.22***	0.19***	0.26***	0.22***
	(0.035)	(0.042)	(0.051)	(0.041)	(0.035)	(0.042)	(0.051)	(0.041)
Observations	3,033	3,033	3,033	3,033	3,033	3,033	3,033	3,033
R-squared	0.040	0.004	0.006	0.004	0.111	0.005	0.012	0.016

Notes: [1] Each column presents a simple OLS regression using as the dependent variable firms' profits. [2] The first four columns include in this calculation Entrant firms' reservation wage, w = 1, in Auctions 1 and 2. The last four columns exclude the reservation wage from profit calculations . [3] Robust standard errors, clustered by session, appear in parentheses. [4] *** p<0.01, ** p<0.05, * p<0.1

Table 10: Buyer's theoretical welfare

	Baseline	*LB*	*MB*	*HB*
$\alpha = \gamma = \delta = 1/3$	0.389	0.488	0.599	0.710
$\alpha = \gamma = ½; \delta = 0$	0.333	0.731	0.648	0.565

Notes: [1] Each cell reports buyer's theoretical welfare evaluated according to the model (described in text). [2] In this theoretical welfare function: α is the weight the buyer places on total transfer, expressed as a discount below the maximum possible transfer without bid subsidies; γ is the weight the buyer places on high quality provision; and δ is the weight placed on entry *per se*.

Table 11: Buyer's empirical welfare

	Baseline	*LB*	*MB*	*HB*
$\alpha = \gamma = \delta = 1/3$	0.432	0.505	0.594	0.580
$\alpha = \gamma = ½; \delta = 0$	0.344	0.546	0.547	0.534

Notes: [1] Each cell reports buyer's empirical welfare (described in text) evaluated using our experimental data. [2] In this empirical welfare function: α is the weight the buyer places on total transfer, expressed as a discount below the maximum possible transfer without bid subsidies; γ is the weight the buyer places on high quality provision; and δ is the weight placed on entry *per se*.

Appendix

Section A: Pairwise Mann-Whitney tests

Table A1:Mann-Whitney tests on quality provision

Pairwise comparison	Obs		Auction 1	Auction 2	Auction 3
BA vs LB	360	*z-stat*	-14.118	-11.839	-3.099
	168	*Prob>/z/*	0.000	0.000	0.002
LB vs. MB	168	*z-stat*	1.061	1.601	-0.862
	264	*Prob>/z/*	0.289	0.109	0.389
MB vs. HB	264	*z-stat*	-0.212	-2.319	2.639
	219	*Prob>/z/*	0.832	0.020	0.008
BA vs. MB	360	*z-stat*	-14.897	-11.150	-4.477
	264	*Prob>/z/*	0.000	0.000	0.000
BA vs. HB	360	*z-stat*	-14.393	-13.010	-1.358
	219	*Prob>/z/*	0.000	0.000	0.174
LB vs. HB	168	*z-stat*	0.837	-0.529	1.581
	219	*Prob>/z/*	0.402	0.597	0.114

Notes: [1] Pairwise Mann-Whitney tests reported, using the following labelling conventions: Ba = "Baseline" treatment; LB = "Low Bonus" treatment; MB = "Medium Bonus" treatment; HB = "High Bonus" Treatment.

Table A2: Mann-Whitney tests on entry

Pairwise comparison	Obs	Non-par test (z, p)
BA vs LB	360	3.991
	168	0.000
LB vs. MB	168	-5.481
	264	0.000
MB vs. HB	264	0.426
	219	0.670
BA vs. MB	360	-2.086
	264	0.037
BA vs. HB	360	-1.521
	219	0.128
LB vs. HB	168	-4.881
	219	0.000

Notes: Pairwise Mann-Whitney tests reported, using the following labelling conventions: Ba = "Baseline" treatment; LB = "Low Bonus" treatment; MB = "Medium Bonus" treatment; HB = "High Bonus" Treatment.

Table A3: Mann-Whitney tests on buyers' transfers

Pairwise comparison	Obs		Auction 1	Auction 2	Auction 3
BA vs LB	360	*z-stat*	7.584	3.381	0.072
	168	*Prob>/z/*	0.000	0.001	0.943
LB vs. MB	168	*z-stat*	4.011	0.790	0.445
	264	*Prob>/z/*	0.000	0.429	0.656
MB vs. HB	264	*z-stat*	-5.492	-0.422	-2.290
	219	*Prob>/z/*	0.000	0.673	0.022
BA vs. MB	360	*z-stat*	12.258	5.800	-0.531
	264	*Prob>/z/*	0.000	0.000	0.595
BA vs. HB	360	*z-stat*	7.316	4.120	-2.563
	219	*Prob>/z/*	0.000	0.000	0.010
LB vs. HB	168	*z-stat*	-1.285	0.586	-1.074
	219	*Prob>/z/*	0.199	0.558	0.283

Notes: [1] Pairwise Mann-Whitney tests reported, using the following labelling conventions: Ba = "Baseline" treatment; LB = "Low Bonus" treatment; MB = "Medium Bonus" treatment; HB = "High Bonus" Treatment.

Table A4: Mann-Whitney tests on profits, pooling over roles

	Including w				Excluding w			
Pairwise comparison	Auction 1	Auction 2	Auction 3	All 3 auctions	Auction 1	Auction 2	Auction 3	All 3 auctions
BA vs LB	7.180	-0.518	-2.590	2.234	11.837	2.989	-0.425	5.703
	(0.000)	(0.604)	(0.010)	(0.026)	(0.000)	(0.003)	(0.671)	(0.000)
LB vs. MB	1.307	-0.137	3.111	1.447	2.203	-0.207	0.929	0.162
	(0.191)	(0.891)	(0.002)	(0.148)	(0.028)	(0.836)	(0.353)	(0.871)
MB vs. HB	-1.558	0.384	-1.191	-1.234	-2.274	0.961	-1.002	-1.431
	(0.119)	(0.701)	(0.234)	(0.217)	(0.023)	(0.337)	(0.317)	(0.153)
BA vs. MB	9.396	-0.693	1.103	4.234	15.779	3.273	0.655	6.058
	(0.000)	(0.488)	(0.270)	(0.000)	(0.000)	(0.001)	(0.513)	(0.000)
BA vs. HB	7.686	-0.420	-0.106	2.670	13.035	3.922	-0.277	4.252
	(0.000)	(0.675)	(0.915)	(0.008)	(0.000)	(0.000)	(0.782)	(0.000)
LB vs. HB	-0.171	0.242	1.985	0.463	0.039	0.696	0.126	-0.900
	(0.864)	(0.809)	(0.047)	(0.644)	(0.969)	(0.487)	(0.900)	(0.368)

Notes: [1] Pairwise Mann-Whitney tests reported, using the following labelling conventions: Ba = "Baseline" treatment; LB = "Low Bonus" treatment; MB = "Medium Bonus" treatment; HB = "High Bonus" Treatment. [2] z-scores from Mann-Whitney tests reported; Prob > |z| appears in parentheses.

Section B: Dynamic trends in our main variables, allowing for non-linear variation

Table B1: Quality Provision

	Auction 1	Auction 2	Auction3	All Auctions
Low Bonus (LB)	0.51***	0.56***	0.10*	0.72***
	(0.045)	(0.065)	(0.061)	(0.109)
Med Bonus (MB)	0.54***	0.52***	0.14**	0.69***
	(0.053)	(0.074)	(0.059)	(0.114)
High Bonus (HB)	0.52***	0.60***	0.04	0.69***
	(0.052)	(0.060)	(0.065)	(0.110)
Period 2 (dummy)	-0.23***	-0.23***	-0.06***	-0.26***
	(0.079)	(0.034)	(0.018)	(0.062)
Period 3 (dummy)	-0.26***	-0.25***	-0.06***	-0.29***
	(0.096)	(0.052)	(0.019)	(0.070)
Period 4 (dummy)	-0.35***	-0.26***	-0.08***	-0.37***
	(0.075)	(0.047)	(0.022)	(0.073)
Period 5 (dummy)	-0.23***	-0.29***	-0.10***	-0.36***
	(0.062)	(0.039)	(0.020)	(0.066)
Period 6 (dummy)	-0.36***	-0.29***	-0.09***	-0.41***
	(0.060)	(0.039)	(0.019)	(0.076)
Period 7 (dummy)	-0.34***	-0.28***	-0.08***	-0.39***
	(0.069)	(0.032)	(0.015)	(0.075)
Period 8 (dummy)	-0.25***	-0.21***	-0.09***	-0.30***
	(0.070)	(0.051)	(0.022)	(0.068)
Period 9 (dummy)	-0.31***	-0.26***	-0.08***	-0.36***
	(0.071)	(0.053)	(0.019)	(0.082)
Period 10 (dummy)	-0.28***	-0.24***	-0.07***	-0.31***
	(0.094)	(0.039)	(0.017)	(0.080)
Period 11 (dummy)	-0.33***	-0.25***	-0.07***	-0.35***
	(0.075)	(0.040)	(0.018)	(0.078)
Period 12 (dummy)	-0.26***	-0.25***	-0.07***	-0.32***
	(0.089)	(0.024)	(0.012)	(0.061)
Period 13 (dummy)	-0.29*	-0.30***	-0.07***	-0.39***
	(0.169)	(0.033)	(0.022)	(0.077)
Period 14 (dummy)	-0.18	-0.30***	-0.09***	-0.37***
	(0.167)	(0.056)	(0.017)	(0.127)
Period 15 (dummy)	-0.42***	-0.33***	-0.09***	-0.58***
	(0.086)	(0.027)	(0.017)	(0.117)
Observations	1,011	1,011	1,011	1,011

Notes: [1] Columns 1-3 present the marginal effects from an estimated probit model using as the dependent variable winning firms' (binary) decision to provide high quality. [2] The fourth column presents results of a tobit regression in which the dependent variable is the n. of times high quality has been produced by the winning firm standardized by the n. of auctions. [3] Robust standard errors, clustered by session, appear in parentheses. [4] *** p<0.01, ** p<0.05, * p<0.1

Table B2: Entry decision

	Auction 3
Low Bonus (LB)	-0.19
	(0.126)
Med Bonus (MB)	0.09**
	(0.044)
High Bonus (HB)	0.07**
	(0.033)
Period 2 (dummy)	-0.13**
	(0.057)
Period 3 (dummy)	-0.17***
	(0.036)
Period 4 (dummy)	-0.15**
	(0.065)
Period 5 (dummy)	-0.27***
	(0.040)
Period 6 (dummy)	-0.25***
	(0.046)
Period 7 (dummy)	-0.24***
	(0.057)
Period 8 (dummy)	-0.34***
	(0.063)
Period 9 (dummy)	-0.33***
	(0.052)
Period 10 (dummy)	-0.31***
	(0.059)
Period 11 (dummy)	-0.35***
	(0.054)
Period 12 (dummy)	-0.34***
	(0.076)
Period 13 (dummy)	-0.15***
	(0.048)
Period 14 (dummy)	-0.25***
	(0.083)
Period 15 (dummy)	-0.49***
	(0.026)
Observations	1,011

Notes: [1] Each column presents the marginal effects from an estimated probit model using as the dependent variable Entrant firms' (binary) decisions to enter Auction 3. [2] Robust standard errors, clustered by session, appear in parentheses. [3] *** p<0.01, ** p<0.05, * p<0.1

Table B3: Buyers' Total Transfers

	Auction 1	Auction 2	Auction3	Average Over All Auctions
Low Bonus (LB)	-0.28**	0.05	0.18	-0.02
	(0.112)	(0.116)	(0.147)	(0.084)
Med Bonus (MB)	-0.47***	-0.04	0.06	-0.15
	(0.098)	(0.109)	(0.139)	(0.113)
High Bonus (HB)	-0.24**	-0.01	0.26*	0.00
	(0.104)	(0.123)	(0.126)	(0.116)
Period 2 (dummy)	-0.23***	-0.35**	-0.28*	-0.29***
	(0.056)	(0.148)	(0.138)	(0.069)
Period 3 (dummy)	-0.43***	-0.52***	-0.42***	-0.46***
	(0.064)	(0.117)	(0.121)	(0.067)
Period 4 (dummy)	-0.43***	-0.61***	-0.48***	-0.51***
	(0.075)	(0.114)	(0.110)	(0.070)
Period 5 (dummy)	-0.45***	-0.59***	-0.56***	-0.53***
	(0.077)	(0.139)	(0.119)	(0.086)
Period 6 (dummy)	-0.42***	-0.57***	-0.50**	-0.50***
	(0.093)	(0.128)	(0.171)	(0.092)
Period 7 (dummy)	-0.44***	-0.67***	-0.52***	-0.54***
	(0.083)	(0.139)	(0.109)	(0.092)
Period 8 (dummy)	-0.42***	-0.58***	-0.51***	-0.51***
	(0.091)	(0.100)	(0.120)	(0.076)
Period 9 (dummy)	-0.40***	-0.70***	-0.54***	-0.55***
	(0.074)	(0.128)	(0.080)	(0.067)
Period 10 (dummy)	-0.45***	-0.72***	-0.61***	-0.59***
	(0.081)	(0.141)	(0.122)	(0.083)
Period 11 (dummy)	-0.43***	-0.61***	-0.56***	-0.53***
	(0.083)	(0.153)	(0.154)	(0.100)
Period 12 (dummy)	-0.47***	-0.67***	-0.63***	-0.59***
	(0.069)	(0.125)	(0.137)	(0.084)
Period 13 (dummy)	-0.30***	-0.57***	-0.74***	-0.54***
	(0.086)	(0.114)	(0.229)	(0.082)
Period 14 (dummy)	-0.35***	-0.80***	-0.69***	-0.62***
	(0.099)	(0.181)	(0.118)	(0.108)
Period 15 (dummy)	-0.38***	-0.59**	-0.42***	-0.46***
	(0.096)	(0.251)	(0.110)	(0.117)
Constant	2.52***	2.52***	2.04***	2.36***
	(0.106)	(0.139)	(0.140)	(0.110)
Observations	1,011	1,011	1,011	1,011
R-squared	0.245	0.076	0.086	0.151

Notes: [1] Columns 1-3 present simple OLS estimates using as the dependent variable buyers' total payments (transfers) to winning firms in auction in the column heading. [2] The fourth column presents a similar OLS estimate, but using average buyers' transfer across all three auctions as the dependent variable. [3] Robust standard errors, clustered by session, appear in parentheses. [4] *** p<0.01, ** p<0.05, * p<0.1

Table B4: Firms' Profits

	Including w				Excluding w			
	Auction 1	Auction 2	Auction 3	All Auctions	Auction 1	Auction 2	Auction 3	All Auctions
Low Bonus (LB)	-0.20***	0.06	0.10	-0.02	-0.20***	0.06	0.04	-0.04
	(0.040)	(0.050)	(0.068)	(0.035)	(0.040)	(0.050)	(0.046)	(0.039)
Med Bonus (MB)	-0.26***	0.05	0.03	-0.06	-0.26***	0.05	0.06	-0.05
	(0.037)	(0.040)	(0.055)	(0.042)	(0.037)	(0.040)	(0.055)	(0.042)
High Bonus (HB)	-0.18***	0.05	0.13**	0.00	-0.18***	0.05	0.15**	0.01
	(0.040)	(0.038)	(0.053)	(0.041)	(0.040)	(0.038)	(0.051)	(0.039)
Period 2 (dummy)	-0.05**	-0.02	0.02	-0.02	-0.05**	-0.02	-0.02	-0.03*
	(0.020)	(0.044)	(0.041)	(0.017)	(0.020)	(0.044)	(0.041)	(0.016)
Period 3 (dummy)	-0.12***	-0.11**	-0.06	-0.09***	-0.12***	-0.11**	-0.11**	-0.11***
	(0.021)	(0.037)	(0.038)	(0.021)	(0.021)	(0.037)	(0.035)	(0.020)
Period 4 (dummy)	-0.10***	-0.15***	-0.03	-0.10***	-0.10***	-0.15***	-0.07	-0.11***
	(0.024)	(0.044)	(0.038)	(0.026)	(0.024)	(0.044)	(0.044)	(0.024)
Period 5 (dummy)	-0.13***	-0.16***	-0.09*	-0.12***	-0.13***	-0.16***	-0.16***	-0.15***
	(0.027)	(0.042)	(0.046)	(0.032)	(0.027)	(0.042)	(0.042)	(0.030)
Period 6 (dummy)	-0.10**	-0.14**	-0.09**	-0.11**	-0.10**	-0.14**	-0.16***	-0.13***
	(0.033)	(0.059)	(0.034)	(0.037)	(0.033)	(0.059)	(0.033)	(0.035)
Period 7 (dummy)	-0.11***	-0.13**	-0.06	-0.10**	-0.11***	-0.13**	-0.12**	-0.12***
	(0.032)	(0.052)	(0.051)	(0.035)	(0.032)	(0.052)	(0.050)	(0.037)
Period 8 (dummy)	-0.11***	-0.13**	-0.04	-0.10**	-0.11***	-0.13**	-0.14***	-0.13***
	(0.032)	(0.054)	(0.035)	(0.032)	(0.032)	(0.054)	(0.037)	(0.034)
Period 9 (dummy)	-0.10***	-0.15***	-0.04	-0.10***	-0.10***	-0.15***	-0.14***	-0.13***
	(0.030)	(0.047)	(0.036)	(0.024)	(0.030)	(0.047)	(0.029)	(0.026)
Period 10 (dummy)	-0.12***	-0.15**	-0.03	-0.10**	-0.12***	-0.15**	-0.12**	-0.13***
	(0.033)	(0.055)	(0.050)	(0.034)	(0.033)	(0.055)	(0.056)	(0.039)
Period 11 (dummy)	-0.11***	-0.14**	-0.05	-0.10**	-0.11***	-0.14**	-0.15**	-0.13***
	(0.031)	(0.048)	(0.053)	(0.034)	(0.031)	(0.048)	(0.053)	(0.037)
Period 12 (dummy)	-0.13***	-0.14**	-0.13**	-0.13***	-0.13***	-0.14**	-0.23***	-0.16***
	(0.025)	(0.054)	(0.056)	(0.030)	(0.025)	(0.054)	(0.044)	(0.030)
Period 13 (dummy)	-0.07**	-0.02	-0.05	-0.05	-0.07**	-0.02	-0.09	-0.06
	(0.023)	(0.036)	(0.091)	(0.040)	(0.023)	(0.036)	(0.083)	(0.038)
Period 14 (dummy)	-0.10*	-0.12	-0.15*	-0.12	-0.10*	-0.12	-0.22***	-0.15*
	(0.047)	(0.117)	(0.077)	(0.076)	(0.047)	(0.117)	(0.057)	(0.069)
Period 15 (dummy)	-0.07	-0.10***	-0.01	-0.06**	-0.07	-0.10***	-0.18***	-0.11***
	(0.049)	(0.029)	(0.038)	(0.026)	(0.049)	(0.029)	(0.036)	(0.025)
Constant	0.62***	0.59***	0.36***	0.52***	0.28***	0.26***	0.30***	0.28***
	(0.039)	(0.054)	(0.056)	(0.046)	(0.039)	(0.054)	(0.054)	(0.045)
Observations	3,033	3,033	3,033	3,033	3,033	3,033	3,033	3,033
R-squared	0.042	0.008	0.008	0.008	0.119	0.011	0.015	0.027

Notes: [1] Each column presents a simple OLS regression using as the dependent variable firms' profits. [2] The first four columns include in this calculation Entrant firms' reservation wage, w = 1, in Auctions 1 and 2. The last four columns exclude the reservation wage from profit calculations . [3] Robust standard errors, clustered by session, appear in parentheses. [4] *** p<0.01, ** p<0.05, * p<0.1

Instructions Appendix

(Translated into English)

A. Instructions

Welcome!

This is a study about how people make decisions. The study is being financed by the Swedish Competition Authority and by EIEF. In this experiment you will participate in auctions allocating contracts for the production of a good or service. If you pay attention to the instructions they will help you make decisions and earn a reasonable amount of money. Your earnings from this experiment will be paid to you in cash at the end of today's session.

We ask you to please turn off your cell phones and to refrain from talking with other persons present in the room until the end of the experiment. If you have questions, please raise your hand and one of the experimenters will respond to you privately.

Today's experiment consists of [12,15] rounds. Every round is composed of three auctions. At the beginning of each round every participant in the room will be assigned randomly and anonymously two other participants. Each of the resulting groups of three participants will take part in a sequence of three auctions of which each round is composed. After the three auctions are concluded, a new round will begin by again randomly and anonymously re-assigning participants into groups of three. This process continues until all [12, 15] round have been completed.

At the beginning of each round, each of the three participants in a group will be assigned (as always, randomly) the role of one of three firms: Firm A, Firm B or Firm C. Firms A and B will participate in all three auctions comprising the round. Firm C, on the other hand, can participate in the third auction if they choose to do so, but cannot participate in the first two auctions. Firm C must wait for Firms A and B to complete the first two auctions. The institution that conducts the auctions and that acquires the good or service produced by the firms is the computer.

<u>Auction 1</u>

At the beginning of the first auction Firms A and B submit a bid, i.e. the price in return for which they are willing to produce the good requested by the purchaser, bearing in mind that the maximum allowable bid is 4.5:

- The firm that submits the lowest bid (i.e., that offers to produce the good or service for the lowest price) wins the auction.

- If both firms submit the same bid, the winning firm will be selected randomly.

The winning firm must also make a production decision: which quality level to produce. For Firm A and Firm B it is possible to produce a high quality good/service at a cost of 2, or to produce low quality at a cost of 1.5. An auction is over when all the participating firms have submitted their bids and the winning firm has made its production decision.

The earnings for the winning firm from the first auction will be the winning firm's bid minus the cost of production. If, for example, the winning firm submitted a bid of 3 and decided to produce high quality at a cost of 2, the this firm's profit will be 3 – 2 = 1. The firm that did not win the auction will (submitted a bid higher than 3) will earn a profit of 0 from this auction.

The buyer prefers high quality to low quality and, as explained in more detail below, rewards in the subsequent auction firms with a good reputation—i.e., those that in the previous period produced high quality—with a bonus on their bid when they win.

At the end of each auction, including this first auction, all three firms will be shown all submitted bids and the quality level which the winning firm decided to produce.

Auction 2

As in the first auction, only Firm A and Firm B participate in Auction 2. Both Firms A and B must submit a bid keeping in mind that the maximum possible bid is 4.5:

- The firm that submits the lowest bid (i.e., that offers to produce the good or service for the lowest price) wins the auction.
- If both firms submit the same bid, the winning firm will be selected randomly.

The firm that won Auction 1, if they produced high quality in that auction, has a good reputation in this second auction. What this means is that if this same firm wins Auction 2 they will be given a bonus equal to 100% of their winning bid. For example, if the bid submitted by a firm with good reputation is 2 and this bid wins Auction 2 (e.g., because the other firm submitted a bid larger than 2) the bonus paid to the winning firm with good reputation will be 100% of 2, i.e., 2, and the price paid to this winning firm for producing by the purchaser will be 2 + 2 = 4.

The firm winning Auction 2 must choose whether to produce high quality, at a cost of 2, or to produce low-quality at a cost of 1.5, exactly as in Auction 1. The winning firm's profit from this second auction will be the price offered plus the bonus (if the winning firm has a good reputation, i.e. had won auction 1 produced high quality there), minus the cost of production. Continuing with the previous example: if the firm with good reputation wins Auction 2 with a bid of 2, it receives its bid plus the bonus of 2, for a total revenue of 2 + 2 = 4; it must then decide whether to produce high or low quality in this second auction. If it decides to produce high quality also in this second race, its profit will be equal to the price with the bonus, minus the cost of producing high quality, that is, 4-2 = 2, and it will also have good reputation in the subsequent, third, auction. If it decides instead to produce low quality Auction 2, it will now have a profit of 4 - 1.5 = 2.5, but will not have a good reputation (nor a bonus) in the third auction.

If the winning firm in the Auction 2 does not have a good reputation (because it did not win the first auction or because it did not produce high quality there) it will not receive a bonus. In this case, its profit from the second auction will be its winning bid minus the cost of production. For example, if its winning bid was 2 and it decides to produce low quality, it will earn a profit of 2 - 1.5 = 0.5 and will not have a good reputation in Auction 3. On the other hand, if it decides to produce high quality its profit in the second auction will be 2 - 2 = 0, but it will have a good reputation in the third auction.

Consequently, if both neither Firm A nor Firm B have a good reputation at the beginning Auction 2, they will compete on equal footing. If one of them has a good reputation, however, the firm with good reputation will have an advantage: getting a bonus if it wins this second period.

At the end of the second auction, all firms will be able to see all bids submitted, which firm won the auction and the quality level the winning firm chose to produce.

<u>Auction 3</u>

At the start of the third auction, having observed what happened in the two previous races, Firm C must decide whether to participate in Auction 3 along with Firms A and B. If Firm C decides to participate, it will receive a bonus equal to [100%, 50%, 0%] of its bid if it wins the auction. For example, if Firm C submits a bid of 2 and wins Auction 3, its bonus will be [2,1, 0], and it will be paid 2 +[2, 1, 0] = [4, 3, 2] by the purchaser. Firm C's profit from this third race will be [4, 3, 2] minus the cost of production which, as will be explained below, may be different from the production costs of Firms A and B. If, instead, Firm C decides to not participate in Auction 3, it will earn 1 euro. If Firm C decides to participate in Auction 3 it will have to submit a bid in the same manner as Firms A and B with a maximum possible bid of 4.5.

In this third auction:

- The firm submitting the lowest bid (i.e, has offered to produce the good or service at the lowest price) wins;
- If more than one firm submits the same lowest bid, the winner will be randomly selected among these firms.

The winning firm must decide the quality level at which to produce. If Firm C is the winning firm, it costs of production are as follows:

- producing low quality entails a production cost of 0.125

- producing high quality entails a production cost of 2.

If either Firm A or Firm B win the third auction, its production costs are as before: producing high quality costs the firm 2, while the cost of producing low quality is 1.5.

<u>Total Earnings</u>

At the end of today's session, one of the [12, 15] rounds will be randomly selected and each participant will be paid their earnings overall all three auctions comprising this randomly-chosen round. Participants assigned the role of Firm A or B will be paid the total euros earned in the three auctions. Participants assigned the role of Firm C will be paid 1 euro for each of the first two auctions plus 1 euro for the third auction if he/she decided not to participate. If he/she did participate in Auction 3, his or her earnings from this third auction will be either 0 if he or she did not win, or his or her bid plus the bonus minus the costs of production.

In addition to the earnings in randomly-selected round, all participants will be paid 5 euros as compensation for participation.

INSTRUCTIONS FOR FIRMS A and B

You are Firm A or Firm B. In this experiment you will take part in a series of auctions to award the production of a good or a service. The experiment consists of [12, 15] rounds. In each round you will participate in three auctions taking place one after the other. At the start of the first auction you must submit a bid—the price for which you will produce a good or service. When both you and the other firm have submitted your bids:

- The company submitting the lowest bid (i.e., has offered to produce the good or service at the lowest price) wins the auction.
- If both firms submit the same bid, one firm will be randomly selected to win the auction.

If you are the firm that wins, you must make a production decision. You can either produce a high level of quality at a cost of 2, or you can produce a low quality good or service at a cost of 1.5.

When all bids are submitted and production decisions are made, the auction is over and all firms will learn all bids that were submitted as well as the quality level production decision of the winning firm.

You will then begin the second auction. Again, in Auction 2 only Firms A and B participate. As in the first auction, you submit a bid. If the firm that won the first auction produced high quality in Auction 1, in this second auction it will have a good reputation. This good reputation gives the firm a bonus of 100% of its (winning) bid, if it wins Auction 2. For example, if the bid submitted by a firm with good reputation in the second auction is 2, and this bid wins the auction, the bonus will also be 2 and the amount that this firm will be paid by the purchaser is 4. Its profit will be its bid plus the bonus minus the cost of production.

If the firm that won the first auction did not produce high quality, it will not have a good reputation in Auction 2 and it will not receive a bonus for winning. I.e., Firms A and B will participate on equal footing in the second auction.

When both you and the other firm have submitted your bids:

- The company submitting the lowest bid (i.e., has offered to produce the good or service at the lowest price) wins the auction.
- If both firms submit the same bid, one firm will be randomly selected to win the auction.

If you are the firm that wins, you must make a production decision. You can either produce a high level of quality at a cost of 2, or you can produce a low quality good or service at a cost of 1.5.

When all bids are submitted and production decisions are made, the auction is over and all firms will learn all bids that were submitted as well as the quality level production decision of the winning firm.

At the start of the third auction, Firm C must decide whether or not to participate. If Firm C decides to participate, you will have two competitors in Auction 3. In the third auction, you submit a bid (as before):

- The company submitting the lowest bid (i.e., has offered to produce the good or service at the lowest price) wins the auction.
- If more than one firm submits the same lowest bid, one firm will be randomly selected from among those submitting the lowest bid to win the auction.

If you win this third auction and you also won the second auction and produced high quality there, you have good reputation. You will be paid the bonus for good reputation, as described above, in addition to your winning bid by the purchaser.

Your earnings in a round is the sum of what earned over all three auctions comprising a round.

In summary, if you win the first auction your earnings from Auction 1 will be your bid minus the cost of production. If you choose to produce with high quality in Auction 1, in the subsequent auction (Auction 2) you will have a good reputation and will be given a bonus if you win: your earnings in Auction 2 will be your winning bid plus the bonus minus the cost of production. If you choose to produce low quality in Auction 1, in the subsequent auction (Auction 2) you will not have a good reputation and will receive no bonus for winning the second auction. If you win the second auction and choose to produce high quality there, you will have a good reputation in the third auction and again receive a bonus for winning Auction 3. If, however, you win Auction 2 and produce low quality, you will not have good reputation in Auction 3 and, so, receive no bonus for winning the third auction.

INSTRUCTIONS FOR FIRM C

You are Firm C. In this experiment you will take part in a series of auctions to award the production of a good or a service. The experiment consists of [12, 15] rounds. Since you are Firm C you cannot participate in the first two auction of each round but will earn 1 euro for each of these auctions. You can, however, participate in the third auction if you choose to.

If you decide not to participate in the third auction, you will earn an additional 1 euro. If you decide to participate in Auction 3, you forgo this 1 euro and must submit a bid. If your bid is the lowest of the three bids made (yours and those of Firms A and B), you win the auction and get will be paid your winning bid plus a bonus equal to [100%, 50%, 0%] of you bid. For example, if your winning bid is is 2, 2 + [2, 1 , 0] = [4, 3, 2] will be the amount you are paid by the purchaser.

If you are the winning firm, you must decide the level of quality to produce. You face the following production costs:

- producing low quality costs 0.125
- producing high quality costs 2

Your earnings in a round will be: 1 euro for the first auction, 1 euro for the second auction. For Auction 3, if you decide not to participate you will again earn 1 euro for the third auction. If, however, you participate in the third auction, your earnings from Auction 3 will be either: 0, if you lose; or your bid plus the bonus minus the cost of production if you win.

B. Individual Screens

[Screen 1A: shown to Incumbent firms only]:

- You have been assigned the role of [Firm A, Firm B]
- Click "Proceed" to begin

[Screen 1B: shown to Entrant firms only]:

- You have been assigned the role of Firm C.
- You can only participate in the third auction.
- Click "Proceed," then please wait patiently for the first two auctions to conclude.
- You will be informed when the third auction is about to begin.

[Screen 2: Auction 1 bid submission screen]:

- Please enter your bid below.
- Then, click "Submit bid."

Your bid: ___

[Screen 3: Auction 1 waiting screen, shown to losing Incumbent firm only]

- You did not win the auction.
- Please click "Proceed" and wait while the winning firm makes its production decision.

[Screen 4: shown to winning firm only]

- You won the auction.
- Please select which quality level to produce below.
- Then, click "Proceed."

Produce:

[order of options randomized]

- ○ High quality
- ○ Low quality

[Screen 5]: Auction 1 summary, shown to all three firms]

Results of Auction 1

- Firm A bid: __
- Firm B bid: __
- The winning firm was [Firm A, Firm B]
- The winning firm produced [low quality, high quality]

[Screen 7]: Auction 2 bid screen, shown to Incumbent firms only]

- You [have, do not have] reputation.
- Please enter your bid below
- Then, click "Submit bid."

Your bid: ___

[Screen 8]: Auction 2 waiting screen, shown to losing Incumbent firm only]

- You did not win the auction.
- Please click "Proceed" and wait while the winning firm makes its production decision.

[Screen 9]: shown to winning firm only]

- You won the auction.
- Please select which quality level to produce below.
- Then, click "Proceed."

Produce:

[order of options randomized]

  - o High quality
  - o Low quality

[Screen 10]: Auction 2 summary, shown to all three firms]

Results of Auction 2

- Firm A bid: __
- Firm B bid: __
- The winning firm was [Firm A, Firm B]
- The winning firm produced [low quality, high quality]

[Screen 11]: Auction 3 Entry decision screen, shown only to Entrant firm]

- Auction 3 is now about to take place.
- Please choose whether you will enter auction 3 below.
- After you have chosen, please click "Proceed."

[order of options randomized]

  - Do not enter
  - Enter the auction

[Screen 12]: Auction 3 Entry decision announcement, shown to all three firms]

- Firm C decided [not to enter, to enter] the auction.
- Please click "Proceed."

[Screen 13A]: Entrant firm Auction 3 bid submission screen, shown only to Entrant firm]

- Your entrant multiplier is __.
- Please enter your bid below.
- Then, click Submit bid.

Your bid: ___

[Screen 13B: Incumbent firm Auction 3 bid submission screen, shown only to Incumbent firms]

- Your entrant multiplier is __.
- Please enter your bid below.
- Then, click Submit bid.

Your bid: ___

[Screen 14: Auction 3 summary, shown to all three firms]

Results of Auction 3

- Firm A bid __
- Firm B bid __
- Firm C [entered / did not enter]
- The winning firm was [Firm A, Firm B, Firm C]
- The winning firm produced [low quality, high quality]

[Screen 15: Profit summary over all three auctions, shown to all three firms]

- If this round is selected, you will earn __ euro
- You earned __ from auction 1
- You earned __ from auction 2
- You earned __ from auction 3

- Please click "Proceed" and wait for the next round to begin.

[Screen 16: Profit summary waiting screen, shown to all three firms]

- Please wait for all other participants to view their potential profits for this round. The next round will automatically start when everyone has clicked "Proceed."