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Past Performance Evaluation in Repeated Procurement: A Simple Model of Handicapping

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Summary

When procurement contracts are awarded through competitive tendering participating firms commit ex ante to fulfil a set of contractual duties. However, selected contractors may find profitable to renege ex post on their promises by opportunistically delivering lower quality standards. In order to deter ex post moral hazard, buyers may use different strategies depending on the extent to which quality dimensions are contractible, that is, verifiable by contracting parties and by courts. We consider a stylized repeated procurement framework in which a buyer awards a contract over time to two firms with different efficiency levels. If the contractor does not deliver the agreed level of performance the buyer may handicap the same firm in future competitive tendering. We prove that under complete information extremely severe handicapping is never a credible strategy for the buyer, rather the latter finds it optimal to punish the opportunistic firm so as to make the pool of competitors more alike. In other words, when opportunistic behaviour arises, the buyer should use handicapping to "level the playing field".

Keywords: Repeated Procurement, Handicapping, Relational Contracts, Stick and Carrot Strategy

JEL Classification: C73, D82, D44, H57, K12, L14

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1. INTRODUCTION

When procurement contracts are awarded through competitive tendering participating firms commit ex ante to fulfill a set of contractual duties. However, selected contractors may find profitable to renege ex post on their promises by opportunistically delivering lower quality standards. In order to deter ex post moral hazard, when delivered quality is verifiable by a third part then a standard principal-agent model applies and an explicit contract can be specified ex ante. However, there exist some goods or services whose quality is hard to verify, for example the services essentially based on a high human capital component like IT and consulting, and also research report, works of art, catering. When the contractor's performance consists essentially in the provision of human capital the buyer may find it hard, if not impossible, to prove *objectively* whether the contractor has exactly complied with the contractual duties. When quality is not verifiable a formal contract cannot be enforced by a third party, therefore it needs to be self-enforcing in order to be effective.

Since procurement contracts are repeatedly awarded over time, reputation mechanisms may play a crucial role in providing dynamic incentives for contractors to fulfill contractual clauses. A special form of reputation mechanism is to award a certain score to a participating firm based on its past performance. For instance, the U.S. Federal Acquisition Regulation prescribes that "[p]ast performance should be an important element of every evaluation and contract award for commercial items. Contracting officers should consider past performance data from a wide variety of sources both inside and outside the Federal Government[...]. (FAR, 12.206)".

In a contest of complete information and observable but non verifiable quality we allow the buyer to handicap a firm that behaved opportunistically in the past. We consider a stylized repeated procurement framework in which a buyer awards a contract over time to two suppliers with different efficiency levels. If the firm did not provide satisfactory quality levels in a previously awarded contract the buyer may reduce at her discretion the score assigned to the tender submitted by a firm in the future competitive tendering. We prove that extremely severe handicapping is never a credible strategy for the buyer, rather the latter finds it optimal to punish the opportunistic firm so as to make the pool of competitors more alike. In other words, when opportunistic behavior arises, the buyer should use handicapping to "level the playing field".

In particular, we set up an infinitely repeated game whose constituent (static) game is composed of three stages. At the first stage a simplified version of the sealed-bid competitive tendering takes place: the buyer requires fulfillment of a minimal quality standard and two fully informed heterogenous firms bid only over price. At the second stage, once awarded the contract, the contractor chooses the quality. At the last stage the buyer observes the effective quality and decides whether to handicap.

We allow the buyer and the contractor to use a single period punishment. When no cheating on quality is observed no handicap is applied; otherwise the buyer handicaps the opportunistic contractor only in the next competitive tendering. On the other hand, the firm does not cheat if no cheating and handicap has occurred until that moment, otherwise it delivers zero quality only for one period.

This paper shows that the optimal strategy for the buyer is imposing in the next competitive tendering a handicap equal to the efficient firm's cost advantage, that also measures the efficient firm's bidding advantage. In this scenario the bidders are symmetric and get the same score in the competitive tendering. Given a tie breaking rule awarding the contract to the efficient firm, a sufficiently patient efficient contractor prefers not to shrink rather than win the next competitive tendering at a lower price. An extremely harsh handicap (that is equivalent to exclusion from the next competitive tendering) is not an optimal strategy for the buyer for two reasons. First, it implicitly awards the contract to the less efficient firm that will bid less aggressively and always deliver zero quality. Second, this reaction by the less efficient firm induces the efficient contractor not to deliver quality as well once it will be rewarded the contract. Moreover, since the handicap is equivalent to an increase in the efficient firm's cost, we show that when the handicap is lower than the firm's cost advantage the efficient firm's equilibrium price is decreasing in the handicap. In this scenario, the efficient firm still wins the competitive tendering by gaining a positive profit, therefore it has a lower incentive to deliver the required quality. In particular, the lower the handicap with respect to the firm's cost advantage the less aggressive is the equilibrium bid and then lower is the procurer's utility.

Our paper shows that repeatedly awarded procurement contracts in which unverifiable quality dimensions are relevant can be reinterpreted as relational contracts between a buyer and a contractor that is threatened by a potentially less efficient competitor. Relational contracts pioneered by MacLeod and Malcomson (1989) and refined by MacLeod (2003), Levin (2003) consider non-verifiable performance dimensions. Since such contracts are not legally enforceable, they need to be self-enforcing in order to be effective. These papers set up a infinitely repeated interaction between a principal and an agent by assuming that the performance of the latter is non-verifiable. The main message is that a wage scheme composed of a fix and a discretionary payment depending on the performance usually characterizes an optimal self-enforcing contract. All these papers employ a trigger strategy as in Abreu (1988) in which the discretionary payment is used by the principal to punish the cheating agent with the worst equilibrium outcome. We do not introduce a direct punishment strategy as in MacLeod and Malcomson (1989), MacLeod (2003) and Levin (2003). Our punishment is indirect in the sense that it does not consist in a direct cost in the contractor's utility, rather we allow the buyer to alter the subsequent competitive tendering by reducing the score of the opportunistic contractor. A further contribution of this paper is that our punishment lasts only one period ("stick and carrot"). Such a strategy sounds more realistic in procurement markets where, unless a serious wrongdoing like corruption o rebury is committed, a buyer cannot resort to trigger strategies thus keeping any form of punishment alive from one specific moment onwards.

Our paper bears some ingredients from MacLeod (2003) that sets up a repeated framework in which the performance evaluation depends on the correlation between the principal's and the agent's beliefs. MacLeod, in fact, assumes that the agent's beliefs about his performance are correlated with the principal's ones. Our paper captures the case of perfect correlation.

To the best of our knowledge papers strictly related to past performance evaluation in repeated procurement are Kim (1998), Doni (2006) and Spagnolo and Calzolari (2006). All of them introduce *assume* an extreme level of handicap since the buyer is allowed to debar the opportunistic contractor from all subsequent competitive tenderings. These papers model a repeated game in which the level of handicapping is *exogenous,* whereas we characterize the credible level of handicapping characterizing a self-enforcing agreement.

The paper is organized as follows. Section 2 presents the static game, Section 3 finds the static equilibrium, and Section 4 introduces the analysis of the repeated game. Section 5 concludes

2. THE MODEL

Consider a buyer who awards a procurement project to one of two firms $i = 1, 2$ by running a sealed-bid competitive tendering

The cost of each bidder is:

$$c_i = \theta_i + \psi(q_i) \tag{1}$$

The cost θ is fixed and it does not change according to the quality provided. It represents the cost each firm experiences in order to partecipate to the competitive tendering. Each firm incurs in the fixed cost θ, even if it will not be awarded the contract. We assumed $\theta_1 = \underline{\theta}, \theta_2 = \overline{\theta}$ with $\overline{\theta} > \underline{\theta}$, that is, firm 1 is the most efficient. $\psi(q_i)$ is the variable cost of providing quality q_i. We follow Kim (1998) and assume that $\psi(.)$ is common to both firms.

The profit of each firm is:

$$\pi_i = p_i - \theta_i - \psi(q_i) \tag{2}$$

where p_i is the price paid to firm i that delivers quality q_i at cost c_i. We also assume that the buyer requires fulfillment of a minimal quality standard denoted by $\overline{q}$. The quality $\overline{q}$ becomes the quality bided in the competitive tendering by both the firms. Once awarded the competitive tendering the firm may shrink on quality and depart from $\overline{q}$, then the effective quality is defined as $q_i = \overline{q} - m$, with $m = \{0, \overline{q}\}$. The variable cost function respects the following conditions: $\psi'(.) \geq 0$, $\psi''(.) \geq 0$, $\psi'(0) = 0$, $\psi(0) = 0$, in particular there exists some points along $\psi(.)$ with slope lower than one[2]. Also, we assume $\overline{\theta} - \underline{\theta} > \psi(\overline{q})$: firm 1 is much more efficient than firm 2. This assumption will be fundamental for the result of the paper, nevertheless it is also quite reasonable.

The utility function of the buyer is as follows:

$$U = q_i - p_i \tag{3}$$

We also assume that *i)* the buyer perfectly observes the quality and the costs of the firms, *ii)* the firms are fully informed. Assumption *i)* is in line with the common idea that a procurer is more informed on the cost of the firm than a standard regulator because the former is usually composed of managers coming from the private sector[3]. Although the buyer knows the costs of the firms she needs to run an competitive tendering to award the project. This apparently counterintuitive assumption actually fits many competitive tendering where the buyer knows *ex-ante* the efficiency of the bidders. This is the case of those procurement acquisitions repeated over time in which bidders are in general always the same and the buyer runs the competitive tendering only because mandatory by the law.

Let us introduce the three-stage static game G whose timing is the following:

[2] The last assumption is purely technical, however its necessity will be clear in the proof of Lemma 1.

[3] As explained in Kim (1998).

First stage A reduced version of the sealed-bid competitive tendering in Burget and Che (2004) takes place. The Buyer requires fulfillment of a minimal quality standard denoted by $\overline{q}$. When firms accept to take part to the competitive tendering they automatically commit to bid quality $\overline{q}$ therefore competitive bidding is only over price. Firms submit their bids simultaneously and non-cooperatively. The highest score (or the lowest price) awards the competitive tendering. In the case of the same score the buyer uses a *tie-breaking rule* awarding the contract to the most efficient firm (firm 1).[4]

Second stage The contractor decides the effective level of quality and may depart from the required level.

Third stage The buyer decides whether to handicap by an amount h the scoring rule of the opportunistic contractor in the next competitive tendering.

We anticipate that G will be the constituent game for the infinitely repeated game introduced in the Section 4.

3. THE EQUILIBRIUM OF THE STATIC GAME

We solve by backward induction. At the third stage the buyer simply decides the level of handicap $h > 0$. Since handicapping will be effective from the next period, in the this section we can only focus on the second and the first stage. We employ the technical assumption that when handicapping is applied it is assumed $2\psi\left(\overline{q}\right) \leq h$. This assumption will mainly determine the result of the paper, however it does not affect the quality of our results[5].

3.1. Second stage: optimal effective quality

Once the competitive tendering has been awarded the contractor faces the following maximization problem:

$$\max_{m} \; p_i - \theta_i - \psi\left(\overline{q} - m\right) \tag{4}$$

solving w.r.t. m the solution is:

$$\psi'\left(\overline{q} - m\right) = 0 \tag{5}$$

this means that $m^* = \overline{q}$. In the static game the contractor has an incentive not to deliver quality at all. The optimal quality will be $q_i^* = 0$. Since the static game ends at the third stage each contractor will behave opportunistically regardless the handicap.

3.2. First stage: competitive tendering

Given the fixed level of quality required by the contract, when firm i is not handicapped it bids under the follwing scoring rule:

[4] This tie-breaking rule is similar to that used in Kim (1998). He assumes that when biders quote the same price the flip of coin determines the winner.

[5] As will be clarify in the Section 4, this assumption is a necessary condition for the existence of a "cooperative" equilibrium in the dynamic game.

$$S_i = \overline{q} - p_i \tag{6}$$

On the other hand, when it is handicapped its scoring rule is:

$$S_i = \overline{q} - p_i - h \tag{7}$$

Following Burguet and Cheb (2004) we define the bidding advantage of firm i over firm 2 as:

$$\Delta = q_1 - \underline{\theta} - \psi(q_1) - \left[q_2 - \overline{\theta} - \psi(q_2)\right] \tag{8}$$

Since we are assuming the fulfillment of a minimal quality standard $\overline{q}$ and identical variable cost, then the bidding advantage of firm 1 when it is handicapped becomes:

$$\Delta = \overline{\theta} - \underline{\theta} - h \tag{9}$$

On the other hand, since we allows either firm to be handicapped, the bidding advantage of firm 1 when firm 2 is handicapped is:

$$\widetilde{\Delta} = \overline{\theta} - \underline{\theta} + h \tag{10}$$

However, since we are solving by backward induction, in the first stage firms anticipate that the optimal (effective) quality delivered in the next stage will be 0, therefore we have $\psi(0) = 0$.

We define the equilibrium bids as follows:

Proposition 1. *Given $\Delta = \overline{\theta} - \underline{\theta} - h$, the equilibrium bids of G are:*

$$p_1^* = \underline{\theta} + \psi(0) + \max\{\Delta, 0\} = \underline{\theta} + \max\{\Delta, 0\} \tag{11}$$

$$p_2^* = \overline{\theta} + \psi(0) + \max\{-\Delta, 0\} = \overline{\theta} + \max\{-\Delta, 0\} \tag{12}$$

the profits of the biders are $\pi_1 = \max\{\Delta, 0\}$ and $\pi_2 = \max\{-\Delta, 0\}$

Proof. See B&C (2004). The difference is that our bidding advantage collapses to $\Delta = \overline{\theta} - \underline{\theta} - h$ because we assume a fixed $\overline{q}$ instead of a continuos quality . Also, differently from B&C, in our model quality and price are chosen sequentially and not simultaneous, therefore by backward induction we have $q = 0$ in the equilibrium price. ∎

Proposition 1 says that, when the handicap is lower than the bidding advantage of firm 1, the competitive tendering is still awarded to the efficient firm that bids a price equal to the fixed cost of firm 2 minus the handicap. In other words, when the score of the efficient firm is reduced by an exogenous amount, then firm 1 needs to reduce its price by the same amount (bid more aggresively) in order to recover the score lost and keep winning the tendering.

To find the equilibrium bids in the static contest we simply consider no handicap ($h = 0$). In this case firm 1 wins the competitive tendering and the equilibrium bids at the first stage are:

$$p_1 = \overline{\theta} \tag{13}$$

$$p_2 = \overline{\theta} \tag{14}$$

In this equilibrium the efficient firm is able to outbid the rival gaining a profit equal to its cost advantage.

On the other hand when firm 2 is handicapped the equilibrium bids are as follows:

PROPOSITION 2. *Given* $\widetilde{\Delta} = \overline{\theta} - \underline{\theta} + h$, *the equilibrium bids of* G *are:*

$$p_1^* = \underline{\theta} + \psi(0) + \widetilde{\Delta} = \overline{\theta} + h \tag{15}$$

$$p_2^* = \overline{\theta} + \psi(0) = \overline{\theta} \tag{16}$$

the profits of the biders are $\pi_1 = \widetilde{\Delta}$ *and* $\pi_2 = 0$

Proof. See the proof of the Proposition 1. ∎

In this case the bidding advantage of firm 1 is higher than in the previous case. The intuition is the same as in the proposition 1: handicapping the less efficient firm is equivalent to increase the score of the efficient one by an exogenous amount, then in equilibrium firm 1 increases its bid (with respect to the case of no handicap) by an amount equal to the handicap of the rival by still winning the competitive tendering and increasing its profit.

4. THE DYNAMIC GAME

In this section we introduce the dynamic game as an infinitely repetition of the static game G. Since $t = 1$ on, the equilibrium of G depends on the h, then in what follows we anticipate three possible equilibria of G according to h.

4.1. The role of handicapping

We recall that the bidding advantage of firm 1 over firm 2, when both bid the same level of quality, is $\Delta = \overline{\theta} - \underline{\theta} - h$. The difference in their fixed costs $\left(\overline{\theta} - \underline{\theta}\right)$ measures the asymmetry among the competitors and it denotes the upper bound level of handicap that make the efficient firm be awarded the contract. The level of h can be also seen as a increase in the fixed cost of firm 1. When $h = \overline{\theta} - \underline{\theta}$, the increase in the fixed cost of firm 1 makes both firms alike and the bidding advantage is exactly compensated. A level $h < \overline{\theta} - \underline{\theta}$ makes firm 1 still more efficient, whereas $h > \overline{\theta} - \underline{\theta}$ fits the scenario in which firm 1 has a higher fixed cost than firm 2. Let us consider the following cases A, B and C.

A) $2\psi(\overline{q}) \leq h < \overline{\theta} - \underline{\theta}$:firm 1 wins the competitive tendering and the equilibrium is:

$$p_1^A = \overline{\theta} - h \tag{17}$$

$$p_2^A = \overline{\theta} \tag{18}$$

$$\pi_1^A = \overline{\theta} - \underline{\theta} - h \tag{19}$$

$$\pi_2^A = 0 \tag{20}$$

In this scenario the handicap is not harsh enough to switch contractors. In particular, when firm 1 is handicapped by h, then the bid $p_1^A = \overline{\theta}$ makes the efficient firm outbided by firm 2.

B) $h = \overline{\theta} - \underline{\theta}$:nobody wins the competitive tendering, however the most efficient firm (firm 1) is awarding the contract by the *tie-breaking rule*. The equilibrium is:

$$p_1^B = \underline{\theta} \tag{21}$$

$$p_2^B = \overline{\theta} \tag{22}$$

$$\pi_1^B = 0 \tag{23}$$

$$\pi_2^B = 0 \tag{24}$$

Note that in this scenario the handicap makes the bidders symmetric.

C) $h > \overline{\theta} - \underline{\theta}$: firm 2 wins the competitive tendering and the equilibrium is:

$$p_1^C = \underline{\theta} \tag{25}$$

$$p_2^C = \underline{\theta} + h \tag{26}$$

$$\pi_1^C = 0 \tag{27}$$

$$\pi_2^C = h - \overline{\theta} + \underline{\theta} \tag{28}$$

This higher level of handicap induces to switch contractor. The efficient firm is no longer able to outbid the less efficient one that wins the competitive tendering by bidding less aggressively than in A) and B). In the next section we will use scenario C as benchmark to study the trade-off from handicapping: although a sufficiently high handicap may give incentive not to shrink, it may implicitly awards the contract to the less efficient firm that wins the next competitive tendering by bidding less aggressively.

The following Corollary defines the equilibrium bids of the stage game when the contractor decides to deliver the quality $\overline{q}$ and no handicapping is applied.

Corollary 1. *In the stage game, when no handicap is applied, firm* 1 *will win the competitive tendering even though it will deliver* $\overline{q}$ *at the last stage. The equilibrium bids are* $p_1^* = p_2^* = \overline{\theta}$

Proof. Proposition 1 shows that firm 1 always wins the competitive tendering when both firms at the first stage make their bids anticipating that they will not deliver quality at the second stage. Hence, to prove Corollary 1 it remains to show that firm 2 will never win the competitive tendering even when firm 1 delivers $\overline{q}$. The proof comes from the assumption $\overline{\theta} - \underline{\theta} > \psi(q)$. Consider that the most aggressive bid by firm 2 is $p_2 = \overline{\theta}$, that is the price bided when firm 2 anticipates that it will not deliver quality in the stage game. When firm 1 wants to deliver quality $\overline{q}$, by assumption $\overline{\theta} - \underline{\theta} > \psi(\overline{q})$ we have that it may win the competitive tendering and gain a positive profit with all the bids from $\underline{\theta} + \psi(\overline{q})$ to $\overline{\theta}$. Thus, given the equilibrium bids of the stage game in (11)-(12), it is possible to see that the only equilibrium when firm 1 decides to deliver $\overline{q}$ is $p_{1,2} = \overline{\theta}$. ∎

4.2. The repeated game

Let G^{∞} be the supergame obtained by an infinite repetition of the game G. We assume that $\underline{\theta}$ and $\overline{\theta}$ are fixed over time. Let δ be the discount factor common to the firms and the buyer. Let H_t be the common knowledge vector of previous actions undertaken by the players in period up to $t-1$. Also, let H_0 be the history at time 0. Consider now the following specifications of the history given in the following definitions.

DEFINITION 1. Let $\widehat{H}_t$ be the history at time t such that up to the second stage of time t the contractor produces $\overline{q}$ and no handicap has occurred.

DEFINITION 2. Let $\widetilde{H}_t$ be the history at time t such that up to time $t-1$ the contractor produces $\overline{q}$ and no handicap has occurred.

Given the history in Definitions 1-2, in the Definition 3-5 we anticipate the "stick and carrot" strategies pioneered in Abreu (1986) that will characterize a SNE of G^{∞}.

DEFINITION 3. Let s_t^b be the strategy of the buyer at time t such that:

- if $H_t = H_0$, no handicap is applied.
- if $H_t = \widehat{H}_t$, no handicap is applied.
- otherwise she decides to handicap (h) the cheating contractor for one period, after which revert to no handicap.

DEFINITION 4. Let s_t^1 be the strategy of firm 1 at time t such that:

- if $H_t = H_0$, it deliver $\overline{q}$
- if $H_t = \widetilde{H}_t$, once the competitive tendering has run, it delivers $\overline{q}$
- If the buyer deviates from its strategy and firm 1 is handicapped even thought it delivers $\overline{q}$, then it decides to deliver q^* for one period, after which revert to $\overline{q}$.

DEFINITION 5. Let s_t^2 be the strategy of firm 2 at time t such that in every period (included $t = 0$) it delivers q^*.

The presence of the less efficient firm serves as threat for the most efficient one who in general would win the competitive tendering and deliver the service.

Given Corollary 1, the static profit for firm 1 when s_t^1, s_t^b and s_t^2 are respected (firm 1 wins and does not shrink and the buyer does not handicap) is:

$$\overline{\pi}_1 = \overline{\theta} - \underline{\theta} - \psi\left(\overline{q}\right) \tag{29}$$

That is, firm 1 wins the competitive tendering by bidding $p_1 = \overline{\theta}$ and providing $\overline{q}$. By Corollary 1 we know that firm 1 still gains positive profit even bidding a price equal to the fixed cost of firm 2 and providing quality $\overline{q}$ as well.

Its discounted payoff is:

$$\overline{V}_1 = \frac{1}{1-\delta}\overline{\pi}_1 \tag{30}$$

When firm 1 does not cheat and no handicap is imposed, the discounted profit for the buyer is:

$$\overline{U} = \frac{1}{1-\delta}\left(\overline{q} - \overline{\theta}\right) \tag{31}$$

When firm 1 respects the quantity $\overline{q}$, the buyer gains exactly $\overline{q}$ and rewards the contractor with a payment equal to bided price $(\overline{\theta})$

The following definition helps to characterize the SNE of G^{∞}.

Definition 6. Let $\widetilde{\delta}$ be the critical level of the discount factor such that the discounted payoff of each player at t when $H_t = \widehat{H}_t$ is equal to the payoff when $H_t \neq \widehat{H}_t$

In line with the "Folk theorem" the enforcement of strategies s_t^1, $s_t^b$and s_t^2 depends on δ and more interesting on h. Thus let us consider the following cases:

A)$2\psi\left(\overline{q}\right) < h \leq \overline{\theta} - \underline{\theta}$. Let h_A be a level of handicap at most equal to $\overline{\theta} - \underline{\theta}$. In this scenario firm 1 still wins the competitive tendering and the static equilibrium bids and profits are[6]:

$$p_1^A = \overline{\theta} - h_A \tag{32}$$

$$p_2^A = \overline{\theta} \tag{33}$$

$$\pi_1^A = \overline{\theta} - \underline{\theta} - h_A \tag{34}$$

$$\pi_2^A = 0 \tag{35}$$

According to Abreu (1988) a necessary condition for the strategies s_t^1, $s_t^b$and s_t^2 to characterize a SNE is that the strategy punishment is credible, that is once the game ends up in the punishment phase then the players effectively acts as explained in s_t^1, $s_t^b$and s_t^2. Now in the following Lemma we can introduce a necessary condition for the SNE to exist.

Lemma 1. *When* $2\psi\left(\overline{q}\right) \leq h \leq \overline{\theta} - \underline{\theta}$*, the necessary conditions for* s_t^1*,* s_t^b *and* s_t^2 *to characterize a SNE of* G^{∞} *are* $\frac{\psi(\overline{q})}{h_A - \psi(\overline{q})} \equiv \widetilde{\delta}_A \leq \delta$ *and* $\overline{q} \geq h$.

Proof. We consider the repeated game starting at $t = 0$ and sketch the proof over two points. We consider only the strategy of firm 1 and the buyer because, given h_A, firm 2 always bids p_2^A and never wins the competitive tendering. **1)** Firstly, consider firm 1. When firm 1 cheats its discounted profit is:

$$V_1^A = \pi_1 + \delta\pi_1^A + \sum_{t=2}^{\infty} \delta^t \overline{\pi}_1{}^7 \tag{36}$$

Where π_1 is the profit gained by firm 1 at time $t = 0$ if it decides to cheat and produce $q^* = 0$. At $t = 1$, according to s_t^b the handicap is applied for one period, however firm 1 still wins the competitive tendering but a more aggressive price,

[6] We recall that when $h_A = \overline{\theta} - \underline{\theta}$ supplier 1 wins the competitive tendering by the *tie-breaking rule*

[7] Where $\pi_1 + \delta\pi_1^A + \sum_{t=2}^{\infty} \delta^t \overline{\pi}_1 = \overline{\theta} - \underline{\theta} + \delta\pi_1^A + \frac{\delta^2}{1-\delta}\overline{\pi}_1$

then it gains π_1^A. Since $t = 2$ on, no handicap is applied and firm 1 reverts to $\overline{q}$ for ever by gaining $\overline{\pi}_1$. Hence, the condition for firm 1 not to cheat on quality is:

$$\overline{V}_1 \geq V_1^A \tag{37}$$

that holds when:

$$\frac{\psi\left(\overline{q}\right)}{\left(h_A - \psi\left(\overline{q}\right)\right)} \equiv \widetilde{\delta}_A \leq \delta \tag{38}$$

To characterize the SNE we also need to show that the punishment strategy of firm 1 is credible. This means that firm 1 should not deviate from his strategy once the punishment phase gets started. The punishment defined in s_t^1 (that is, firm 1 delivers $q^* = 0$ only for one period and then reverts to $\overline{q}$) is credible when, once the punishment is effective, then firm 1 has not incentive to deviate from $q^* = 0$ during the period of the punishment phase. Nevertheless, since $q^* = 0$ is its best reply in the static three stage game, then during the punishment firm 1 does not deviate from $q^* = 0$. Hence, s_t^1 is credible. Then the necessary condition for s_t^1 to characterize a SNE is $\widetilde{\delta}_A \leq \delta$. It is possible to see that without the assumption $2\psi\left(\overline{q}\right) < h_A$ we have $\widetilde{\delta}_A > 1$ implying that strategy s_t^1 cannot characterize a SNE and firm 1 would never deliver $\overline{q}$[8]. **2)** Second, consider the buyer. When the punishment as defined in s_t^b and s_t^1starts the effective quality is zero for one period and then it reverts to $\overline{q}$. The discounted utility of the buyer if she deviates is:

$$U_A = \left(\overline{q} - \overline{\theta}\right) + \delta\left(0 - \overline{\theta} + h_A\right) + \frac{\delta^2}{1-\delta}\left(\overline{q} - \overline{\theta}\right) \tag{39}$$

If at time $t = 0$ the buyer deviates and decide to handicap firm 1 even if it has delivered $\overline{q}$, she receive $\overline{q}$ and pays $\overline{\theta}$ and her profit is $\left(0 - \overline{\theta}\right)$. At time $t = 1$, under h_A, firm 1 wins the competitive tendering at price $p_1^A = \overline{\theta} - h_A$ and, according to s_t^1, it delivers zero quality. Since $t = 2$ on, the buyer and the efficient firm revert to their strategy, that is firm 1 reverts to $\overline{q}$ and wins all the competitive tenderings at price $p_1 = \overline{\theta}$ and no handicap is applied, then the buyer gains $\left(\overline{q} - \overline{\theta}\right)$ in every period. Thus the necessary condition for the buyer not to cheat is:

$$\overline{U} \geqslant U_A \tag{40}$$

that holds for every $\delta \in [0, 1]$ when $\overline{q} \geq h_A$. Hence, the buyer always respects her strategy only for sufficiently small level of handicapping[9]. ∎

Although handicapping is such that the most efficient firm keeps winning the competitive tendering, cheating is not a so optimum strategy as it seems. There are two effects working at this level: cheating on q will directly increase the utility

[8] Since we will show that under a handicap $h > \overline{\theta} - \underline{\theta}$ the strategy s_t^1 will not characterize a SNE as well, then without the assumption $2\psi\left(\overline{q}\right) < h_A$ our model collapses.

[9] Since we assume $h_A \geq 2\psi\left(\overline{q}\right)$ and $\overline{\theta} - \underline{\theta} > \psi\left(\overline{q}\right)$, the necessary condition for $\overline{q} > h_A$ to holds is $\overline{q} > 2\psi\left(\overline{q}\right)$.However, whether the condition $\overline{q} \geq h_A$ holds or not depends on the slope of the variable cost. In particular, since $\psi\left(\overline{q}\right)$ is convex, the choice of a level $\overline{q}$ such that $\overline{q} > 2\psi\left(\overline{q}\right)$ depends on the slope and the degree of convexity of $\psi\left(.\right)$. However, it is straightforward to show that whenever the slope of $\psi\left(.\right)$ is lower than one then there always exists a level of $\overline{q}$such that $\overline{q} > h_A$ holds. On the other hand, it is also straightforward to show that when the slope of $\psi\left(.\right)$ is always higher than one, then we always have $\overline{q} < 2\psi\left(\overline{q}\right)$ then $\overline{q} < h_A$.

Furthermore, if we assume a linear variable cost $\psi\overline{q}$ with slope $\psi < \frac{1}{2}$, then the necessary condition for $\overline{q} > h_A$ to hold is always respected.

of the contractor, nevertheless this handicap will induce the efficient firm to charge a lower price in order to win the next competitive tenderings. When the variable cost of producing q is sufficiently low then the gain from cheating on q is also low therefore firm 1 prefers not to cheat at $t = 0$ and gain the "cooperative" profit over time rather than cheat and winning the next competitive tenderings at a lower price.

B) $h > \overline{\theta} - \underline{\theta}$. Let h_B be a level of handicap strictly higher than $\overline{\theta} - \underline{\theta}$. In this scenario firm 2 wins the competitive tendering and the static equilibrium bids and profits are:

$$p_1^B = \underline{\theta} \tag{41}$$

$$p_2^B = \underline{\theta} + h_B \tag{42}$$

$$\pi_1^B = 0 \tag{43}$$

$$\pi_2^B = h_B - \overline{\theta} + \underline{\theta} \tag{44}$$

LEMMA 2. *When* $h > \overline{\theta} - \underline{\theta}$*, the efficient firm never respects* s_t^1 *and finds it optimal to deliver* q^**, then* s_t^1*,* s_t^b *and* s_t^2 *cannot characterize a SNE of* G^∞*.*

Proof. We show that the strategy of firm 1, s_t^1, can not characterize a SNE. Since the respect of the strategy s_t^1 is a sufficient condition for strategies s_t^1, s_t^b and s_t^2 to characterize a SNE of G^∞, we can avoid the analysis of strategy s_t^b. Again consider the repeated game starting at $t = 0$. Since under h_B firm 2 wins the next competitive tendering we now need to consider also the quality choice of firm 2. The rest of the proof proceeds over two steps. **1)** Firstly, we show that in every period of the repeated game firm 2 always delivers q^*(that is, it never delivers a positive quality). Assume that firm 2 delivers $\overline{q}$; in this case it gains $\pi_2 = h_B - \overline{\theta} + \underline{\theta} - \psi(\overline{q})$; however, according to the strategy s_t^b, no handicap will be applied in the next period, then firm 2 will lose the next competitive tendering. On the other hand, if firm 2 delivers $q = 0$ it gains π_2^B as in (44); in this case firm 2 will be handicapped and will lose the next competitive tendering as well. Hence, given $\pi_2 < \pi_2^B$, firm 2 always cheats on quality under h_B. **2)** Secondly, consider firm 1. Now we shows that firm 1 always prefers to cheat on quality (deliver $q^* = 0$) instead of delivering $\overline{q}$. Given the result in point 1, by Proposition 2 the bidding advantage of firm 1 becomes $\widetilde{\Delta} = \overline{\theta} - \underline{\theta} + h_B$. Thus, the equilibrium bid in (15)-(16) implies that firm 1 wins the competitive tendering by bidding $p_1^* = \overline{\theta} + h_B$. Let $\widetilde{\pi}_{1,\overline{q}}$ denote the profit firm 1 gains by bidding $p_1^* = \overline{\theta} + h_B$ and providing $\overline{q}$, then:

$$\widetilde{\pi}_{1,\overline{q}} = h_B + \overline{\theta} - \underline{\theta} - \psi(\overline{q}) \tag{45}$$

Deviation entails that firm 1 produces $q^*(q = 0)$ for one period and then revert to $\overline{q}$. When firm 1 deviates its discounted profit is:

$$V_1^B = \pi_1 + \delta(0) + \delta^2 \widetilde{\pi}_{1,\overline{q}} + \sum_{t=3}^{\infty} \delta^t \overline{\pi}_1 \tag{46}$$

If firm 1 deviates at $t = 0$ its current profit is π_1. At $t = 1$ it will be handicapped and the competitive tendering will be won by firm 2, then firm 1 gains zero. By point 1, we know that firm 2 always delivers $q^* = 0$, then it will be handicapped as well at time $t = 1$[10], therefore, at time $t = 2$, firm 1 wins again the competitive tenderings but at price $p_1^* = \overline{\theta} + h_B$. However, since $t = 2$ on firm 1 reverts to $\overline{q}$, then it gains $\overline{\pi}_1$ from $t = 3$ on. The condition for firm 1 to always deliver $\overline{q}$ is:

$$\overline{V}_1 > V_1^B \tag{47}$$

that never holds for every $\delta \in [0,1]$[11][12]. ∎

Lemma 2 says that when the handicap is higher than the bidding advantage of firm 1, the efficient firm never respects its strategy s_t^1. The reason is that firm 2 finds it optimal not to deliver quality in every period. In particular, firm 1 finds it more profitable providing zero quality, losing the tendering for one period and being reawarded the contract when firm 2 is handicapped rather than delivering $\overline{q}$ for ever.

Once shown that a too harsh handicap does not induce the most efficient firm to deliver $\overline{q}$, we know that under h_B the strategies in definition 1-3 will never characterize a SNE. Thus the only handicap we can consider is h_A. However, to show that the handicap h_A is SNE we need to check for the credibility of s_t^b. We do that in proof of the following Proposition:

PROPOSITION 3. *When $h_A = \overline{\theta} - \underline{\theta}$ and $\widetilde{\delta}_A \leq \delta$, s_t^b, s_t^1 and s_t^2 characterize a SNE of G^∞ in which in every period the efficient firm is awarded the contract and it delivers $\overline{q}$.*

Proof. Given the results in Lemma 1-2, the last step to characterize the SNE is finding whether the level h_A makes the strategy punishment in s_t^b credible for the buyer. The punishment is credible when, given the choice of the contractor, the action played by the buyer really represents her best reply. Now considering that the buyer can react to the opportunistic firm by using $h = \{0, h_A, h_B\}$, then finding the credible punishment is equivalent to find which level of h allows the buyer the highest utility given that the contractor has cheated. Since, by Lemma 2, s_t^b, s_t^1 and s_t^2 cannot characterize a SNE under h_B, in order to find the most credible handicap we focus only on h_A[13] . Under h_A, once the punishment gets started the buyer gains $U_A = \left(0 - \overline{\theta} + h_A\right) + \frac{\delta}{1-\delta}\left(\overline{q} - \overline{\theta}\right)$; this is maximized at the highest value of h_A that is $h_A = \overline{\theta} - \underline{\theta}$[14], then $h_A = \overline{\theta} - \underline{\theta}$ represents the credible strategy. ∎

[10] We recall that handicapping at time $t = 1$ entails that the reduction in the score will be applied on the scoring rule at time $t = 2$

[11] By rewriting inequality $\overline{V}_1 > V_1^B$ we have $\frac{1}{1-\delta}\overline{\pi}_1 > \pi_1 + \delta^2\widetilde{\pi}_{1,\overline{q}} + \sum_{t=3}^{\infty}\delta^t\overline{\pi}_1$, that simplified becomes $\delta^2 h - \delta\left(\overline{\theta} - \underline{\theta} - \psi\right) + \psi < 0$. This holds for every $\frac{(\overline{\theta}-\underline{\theta}-\psi)-\sqrt{(\overline{\theta}-\underline{\theta}-\psi)^2-4h\psi}}{2h} \leq \delta \leq \frac{(\overline{\theta}-\underline{\theta}-\psi)+\sqrt{(\overline{\theta}-\underline{\theta}-\psi)^2-4h\psi}}{2h}$. However, it is straightforward to show that $\frac{(\overline{\theta}-\underline{\theta}-\psi)+\sqrt{(\overline{\theta}-\underline{\theta}-\psi)^2-4h\psi}}{2h} < 0$.

[12] The threat of firm 1 is credible because, according to the strategy s_t^1, in the period of punishment firm 1 delivers $q^* = 0$ (that is its short-run best reaction).

[13] We recall that $2\psi(\overline{q}) < h_A \leq \overline{\theta} - \underline{\theta}$

[14] In fact, is it possible to see that when $h_A = \overline{\theta} - \underline{\theta}$ we have $U_A = (-\underline{\theta}) + \frac{\delta}{1-\delta}\left(\overline{q} - \overline{\theta}\right)$ that is also higher than the utility of the buyer when $h = 0$ (that is $U_A = \frac{1}{1-\delta}\left(-\overline{\theta}\right)$)

Proposition 3 highlights the trade off from handicapping and confirms the intuition according to which a strong handicap as deterrence for moral hazard on quality does not effectively benefit the buyer when the contract is awarded by a competitive tendering. In particular, proposition 3 says that the best strategy for the buyer is to punish the cheating efficient firm by choosing a level of handicap that makes the heterogeneous competitors more symmetric. A too harsh handicap makes the buyer worse off because of two effects. First, when the handicap is higher than the bidding advantage of the efficient firm, the less efficient supplier wins the next competitive tendering by bidding less aggressively and providing zero quality; second, this behavior induces the efficient firm to behave opportunistically: it prefers losing the tendering for one period but be reawarded the contract at less aggresive condition when firm 2 is handicapped.

Proposition 3 also shows that the optimal handicapping strategy does not only depend on the performance but also on the degree of asymmetry among the competitors. Consider $h = \overline{\theta} - \underline{\theta}$. It is straightforward to see that the willingness of the efficient contractor to delivery quality $\overline{q}$ over time is increasing in the asymmetry between the competitors $\left(\overline{\theta} - \underline{\theta}\right)$ [15]. When the competitors are very asymmetric the buyer needs a harsh handicap to make more effective the threat of switching contractor and induce the efficient firm to deliver $\overline{q}$. In fact, in the extreme case of perfect symmetry $(\overline{\theta} - \underline{\theta} = 0)$ the efficient firm will never deliver $\overline{q}$ in every period. In particular, when the firms are identical the buyer does not need the threat of switching contractor in order to induce the firm to deliver $\overline{q}$. Nevertheless, when no handicap is applied the contractor has incentive to behave opportunistically[16].

5. CONCLUSIONS

This paper provides a solution to deter ex post moral hazard in repeated procurement when the quality delivered by the contractor is not verifiable by a third part. We have considered a framework in which a long-run relationship between a buyer and an efficient seller is built on a series of short-run contracts. In principle, the presence of a less efficient supplier puts an upper bound to the incumbent seller's profit per-period profit. However, the efficient seller may be tempted to increase its profit by not delivering the agreed level of (unverifiable) quality.

We have then explored how the buyer would optimally use a discipline device that consists in altering at her discretion the incumbent seller's score in subsequent competitive tendering (handicapping). In other words, what would happen if the buyer could resort to an indirect punishment device that goes through the modification of the "playing field" between the two competitors? Our answer is that extreme forms of punishment are never credible, that is, it is never in the buyer's interest to kick the deviant incumbent out of the playing field. The buyer's optimal strategy is, rather, to perfectly level the playing field for once if the incumbent had deviated from the cooperative strategy (i.e., deliver the agreed level of quality).

There are at least two directions for further investigation. First, we have implicitly assumed that both the buyer and the incumbent contractor observe a perfectly

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[15] We recall that, under $h_A = \overline{\theta} - \underline{\theta}$, the condition for the efficient firm to deliver $\overline{q}$ is $\frac{\psi(\overline{q})}{h_A - \psi(\overline{q})} \leq \delta$. Given $\delta \in [0,1]$, the willingness to respect $\overline{q}$ over time is $\left(1 - \frac{\psi(\overline{q})}{\overline{\theta} - \underline{\theta} - \psi(\overline{q})}\right)$ that is increasing in $\left(\overline{\theta} - \underline{\theta}\right)$.

[16] However, by the assumption $\overline{\theta} > \underline{\theta} + \psi(\overline{q})$, we rule out the case of perfect symmetry between firms because when $\overline{\theta} - \underline{\theta} = 0$ the profit gained by the contractor would be $\overline{\pi}_1 < 0$.

correlated signal about delivered quality. It would be worth testing the robustness of our predictions when the two signals are imperfectly correlated as in McLeod (2003). Secondly, the assumption of complete information about firms' efficiency levels is instrumental to buyer for fine-tuning the optimal handicapping strategy. When the buyer is uncertain about firms' costs the former has to rely on equilibrium bids to learn about firms' efficiency levels. The interaction between learning and handicapping certainly deserves a closer attention.

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