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STICKS AND CARROTS IN PROCUREMENT: AN EXPERIMENTAL EXPLORATION

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Sticks and Carrots in Procurement: an Experimental Exploration*

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Abstract

We test the robustness of recent findings on the benefits of explicit contracts framed as penalties to the complex environments typical of B2B (and B2G) procurement, where penalty contracts are common. In our framework, matching is endogenous and competitive, there are contractible and non-contractible tasks, subjects play repeatedly and maintain their identity so that reputation-based relationships can form. We find that the introduction of explicit incentives boosts efficiency, strongly increasing effort in the contractible task while only mildly crowding it out in the non-contractible one. Bonuses and penalties are equivalent for efficiency and crowding-out, but different in distributional effects: sellers' surplus increases significantly with bonuses as buyers' offers become more generous. Consistently, buyers tend to prefer penalties, which may help explaining why they are so widespread in procurement.

Keywords: bonuses, B2B and B2G transactions, buyer-seller frame, experiment, explicit incentives, incomplete contracts, loss-aversion, multitasking, penalties, procurement, relational contract.

JEL: H57, C92, L14, M52

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1 Introduction

Procurement, exchanges between businesses (B2B) or businesses and government (B2G), account for a large portion of the world economy. Typical contractual forms are fixed price contracts stipulating price, quality standards and penalties ('deductions', 'liquidated damages') in case these are not met; and cost-plus contracts, where the buyer reimburses suppliers for the incurred costs, allowing also for a pre-specified margin.[1] Less used are contractual arrangements framed as bonuses, with a lower base payment and rewards conditional on meeting some target quality standards, which – by contrast – are quite common in labor relationships. The infrequent use of bonus contracts in procurement is all the more puzzling if one considers that most legal systems cap the level of enforceable penalties in contracts but not that of bonuses.[2]

A potential explanation for the popularity of penalty contracts in procurement is that they benefit buyers, who typically choose the contractual framework, by eliciting more effort or a better price from suppliers. In an experimental study on employment relationships, Hannan et al. (2005) compared differently framed but otherwise equivalent explicit contractual incentives, finding that – due to agents' loss aversion – incentives framed as penalties elicit substantially higher effort than equivalent incentives framed as bonuses.[3] Hossain and List (2012) recently measured an analogous effect in the field. They ran a randomized experiment in a Chinese factory comparing the effects of equivalent monetary incentives alternatively framed as penalties and bonuses, and found that in the presence of uncertainty generated by team production, penalties generated a 1% increase in workers productivity.

This evidence comes from relatively simple environments with an exogenous contract assignment which allow for a clean identification and measurement of the effects of framing. Procurement transactions are typically more complex. They tend to involve multiple tasks, limited enforcement on some of them, competition among suppliers, endogenous contract choice, repeated interaction and reputational considerations. The positive effect of penalties mentioned

[1]See e.g. Laffont and Tirole (1993), Bajari and Tadelis (2001), Albano et al. (2006). The USA government procurement uses both fixed-price and cost-plus contracts. Recently, President Obama has signed a memorandum addressed to Federal Executive Departments and Agencies where he explicitly declares that "there shall be a preference for fixed-price type contracts" to eliminate wasteful and inefficient government contracts (Obama, 2009).

[2]In Anglo-Saxon countries liquidated damages are only enforceable up to the courts' estimates of the harm produced by the contractual violation; and in most other countries, contractual penalties are only enforceable up to a fraction of the value of the exchange.

[3]Kahneman et al. (1986) pointed out that, in violation of normative standards, people tend to be more sensitive to losses than to foregone gains, which renders their preferences vulnerable to framing effects (see also Tversky and Kahneman 1986).

above cannot be plausibly counted among the explanations for the popularity of penalty contracts in procurement if it is not robust to the presence of these additional complications, nor if penalty contracts have strong negative externalities on the governance of non-contractible tasks by reputation/repeated interaction (e.g. by reducing trust among parties) that dominate the direct positive effect on effort.[4] This study is a first step in testing the performance of differently framed explicit incentives in a more complex environment, as is typical of procurement (and many other) transactions.

Our Paper. We run a laboratory experiment measuring the effects of framing explicit incentives as penalties or bonuses in an environment incorporating several of the aforementioned features of procurement in an imperfect contracting environment. We allow for contractible and non-contractible performance dimensions/tasks, competitive buyer-seller matching, endogenous contract choice and repeated interaction with known identities (which allows for long-term reputation-based relationships to form and govern non-contractible tasks).

In each round of our experiment, buyers can purchase from sellers a good having two dimensions, determined by sellers' exerted effort in two tasks, one contractible (delivery time) and the other not (quality). The matching between buyers and sellers is endogenous, as in each round buyers post contractual offers to sellers, who can choose to accept them or not. Offers can be addressed to all sellers, or targeted to a specific seller, and buyers and sellers can identify each other across different rounds of interaction.

We implement four treatments, which differ in the set of equivalent explicit incentives buyers could choose to adopt: bonuses, penalties, both and none. In the first three treatments, buyers can include in the contract an explicit incentive related to the contractible performance dimension. Comparing the results across treatments and across contracts within each treatment, we then investigate how the chosen incentive scheme affects the level of effort that sellers exert in both contractible and non-contractible dimensions, as well as the formation of long-term relationships and transaction prices.

Several forces could interact with the framing of explicit contracts in such a complex, dynamic environment. Since transactions involve contractible and non-contractible dimensions,

[4] Hannan et al. (2005) confirm Luft (1994)'s result that agents prefer bonus contracts and perceive them to be fairer than penalty contracts. They also find that incentives framed as bonuses foster more trust and reciprocity, although this effect is dominated by a substantially larger increase in effort induced by penalties because of loss aversion.

the introduction of explicit incentives for the former could crowd out attention and effort from the latter.[5] Reputation-based relational agreements could form to govern non-contractible dimensions, and the availability and use of different explicit incentives could impact the viability of these agreements.[6] The framing of explicit incentives could then affect outcomes directly, through its impact on long-term relationships and through the forms of crowding-out mentioned above.[7]

The introduction of explicit incentives could also crowd out intrinsic motivation, altruism and social preferences (Fehr and List 2004, Mellström and Johannesson 2008). These forces, however, are unlikely to play a major role in the impersonal B2B (or B2G) transactions on which we are focusing (Armstrong and Huck 2010). We tried, therefore, to reduce their impact by framing the instructions as impersonal B2B transactions, by recruiting from a subject pool that some consider less sensitive to these concerns (economics and business students, the pool from which procurement managers are often hired);[8] and by providing subjects with a profit calculator that offered a comprehensive overview of all feasible payoff configurations.[9]

Results. Consistently with Hannan et al. (2005) and Hossain and List (2012), we find that when explicit incentives are chosen, they strongly increase overall effort and surplus. The absence of explicit incentives always led to rather low levels of effort/performance in both of

[5]In the words of Holmstrom and Milgrom (1991), "Incentive pay serves not only to allocate risks and motivate hard work, it also serves to direct the allocation of the agents' attention among their various duties."

[6]The availability of explicit contracting may reduce effort on non-contractible tasks by undermining parties' ability to punish deviations from implicit agreements (see Baker et al. 1994; Schmidt and Schnitzer 1995). On the other hand, by restricting the ways in which parties can defect and by increasing their interdependence, explicit contracts may also facilitate cooperation between parties (e.g. Klein 2000). See MacLeod (2007) for an excellent recent survey.

[7]Bonuses are typically seen as "positive" incentives, favoring trust among the parties and possibly facilitating cooperation (Luft, 1994; Hallman et al., 2005). Fehr and Gächter (2002) observe that if, for a given incentive contract, multiple effort levels are consistent with equilibrium behavior, then the framing may affect the selection of equilibria, thus leading to a different outcome for the game. They also point out that, in cases where concerns of fairness and reciprocity are important, the framing of incentives may affect perceptions of the kindness or hostility of the principals' actions, which are crucial for reciprocal responses.

[8]Frank et al. (1993) report several empirical results suggesting that economics and business students appear less cooperative than others. Yezer et al. (1996) provide further evidence that undergraduate students of economics display uncooperative behavior in specialized games or surveys, although they disagree with Frank et al. (1993) on the additional conclusion that economists' "real-world" behavior is also less cooperative. More recently, Gaechter et al. (2012) find that economists cooperate less - i.e. contribute less - than non-economists in a leader-follower experimental set-up.

[9]Evidence of the framing effects of instruction in this and similar settings is also somewhat mixed. Charness et al. (2004) found that providing complete and detailed information about the players' feasible payoffs – in their case by means of a profit table – significantly reduces the impact of intrinsic motivation and fairness in gift exchange laboratory experiments. Engelmann and Ortmann (2009) recently found that the framing of instructions exerts only limited effects on subjects' behavior in gift-exchange games. Hoffman et al. (1994) did find that ultimatum game offers are lower in a buyer-seller frame than in a standard bargaining frame, but in a following study, Hoffman et al. (2000) report treatments where offers in a buyer-seller frame were similar to those from bargaining frames.

the good's dimensions.

Also, when adopted, explicit incentives (however framed) strongly boosted effort in the contractible task while only slightly reducing effort in the non-contractible dimension. The two types of incentives emerge, therefore, as substitutes in our experiment. This finding is also in line with Hossain and List (2012), although the implicit incentives considered in the two studies are somewhat different.

As for the framing of explicit incentives, bonuses and penalties were indeed not fungible. In particular, buyers' offers with bonuses were significantly more generous than those with penalties. This appears consistent with buyers being loss-averse when evaluating the consequences of sellers' possible choices of effort, as penalty contracts entailed a higher up-front payment than equally generous bonus contracts. Sellers, on the other hand, did not react differently to bonuses and penalties, which is what one should expect given that they have full control of their actions and therefore face no risk.[10]

Most buyers preferred penalties over bonuses when they could choose, and they generally benefited from such a choice by getting a bigger share of the surplus. Interestingly, part of this difference was driven by a subset of the buyers who chose to offer 'exploitative' contracts leaving sellers below their outside option once accepting these offers. Smarter buyers therefore appeared to correctly predict the presence of some naive sellers in the population and successfully took advantage of them, much in line with the recent evidence on overbidding in auctions in Lee and Malmendier (2011). Still, if we disregard these exploitative contracts, the different partitioning of surplus with bonuses or penalties persists.

Taken together, these results suggest that the effect of framing the contract as penalty discussed by Hannan et al. (2005) and Hossain and List (2012) could be one of the contributing factors to the prevalence of fixed-price penalty contracts in procurement, although the channel through which buyers benefit from such contracts in our study appears more linked to distributional effects than to productivity/effort considerations.

Related Literature. To the best of our knowledge, ours is the first study of framing effects of explicit contracts in a complex, competitive environment with multitasking, limited enforcement, repeated play and endogenous matching. The closest studies to ours are the already

[10]This result is also in line with Hossain and List (2012), where workers increase effort more under penalty contracts when the prospect is risky because of team production externalities, but not when subjects have full control of their effort/performance dimension.

mentioned ones of Hannan et al. (2005) and Hossain and List (2012). In order to enrich the environment and test for the robustness of contract framing effects, we adopted several features of Brown et al. (2004). As in their design, our experiment provides room for *i)* one side posted offers, *ii)* the choice among private and public offers, *iii)* repeated interaction with reputation building, *iv)* seller/agent competition (fewer buyers/principals than sellers). Differently from them, we specifically allow for the choice of incentives on the contractible dimension. Relational contracts appear less powerful in our setting than in theirs, possibly because we succeed in our attempt to attenuate the effects of social preferences (though our parametrization and termination rule are also different).[11]

Related are also previous experiments on repeated procurement, such as Dufwenberg and Gneezy (2000, 2002), looking at the effects of the number of competitors and information about past bids on outcomes; and those comparing explicit and implicit/discretionary incentives. Among the latter, Gächter et al. (2010) and Fehr and Gächter (2002) find that explicit non-discretionary incentives undermine voluntary cooperation, but while in the former work no evidence emerges in favor of a framing effect, the latter shows that if the incentive is framed as a price deduction (penalty) rather than a bonus, motivational crowding-out is stronger. Our investigation of this aspect indicates that framing may have an impact not only on sellers', but also on buyers' behavior, which may be at the root of the different results. Fehr and Schmidt (2004) highlight that in a multi-tasking setting with one-shot transactions, a bonus contract offering implicit incentives outperforms a piece-rate contract that makes the agent's pay explicitly tied to his effort. Fehr et al. (2007) report that in their experimental setting, when principals can choose between a contract with an implicit incentive (in the form of a discretionary bonus) and a contract with an explicit incentive (in the form of a deterministic penalty), they predominantly prefer to adopt the former one and this choice induces agents to exert higher efforts.[12] Lazzarini et al. (2004) also study repeated buyer-seller relationships with a contractible and a non-contractible dimension. They adopt an exogenous matching environment where each buyer can make only one take-it-or-leave-it offer per period, sellers cannot choose between different offers, and explicit incentives are always framed as penalties. They find that explicit contracts may induce higher levels of effort in the non-contractible dimension.

[11] If our result is confirmed in future studies, it may imply that social preferences are not only complementary to reputation, as suggested by Brown et al. (2004), but may actually be essential to its effectiveness.

[12] In our setting, explicit incentives are deterministic, and the punishment in the event of a seller's default is automatic and cost-free for the buyer. This is consistent with procurement practice but contrasts with the typical set-up adopted in previous experiments (Andreoni et al., 2003; Fehr and Schmidt, 2007; Sutter et al., 2010).

The remainder of the paper is organized as follows. Section 2 describes the four treatments. There, we first present players' strategy sets and payoff functions; then, we outline and discuss both rational and alternative predictions (Section 2.2). In Section 3 we present and interpret the results from our experiment and Section 4 concludes. Instructions are presented in Appendix A, and in Appendix B we derive the analytical solutions for the simple buyer-seller game.

2 The Experiment

Our experiment is based on a dynamic and competitive game framed as *multiple buyer - multiple seller* corporate relationships with multitasking and endogenous matching. We adopt a between-subjects design which comprises four treatments, which differ only in the types of explicit incentives buyers can introduce into their contractual offers. In this Section, we first describe the main game and the differences across treatments; we then discuss the benchmark solutions for 'rational' and selfish players; finally, we compare these solutions with alternative predictions.

2.1 Design

Players, Tasks and Timing. At the beginning of each session, subjects are randomly assigned a role, 'buyer' or 'seller', which remains constant throughout all rounds of the session. In each round, buyers can place contract offers to purchase a good from sellers; this good has two dimensions: one is contractible and the other is not. For concreteness, we refer to the former as "delivery time", and to the latter as "quality" of the good. Correspondingly, the sellers' effort in supplying the good has one contractible dimension, e_1, and one non-contractible, e_2, with $e_1, e_2 \in [0, 4]$. In three out of our four treatments, buyers may adopt explicit incentives in the contract they offer - a bonus, penalty or both - conditional on the contractible effort e_1 – i.e. buyers are allowed to insert a 'time incentive' for delivery.

In each treatment, the procurement game is repeated finitely but with an uncertain end: it lasts for at least 15 rounds, after which it continues for one more round with a probability of 67% (and it comes to an end with the complementary probability); if it reaches round $t = 30$, then it is required to end.[13] In expectation, a session thus lasts for 18 rounds.

[13]We opted for an uncertain time horizon to minimize backward induction reasoning that could have been facilitated by our attempt to minimize the impact of social preferences, but also to mimic real life procurement interactions more closely. This marks a difference from most closely related previous experiments where subjects knew they were playing for a fixed number of rounds: in Brown et al. (2004) the number of rounds was 15, in Falk et al. (2008), in Fehr and Gächter (2002) and in Gächter et al. (2010) it was 18, 12 and 10, respectively.

Each round t consists of three stages.

1. In *stage one*, each buyer can post a number of private or public contract offers for sellers. In each offer, the buyer indicates a fixed 'wage' $w \in [0, 130]$, a desired level of quality, i.e. of non-contractible effort, and a desired delivery time, i.e. the level of the contractible effort. This setting constitutes the *Trust* treatment. In addition, in *Incentive*, *Bonus* and *Penalty* treatments, each buyer may choose to include an explicit incentive $I(\cdot)$ for delivery time, and specify the level of the contractible effort $e_1^* \in [0, 4]$ that triggers the incentive rule $I(\cdot)$.

   The sellers observe the buyers' offers and decide whether to accept any of them. When a seller accepts an offer, an endogenous match between the two parties arises. Each seller can accept only one offer per round. Likewise, buyers cannot sign more than one contract per round, so once an offer is accepted all other offers from the same buyer decay.

2. In *stage two*, each seller who has signed a contract chooses the level of effort to exert on the two dimensions.

3. In *stage three*, profits from the signed contracts are realized and shared between the matched parties.

Strategies. The set of strategies available to players is treatment-specific. In particular, in the *Incentive* (**I**), *Bonus* (**B**) and *Penalty* (**P**) treatments, the buyer can choose whether to adopt explicit incentives, thereby conditioning the seller's payment on their performance in the verifiable dimension: in treatment **I**, the buyer can choose between adopting a penalty, a bonus, or no incentive at all; in **B** (respectively, **P**), the buyer can include in the contract only bonus (respectively, penalty) incentives, or no incentive at all. Explicit incentives can be adopted at no costs for the buyer. In the *Trust* (**T**) treatment, explicit incentives are not available.

In all treatments buyers can choose to make both '*public*' and '*private*' contractual offers. The former are addressed to any seller, while the latter are addressed to a specific seller – identified through his/her ID number – and thus can be accepted only by that seller. Each seller can accept one among all the buyers' public offers and the buyers' private offers that are addressed to her.

To mimic some degree of competition on the supply side of the market, in every treatment we set the number of sellers two units above the number of buyers: that is, in each period, at least two sellers will not get a contract. This is common knowledge among all participants.

Payoffs. The players' payoff and cost functions are common knowledge. We now present the buyer's and the seller's profits maximization problem in period t. Detailed analytical solutions are presented in Appendix B.

The buyer's profit, π_t^B. In each treatment and during every round t, the buyer's contractual offer includes the fixed wage w, the levels of desired contractible and non-contractible efforts and, where incentives are available, it may include the level of contractible effort e_1^* triggering the explicit incentive, if any, and a parameter $\iota \in \{1, -1, 0\}$, whose value identifies the sign of the explicit incentive. The buyer's profit π_t^B is then:

$$\pi_t^B\left(w_t, e_{1,t}^*, e_t, \iota_t\right) = \begin{cases} v\left(e_t\right) - w_t - kI\left(e_{1,t}^*, e_t, \iota_t\right) & \text{if a contract is concluded} \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

where $e_t = (e_{1,t}, e_{2,t})$ is the vector of the seller's efforts actually exerted in the contractible and non-contractible dimension at time t; $v\left(e_t\right) = 8 + 16(e_1 + e_2)$ is the realized value from the contract;[14] $k = 20$ represents the fixed size of the explicit incentive; $I(.)$ is the incentive rule, defined as

$$I\left(e_1, e_1^*, \iota\right) = \begin{cases} 1 \ (\textit{bonus}) & \text{if } \iota = 1 \text{ and } e_1 \geq e_1^* \\ -1 \ (\textit{penalty}) & \text{if } \iota = -1 \text{ and } e_1 < e_1^* \\ 0 \ (\textit{no incentives}) & \text{otherwise} \end{cases}$$

The seller's profit, π_t^S. The seller's total cost of effort is $c(e_t) = (e_{1,t} + e_{2,t})^2$. Thus, seller's payoff π_t^S is:

$$\pi_t^S\left(w_t, e_{1,t}^*, e_t, \iota_t\right) = \begin{cases} w_t - c\left(e_t\right) + kI\left(e_{1,t}^*, e_t, \iota_t\right) & \text{if a contract is concluded} \\ \sigma & \text{otherwise} \end{cases} \tag{2}$$

[14] Our theoretical predictions and experimental results are specific to this production function. Whether a higher degree of complementarity between the two efforts would have generated different results is an interesting research question, which is outside the scope of this study.

where σ is the seller's outside option, which in all our treatments is set equal to 4 and is common knowledge.

2.2 Predictions

'Rational' Predictions. In every round t for each treatment, the buyer offers a contract that maximizes his expected value of present and future profits under the usual participation and incentive compatibility constraints – respectively (4) and (5) in Appendix B.

In our finite horizon game, if all players are perfectly rational and selfish and this is common knowledge, all the sellers will exert minimal enforceable efforts in the final period and – accordingly – all the buyers will offer them zero rent. Therefore, by backward induction, the value of future rents for sellers is zero, and positive effort is never sustainable as an equilibrium outcome in the absence of explicit incentives. Consider now the benchmark solutions for each version of the game.

In treatment **T**, since it is costly for the seller to exert effort and because the buyer's payments are not related to effort (no explicit incentives can be provided here), in every round t, there is a unique Nash equilibrium strategy whereby the buyer offers a fixed wage just barely equal to the seller's outside option, i.e.: $w_t = \sigma = 4$, to guarantee acceptability, and the seller exerts no effort $(e_1, e_2 = 0)$ in both dimensions.

In treatment **I**, the buyer can include an incentive, either a bonus or a penalty, in his offer. Given our parameters, it is always optimal for each seller who accepts an offer to set $e_1 = e_1^*$. Accordingly, it will be optimal for the buyer to set $e_1^* = 4$, which is the maximum value of the contractible effort. To maximize his profit, the buyer will also set w to the lowest value that satisfies the seller's participation constraint. By design, the buyer and the seller will be indifferent between a contract with a bonus and fixed payment $w = 0$, and one with a penalty and a fixed payment $w = 20$, as these are outcome-equivalent contracts granting the seller $\pi_t^S = 4$ and the buyer $\pi_t^P = 52$. Instead, the maximum profit that the buyer may obtain without using explicit incentives is 4, which is why rational buyers should always be expected to use explicit incentives when these are available. The predictions for treatments **B** and **P** follow directly from the above predictions for treatment **I**.

To summarize, standard assumptions regarding players' rationality and selfishness yield the following conclusions:

i) it is always optimal for buyers to adopt explicit incentives, if available;

ii) the consequences of the introduction of an explicit incentive mechanism do not depend on whether the incentive is framed as a bonus or as a penalty;

iii) it is always optimal for buyers to explicitly set their contracts' target e_1^* to its maximum possible level (i.e.: $e_1^* = 4$);

iv) in all four treatments, the level of effort in the non-verifiable dimension should be 0.[15]

'Non-standard' Predictions. If the traders are characterized by bounded rationality, or if their rationality and selfishness are not common knowledge, the predictions can change markedly. Selfish players with bounded rationality may not apply backward induction until they approach the end of the game, making cooperative relations sustainable.[16] Indeed, along the lines of Brown et al. (2004) it can also be shown for our game that high effort levels are sustainable if all players share the prior knowledge that there exists a sufficient number of fair traders who reciprocate generous contract offers with generous effort levels, even when explicit incentives are not used. Under this hypothesis, we should observe a level of surplus close to the maximum value (corresponding to 72 points) in all treatments, and a rather even distribution of this surplus between buyers and sellers.

A second possible deviation from standard predictions concerns the 'framing effect'. Fehr and Gächter (2002) pointed out that the framing of incentives as bonuses or penalties may affect the reference point that is used to categorize an action as kind or hostile. According to this approach, the buyer's introduction of a penalty in a contract may be perceived by sellers as a signal of hostile intentions, or as an indication of distrust. As a consequence, in our setting we should find that penalty contracts give rise to a lower number of long-term contracts than contracts including a bonus (or no incentive at all).

The last departure from the standard predictions that we consider here concerns motivational crowding-out (Frey and Oberholzer-Gee 1997; Benabou and Tirole 2003). Gächter et al. (2010) point out that "[...] explicit incentives may transform a good-will based relationship into a monetized relationship which is governed by selfish cost-benefit considerations rather than good

[15]In Appendix B we show that, if we assume that sellers require a small but positive rent to accept the contract, and a long term relationship between a buyer and a seller emerges, then prediction *(iv)* no longer holds, since a positive but decreasing level of non-verifiable effort is sustainable in equilibrium.

[16]Even when all traders are rational, Kreps et al. (1982) show that cooperation can be sustained in a finite horizon game by players who are aware of its finite duration as long as they believe that, with some positive probability, they are facing a certain 'commitment type'.

will, reciprocity and other intrinsic motivations." Under such circumstances, the introduction of explicit incentives in our setting may backfire, as sellers who are intrinsically motivated to cooperate could lose this motivation and cooperate less when explicit incentives are used.

2.3 Experimental Procedure

The experiment is computer-based and was programmed and conducted with the software "z-Tree" (Fischbacher 2007). Besides the standard interface to play the game, we also programmed a profit calculator that was always available on subjects' computer screens, to help them calculate the profits for them and for their opponent, given certain specific contract characteristics (w, e_1^*, ι), in correspondence to all possible levels of the two efforts.

The experiment was conducted between November 2008 and January 2009, and it involved 186 participants, all undergraduates in Economics, Finance and Management at the University of Bologna.

Treatment	**Session date**	**N. of participants**	**N. of sellers**	**N. of buyers**	**N. of periods**
Trust (T)	Nov. 26, 2008	16	9	7	17
	Dec. 05, 2008	16	9	7	18
	Jan. 30, 2009	16	9	7	17
Bonus (B)	Nov. 26, 2008	16	9	7	18
	Dec. 05, 2008	16	9	7	15
	Dec. 17, 2008	14	8	6	15
Penalty (P)	Nov. 26, 2008	16	9	7	16
	Dec. 05, 2008	16	9	7	16
	Jan. 30, 2009	16	9	7	16
Incentive (I)	Dec. 03, 2008	12	7	5	15
	Dec. 03, 2008	16	9	7	16
	Dec. 03, 2008	16	9	7	17

Table 1: Treatments and sessions.

We ran three sessions for each of the four treatments, for a total of twelve sessions, as listed in Table 1.[17] Instructions – presented in Appendix A – were distributed to subjects at the beginning of the session, and were read aloud to make them common knowledge. Before starting the real experiment, we asked subjects to answer some control questions, to facilitate their understanding of the instructions. More specifically, subjects were asked to compute the

[17]We had one session with 14 subjects, and one with 12 because some subjects failed to show up.

seller's and buyer's profits under three different scenarios. The experiment started only when all subjects correctly answered all the control questions, hence we can be confident that they understood the main elements of the economic problem. After the control questions, we let participants play three practice periods in order to make them familiar with the game and the profit calculator. In the practice periods, subjects were assigned the same role (buyer or seller) that they would have during the real game, but their IDs were changed at the end of the practice periods to avoid reputational consequences on the real game. On average, a session lasted for about 90 minutes, including instructions and payment. At the end of each session, subjects were paid in cash, privately. The total number of points they accumulated during the experiment was converted into Euros at the rate: 1 point=0.02 €.[18] The average payment was about 11.5 Euro, with a minimum of 5 Euro and a maximum of 22.5 Euro, including a show-up fee of 4 Euro.

3 Results

We begin by discussing the overall effect of introducing explicit incentives on the level of surplus generated in each period within the contracts. We then study how the level of effort exerted by the sellers in the verifiable and non-verifiable dimensions varies across treatments and how it changes depending on the type of incentive adopted. Further, we investigate whether and to what extent explicit incentives crowd out voluntary effort. Finally, we analyze in more detail the observed differences between contracts with bonuses and penalties, both in the elements of the contractual offers (i.e. the level of the fixed payment offered to the seller, and the threshold level of effort necessary to get the bonus or to avoid the penalty) and in the preferences of buyers and sellers for the two types of incentives.

3.1 Surplus

We set the stage for our analysis by looking at the surplus generated on average in the four different treatments (Figure 1).[19] The right panel of Figure 1 reports the average level of surplus produced in each treatment. We observe that the level of surplus produced in treatment **T** is

[18] The instructions explicitly informed the subjects that, in the event their total number of points at the end of the experiment was lower than zero, they would not have to pay any money to the experimenters, and that they would receive the show-up fee regardless. This circumstance, however, never took place.

[19] In all the analyses contained in this Section, we consider only the first 15 periods of each session, so to even out the end game effect. If not otherwise specified, the unit of observation is the average, per session, per period; this allows us to equalize to 45 the number of observations per treatment.

much lower than in the other three treatments, denoted **B**, **P** and **I**.

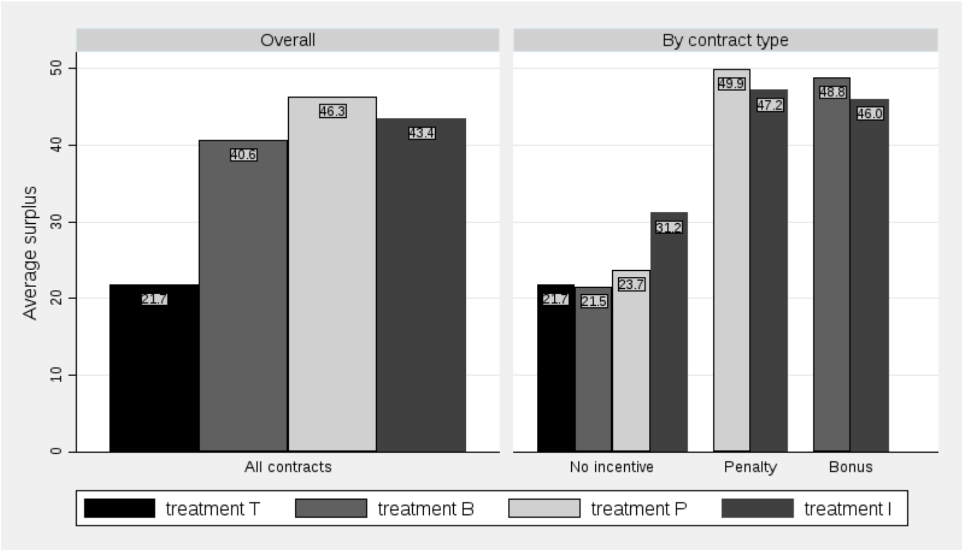

Figure 1: Average surplus.

To test the significance of this difference, we run a GLS panel regression, with period-session averages as independent observations (Table D.1 in Appendix D). Results indicate that the difference between treatment **T** and the other three treatments – in which explicit incentives could be used – is significant at the 1% level.

The right panel of Figure 1 allows for a comparison between the average surplus produced with contracts characterized by the presence or absence of explicit incentives. Our data indicate that adopting explicit incentives substantially increases surplus in all treatments where this is possible. A GLS panel regression (Table D.2 in Appendix D) confirms that the difference between contracts with and without explicit incentives is significant at the 1% level in Treatments **B**, **P** and **I**. Summing up, we found that explicit incentives are associated with a higher surplus than contracts without explicit incentives.

In our game, buyers can discipline sellers both by introducing explicit incentives and by paying rents to sellers in an attempt to establish long term relationships, which they will break off in the event the seller shirks by exerting a low level of effort. We observe that this latter option is seldom chosen by our subjects, even in treatment **T**, where the former option is not viable. Indeed, across all treatments only 26.0% of the offers are private. Specifically, in treatment **T** the relative share of contracts initiated by private offers is 41.2%. When buyers have the opportunity to use explicit incentives in addition to relational ones, the share of contracts initiated by private offers is even lower (26.1%, 17.1% and 19.8% in treatment **B**, **P** and **I**, respectively). A GLS panel regression confirms that the share of private offers in treatment **T** is higher than in any other treatment, and the difference is significant at the 1% level (Table D.3 in Appendix D).

Figure 2 confirms that relational incentives sustained by repeated interaction play a minor role in our game. The figure displays the cumulative frequency of trades in buyer-seller relationships of different durations. It shows that, in all treatments, more than 80% of the interactions took place in one-shot encounters. The longest relationships emerge in treatment **T**, but they represent just a tiny minority. In treatments **B** and **I**, no relationship lasts more than 4 periods, and in treatment **P**, the maximum length is two.

Result 1. *Absent explicit incentives, relational incentives are weak. When buyers have the opportunity to use explicit incentives, the relational dimension of the contract becomes even less important.*

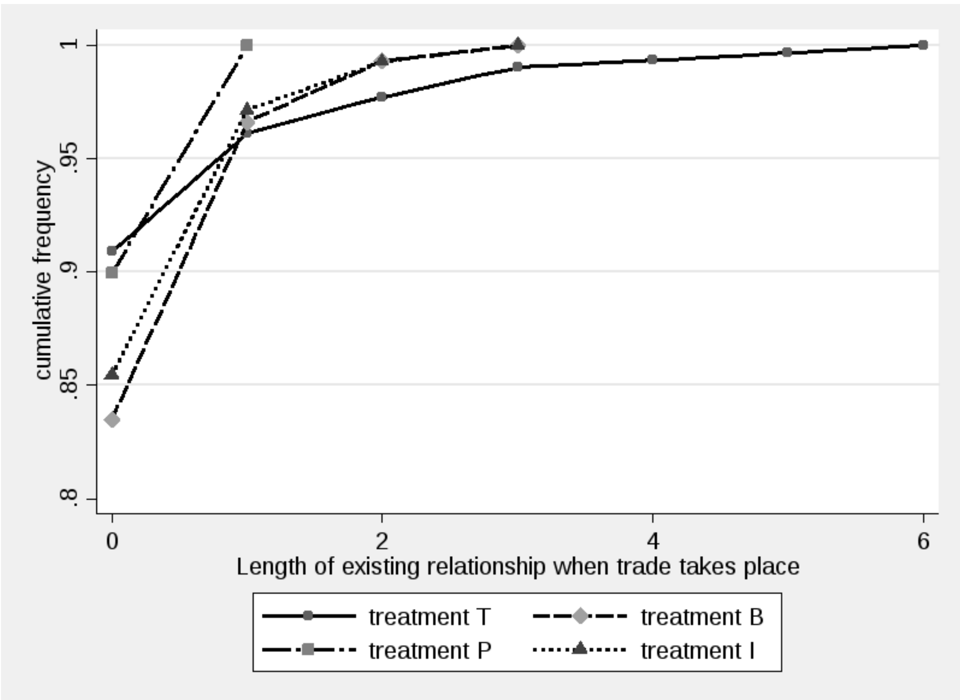

Figure 2: Cumulative frequency of trades in relationships of different lengths.

3.2 Displacement Effect

Result 1 emphasizes the minimal importance of relational concerns in treatment **T**. As explained in Section 2.2, in a situation in which one-shot interactions prevail, selfish sellers should choose a level of effort that is equal to 0. Figure 3 suggests that our results do not differ markedly from these theoretical predictions, as on average, the level of effort exerted by sellers in both dimensions in treatment **T** is less than 1. So, in general, the level of cooperation – and of efficiency – in our benchmark treatment (**T**) remains very low. This result contrasts with previous experiments (Fehr and Gächter, 2002; Brown et al., 2004; Falk et al., 2008; Gächter et al., 2010). The difference is possibly due, at least in part, to our game being framed as an impersonal B2B (or B2G) procurement exchange, rather than an interpersonal employment relationship where the effects of fairness and social preferences are dominant.

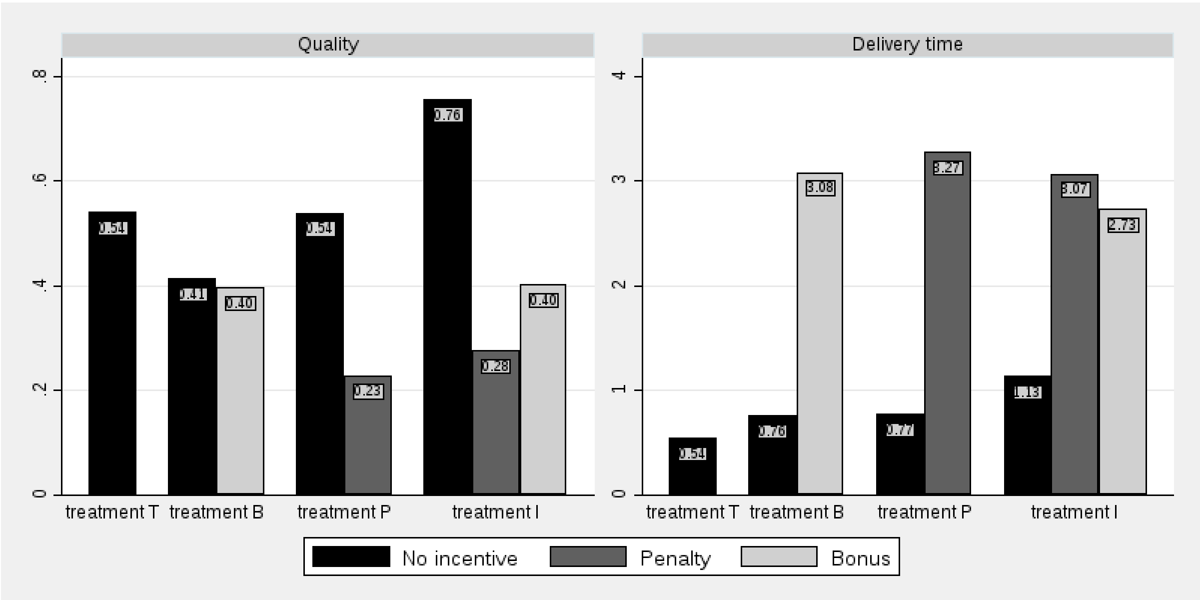

Figure 3: Average level of effort in the non-verifiable and verifiable tasks.

The level of the verifiable effort (delivery time) is significantly higher in treatments **I**, **B** and **P** when explicit incentives are in place, which is consistent with the standard theoretical predictions for selfish, rational sellers.[20] In contrast, when explicit incentives are adopted in treatments **P** and **I**, the level of the non-verifiable effort significantly decreases, while the decrease is not significant in treatment **B**.[21]

The increased surplus generated by the adoption of explicit incentives stems from the fact that the increase in the level of effort exerted by sellers in the verifiable dimension is greater than the decrease in effort in the non-verifiable dimension.

[20]The positive effect of incentives on the level of verifiable effort is significant at the 1% level in treatments **P, B** and **I**, according to a GLS panel regression (Table D.4 in Appendix D). In treatment **I**, the estimated coefficients for bonuses and penalties are not significantly different.

[21]The negative effect of penalties on the level of non-verifiable effort is significant at the 1% level in treatment **I** and at the 10% level in treatment **P**, and the negative effect of bonuses in treatment **I** is significant at the 10% level, according to a GLS panel regression (Table D.4 in Appendix D). In treatment **I**, the estimated coefficients for bonuses and penalties are not significantly different.

Result 2. *The adoption of explicit incentives is associated with a higher level of verifiable effort and with a weakly lower level of non-verifiable effort. The former effect more than compensates for the latter, so that the introduction of explicit incentives yields an overall increase in surplus.*

3.3 Voluntary Effort

Result 1 stresses how an overwhelming majority of the contractual interactions in our experiment are not part of a bilateral repeated relationship. Standard theoretical analysis (see Section 2.2) suggests that if rational and selfish players can correctly anticipate this, they should never provide positive levels of non-verifiable effort, nor levels of verifiable effort above the threshold that triggers the explicit incentive.

The seller's cost function is quadratic in the sum of the two efforts (see Section 2), so that e_1 and e_2 are not qualitatively different from the point of view of the seller. Therefore, we can take as a measure of voluntary effort provision the additional cost of effort incurred by the seller relative to that necessary to satisfy the explicit contract, i.e. $c(e_1 + e_2) - c(e_1^*)$.[22] We call this measure 'cost of voluntary effort'.[23]

Several previous experiments (Fehr and Gächter 2002; Fehr and List 2004, Gächter et al. 2010) have shown how explicit incentives may backfire, reducing the level of voluntary effort. We have already noticed that in our benchmark treatment (**T**) – where explicit incentives are not a permitted option – the level of voluntary effort is quite low. Still, our Result 2 may be compatible with a crowding-out effect of voluntary effort due to the adoption of explicit incentives. Figure 4 suggests that this is indeed the case. The average cost of voluntary effort is highest when explicit incentives are available but not adopted, but it approaches 0 when they are used. Results from a GLS panel regression confirm that the difference in the cost of voluntary effort between treatment **T** and **I**, when incentives are available but not used, is significant at the 1% level (Table D.5 in Appendix D).[24]

To further investigate the presence of motivational crowding-out, we run a regression analysis separately for each treatment. The dependent variable is the cost of voluntary effort, and among the regressors we include several elements of the contract signed by the seller that might affect her performance. We include fixed effects at the subject's level to account for possible effects of unobservable individual characteristics. Results are reported in Table 2.

[22] We drop from the following analyses 3 out of 1290 observations, in which $e_1 < e_1^*$ and $e_2 > 0$.
[23] We set $c(e_1^*) = 0$ when no explicit incentives are present.
[24] The difference is not significant when we compare treatment **T** with either **B** or **P**.

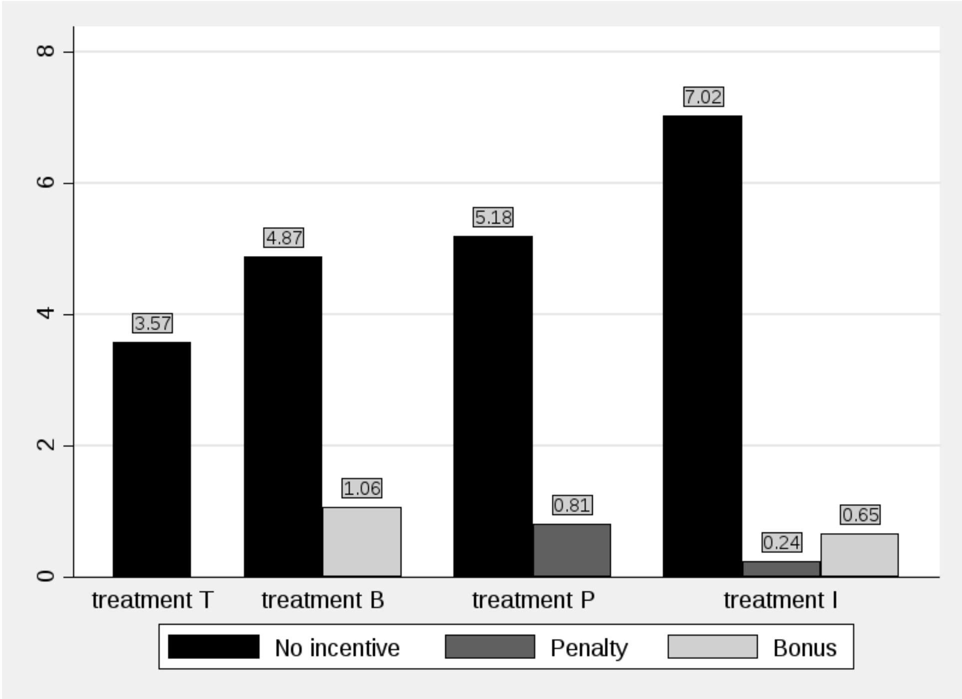

Figure 4: Average cost of voluntary effort in the four treatments.

In treatment **T**, the cost of voluntary effort that the seller is willing to provide increases with the level of fixed compensation w and with the duration of the ongoing buyer-seller relationship. The requests of the buyer in terms of non-verifiable effort (e_2^d) and of verifiable effort beyond the level possibly enforced by an explicit incentive ($e_1^d - e_1^*$) are also positively correlated with the cost of voluntary effort, though not significantly. This piece of evidence supports the idea that – absent explicit incentives – subjects are at least partially willing to reciprocate high compensations (trust) with high effort (trustworthiness), and willing to meet buyers' expectations. The positive correlation between the level of the fixed payment and voluntary effort persists in treatments **B** and **I**. In these treatments, however, we also find a strong, negative effect of explicit incentives – bonus and penalty – on the level of voluntary effort: this supports the hypothesis of motivational crowding-out. In treatment **P**, by contrast, relational concerns seem to be more important: this is indicated by *i)* the sizable and significant coefficient for *Private Offer* and *ii)* the positive and significant effect of the level of effort requested both in the verifiable and in the non-verifiable dimension. From Table 2 it is also clear that voluntary effort decreases as the game proceeds in treatments **P**, **B**, and **I**, as the coefficient for *Period* is always negative.

Result 3. *Weak, but positive, voluntary effort is exerted by sellers without explicit incentives, at least in early periods of the game. When bonuses or penalties are adopted, the level of voluntary*

	dependent variable: cost of voluntary effort			
	treatment			
	T	B	P	I
Fixed compensation†	0.135	0.181	0.025	0.338
	(0.033)***	(0.055)***	(0.046)	(0.056)***
Period	-0.049	-0.208	-0.384	-0.275
	(0.135)	(0.090)**	(0.175)**	(0.148)*
Private Offer (dummy)	-0.776	0.833	4.102	-3.164
	(0.931)	(1.871)	(1.324)***	(1.662)*
Duration of relationship when trade takes place	0.649	-1.078	1.637	0.718
	(0.250)**	(0.666)	(1.217)	(0.764)
Requested non-verifiable effort e_2^d	0.464	0.376	1.657	0.989
	(0.366)	(0.623)	(0.705)**	(0.525)*
Requested verifiable effort $(e_1^d - e_1^*)$	0.338	0.487	1.255	0.469
	(0.235)	(0.565)	(0.596)**	(0.657)
Bonus (1 if contract with bonus)		-5.282		-9.589
		(1.866)***		(2.452)***
Penalty (1 if contract with penalty)			2.052	-4.559
			(2.003)	(2.621)*
Constant	-0.224	1.663	-2.505	-3.794
	(1.600)	(2.228)	(2.933)	(3.190)
R2-between	0.094	0.307	0.034	0.029
R2-within	0.167	0.201	0.191	0.355
R2-overall	0.151	0.212	0.157	0.278
N. observations	308	297	299	282
Number of individuals	27	26	27	25

†To allow for direct comparisons between contracts with bonuses and penalties, when the contract includes a bonus, the fixed payment is increased by 20 points.
Standard errors robust for heteroskedasticity in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 2: Fixed effects panel regression of the cost of voluntary effort over contract's characteristics in the four treatments.

effort tends to drop.

3.4 Differences between Bonuses and Penalties

The data analyzed so far have shown that, in aggregate, bonuses and penalties have similar effects on the surplus generated by contracts and also on the level of voluntary cooperation. However, in all of the three sessions of treatment **I**, a substantial majority of contractual offers formulated by buyers include penalties rather than bonuses (61.2% of offers with penalties over the three sessions, vs. 19.0% of offers with bonuses), which corresponds with what we observe in real world procurement. The main purpose of this subsection is to understand why.

Rate of Acceptance. One possible explanation is that contracts with penalties are more readily accepted by sellers. To investigate this, we ran a logit regression on the contractual offers formulated by buyers. The dependent variable, *offer accepted*, takes the value 1 if the contractual offer was accepted by one of the sellers, and the value 0 otherwise. We estimated the model

	dependent variable: Offer Accepted		
	treatment		
	B	P	I
Fixed compensation†	0.006***	0.026***	0.013***
	(0.002)	(0.002)	(0.002)
Period	-0.011**	-0.030***	-0.011**
	(0.005)	(0.007)	(0.004)
Private Offer (yes=1)	-0.338***	-0.241***	-0.318***
	(0.056)	(0.051)	(0.060)
Requested non-verifiable effort	-0.003	0.002	-0.019
	(0.010)	(0.018)	(0.014)
Requested verifiable effort	-0.019	-0.028	-0.017
(net of the threshold)	(0.015)	(0.028)	(0.023)
Penalty	-0.150		-0.200**
(1 if contract with penalty)	(0.108)		(0.088)
Bonus		-0.306*	-0.083
(1 if contract with bonus)		(0.157)	(0.074)
pseudo R-squared	0.276	0.389	0.376
N. obs.	378	530	397
N. clusters	20	21	19

†To allow for direct comparisons between contracts with bonuses and penalties, when the contract includes a bonus, the fixed payment is incremented by 20 points.
Standard errors robust for heteroskedasticity (clustering by subject and session) in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3: Logit regression of variable 'offer accepted' over contract's characteristics in the three treatments with explicit incentives.

separately for the three treatments in which explicit incentives were available, controlling for other contractual characteristics.[25] Table 3 lists the results, and suggests that the hypothesis that contracts with penalties are more readily accepted is not supported by our data; quite the opposite. Under both treatments **P** and **I**, the coefficient for Penalty is negative, and in treatment **I** it is significant at the 5% level.

[25]These are: fixed compensation offered to the seller, a dummy indicating whether the offer is public or private, and the desired levels of non-verifiable and verifiable effort. The threshold level of verifiable effort that triggers the explicit incentive is not included, as it is too strongly correlated with the Bonus and Penalty dummies.

Penalty Contracts are more Profitable for Buyers. Another possible reason why buyers prefer contracts with penalties is that these contracts yield higher profits. Table 4 provides evidence in favor of this second hypothesis. A GLS panel regression confirms that the

	Incentive		
Treatment	**Penalty**	**Bonus**	**Total**
	buyers' average profit		
I	36.63	19.95	28.78
B		32.96	32.96
P	38.68		38.68
Total	37.66	26.84	32.40
	excluding exploitative contracts		
I	33.25	19.95	26.99
B		32.96	32.96
P	33.32		33.32
Total	33.28	26.84	30.15

Table 4: Average buyers' profits.

difference in profits between contracts with bonuses and with penalties is statistically significant: in treatment **I**, the effect is significant at the 5% level (Table D.6 in Appendix D), and the estimated coefficients for treatments **B** and **P** are significantly different at the 5% level according to a Wald test.

Exploitative Offers. One possible reason behind this difference is that the set of possible offers that buyers can make differs depending on the type of incentive adopted.[26] The worst possible offer a buyer can make entails a fixed compensation $w = 0$ and a threshold level of the verifiable effort $e^* = 4$. Such a contract pays the seller at most 4 points, if it includes a bonus, but it pays at most -16 points, if it includes a penalty. In fact, the whole set of possible offers is shifted down by 20 points when there is a penalty instead of a bonus.[27] From the standard theoretical point of view, this should not make any difference, as rational sellers should never accept contracts that are not guaranteed to pay them at least 4 points, equal to their outside

[26] We thank Dirk Engelmann for pointing this out.

[27] To avoid such an asymmetry across treatments, we should have set different restrictions on the set of possible fixed wages w, depending on the type of incentive adopted. More specifically, we should have allowed buyers to choose w from the set $[16, 146]$ in contracts with a penalty, and from the set $[-4, 126]$ in contracts with a bonus, so that the minimum possible earning for the seller is zero, both in trust contracts and in contracts with explicit incentives. Yet, we believe this would have seriously distorted subjects' perception of the alternatives.

option. Yet, we observe that such 'exploitative' offers – that can be formulated with penalties but not with bonuses – are in fact proposed by buyers, and in some cases they are also accepted by sellers.[28]

Our data suggest that these exploitative offers are not made by mistake, i.e., by buyers who have not clearly understood the game. Rather, they are made strategically, to exploit sellers' *naïveté*. To measure subjects' understanding of the game, we count the number of wrong answers they gave to each control question before correctly answering it. We notice that subjects who had made at most one mistake in answering the question asking to evaluate the buyer's profit in a given situation made exploitative offers significantly more often.[29] Thus, buyers who can better evaluate the payoff consequences of their contracts tend to make more exploitative offers. Conversely, sellers who made more than one mistake in evaluating the seller's profit in the control questions accepted exploitative offers more often.[30] Moreover, if we rank buyers by the frequency of exploitative offers they made throughout the game, we observe that the top 20% (who made at least two exploitative offers out of five) on average earned a per-period profit that is significantly higher than that of the rest of the sample.[31] By contrast, sellers who accepted at least one exploitative contract reported significantly lower profits, on average.[32] The sellers' acceptance of exploitative offers recalls the empirical evidence reported by Lee and Malmendier (2011) about overbidding in electronic (quasi second price) auctions. These authors ascribe such bidders' behavior to i) limited attention regarding their outside option (fixed price) and ii) utility from winning an auction (bidding fever).[33]

Loss-Aversion. We drop all of the contracts arising from exploitative offers, to check whether this is the only reason why buyers record higher profits with penalties than with bonuses. The results reported in the lower part of Table 4 show that the difference, though smaller, persists.[34]

[28] 25.9% of the total offers are unacceptable, and 11.2% of the contracts originate from unacceptable offers.

[29] 21.4% vs 7.3%. The Wilcoxon signed-rank test with N=8 confirms that the difference is significant at the 5% level. In 4 out of 12 sessions, all buyers made at least two mistakes, so no matched observations are available.

[30] 11.2% vs 6.4%. The difference is significant at the 5% level, according to a Wilcoxon signed-rank test with N=11. In one out of 11 sessions, all sellers made at least two mistakes, so no matched observations are available.

[31] 28.0 vs. 20.5. The difference is significant at the 5% level, according to a Wilcoxon signed-rank test with N=9 (the comparison is not possible for 3 sessions).

[32] 11.2 vs. 14.8. The difference is significant at the 5% level according to a Wilcoxon signed-rank test with N=10 (the comparison is not possible for 2 sessions).

[33] Filiz-Ozbay and Ozbay (2007) also report the presence of overbidding in experimental auctions, and explain it by arguing that bidders may overbid if they anticipate regret for losing the auction.

[34] According to a GLS panel regression, however, the difference is significant only when we compare contracts with bonuses and with penalties in treatment **I**, while the estimated coefficients from treatments **B** and **P** are not significantly different at the 10% level according to a Wald test.

Treatment	Incentive Penalty	 Bonus	 Total
	buyers' average profit		
Incentive	13.46	29.90	21.20
Bonus		19.81	19.81
Penalty	9.89		9.89
Total	11.68	24.56	17.93
	excluding unacceptable contracts		
Incentive	18.34	29.90	23.78
Bonus		19.81	19.81
Penalty	17.31		17.31
Total	17.82	24.56	21.10

Table 5: Maximum profit offered to the sellers.

Table 5 presents a measure of the generosity of buyers' offers, calculated from the maximum profit a seller could achieve by accepting the offer and myopically best replying to it.[35] It shows that the maximum profit offered to the sellers when explicit incentives are used is higher in treatment **B** than in treatment **P**. According to a GLS panel regression, the difference, however, is significant at the 10% level only if we consider all the offers, including the exploitative ones.[36] The same difference emerges in treatment **I** and is significant at the 1% level both including and excluding the exploitative offers. While this last finding could be explained by assuming that more generous buyers prefer bonus to penalty contracts, the cause of the difference between treatments **B** and **P** cannot be interpreted in this way. Moreover, when looking at sellers' behavior we find no differences between choices made with bonus and penalty contracts (see Section 3.2)

This pattern is consistent with subjects, particularly buyers, being loss-averse, according to Tversky and Kahneman (1991). In principle, in our setting the explicit effect induced by a penalty may not be perceived as symmetrically equivalent to that produced by a bonus of the same amount. Penalties may represent stronger incentives to perform for sellers or bring lower expected utility to buyers than equivalent incentives framed as bonuses. In fact, in Appendix C we show that if buyers are loss-averse, their ex-ante evaluation of a contract with bonus should indeed be larger than that from a payoff-equivalent contract with penalty: the buyer's risky

[35] In our game, this is always equal to $w - (e^*)^2$.
[36] Table D.7 in Appendix D.

prospect of paying a larger sum, part of which could be returned later through a penalty if the seller shirks, is not equivalent to the risky prospect of paying a smaller amount first and the remainder later in the form of a bonus only if the seller performs well. This asymmetry may induce buyers to make less generous contract offers with penalties than with bonuses, as we seem to observe in our experiment.

On the other hand, suppliers do not face any risk in our setup: once they accept the contract, they alone have full control over their action and payoff. Hence, even if they are loss-averse, we should not expect them to behave differently with the differently framed contracts. The fact that sellers do not react to the framing of incentives in our setup is therefore consistent with the evidence reported by Hossain and List (2012), who show that workers increase effort more if incentives are framed as penalties than if they are framed as bonuses, but only if the prospect is risky because of other agents' choices in team production environments. In other words, some source of risk must be present for loss-aversion to matter.

Result 4. *Consistent with the hypothesis that subjects are loss-averse, buyers' offers with bonuses are more generous than offers with penalties, while sellers (who face no risk) react in the same way to these contracts.*

This may explain why, in our experiment, buyers' profits are marginally higher when they use contracts with penalties rather than with bonuses, even excluding exploitative offers from the data. It may also provide one potential explanation of the puzzling observation that bonus contracts are rarely observed in real world procurement contexts.

4 Conclusion

This paper presents results from a laboratory experiment on the effects of differently framed explicit contracts – bonuses and penalties – in a complex, dynamic, incomplete contracting environment as is typical of B2B and B2G procurement relationships. Our framework is characterized by repeated interaction, endogenous competitive matching between buyers and sellers, and coexistence of contractible and non-contractible dimensions. Buyers have the option to restrict contract offers to particular sellers (so that reputation may matter), and can choose whether to introduce explicit incentives and how to frame them (whether as penalties or bonuses).

We find that – absent explicit incentives – sellers' effort is low in all dimensions and so is surplus. Effort on the contractible dimension increases substantially with the introduction of explicit incentives, while effort in non-contractible dimensions is only mildly reduced, leading to an increase in surplus that mainly benefits buyers, particularly when they use fixed price contracts with penalties for non-compliance.

When using equivalent contracts framed as bonuses, buyers tend to be more generous in their contract offers to sellers (a bias consistent with buyers' loss-aversion), seller effort does not increase, and buyers' profits fall. When buyers can choose the type of contract to offer, they prefer contracts framed as penalties, and they profit from this choice.

The results suggest that framing effects may be a reason why fixed price contracts with penalties are common in real-life procurement, while contracts framed as bonuses are not.

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Appendix

A Instructions for Treatment I

(originally in Italian)

Introduction

Welcome to this experiment. These instructions contain all the information you need to participate, read them carefully. If something remains unclear, please raise your hand and we will answer your questions individually. From now on, we ask you not to communicate with other participants in any way, until the end of the experiment.

During the experiment your earnings will be calculated in points. At the beginning of the experiment you will receive an endowment of 100 points. Over the course of the experiment you can gain or lose points. The number of points you will earn depends on your decisions, and on the decisions of other participants.
At the end of the experiment your points will be converted to Euros, according to the following rate:

1 point = 0.02€

If at the end of the experiment the sum of the points you have was negative, your earnings will be equal to 0 Euros. In addition to the sum that corresponds to the points you accumulated, in any event you will receive 4€ for your participation. Your earnings, plus the 4€ attendance payment will be paid to you privately and in cash at the end of the session.

In this experiment we reproduce a situation involving two agents: a **buyer** and a **seller**. All participants in the experiment are divided into two groups: the group of buyers and the group of sellers. At the beginning of the experiment you will be told whether you are a buyer or a seller, and the role you are assigned will remain the same throughout the experiment.

In every period each buyer can buy a good from a seller. The seller profits from this transaction if he sells the good at a price that is higher than its production cost. The buyer gets a profit from the transaction if he buys the good at a price below the value he attributes to it.

The cost of production for the seller and the value of the good for the buyer both depend on the **quality of the good** and on the **delivery time** of the good itself.

All the choices you make during this experiment are anonymous. You will not know the identity of the other participants with whom you will interact in the course of the experiment; similarly, your identity will remain hidden.
Every participant, however, will receive an **identification number (ID)** which will remain the same throughout the whole experiment. You will be told your ID at the beginning of the experiment, and it will always be visible in the upper part of your screen.

General elements of the experiment

1. Every period starts with a **contracting phase.** In this phase, buyers can make contractual offers, which can be accepted or rejected by sellers. Each contractual offer proposed by a buyer should specify:

    - the base compensation offered to the seller
    - the delivery time requested
    - the quality requested
    - the addressee of the offer. Buyers can make two types of offers: public offers and private offers. **Public offers** are posted to every seller, and any seller can accept them. **Private offers** are addressed to a specific seller, and can be accepted only by that seller.

    The buyer can also introduce in the offered contract an **incentive** mechanism. The incentive can be in the form of a **penalty** or a **bonus**. The activation of the incentive depends on the delivery time for the good. For example, the buyer may decide that the seller will receive a bonus if he delivers the good by a given deadline, or that the seller will have to pay a penalty in the event he fails to deliver the good by a given deadline.

    There is no limit to the number of offers a buyer can make in each period. The offers can be accepted by sellers at any moment.
    Each seller, however, **cannot accept more than one contractual offer in each period.** Similarly, in each period **each buyer can sign only one contract.**

In this experiment, the number of sellers is two more than the number of buyers. For this reason, **in every period at least two sellers will not sign any contracts.**

2. After the contracting phase, all sellers who have signed a contract will have to choose the quality of the good they actually produce for the buyer, and the actual delivery time. **The seller is not compelled to provide the quality requested by the buyer, nor to deliver the good by the deadline requested.**

3. When every seller has made his decisions, the profits earned by each participant will be calculated. Every participant will be able to read on his screen the profits they recorded in that period, together with the profits of the other player with whom he signed a contract in that period, if any. Once the profits have been displayed, a new period begins.

The experiment in details

The contracting phase:

Every period begins with a contracting phase. **This phase lasts no more than 150 seconds.** At the end of this time, it will not be possible for buyers to make offers, or for sellers to accept them.

During this phase, every buyer will be able to make both public offers and private offers. To address a private offer to a specific seller, the buyer will have to indicate the ID of the seller in the contractual offer. It will not be possible to address private offers to sellers who have already accepted an offer in that period. Buyers will be shown the IDs of sellers that are still available in a box in the lower-right corner of the screen.

Every offer should indicate:

- **the base compensation** offered to the seller. This compensation should be between 0 and 130.
- **the delivery time** requested, which can be equal to 1, 2, 3, 4, or 5 weeks.
- **the quality** requested, that can be equal to 0 (minimum), 1, 2, 3, or 4 (maximum)
- the **addressee** of the offer
  - all sellers (public offer)

    - a specific seller, identified by his ID (private offer)

- the type of **incentive,** which can be
    - bonus
    - penalty
    - no incentives

In the event the buyer chooses to introduce a bonus or a penalty, he will also have to specify in the offer the deadline by which the good should be delivered by the seller to secure the bonus or to avoid the penalty.
This deadline can be equal to 1, 2, 3, 4, or 5 weeks.

The value of the bonus or of the penalty is equal to **20 points.**

Every buyer can make as many offers as they wish, within the time limit (150 seconds). As soon as one of these offers is accepted, however, all other offers made by the same buyer will be closed, as every buyer can sign only one contract per period.

Every buyer will see on his screen a list of all the public and private offers he has made in that period. In a second table, he will also be shown a list of the public offers – but not of the private offers – made by other buyers.

Every seller will be shown an on-screen list of all the public offers input by every buyer, and all the private offers addressed to him. To accept an offer, the seller will have to select it with the mouse, and then click 'Accept'.

Once he has accepted an offer, the seller will not be able to receive other offers, as no sellers can sign more than one contract per period.

In the contracting phase, when a seller receives a contractual offer – public or private – he is also informed of the ID of the buyer who made it. When an offer is accepted by a seller, the buyer is also informed of the ID of the seller who accepted it.

The contracting phase ends when all the buyers have signed a contract, or at the end of the 150-seconds window.

The decision of the sellers:

After the contracting phase, all sellers who have signed a contract have to determine the quality of the good they provide to the buyer and the actual delivery time. **The delivery time and the quality requested in the contract are not binding for the seller.**

Calculating profits:

When the seller has made his decisions, the computer evaluates the profits of the buyer and of the seller, given the terms of the contract, the value of the good for the buyer and the cost of production for the seller.

Value of the good for the buyer

The value of the good for the buyer depends on the actual delivery time and on the quality of the good provided. The value of the good is defined depending on the possible levels of quality and on the possible delivery times, and is listed in Table 1:

		Quality				
		1	2	3	4	5
Delivery time	**1 week**	72	88	104	120	136
	2 weeks	56	72	88	104	120
	3 weeks	40	56	72	88	104
	4 weeks	24	40	56	72	88
	5 weeks	8	24	40	56	72

Table 1: Value of the good for the buyer

For example, from Table 1 we can see that, if the quality is equal to 3 and the good is delivered in 2 weeks, the value of the good for the buyer is equal to 104.

		Quality				
		1	2	3	4	5
Delivery time	**1 week**	16	25	36	49	64
	2 weeks	9	16	25	36	49
	3 weeks	4	9	16	25	36
	4 weeks	1	4	9	16	25
	5 weeks	0	1	4	9	16

Table 2: Cost of the good for the buyer

Production cost

The cost of production for the seller also depends on the actual delivery time, and on the quality of the good provided. The cost of production corresponding to the various possible levels of quality and the possible delivery times is listed in Table 2.

For example, from Table 2 we can see that, to produce a good with quality equal to 1 and to deliver it within 4 weeks, the seller bears a cost equal to 4.

Profits

The buyer's and seller's profits depend on the type of contract they have signed and on the decisions made by the seller. Table 3 lists all the possible cases.

Profit of the seller	**Profit of the buyer**
1. If he does not sign any contract	
4	0
2. Contract without any incentive	
Base compensation - production cost	Value of the good - base compensation
3. Contract with bonus, if the seller delivers the good by the deadline	
Base compensation - production cost + 20 (**bonus**)	Value of the good - base compensation - 20 (**bonus**)
4. Contract with bonus, if the seller does not deliver the good by the deadline	
Base compensation - production cost	Value of the good - base compensation
5. Contract with penalty, if the seller delivers the good by the deadline	
Base compensation - production cost	Value of the good - base compensation
6. Contract with penalty, if the seller does not deliver the good by the deadline	
Base compensation - production cost - 20 (**penalty**)	Value of the good - base compensation + 20 (**penalty**)

Table 3: Profits

Number of periods and end of the experiment:

The total duration of the experiment is random. The experiment will last at least 15 periods, and not more than 30. From the fifteenth until the twenty-ninth period, the computer will draw a number between 1 and 100. If this number is higher than 33, the experiment continues for an additional period; if instead it is less than or equal to 33 the experiment ends. This means that from the fifteenth to the twenty-ninth period, the experiment continues for an additional period with a probability of 67%, while it ends with a probability of 33%.

Available Information

Profit calculator

Every participant will have access to a 'profit calculator', which can be activated by pressing the 'profit calculator' button on the computer screen.
The profit calculator evaluates profits for the buyer and for the seller, corresponding to each possible level of quality and to each delivery time, given the level of the base compensation and the type of incentive adopted (as presented in Tables 1 and 2). The results generated by the profit calculator are displayed on the screen in two tables, called 'your profits' and 'profits of the seller' (in the event the participant plays the role of a buyer) or 'profits of the buyer' (in the event the participant plays the role of a seller).

Before the experiment, you will be allowed to practice using this calculator in order to understand its operation.

Information about the game and history of play

At the end of each period, all participants will be informed of their profit in that period. Participants who have signed a contract in that period will also be able to read on their screen:

- the ID of their counterpart
- the base compensation fixed by the contract
- the delivery time requested in the contract
- the quality requested in the contract
- the type of incentive possibly used and its deadline
- the actual delivery time
- the quality actually provided by the seller
- the profit recorded by the counterpart

All these data, relative to each of the previous periods, are also collected in a table called 'history table', to which every participant can refer throughout the experiment, starting from the second period of play, by clicking the 'history of play' button.

In the top right corner of the screen, each participant will also see his ‘total score’, that is, the number of points accumulated since the beginning of the experiment.

Trial periods and control questions

You will be able to operate the computer with your keyboard or with the mouse. Before the experiment starts, you will have a chance to familiarize yourself with the program over the course of three trial periods. During these periods, the ID (identifying number) assigned to you and to each of the other participants will be different from the one you will be assigned for the real experiment.
Profits earned during the trial periods do not count towards your earnings during the experiment.

Before starting the trial periods, you will be asked to answer some control questions to verify your complete understanding of the instructions. The trial periods will start as soon as all participants have correctly answered all the control questions.

We remind you once more that you are not allowed to talk during the experiment. If you have questions or concerns, please raise your hand and we will come to your desk.

B Theoretical Predictions

In this Appendix we explain in detail the analytical problem related to the standard buyer-seller interaction investigated in our repeated games with uncertain end and finite time horizon. In particular, in what follows, we provide solutions for the dynamic games distinguishing between *Trust* contract (i.e. benchmark for treatment **T**) and *Incentive* contracts (i.e. benchmark for treatments **I**, **B** and **P**).

Recall from Section 2 that our game lasts at least $\hat{t}$ period after which it continues with a probability $\delta \in (0,1)$ until at most period T, that is, the continuation probability δ_t is defined as

$$\delta_t = \begin{cases} 1 & \text{if } t < \hat{t} \\ \delta & \text{if } \hat{t} \leq t < T \\ 0 & \text{if } t = T \end{cases}$$

Given our parametrization, the seller's effort in the two dimensions $e_{t,1}$ and $e_{t,2}$ is always additive. For simplicity here we code $e_t = e_{t,1} + e_{t,2}$, where $e_t \in [0, \bar{e}]$.
The buyer's profit is defined as

$$\pi_t^B \left(w_t, e_t^*, e_t, \iota_t\right) = \begin{cases} v\left(e_t\right) - w_t - kI\left(e_t, e_t^*, \iota_t\right) & \text{if a contract is concluded} \\ 0 & \text{if no contract is concluded} \end{cases} \tag{1}$$

where $e_t^* \in [0, \frac{\bar{e}}{2}]$ is the level of effort triggering the incentive, k is some positive constant and

$$I\left(e_t, e_t^*, \iota\right) = \begin{cases} 1 \; (\textit{bonus}) & \text{if } \iota = 1 \text{ and } e_t \geq e_t^* \\ -1 \; (\textit{penalty}) & \text{if } \iota = -1 \text{ and } e_t < e_t^* \\ 0 \; (\textit{no incentives}) & \text{otherwise} \end{cases} \cdot$$

The seller's profit is

$$\pi_t^S \left(w_t, e_t^*, e_t, \iota_t\right) = \begin{cases} w_t - c\left(e_t\right) + kI\left(e_t, e_t^*, \iota_t\right) & \text{if a contract is concluded} \\ \sigma & \text{if no contract is concluded} \end{cases} \tag{2}$$

where $\sigma > 0$ represents the seller's outside option, and the cost function $c(e)$ is assumed to be differentiable on $[0, \bar{e}]$, with $c(0) = 0$, $c'(e) > 0$ and $c''(e) > 0$.

The buyer's problem. In every period t, in order to maximize his expected profits $E\left(Z^B\right)$, the buyer chooses a fixed wage w_t, and a desired level of seller's effort e_t^d. If an explicit incentive is available, the buyer also chooses the incentive sign $\iota_t \in \{-1, 0, 1\}$ and the threshold level of effort e_t^* that triggers the incentive. We say that the seller performs in period t if $e_t \geq e_t^d$.
The buyer's profit maximization problem is

$$\max_{w_t, i_t, e_t^d,} E\left(Z^B\right) = \pi_t^B + \sum_{\tau=t+1}^{T} \pi_\tau^B \left(\prod_{\theta=t}^{\tau-1} \delta_\theta\right) \tag{3}$$

s.t. :

$$\begin{aligned} w_t + kI\left(e_t^d, e_t^*, \iota_t\right) - c\left(e_t^d\right) &\geq \sigma + \varepsilon && (4) \\ \pi_t^{SC}\left(e_t^d, e_t^*, \iota_t, w_t\right) + S_t(\cdot) &\geq \pi_t^{SD}\left(e_t, e_t^*, \iota_t, w_t\right) + D_t(\cdot) && (5) \\ e_t^* &\leq \frac{\bar{e}}{2} && (6) \end{aligned}$$

where (4) and (5) are respectively the participation and the incentive compatibility constraint, derived from the seller's maximization problem.

The seller's problem. According to the participation constraint (4), the seller's net gain from executing the contract should be equal or higher than σ, the seller's outside option, plus ε, the gain the seller wishes to collect by accepting the contract. While σ is common knowledge and equal for all the sellers, ε depends on each seller's preferences. In Section 2.2, we assumed that $\varepsilon = 0$, while here we will also consider the case for $\varepsilon > 0$.
The incentive compatibility constraint (5) to sustain cooperation in the long run requires that the seller's total profit from cooperation is greater than the total profit from deviation. Specifically, the total profit from cooperation is given by the sum of the profit from cooperation π_t^{SC} at time t,

$$\pi_t^{SC} = w_t - c\left(e_t^d\right) + kI\left(e_t^d, e_t^*, \iota_t\right) \tag{7}$$

and the expected profits from cooperation in the periods which follow, $S_t(\cdot)$.
Similarly, the seller's total profit from deviation is the sum of profit form deviation π_t^{SD} at time t,

$$\pi_t^{SD} = w_t - c\left(e_t\right) + kI\left(e_t, e_t^*, \iota_t\right) \tag{8}$$

plus the expected profits from punishment in the periods which follow, $D_t(\cdot)$.

Assuming no discounting, the seller's expected profit respectively from cooperation $S_t(\cdot)$ and deviation $D_t(\cdot)$ are defined as follows:

$$S_t = \begin{cases} \sum_{\tau=t+1}^{\hat{t}} \pi_\tau^{SC} + \sum_{\tau=\hat{t}+1}^{T} \pi_\tau^{SC} \cdot \delta^{\tau-\hat{t}} & \text{if } t < \hat{t} \\ \sum_{\tau=t+1}^{T} \pi_\tau^{SC} \cdot \delta^{\tau-t} & \text{if } \hat{t} \leq t < T \\ 0 & \text{if } t = T \end{cases} \tag{9}$$

and

$$D_t = \begin{cases} \sigma\left[\left(\hat{t} - t\right) + \delta\frac{1-\delta^{T-\hat{t}}}{1-\delta}\right] & \text{if } t < \hat{t} \\ \delta\frac{1-\delta^{T-t}}{1-\delta} \cdot \sigma & \text{if } \hat{t} \leq t < T \\ 0 & \text{if } t = T \end{cases} \tag{10}$$

Note that in the definition of D_t (10) we adopted a simplifying assumption. We posit that the seller's expected profit in the punishment phase – i.e. once she has deviated – is always equal (or close) to σ. This assumption rests on the hypothesis that if a seller shirks, the buyer will not offer another contract to that seller in the future; moreover, since there is competition on the sellers' side of the market, the shirking seller can be 'ostracized' and her profit will be lower than if she had not shirked. In particular, the seller knows that - once she has shirked - the buyer will never send her a new private offer: this is a signal for the other buyers too and, thus, the gain she will collect in future contract is σ.

In order to compute both the seller's optimal level of effort and the buyer's optimal fixed wage, in what follows we derive solutions for the *Trust contract* (i.e. contracts belonging to treatment **T** and where no explicit incentive can be provided) and the *Incentive contract* (i.e. contracts 'potentially' belonging to treatments **I**, **P** and **B**); in so doing, we distinguish for different values of ε, the positive gain the seller wishes to collect to accept the contract.

Trust Contracts In the simpler case of the absence of explicit incentives, the buyer's profit (3) becomes $\pi_t^B = v\left(e_t\right) - w_t$. The seller's participation constraint (4) becomes

$$c\left(e_t^d\right) - w_t + \sigma + \varepsilon \leq 0 \tag{11}$$

and her incentive compatibility constraint (5) becomes

$$\pi_t^{SC}\left(e_t^d, w_t\right) + S_t(\cdot) \geq \pi_t^{SD}\left(e_t, w_t\right) + D_t(\cdot) \tag{12}$$

Absent explicit incentives, if the seller deviates it is always optimal for her to choose $e_t = 0$, while if she cooperates, she should set $e_t = e_t^d$. Thus, in period t, the seller's profits from cooperation and from deviation are respectively $\pi_t^{SC}\left(e_t^d, w_t\right) = w_t - c\left(e_t^d\right)$ and $\pi_t^{SD}\left(e_t, w_t\right) = w_t$. By substitution, (12) is now

$$c\left(e_t^d\right) - \left(S_t(\cdot) - D_t(\cdot)\right) \leq 0 \tag{13}$$

The Kuhn-Tucker conditions of the maximization problem in the case of a trust contract are as follows:

$$\begin{cases} v'\left(e_t^d\right) - \lambda_1 c'\left(e_t^d\right) - \lambda_2 c'\left(e_t^d\right) = 0 & (KTt1) \\ -1 + \lambda_1 = 0 & (KTt2) \\ \lambda_1\left(c\left(e_t^d\right) - w_t + \sigma + \varepsilon\right) = 0 & (KTt3) \\ \lambda_2\left(c\left(e_t^d\right) - \left(S_t(\cdot) - D_t(\cdot)\right)\right) = 0 & (KTt4) \\ \lambda_1 \geq 0 & (KTt5) \\ \lambda_2 \geq 0 & (KTt6) \end{cases} \tag{14}$$

From *(KTt2)* and *(KTt3)* we get $\pi_t^{SC}\left(w_t\right) = w_t - c\left(e_t^d\right) = \sigma + \varepsilon$. Accordingly, the seller's expected profit from cooperation (9) becomes

$$S_t = \begin{cases} (\sigma + \varepsilon)\left[\left(\hat{t} - t\right) + \delta\frac{1-\delta^{T-\hat{t}}}{1-\delta}\right] & \text{if } t < \hat{t} \\ (\sigma + \varepsilon)\delta \cdot \frac{1-\delta^{T-t}}{1-\delta} & \text{if } \hat{t} \leq t < T \\ 0 & \text{if } t = T \end{cases}$$

As a consequence, in the incentive compatibility constraint (13), the value of $[S_t(\cdot) - D_t(\cdot)]$ depends only on ε and on t.

Consider the case for $\varepsilon = 0$. In this case, $S_t(\cdot) = D_t(\cdot)$ for all t. As a consequence, from the incentive compatibility constraint (13) and from our assumptions on the shape of the cost function $c(\cdot)$ it follows that $e_t^d = 0$ in every t, and – from *(KTt3)* – the fixed wage offered to the seller is $w_t = \sigma$.

In contrast, if $\varepsilon > 0$ we have that $S_t(\cdot) > D_t(\cdot)$ for every $t < T$, and the system (14) has two solutions: one for $\lambda_2 = 0$, the other for $\lambda_2 > 0$. If $\lambda_2 = 0$, from *(KTt1)* it follows that $v'(e_t^d) = c'(e_t^d)$, which with our parametrization implies that $e_t^d = \bar{e}$, but this can never be compatible with the seller's incentive compatibility constraint (13) in our setting. If instead $\lambda_2 > 0$, from *(KTt4)* we have that $c(e_t^d) = S_t(\cdot) - D_t(\cdot)$, which is positive and decreasing in t, for $t < T$, and equal to 0 in $t = T$. Thus, if $\varepsilon > 0$, the buyer will optimally choose $e_t^d = c^{-1}(S_t(\cdot) - D_t(\cdot))$ and $w_t = c(e_t^d) + \sigma + \varepsilon$.

Incentive Contracts With our parametrization, when the buyer can adopt explicit incentives (bonuses or penalties) in contractual offers, the following condition holds:

$$kI\left(e_t^*, e_t^*, \iota_t\right) - c\left(e_t^*\right) > kI\left(e_t, e_t^*, \iota_t\right) - c\left(e_t\right) \ \forall e_t \neq e_t^* \tag{15}$$

This implies that in a one-shot game it would always be optimal for the seller to choose $e_t = e_t^*$. As a consequence, the seller's profit in the event of compliance is $\pi_t^{SC}\left(w_t, e_t^*, e_t^d, \iota_t\right) = w_t - c\left(e_t^d\right) + kI(e_t^d, e_t^*, \iota_t)$ and the profit in the event of deviation is $\pi_t^{SD}\left(w_t, e_t^*, e_t, \iota_t\right) = w_t - c\left(e_t^*\right) + kI(e_t^*, e_t^*, \iota_t)$. Substituting in the seller's incentive compatibility constraint (5), we get

$$c\left(e_t^d\right) - c\left(e_t^*\right) - \left(S_t - D_t\right) \leq 0. \tag{16}$$

The Kuhn-Tucker conditions for the maximization problem are as follows:

$$\begin{cases} v'\left(e_t^d\right) - \lambda_1 c'\left(e_t^d\right) - \lambda_2 c'\left(e_t^d\right) = 0 & (KTi1) \\ -1 + \lambda_1 = 0 & (KTi2) \\ -\lambda_3 = 0 & (KTi3) \\ \lambda_1\left(c\left(e_t^d\right) - w_t + \sigma + \varepsilon - kI(e_t^d, e_t^*, \iota_t)\right) = 0 & (KTi4) \\ \lambda_2\left(c\left(e_t^d\right) - c\left(e_t^*\right) - \left(S_t(\cdot) - D_t(\cdot)\right)\right) = 0 & (KTi5) \\ \lambda_3\left(e_t^* - \frac{\bar{e}}{2}\right) = 0 & (KTi6) \\ \lambda_1 \geq 0 & (KTi7) \\ \lambda_2 \geq 0 & (KTi8) \\ \lambda_3 \geq 0 & (KTi9) \end{cases} \tag{17}$$

from which $\lambda_1 = 1$, $\lambda_3 = 0$, and, from (KTi4),

$$c\left(e_t\right) - w_t + \sigma + \varepsilon - kI(e_t^d, e_t^*, \iota_t) = 0 \tag{18}$$

which implies

$$\pi_t^{SC} = \sigma + \varepsilon \quad \text{for all } t.$$

The expected value of the seller's future profits $S_t(\cdot)$ can thus be written as

$$S_t\left(\cdot\right) = \begin{cases} (\sigma+\varepsilon)\left[\left(\hat{t}-t\right)+\delta\frac{1-\delta^{T-\hat{t}}}{1-\delta}\right] & \text{if } t < \hat{t} \\ (\sigma+\varepsilon)\delta\cdot\frac{1-\delta^{T-t}}{1-\delta} & \text{if } \hat{t} \leq t < T \\ 0 & \text{if } t = T \end{cases}$$

Thus, the difference $S_t\left(\cdot\right) - D_t\left(\cdot\right)$ in the seller's incentive compatibility constraint (16) is

$$S_t\left(\cdot\right) - D_t\left(\cdot\right) = \begin{cases} \varepsilon\left[\left(\hat{t}-t\right)+\delta\frac{1-\delta^{T-\hat{t}}}{1-\delta}\right] & \text{if } t < \hat{t} \\ \varepsilon\left[\delta\cdot\frac{1-\delta^{T-t}}{1-\delta}\right] & \text{if } \hat{t} \leq t < T \\ 0 & \text{if } t = T \end{cases}$$

and – as in the above case of trust contracts – depends on the value of ε and t.

If $\varepsilon = 0$, then $S_t = D_t$ for all t. From condition (15) and from the incentive compatibility constraint (16) it follows that in equilibrium $e_t^d = e_t^*$. For the buyer it is therefore optimal to set $e_t^* = \frac{\bar{e}}{2}$ and either

$$\iota_t = 1 \text{ and } w_t = c(e_t^*) + \sigma$$

or

$$\iota_t = -1 \text{ and } w_t = c(e_t^*) + \sigma + k.$$

As for the case of Trust Contracts, if $\varepsilon > 0$, we have that $S_t(\cdot) > D_t(\cdot)$ for every $t < T$, and the system (17) has two solutions: one for $\lambda_2 = 0$, the other for $\lambda_2 > 0$. If $\lambda_2 = 0$, it follows from (KTi1) that $v'(e_t^d) = c'(e_t^d)$ which in our setting means that $e_t^d = \bar{e}$. This may be the solution of the system only if t and ε are sufficiently large that the incentive compatibility constraint (16) is satisfied with $e_t^d = \bar{e}$. If this is not the case, then λ_2 must be strictly positive. From (KTi5) it follows that

$$c(e_t^d) = c(e_t^*) + (S_t(\cdot) - D_t(\cdot)).$$

Then, it is optimal for the buyer to set $e_t^* = \frac{\bar{e}}{2}$, and to ask the seller for a level of effort $e_t^d = c^{-1}\left(c(e_t^*) + (S_t(\cdot) - D_t(\cdot))\right)$, which is increasing in t and ε. The buyer will be indifferent between a contract with bonus, where

$$\iota_t = 1 \text{ and } w_t = c(e_t^d) + \sigma + \varepsilon$$

and a contract with penalty, where

$$\iota_t = -1 \text{ and } w_t = c(e_t^d) + \sigma + \varepsilon + k.$$

C Loss-Averse Buyers

We now present a simple application of prospect theory (Tversky and Kahneman, 1992) showing that the expected utility for a loss-averse buyer tends to be higher with bonus contracts than with payoff-equivalent penalty contracts.

Consider a simple static setting in which a buyer offers a contract with a penalty to a seller. If after signing the contract the seller complies with it, the buyer earns

$$\nu - w_{pe},$$

where ν is the buyer's gross profit and w_{pe} is the wage paid to the seller. If the seller shirks instead, the buyer's gross profit is 0 and he up ends with

$$-w_{pe} + 20$$

where 20 is the penalty the buyer will receive from the seller for her poor performance.

When the buyer offers a contract with a bonus – where w_{bo} is the wage paid to the seller – the buyer gets

$$\nu - w_{bo} - 20,$$

in the event the seller complies, and he gets

$$-w_{bo}$$

if the seller shirks.

The buyer's payoffs in adopting a bonus or penalty are equivalent for

$$w_{pe} = w_{bo} + 20. \tag{19}$$

Assume now the buyer believes that the seller may make a mistake and shirk with some small probability p. When choosing between bonus and penalty contracts, the buyer needs to compare two prospects, P_{bo} and P_{pe}, where:

$$P_{bo} = (\nu - w_{bo} - 20, (1-p);\ -w_{bo}, p)$$

and

$$P_{pe} = (\nu - w_{pe}, (1-p);\ -w_{pe} + 20, p)$$

Let us assume the buyer's decision process is consistent with Cumulative Prospect Theory (Tversky and Kahneman, 1992): they code outcomes as gains and losses, and simplify prospects by combining the probability associated with identical outcomes. The two prospects are then perceived as follows:

$$P_{bo} = -w_{bo} + (\nu - 20, (1-p);\ 0, p)$$

and

$$P_{pe} = -w_{pe} + (\nu, (1-p);\ 20, p)$$

In addition, we assume that buyers' preferences can be represented by a function $V(\cdot)$ For simplicity, we assume that the probability weighting functions ω^{+} and ω^{-} for positive and negative outcomes are identical and given by

$$\omega^{+}(q) = \omega^{-}(q) = q$$

To simplify the problem even further, we consider a linear value function $v(\cdot)$:

$$v(x) = \begin{cases} x & \text{if } x \geq 0 \\ \lambda x & \text{if } x < 0 \end{cases}$$

where $\lambda > 1$ is the measure of loss-aversion.

We now compute the value of the two prospects P_{bo} and P_{pe} for the buyer:

$$\begin{aligned} V(P_{pe}) &= v(-w_{pe}) + pv(20) + (1-p)\, v(\nu) = -\lambda w_{pe} + p(20) + (1-p)\,\nu \\ V(P_{bo}) &= v(-w_{bo}) + (1-p)\,[v(\nu - 20)] = -\lambda w_{bo} + (1-p)(\nu - 20)\,. \end{aligned}$$

If the penalty and the bonus contracts are payoff-equivalent, as in (19), it is easy to show that the value of prospect P_{bo} for the buyer is higher than the value of prospect P_{pe} for every $\lambda > 1$:

$$
\begin{aligned}
-\lambda\left(w_{pe}-20\right)+(1-p)\left(\nu-20\right) &> -\lambda w_{pe}+(1-p)\,\nu+p20 \\
\lambda 20-(1-p)\,20 &> p20 \\
20(\lambda-1)p &> 0.
\end{aligned}
$$

This shows that – to be equivalent from the point of view of a loss-averse buyer – a penalty and a bonus contract should offer the seller a different profit levels, i.e., the penalty contract should feature a lower profit than the corresponding bonus contract.

D Additional regressions

Dependent variable: average surplus

	Coefficient	***Standard error***
Treatment T	*baseline*	
Treatment B	18.867	*3.648****
Treatment P	24.572	*3.419****
Treatment I	21.684	*3.972****
Period	-0.436	*0.148****
Constant	25.234	*3.143****
R2-between	0.856	
R2-within	0.075	
R2-overall	0.618	
N. observations	180	

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.
Standard errors robust for heteroskedasticity.

Table D.1: Treatment effect on the average surplus – GLS panel regression.

Dependent variable: average surplus

	Coefficient	***Standard error***
Treatment T	*baseline*	
Treatment B	-0.283	*4.604*
Treatment P	0.760	*5.614*
Treatment I	9.197	*3.100****
Treatment P – Penalty	27.374	*4.933****
Treatment I – Penalty	16.223	*2.150****
Treatment B – Bonus	27.316	*4.362****
Treatment I – Bonus	14.909	*3.586****
Period	-0.757	*0.177****
Constant	27.800	*3.209****
R2-between	0.864	
R2-within	0.082	
R2-overall	0.531	
N. observations	328	

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Standard errors robust for heteroskedasticity. One observation per session, per period, per type of incentive.

Table D.2: Treatment and incentive effect on the average surplus – GLS panel regression.

Dependent variable: average share of private offers

	Coefficient	***Standard error***
Treatment T	*baseline*	
Treatment B	-0.151	*0.052****
Treatment P	-0.242	*0.075****
Treatment I	-0.215	*0.051****
Period	0.006	*0.003***
Constant	0.365	*0.042****
R2-between	0.662	
R2-within	0.035	
R2-overall	0.292	
N. observations	180	

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Standard errors robust for heteroskedasticity.

Table D.3: Treatment effect on the average share of private offers – GLS panel regression.

Dependent variable: average effort

	quality		delivery time	
	Coefficient	***S.e***	**Coefficient**	***S.e***
Treatment T	*baseline*	*baseline*		
Treatment B	-0.137	*0.194*	0.217	*0.234*
Treatment P	-0.049	*0.209*	0.186	*0.294*
Treatment I	0.217	*0.203*	0.570	*0.120****
Treatment P – Penalty	-0.262	*0.145**	2.541	*0.302****
Treatment I – Penalty	-0.480	*0.141****	1.953	*0.177****
Treatment B – Bonus	-0.006	*0.189*	2.321	*0.256****
Treatment I – Bonus	-0.352	*0.181**	1.604	*0.240****
Period	-0.050	*0.008****	-0.020	*0.012**
Constant	0.936	*0.169****	0.705	*0.135****
R2-between	0.415		0.936	
R2-within	0.174		0.012	
R2-overall	0.215		0.651	
N. observations	327		327	

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Standard errors robust for heteroskedasticity. One observation per session, per period, per type of incentive.

Table D.4: Treatment and incentive effect on the average effort – GLS panel regression.

Dependent variable: average cost of voluntary effort

	Coefficient	***Standard error***
Treatment T	*baseline*	
Treatment B	1.188	*1.934*
Treatment P	1.286	*1.889*
Treatment I	3.313	*1.000****
Treatment P – Penalty	-4.046	*1.729***
Treatment I – Penalty	-6.643	*1.131****
Treatment B – Bonus	-3.690	*2.452*
Treatment I – Bonus	-6.278	*1.579****
Period	-0.481	*0.102****
Constant	7.414	*1.286****
R2-between	0.560	
R2-within	0.124	
R2-overall	0.223	
N. observations	327	

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Standard errors robust for heteroskedasticity. One observation per session, per period, per type of incentive.

Table D.5: Treatment and incentive effect on the average cost of voluntary effort – GLS panel regression.

Dependent variable: average buyers' profit

	all contracts		excluding unaccept. contracts	
	Coefficient	***S.e.***	**Coefficient**	***S.e.***
Treatment I – Bonus	*baseline*			
Treatment B	14.117	*6.978***	14.078	*6.975***
Treatment P	19.842	*7.122****	14.437	*7.545**
Treatment I – Penalty	17.793	*7.827***	14.369	*7.794**
Period	0.438	*0.211***	0.341	*0.204**
Constant	15.335	*7.169***	16.149	*7.150***
R2-between	0.563		0.434	
R2-within	0.024		0.012	
R2-overall	0.222		0.131	
N. observations	175		175	

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Standard errors robust for heteroskedasticity. One observation per session, per period, per type of incentive.

Table D.6: Treatment and incentive effect on the average buyers' profits – GLS panel regression.

Dependent variable: offered profit

	all contracts		excluding unaccept. contracts	
	Coefficient	***S.e.***	**Coefficient**	***S.e.***
Treatment I – Bonus	*baseline*			
Treatment B	-11.039	*5.992**	-10.997	*5.991**
Treatment P	-20.959	*3.197****	-13.500	*4.079****
Treatment I – Penalty	-17.392	*4.098****	-12.472	*3.799****
Period	-1.578	*0.197****	-1.390	*0.200****
Constant	43.476	*3.166****	41.930	*3.157****
R2-between	0.681		0.470	
R2-within	0.407		0.330	
R2-overall	0.514		0.364	
N. observations	175		175	

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Standard errors robust for heteroskedasticity. One observation per session, per period, per type of incentive.

Table D.7: Treatment and incentive effect on the average profit offered to buyers – GLS panel regression.