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STICKS AND CARROTS IN PROCUREMENT

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Abstract

We study differently framed incentives in dynamic laboratory buyer-seller relationships with multi-tasking and endogenous matching. The experimental design tries to mitigate the role of social preferences and intrinsic motivation. Absent explicit incentives, effort is low in both tasks. Their introduction boosts efficiency substantially increasing effort in the contractible task, mildly crowding it out in the non-contractible one, and increasing buyer surplus. Bonuses and penalties are equivalent for efficiency and crowding-out, but different in distributional effects: sellers' surplus increases with bonuses as buyers' offers become more generous. Buyers tend to prefer penalties, which may explain why they are dominant in procurement.

Key words: bonuses, business-to-business, contract choice, experiment, framing, explicit incentives, incomplete contracts, loss-aversion, motivation, penalties, procurement, multi-tasking, relational contracts, rewards

JEL: H57, C92, L14, M52

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1 Introduction

Procurement, exchanges between businesses or between government and business, accounts for a large portion of the world economy. Many of these transactions are governed by fixed-price contracts stipulating price, minimum quality standards, and a set of penalties ("deductions", "liquidated damages") that the seller must pay if these standards are not met. Analogous arrangements framed as bonuses, i.e., with a lower base payment and additional payments that reward sellers' good performance, are far less common.[1] This is reflected in the recent literature on procurement contracting, which focuses mainly on the choice between fixed price and cost-plus contracts.[2] The infrequent use of bonuses in procurement is puzzling, because many countries have regulations that cap the level of enforceable penalties, but not that of performance bonuses. For example, in Anglo-Saxon countries, liquidated damages are only enforceable up to the courts' estimates of the damage produced by the contractual violation; and in most countries contractual penalties are only enforceable up to a fraction of the value of the exchange. This suggests that there may be real benefits in framing incentives as bonuses, rather than as penalties.

This paper presents results from a laboratory experiment on procurement, which aims in part to shed some light on this puzzling phenomenon. More generally, our aim is to understand the role played by different types of incentives in private and public procurement, taking into account that procurement is typically a repeated activity and that the supply inevitably contains contractible and non-contractible quality dimensions (e.g., Kelman, 1990). In our experiment, therefore, we introduce explicit incentives framed as bonuses or penalties in an environment characterized by moral hazard, repeated interaction and private offers (so that reputational forces may play a role), a contractible and a non-contractible task, and endogenous matching between a set of buyers and a set of competing sellers.

Several forces may act in such an environment. Since transactions involve contractible and non-contractible tasks, the introduction of explicit incentives for the first task may crowd out attention and effort for the second.[3] In a dynamic environment, implicit (relational) agreements may be used to govern non-contractible tasks, and the availability and use of different explicit incentives may impact these implicit understandings in different ways.[4] The

[1] In our own experience as public and private procurement consultants, in Italy and across Europe, we rarely observe bonus incentives and we always face substantial resistance when we suggest adopting them. In the US, procurement contracts for highway construction typically include deductions or liquidated damages for delayed project completion (e.g., Bajari, Houghton and Tadelis, 2007). Contract rewards, such as for early completion, are considered a recent innovation (Bajari and Lewis, 2009).

[2] E.g., see Bajari and Tadelis (2001), Tadelis (2002), and Corts (2009) for theoretical analyses; and Corts and Singh (2004) or Kalnins and Mayer (2004) for empirical ones.

[3] 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."

[4] For example, the simple availability of explicit contracting may undermine the parties' ability to punish deviations in long-term relationships (see Baker et al., 1994; Schmidt and Schnitzer, 1995). The use of explicit contracts may also limit parties' abilities to discipline defections and sustain implicit agreements (Bernheim and Whinston, 1998). 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, Baker et al., 2006).

introduction of explicit incentives may crowd out intrinsic motivation and social preferences/fairness concerns.[5] More central to our study, the framing of explicit incentives as bonuses rather than as penalties may affect outcomes, directly or through its impact on long-term relationships and through the forms of crowding-out mentioned above.[6]

Most of these forces have been analyzed experimentally before, but typically in isolation and with a focus on the employment relation where 'behavioral' effects tend to be stronger. Our design seeks to account for possible interactions between these forces, and to attenuate the impact of behavioral forces (intrinsic motivation and social preferences), as these are likely to play a smaller role in the impersonal types of transactions that are our primary focus.

In our experiment, at the beginning of each session subjects are randomly assigned a role, namely "buyer" or "seller". In each session, subjects play at least fifteen 'trading periods' (rounds) in the same role, after which new rounds only start with a commonly known probability. This continues up to a maximum of thirty rounds, after which the session ends with certainty. At the beginning of each round, buyers – the short side of the market – can repeatedly post offers for sellers until one seller accepts. Each buyer can choose the contractible terms of payment (a 'wage', and if an explicit incentive is available and is chosen, a 'penalty' or a 'bonus') and the required effort on the two tasks, and can change all the terms in new offers until one seller accepts. As in Brown et al. (2004) and Falk et al. (2008), offers can be "public", i.e., open for any of the sellers to accept, or "private", directed at one specific seller, so that repeated buyer-seller relationships can form. In each round, at the end of the initial contracting phase, some or all of the buyers end up matched with sellers (some sellers remain unmatched and earn an exogenous outside option): the game proceeds with matched sellers choosing effort levels for the two tasks, until eventually the payoffs for that round are realized. Then a new round begins, and rounds continue in this way until the end of the session.

We try to mitigate the impact of intrinsic motivation and social preferences by recruiting a subject pool that is known to be less sensitive to these concerns (economics and business students, the pool from which procurement managers are often hired), by providing the subjects with a profit calculator that offers them a comprehensive overview of all feasible payoff configurations,[7] and by explicitly framing the instructions as a business-to-business buyer-seller environment.[8]

[5] See e.g. Frey and Jegen (2001) and Benabou and Tirole (2003) for theories, and Mellström and Johannesson (2008) and Fehr and List (2004) for experimental evidence.

[6] For example, 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). 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 also affect perceptions of the kindness or hostility of the principals' actions, which are crucial for reciprocal responses.

[7] 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.

[8] However, Engelmann and Ortmann (2009) recently found that the framing of instructions exerts only limited effects on their experimental results. Also, in some earlier experiments discussed below, the instructions were similarly framed as buyer-seller relations.

Using this framework, we implement four different treatments – *Incentive, Penalty, Bonus* and *Trust* – which differ in the set of explicit monetary incentives that buyers can choose to adopt. Comparing the results across treatments and across contracts within each treatment, we investigate how the chosen incentive scheme affects the level of effort that sellers exert in both contractible and non contractible tasks.

In our experiment, the absence of explicit incentives always leads to rather low levels of effort in both tasks, perhaps suggesting that our attempt to minimize the impact of intrinsic motivation and social preferences was successful. Effort, on the other hand, is significantly lower in treatments where explicit contracts are not available than where they are available but were deliberately not chosen by the buyer. These results appear consistent with signaling effects of the type analyzed in recent work on psychological games.[9]

When explicit incentives are chosen, they do reduce effort in the non-contractible task, but only mildly, while they increase effort in the contractible task substantially more, with significant positive net effects on the overall surplus. Explicit and implicit incentives therefore emerge as substitutes in our experiment.

As for the framing of explicit incentives, we find that bonuses and penalties are indeed not fungible. In particular, buyers' offers with bonuses are significantly more generous than with penalties, even though the crowding-out effect is no weaker with bonuses than with penalties. This evidence appears consistent with buyers being loss-averse when evaluating the consequences of sellers' possible choices of effort. Such a bias may have induced them to make less generous contract offers with penalties than with bonuses because the upfront payments are higher with penalties. Sellers, on the other hand, do not seem to 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. This evidence and interpretation seems consistent with a recent field experiment by Hossain and List (2009) showing that workers increase their effort more if incentives are framed as penalties rather than as bonuses, but only if the prospect is risky because of team production externalities. For loss-aversion to matter, some element of risk must be present.

Finally, in our experiment, most buyers prefer penalties over bonuses when they can choose, and they generally benefit from such a choice. Interestingly, part of this difference is driven by a subset of the buyers – those who understood the game faster – who chose to offer 'exploitative' contracts that leave sellers below their outside option, and by some sellers – those that understood the game less quickly – accepting these offers. Smarter subjects therefore appear to correctly predict the presence of some naive subjects in the population and successfully take advantage of them. The different partitioning of surplus with bonuses or penalties, however, persists even if we disregard these cases.

Our work builds on several previous experimental studies of contract choice, but to the best of our knowledge ours is the first to combine the three main features that characterize our design: multitasking, repeated play with endogenous matching, and explicit incentives that are framed as bonuses and penalties.

Our matching procedure replicates the approach used in Brown et al. (2004) and in Falk et al. (2008), who find that – absent explicit monetary incentives

[9] E.g., Geanakoplos et al. (1989), Rabin (1993), and Battigalli and Dufwenberg (2009).

– long term cooperative relationships between trading parties typically emerge. Relational contracts appear less powerful in our setting, probably because our design tried to attenuate the effects of intrinsic motivation and social preference, though our parametrization and ending rule are also different.

Falk et al. (2008) also find that when buyers are offered the option to reward sellers' performances with a discretionary bonus, they actually use it, partly replacing relational incentives with their contract enforcement policies. Our results are consistent with this finding, although our explicit incentives are not discretionary.[10]

Previous experimental evidence on the effects of non-discretionary incentives on sellers' performance is mixed. Both Gächter et al. (2008) and Fehr and Gächter (2002) find those 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 much 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.

The higher level of voluntary effort that we observe when buyers deliberately choose not to use available explicit incentives also relates our work to that of Charness and Dufwenberg (2006), whose laboratory study of a one-shot trust game with hidden ac concludes that signaling intentions in pre-play communication may affect players' beliefs, triggering guilt aversion and more trustworthy behavior.

Finally, Lazzarini et al. (2004) also study repeated buyer-seller relationships with a contractible and a non-contractible task, finding that – in contrast to the crowding-out hypothesis – explicit contracts may similarly induce higher levels of effort in the non-contractible task. Their design, however, differs from ours in so many crucial respects that the results are hardly comparable.[11]

The reminder 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 experiments 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

We run four versions of a dynamic and competitive game framed as *multiple buyer - multiple seller* corporate relationships with multitasking and endogenous

[10] In our setting, explicit incentives are deterministic, and the punishment in the event of an agent's default is automatic and cost-free for the buyer. This is consistent with procurement practice but it contrasts with the related scenarios investigated by Andreoni et al. (2003), Fehr and Schmidt (2007), and Sutter et al. (2006), who focus more directly on employment relationships.

[11] In particular, they use fixed exogenous matching, each buyer can make only one take-it-or-leave-it offer per period, sellers cannot choose between different offers, nobody can change trading partner across periods, explicit incentives are always framed as penalties, and the effort choices are two-dimensional.

matching. These games correspond to our four treatments: *Incentive, Trust, Bonus* and *Penalty*. In this Section we first describe the four games; 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. In each version of the procurement game, buyers can place contract offers to trade with one of the sellers on two tasks, one contractible and the other not. The sellers' effort therefore has two dimensions: one contractible, e_1, which for concreteness we say determines 'delivery time'; one non-contractible, e_2, determining the 'non-contractible quality' of supply, with $e_1, e_2 \in [0, 4]$. In some, but not all of the treatments buyers may adopt explicit incentives in the contract they offer, a bonus or penalty conditional on the contractible effort e_1 – i.e. a 'time incentive' for delivery.

The procurement games are repeated finitely but with an uncertain end: they last for at least 15 trading periods, after which they continue for one more period with a probability of 67% (and they come to an end with the complementary probability); if they reach period $t = 30$, then they are required to end.[12] The expected end of the games is at $t = 18$.

Each trading period t consists of three stages:

1. In *stage one,* each buyer can display 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. In addition, in *Incentive*, *Bonus* and *Penalty* treatments, each buyer may choose to include an explicit incentive that is conditional on 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 is the result.

2. In *stage two,* each seller who has signed a contract chooses the levels of effort that are exerted on the two tasks.

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

Strategies. The set of strategies available to players is specific to each version of the game (treatment). 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 task: in treatment **I**, the buyer can choose between adopting a penalty,

[12] 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 agents knew they were playing for a fixed number of periods: in Brown et al. (2004) the number of periods was 15, in Falk et al. (2008) it was 18, in Fehr and Gaechter (2002) it was 12 and in Gaechter et al. (2008) it was 10.

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. 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 only one offer in each trading period t, choosing among all the buyers' public offers and the buyers' private offers that are available to the seller; likewise, each buyer can carry out only one contract per trading period t.[13]

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

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^P. In each treatment and during every trading period 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^P is then:

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

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 task at time t; $v\left(e_t\right) = 8 + 16(e_1 + e_2)$ is the realized value from the contract; $k = 20$ represents the fixed size of the explicit incentive; $I(.)$ is the incentive rule, defined as

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

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

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

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

[13] As soon as one principal's offer is accepted by an agent, all other offers by the same principal are deleted.

2.2 Predictions

"Rational" Predictions. In every trading period t for each treatment, the buyer presents a contract that maximizes his expected value of present and future profits under the usual participation and incentive compatibility constraints – respectively (6) and (7) 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 rents. 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 trading period 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 exercises no effort $(e_1, e_2 = 0)$ in both tasks.

In treatment **I**, the buyer can include an incentive, either a bonus or 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 $\pi_t^A = 4$ 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 they are available. The predictions for treatments **B** and **P** follow directly from the above predictions for **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 results of their introduction should not depend on the sign of the explicit incentive adopted;

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 the four treatments the level of effort in the non-verifiable task should be 0.[14]

"Non-standard" Predictions. If the traders are boundedly rational, or if their rationality and selfishness are not common knowledge, the predictions can change markedly. Boundedly rational selfish players may not apply backward induction until they approach the end of the game, making cooperative relations

[14] 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 hold, as a positive but decreasing level of non-verifiable effort is sustainable in equilibrium.

sustainable.[15] 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 (72) 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 Gaechter (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. According to this view, in our setting we should find than contracts that include a penalty give rise to a lower number of long term contracts than contracts including a bonus (or no incentive at all).

An additional perspective arises from the hypothesis of loss-aversion (Tversky and Kahneman 1991, 1992), suggesting that the monetary effect induced by a penalty may not be perceived as symmetrically equivalent to that produced by a bonus of the same amount. Accordingly, penalties may represent stronger incentives to perform for sellers or bring lower expected utility to buyers than equivalent incentives framed as bonuses.

The last departure from the standard predictions that we consider here concerns motivational crowding-out (Frey and Oberholzer , 1997; Benabou and Tirole, 2003). Gaechter et al. (2008) 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 will, reciprocity and other intrinsic motivations". Under such circumstances the introduction of explicit incentives in our setting may backfire, as sellers who were 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 of 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.[16]

We conducted three sessions for each of the four treatments, for a total of

[15] Even when all traders are rational, Kreps et al. (1982) concluded 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".

[16] A subject pool composed of 'future managers' should help minimize the fairness and related considerations that are likely to be less relevant in firm-to-firm transactions, which is the focus of our study.

Treatment	Session date	N. of participants	N. of periods
Trust	Nov. 26, 2008	16	17
	Dec. 05, 2008	16	18
	Jan. 30, 2009	16	17
Bonus	Nov. 26, 2008	16	18
	Dec. 05, 2008	16	15
	Dec. 17, 2008	14	15
Penalty	Nov. 26, 2008	16	16
	Dec. 05, 2008	16	16
	Jan. 30, 2009	16	16
Incentive	Dec. 03, 2008	12	15
	Dec. 03, 2008	16	16
	Dec. 03, 2008	16	17

Table 1: Treatments and sessions.

twelve sessions, as listed in Table 1 [17]. Instructions – presented in Appendix A – were distributed to subjects at the beginning of the session, then they were read aloud to make them common knowledge. Before starting the real experiment, we asked subjects to answer certain control questions, to confirm their understanding of the instructions. More specifically, subjects were asked to compute the seller's and buyer's profits under three different scenarios. All subjects were able to solve the task before the experiment started. Therefore, we can be confident that the economic problem was fully understood by the participants. When all the participants had given all the correct answers, we let them 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 spillovers into 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 tasks varies across treatments and how it changes depending on the type of

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

[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.

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 (Table 2). The last column of Table 2 reports the average level of surplus produced in each treatment. We observe that the level of surplus produced in treatment **T** is much lower than in the other three treatments, denoted **B**, **P** and **I**.

Table 2: Average surplus.

Treatment	**Incentive**			**Total**
	No incentive	**Penalty**	**Bonus**	
	Average surplus			
T (n=353)	20.86			20.86
I (n=301)	32.58	47.62	46.97	44.12
B (n=319)	24.93		49.21	40.99
P (n=318)	23.89	49.82		46.23
Total (n=1,291)	23.23	49.00	48.65	37.51

To test the significance of this difference, we use a non-parametric Wilcoxon Mann-Whitney test, with the session averages as independent observations.[19] The test indicates that the difference between treatment **T** and the other three treatments – in which monetary incentives could be used – is significant at the 1% level (N_1=3, N_2=9), while the differences across treatments **B**, **P** and **I** are not.

A comparison between the average surplus produced with contracts characterized by the presence or absence of explicit incentives was run separately for bonus contracts (treatments **B** and **I**) and for penalty contracts (treatments **P** and **I**) and confirmed that the difference between contracts with and without explicit incentives is significant at the 5% level.[20]

Result 1. *Explicit incentives have a positive net effect on surplus.*

As an aside, we notice that when incentives are not used (column 1 in Table 2), the surplus generated in treatment **I** is significantly higher than in treatment **T**.[21] This suggests that when a buyer voluntarily refrains from using explicit

[19] All tests reported in the paper are two-sided.

[20] According to signed-rank tests with N=6. Tests are performed by pooling treatments **B** and **I** (or **P** and **I**) together.

[21] Significant at the 10% level according to a Mann-Whitney test with N_1=N_2=3. The 10% level is the maximum significance level achievable with this sample size.

incentives, the seller is more willing to cooperate by exerting a higher effort.[22] We will further investigate this effect in Section 3.3.1.

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 was not viable. Indeed,

Table 3: Relative share of contracts initiated by private offers.

Treatment	Incentive			**Total**
	No incentive	**Penalty**	**Bonus**	
	relative share			
T (n=353)	0.33			0.33
I (n=301)	0.34	0.12	0.10	0.17
B (n=318)	0.10		0.26	0.21
P (n=318)	0.16	0.14		0.14
Total (n=1,290)	0.27	0.14	0.22	0.22

Table 3 shows that, across all treatments, most of the contracts are initiated by public offers. Specifically, in treatment **T** the relative share of contracts initiated by private offers is 33% and we fail to observe any significant tendency towards an increase in private offers over the course of the game (see Figure 1).

When buyers have the opportunity to use monetary incentives in addition to relational ones (treatments **B**, **P** and **I**), the share of contracts initiated by private offers is even lower. A Mann-Whitney test comparing treatment **T** with treatments **I**, **B** and **P** reports that the difference is significant at the 5% level (N_1=3, N_2=9).

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 85% 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 2. *Absent monetary incentives, relational incentives are weak. When buyers have the opportunity to use monetary incentives, the relational dimension of the contract becomes even less important.*

3.2 Displacement Effect

Result 2 emphasizes the minimal importance of relational concerns in treatment **T**. As explained in Section 2.2, in a situation in which one-shot interactions

[22] This result is consistent with what was observed by Fehr and Gächter (2002), and also by Fehr and List (2004) in the different framing of a one-shot investment game.

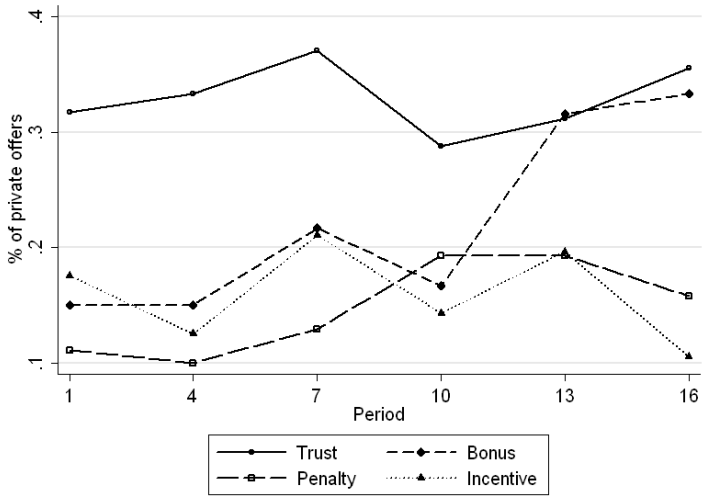


Figure 1: Relative share of contract initiated by private offers.

prevail, selfish sellers should choose a level of effort that is equal to 0. Figures 3a and 3b suggest that our results do not differ markedly from these theoretical predictions, as on average the level of effort exerted by sellers in both tasks 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 (see Fehr and Gächter 2002; Brown et al. 2004; Falk et al. 2008; Gächter et al. 2008). The difference is likely due to our (apparently successful) attempt to minimize the effects of fairness and social preferences.

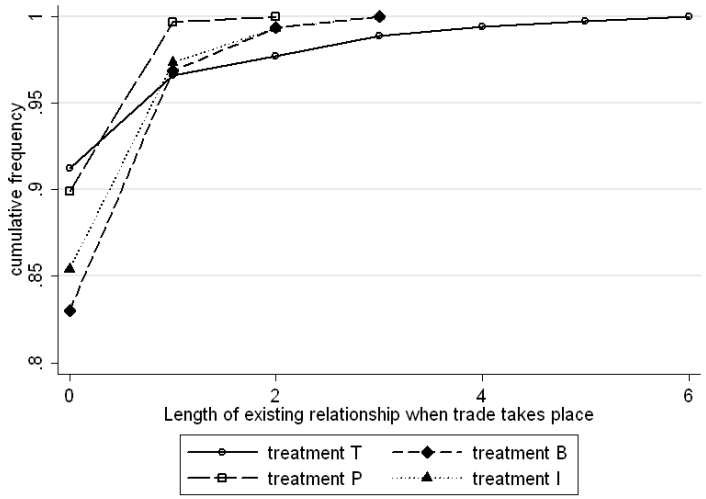
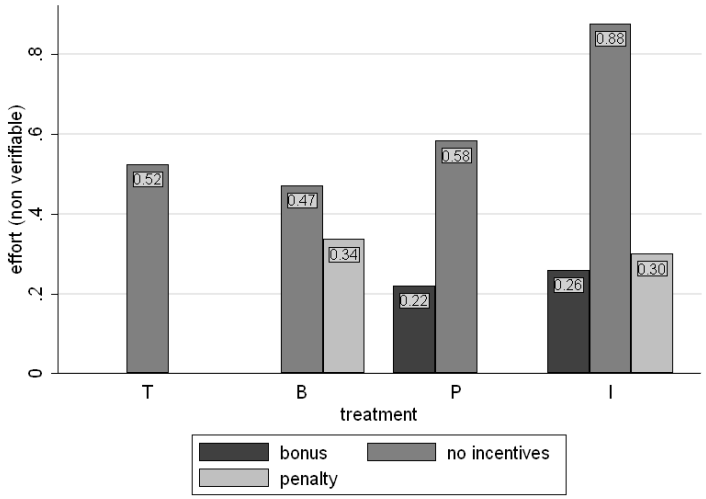
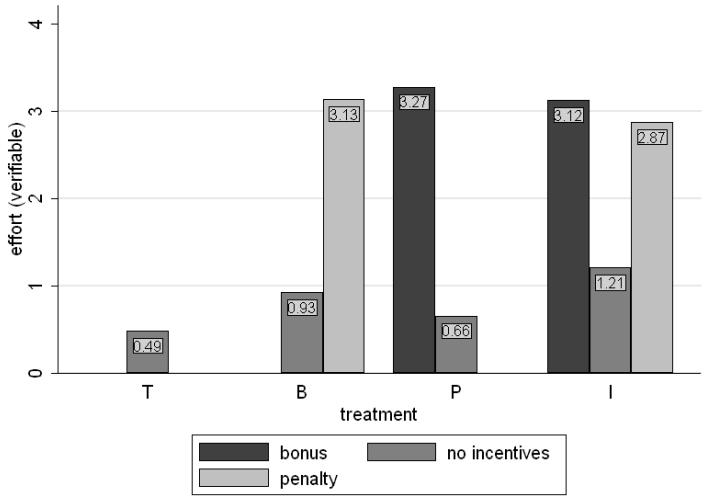


Figure 2: Cumulative frequency of trades in relationships of different lengths.



(a)



(b)

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

The level of the verifiable effort 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.[23] In contrast, when penalties are adopted in treatments **P** and **I** the level of the non verifiable effort significantly decreases,[24] while the decrease is not significant for bonuses.[25]

Both the average increase in the level of verifiable effort and the average decrease in the level of non-verifiable effort determined by the adoption of explicit incentives are not significantly different for bonuses and penalties.[26]

The increased surplus generated by the adoption of explicit incentives (see Result 1) stems from the fact that the increase in the level of effort exerted by sellers in the verifiable task is greater than the decrease in effort in the non-verifiable task.

Result 3. *The adoption of explicit incentives significantly increases the level of verifiable effort, but may reduce the 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 2 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 monetary 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. $c(e_1 + e_2) - c(e_1^*)$.[27] We call this measure "cost of voluntary effort".[28]

Numerous previous experiments (Fehr and Gächter 2002, Fehr and List 2004, Gächter et al. 2008) have shown how explicit incentives may backfire, reducing the level of voluntary effort. We have already noticed that in our benchmark treatment (**T**) – where monetary incentives are not a permitted option – the level of voluntary effort is quite low. Still, our Result 3 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. A rank-sum test confirms that the cost

[23] Two-sided signed-rank tests are used, and session averages are used as observations. N=6 both for the comparison between contracts with and without bonuses (treatments **B** and **I**) and for the comparison between contracts with and without penalties (treatments **P** and **I**)

[24] At the 5% significance level, according to a signed-rank test with N=6.

[25] Signed-rank test with N=6, run on treatments **B** and **I**.

[26] This result comes from comparing treatments **B** and **P** (Mann-Whitney tests, with N_1=N_2=3, yield U=2 for the effect on the non-verifiable effort, and U=4 for the effect on the verifiable effort).

[27] We drop from the following analyses 3 out of 1290 observations, in which $e_1 < e_1^*$ and $e_2 > 0$.

[28] We set $c(e_1^*) = 0$ when no explicit incentives are present.

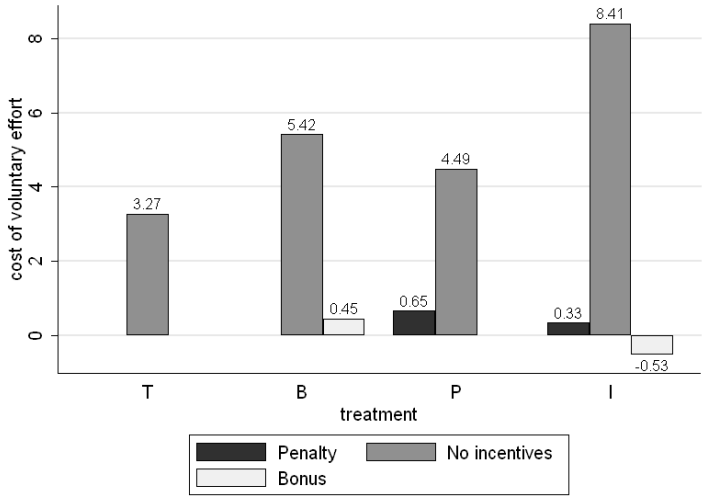


Figure 4: Average cost of voluntary effort in the four treatments.

of voluntary effort is significantly lower in treatment **T** than in treatment **I**[29] when incentives are available but not used[30]. (As mentioned above, this aspect is investigated in detail in Section 3.3.1).

To further investigate the presence of motivational crowding-out, we run a regression analysis (with fixed effects for individual subjects). The results are reported in Table 4. 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 on-going 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 monetary 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 4 it is also clear that voluntary effort decreases as the game proceeds in treatments **P** and **B**, as the coefficient for *Period* is always negative.

Result 4. *Weak, but positive, voluntary effort is exerted by sellers without ex-*

[29]This difference is significant at the 10% level according to a Mann-Whitney test, with N_1=N_2=3.

[30]The difference is not significant when we compare treatment **T** with either **B** or **P** (N_1=N_2=3 in both tests. U=3 for **T** vs. **B**, and U=2 for **T** vs. **P** treatments).

Table 4: Fixed effects panel regression of the cost of voluntary effort over contract's characteristics in the four treatments.

	dependent variable: cost of voluntary effort			
	treatment			
	T	B	P	I
Fixed compensation†	0.126***	0.179***	0.022	0.336***
	(0.032)	(0.057)	(0.045)	(0.055)
Period	-0.107	-0.271**	-0.380**	-0.211
	(0.115)	(0.117)	(0.148)	(0.126)
Private Offer (dummy)	-0.956	0.334	4.426***	-3.312*
	(0.861)	(1.683)	(1.297)	(1.627)
Duration of relationship when trade takes place	0.549**	-0.499	1.544	1.248
	(0.236)	(0.800)	(1.329)	(0.946)
Requested non-verifiable effort e_2^d	0.355	0.327	1.691**	0.856*
	(0.309)	(0.606)	(0.672)	(0.459)
Requested verifiable effort $(e_1^d - e_1^*)$	0.159	0.330	1.219**	0.399
	(0.223)	(0.505)	(0.581)	(0.634)
Bonus (1 if contract with bonus)		-5.500***		-9.616***
		(1.929)		(2.494)
Penalty (1 if contract with penalty)			1.872	-5.007*
			(1.929)	(2.573)
Constant	1.008	2.461	-2.356	-3.581
	(1.554)	(2.142)	(2.839)	(3.149)
Observations	353	318	318	301
Number of individuals	27	26	27	25
R2-between	0.093	0.238	0.015	0.031
R2-within	0.156	0.203	0.208	0.348
R2-overall	0.146	0.205	0.161	0.274

†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 (clustering by subject and session) in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

plicit incentives, at least in early periods of the game. When bonuses or penalties are used, the level of voluntary effort tends to drop.

3.3.1 Voluntary Effort in Trust Contracts

Figure 4 shows that the level of voluntary effort exerted in the absence of explicit incentives ("trust contracts", from now on) is lower in treatment **T** – where explicit incentives are not available by design – than in the other three treatments. A similar effect emerges when we focus on the average surplus produced (see Table 2).

This result may be driven by three potential factors. First, there may be a selection effect on buyers, if more generous buyers choose trust contracts in treatments **I**, **B** and **P**, although they could use an incentive contract instead. Thus, the profit offered to sellers in these contracts would be on average higher than in treatment **T**, and reciprocating sellers would react to this by choosing a higher level of effort. Second, we could think of a selection effect on the sellers' side, if reciprocating sellers prefer trust contracts and accept these contracts more often than non-reciprocators under treatments **I**, **B** and **P**. Third, there may be an "induction of beliefs" effect, as in the psychological games introduced

by Geanakoplos et al. (1989) and further analyzed by Rabin (1993), Charness and Dufwenberg (2006) and Battigalli and Dufwenberg (2009). In this case, the choice of offering a trust contract when the buyer could have opted for a contract with explicit incentives signals trust, thus affecting sellers' beliefs about the kindness of the buyer's intentions and triggering guilt aversion in some sellers, who may therefore reciprocate more.

To test for a selection effect on the buyers' side, we compared the average profit offered to sellers in trust contracts in treatment **T** (4.41) and in the other three treatments (8.44).[31] We restrict our observations to data from Period 1 only, to exclude learning effects. The observed difference is not significant, according to a rank-sum test (p-value. 0.5718, N_1=22, N_2=25). Thus, a selection effect on buyers does not seem to be the main driver of the difference in sellers' levels of cooperation across treatments.

Table 5: Tobit regression on effort exerted in Trust contracts.

	dependent variable: Total Tffort $e_1 + e_2$	
	coeff.	**standard error**
Treatment T	-0.036	0.825
OfferedProfit	0.069**	0.027
OfferedProft X treatment T	-0.107***	0.035
Constant	1.439**	0.590
Observations	45	
pseudo R-squared	0.060	

We then check whether there is a difference in sellers' behavior when we control for the generosity of the buyer's offer. For this purpose, we ran a Tobit regression on sellers' total effort ($e_1 + e_2$) across all contracts without explicit incentives, in Period 1. The explanatory variables are the profit offered by the buyer to the seller (*OfferedProfit*$= w - (e_1^d + e_2^d)^2$), a dummy taking the value 1 for treatment **T**, and 0 otherwise (*Treatment T*), and an interaction term between these two variables.

The results – reported in Table 5 – indicate that the sellers' level of effort is positively related to the profit offered to them by buyers in treatments **I**, **B** and **P**, but not in treatment **T**. In principle, this finding is compatible both with a selection effect on sellers, and with an "induction of beliefs" effect. Yet, a visual inspection of the outcome of trust contracts in period 1 (represented in Figure 5) leads us to reject the former explanation in favour of the latter. If a selection effect on sellers were present, in treatment **T** we should observe some sellers reciprocating generous offers with a high level of effort, and others shirking even if the offered profit is relatively high. In the other three treatments, we should find roughly the same number of sellers who reciprocate generous offers as in treatment **T**, and fewer sellers shirking. Instead, we observe an increase in the density of contracts in the top-right corner for treatments **I**, **B** and **P**, compared to treatment **T**. This suggests that sellers' reaction to generous offers when a trust contract is deliberately chosen by buyers is more reciprocative –

[31] The profit offered to agents is measured as $w - (e_1^d + e_2^d)^2$.

consistent with the "induction of beliefs" effect highlighted by the theory of psychological games.

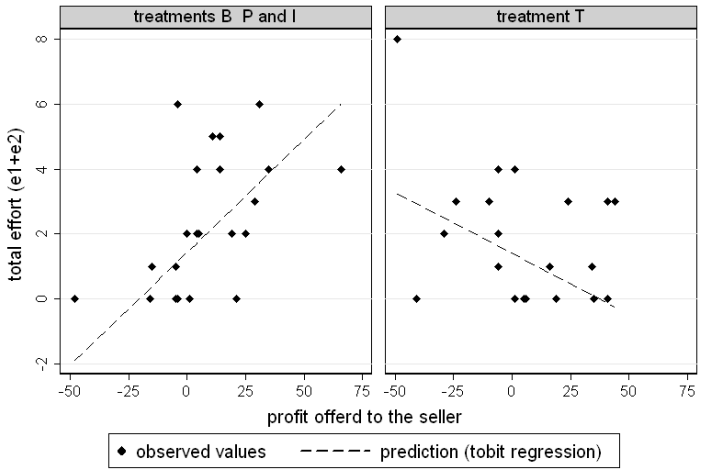


Figure 5: Outcome of trust contracts in period 1.

Result 5. *In the absence of explicit incentives, sellers' voluntary effort is greater when the buyer has the opportunity to use such incentives but deliberately chooses not to do so. These results are consistent with an "induction of beliefs" effect.*

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 (see Table 6), as in real world procurement. The main purpose of this subsection is to understand why.

Table 6: % of contracts with bonus and penalty in treatment I.

	% of bonuses	*% of penalties*
session 1	17.95%	46.15%
session 2	24.52%	62.58%
session 3	12.80%	71.95%

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 separately

Table 7: Logit regression of variable "offer accepted" over contract's characteristics in the three treatments with monetary incentives.

	dependent variable: Offer Accepted		
	treatment		
	B	P	I
Fixed compensation†	0.006***	0.027***	0.015***
	(0.002)	(0.002)	(0.002)
Period	-0.009**	-0.029***	-0.014***
	(0.004)	(0.007)	(0.003)
Private Offer (yes=1)	-0.335***	-0.244***	-0.316***
	(0.056)	(0.048)	(0.053)
Requested non-verifiable effort	-0.002	0.002	-0.024*
	(0.009)	(0.017)	(0.013)
Requested verifiable effort	-0.018	-0.010	-0.023
(net of the threshold)	(0.014)	(0.028)	(0.024)
Penalty		-0.283*	-0.233***
(1 if contract with penalty)		(0.150)	(0.084)
Bonus	-0.148		-0.084
(1 if contract with bonus)	(0.098)		(0.071)
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%

for the three treatments in which explicit incentives were available, controlling for other contractual characteristics.[32] Table 7 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 significant.

Penalty Contracts are more Profitable for Buyers. Another possible reason why buyers prefer contracts with penalties is that these contracts yield higher profits. Table 8 provides evidence in favor of this second hypothesis. Although this difference in profits is not statistically significant according to a rank-sum test, from an economic point of view it is relevant in treatment **I**, and it persists across treatments **B** and **P**, where the alternative type of incentive was not available.

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.[33] The worst possible offer a buyer can make entails a

[32]These are: fixed compensation offered to the agent, 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 monetary incentive is not included, as it is too strongly correlated with the Bonus and Penalty dummies.

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

Table 8: Average principals' profits.

Treatment	Incentive		
	Penalty	**Bonus**	**Total**
	principals' average profit		
I (n=234)	37.77	23.62	33.47
B (n=211)		32.78	32.78
P (n=274)	39.22		39.22
Total (n=719)	38.68	30.48	35.46
	excluding exploitative contracts		
I (n=204)	34.86	23.62	30.95
B (n=211)		32.78	32.78
P (n=218)	34.37		34.37
Total (n=633)	34.56	30.48	32.74

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. 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 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[34].

Our data suggest that these exploitative offers are not made by mistake, i.e., by subjects who have not clearly understood the game. Rather, they are made strategically, to exploit other agents' *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.[35] 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[36]. 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.[37] By contrast, sellers who had accepted at least one exploitative

[34] 29% of the total offers are unacceptable, and 12% of the contracts originate from unacceptable offers.

[35] 22.2% vs 8.2%. The signed-rank test with N=8 confirms that the difference is significant at the 5% level. In 4 out of 12 sessions, all principals made at least two mistakes, so no matched observations are available.

[36] 10.9% vs 6.2%. The difference, however, is not significant at the 10% level, according to a signed-rank test with N=9. In three out of 12 sessions, all agents made at least two mistakes, so no matched observations are available.

[37] 28.2 vs. 19.6. The difference is significant at the 5% level, according to a signed-rank test

contract reported significantly lower profits, on average.[38]

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 8 show that the difference, though smaller, persists.

Table 9 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[39]. It shows that the maximum profit offered to the sellers when monetary incentives are used is higher in treatment **B** than in treatment **P**. The difference, however, is significant at the 10% level only if we consider all the offers, including the exploitative ones[40]. The same difference emerges in treatment **I**. 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, in particularly buyers, being loss-averse according to Tversky and Kahneman (1992) definition. In Appendix C we show more formally why 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 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 set-up: 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 in our set-up sellers do not react to the framing of incentives is therefore consistent with the evidence from a recent field experiment by Hossain and List (2009). These authors 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 6. *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

with N=8 (the comparison is not possible for 4 sessions).

[38] 10.93 vs. 14.58. The difference is significant at the 5% level according to a signed-rank test with N=10 (the comparison is not possible for 2 sessions).

[39] In our game, this is always equal to $w - (e^*)^2$.

[40] N_1=N_2=3

Table 9: Maximum profit offered to the agents.

Treatment	Incentive		
	Penalty	**Bonus**	**Total**
	principals' average profit		
Incentive (n=324)	8.76	26.74	12.81
Bonus (n=262)		19.07	19.07
Penalty (n=468)	7.01		7.01
Total (n=1,054)	7.62	20.74	11.79
	excluding unacceptable contracts		
Incentive (n=227)	16.55	26.74	19.82
Bonus (n=262)		19.07	19.07
Penalty (n=267)	15.33		15.33
Total (n=756)	15.77	20.74	17.97

of the puzzling observation that bonus contracts are rarely observed in real world procurement contexts.

4 Conclusion

This paper explores experimentally the interaction between different types of incentives in dynamic procurement scenarios. Our framework is characterized by repeated interaction, endogenous matching between buyers and sellers, coexistence of contractible and non-contractible tasks, the option to restrict contract offers to particular sellers (so that reputation may matter), and endogenous choice as to whether to introduce explicit incentives and how to frame them (whether as penalties or bonuses). The experimental design aimed to mitigate the role of intrinsic motivation and social preferences, as these forces are likely to play a minor role in the large business-to-business and government-to-business procurement transactions we are interested in.

In this environment, we observe that – absent explicit incentives – sellers' effort is low on all dimensions and so is the surplus. Effort on the contractible task increases substantially with the introduction of explicit incentives, while effort in non-contractible dimensions is somewhat reduced. The first effect dominates, and the surplus increases mainly to the benefit of buyers, particularly when they use penalty contracts. When using equivalent contracts with bonuses, buyers tend to be more generous in their contract offers to sellers, a bias consistent with loss-aversion. When buyers can choose the type of contract to offer, they tend to prefer contracts with penalties, and they profit from this choice. This could be one explanation of why bonus contracts are somewhat rare in real-life procurement contexts.

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 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.

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

		Quality				
		0	**1**	**2**	**3**	**4**
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

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**) - 20 (**bonus**)	Value of the good - base compensation
4. Contract with bonus, if the seller does <u>not</u> 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 <u>not</u> deliver the good by the deadline	
Base compensation - production cost - 20 (**penalty**) + 20 (**penalty**)	Value of the good - base compensation

Table 3: Profits

<u>Number of periods and end of the experiment:</u>

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 treatment **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 agent'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

$$\pi_t^P\left(w_t, e_t^*, e_t, \iota_t\right) = \begin{cases} v\left(e_t\right) - w_t - kI\left(e_t, e_t^*, \iota_t\right) & \text{if a contract is concluded} \\ 0 & \text{if no contract is concluded} \end{cases} \tag{3}$$

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

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

The seller's profit is

$$\pi_t^A\left(w_t, e_t^*, e_t, \iota_t\right) = \begin{cases} w_t - c\left(e_t\right) + kI\left(e_t, e_t^*, \iota_t\right) & \text{if a contract is concluded} \\ \sigma & \text{if no contract is concluded} \end{cases} \tag{4}$$

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 $E\left(Z^P\right)$, 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 agent performs in period t if $e_t \geq e_t^d$.
The buyer's profit maximization problem is

$$\max_{w_t, i_t, e_t^d,} E\left(Z^P\right) = \pi_t^P + \sum_{\tau=t+1}^{T} \pi_\tau^P \left(\prod_{\theta=t}^{\tau-1} \delta_\theta\right) \tag{5}$$

s.t. :

$$
\begin{aligned}
w_t + kI\left(e_t^d, e_t^*, \iota_t\right) - c\left(e_t^d\right) &\geq \sigma + \varepsilon && (6)\\
\pi_t^{AS}\left(e_t^d, e_t^*, \iota_t, w_t\right) + S_t(\cdot) &\geq \pi_t^{AD}\left(e_t, e_t^*, \iota_t, w_t\right) + D_t(\cdot) && (7)\\
e_t^* &\leq \frac{\bar{e}}{2} && (8)
\end{aligned}
$$

where (6) and (7) 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 (6), 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 (7) 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^{AS} at time t,

$$
\pi_t^{AS} = w_t - c\left(e_t^d\right) + kI\left(e_t^d, e_t^*, \iota_t\right) \tag{9}
$$

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^{AD} at time t,

$$
\pi_t^{AD} = w_t - c\left(e_t\right) + kI\left(e_t, e_t^*, \iota_t\right) \tag{10}
$$

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:

$$
S_t = \begin{cases} \sum_{\tau=t+1}^{\hat{t}} \pi_\tau^{AS} + \sum_{\tau=\hat{t}+1}^{T} \pi_\tau^{AS} \cdot \delta^{\tau-\hat{t}} & \text{if } t < \hat{t} \\ \sum_{\tau=t+1}^{T} \pi_\tau^{AS} \cdot \delta^{\tau-t} & \text{if } \hat{t} \leq t < T \\ 0 & \text{if } t = T \end{cases} \tag{11}
$$

and

$$
D_t = \begin{cases} \sigma\left[\left(\hat{t} - t\right) + \delta\frac{1-\delta^{T-\hat{t}}}{1-\delta}\right] & \text{if } t < \hat{t} \\ \delta\frac{1-\delta^{T-t}}{1-\delta} \cdot \sigma & \text{if } \hat{t} \leq t < T \\ 0 & \text{if } t = T \end{cases} \tag{12}
$$

Note that in the definition of D_t (12) 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 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 left out of the market for all future periods.

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 (5) becomes $\pi_t^P = v\left(e_t\right) - w_t$. The seller's participation constraint (6) becomes

$$c\left(e_t^d\right) - w_t + \sigma + \varepsilon \leq 0 \tag{13}$$

and her incentive compatibility constraint (7) becomes

$$\pi_t^{AS}\left(e_t^d, w_t\right) + S_t(\cdot) \geq \pi_t^{AD}\left(e_t, w_t\right) + D_t(\cdot) \tag{14}$$

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 $\pi_t^{AS}\left(e_t^d, w_t\right) = w_t - c\left(e_t^d\right)$ and $\pi_t^{AD}\left(e_t, w_t\right) = w_t$. By substitution, (14) is now

$$c\left(e_t^d\right) - \left(S_t(\cdot) - D_t(\cdot)\right) \leq 0 \tag{15}$$

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

$$\begin{cases} v'\left(e_t^d\right) - \lambda_1 c'\left(e_t^d\right) - \lambda_2 c'\left(e_t^d\right) = 0 & (KTt1) \\ -1 + \lambda_1 = 0 & (KTt2) \\ \lambda_1\left(c\left(e_t^d\right) - w_t + \sigma + \varepsilon\right) = 0 & (KTt3) \\ \lambda_2\left(c\left(e_t^d\right) - \left(S_t(\cdot) - D_t(\cdot)\right)\right) = 0 & (KTt4) \\ \lambda_1 \geq 0 & (KTt5) \\ \lambda_2 \geq 0 & (KTt6) \end{cases} \tag{16}$$

From *(KTt2)* and *(KTt3)* we get $\pi_t^{AS}\left(w_t\right) = w_t - c\left(e_t^d\right) = \sigma + \varepsilon$. Accordingly, the seller's expected profit from cooperation (11) 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 (15), 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 (15) 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 (16) 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 (15) 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:

$$kI\left(e_t^*, e_t^*, \iota_t\right) - c\left(e_t^*\right) > kI\left(e_t, e_t^*, \iota_t\right) - c\left(e_t\right) \ \forall e_t \neq e_t^* \tag{17}$$

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 $\pi_t^{AS}\left(w_t, e_t^*, e_t^d, \iota_t\right) = w_t - c\left(e_t^d\right) + kI(e_t^d, e_t^*, \iota_t)$ and the profit in the event of deviation is $\pi_t^{AD}\left(w_t, e_t^*, e_t, \iota_t\right) = w_t - c\left(e_t^*\right) + kI(e_t^*, e_t^*, \iota_t)$. Substituting in the seller's incentive compatibility constraint (7), we get

$$c\left(e_t^d\right) - c\left(e_t^*\right) - \left(S_t - D_t\right) \leq 0. \tag{18}$$

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

$$\begin{cases} v'\left(e_t^d\right) - \lambda_1 c'\left(e_t^d\right) - \lambda_2 c'\left(e_t^d\right) = 0 & (KTi1) \\ -1 + \lambda_1 = 0 & (KTi2) \\ -\lambda_3 = 0 & (KTi3) \\ \lambda_1\left(c\left(e_t^d\right) - w_t + \sigma + \varepsilon - kI(e_t^d, e_t^*, \iota_t)\right) = 0 & (KTi4) \\ \lambda_2\left(c\left(e_t^d\right) - c\left(e_t^*\right) - \left(S_t(\cdot) - D_t(\cdot)\right)\right) = 0 & (KTi5) \\ \lambda_3\left(e_t^* - \frac{\bar{e}}{2}\right) = 0 & (KTi6) \\ \lambda_1 \geq 0 & (KTi7) \\ \lambda_2 \geq 0 & (KTi8) \\ \lambda_3 \geq 0 & (KTi9) \end{cases} \tag{19}$$

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

$$c\left(e_t\right) - w_t + \sigma + \varepsilon - kI(e_t^d, e_t^*, \iota_t) = 0 \tag{20}$$

which implies

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

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 (18) 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 (17) and from the incentive compatibility constraint (18) 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 (19) 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 (18) 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

$$w_{pe} = w_{bo} + 20. \tag{21}$$

Assume now the buyer believes that the seller will 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 that the buyer's preferences can be represented by a function $V(\cdot)$ consistent with Cumulated Prospect Theory (Tversky and Kahneman 1992). 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 (21), 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 $\lambda > 1$:

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

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.

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