DYNAMIC YARDSTICK REGULATION*

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Abstract

This paper shows that the inability of regulators to commit to long-term contracts is irrelevant when there is some competition between regulated firms and when firms' private information is correlated. This sharply contrasts with the dynamic of regulation without such competition. The paper also explores what limitations on yardstick mechanisms can justify the use of long-term contracts. We found that the inability of a regulator to commit not to renegotiate long-term contracts is without consequences even if there is a bound on transfers that a firm can be asked to pay. In contrast, short-term contracting fails to implement the commitment solution with constraints on transfers. Second, absent current competition, the possibility of future entry allows the regulator to implement the first-best with a renegotiation-proof long-term contract whereas this cannot be achieved with short-term contracting.

Keywords: Yardstick regulation; ratchet effect; short and long-term contracts; commitment.
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1 Introduction

Twenty years ago, most regulated firms were operating as monopolies. It has been recognized both in academic circles (Baron and Myerson 1982, and Laffont and Tirole 1986) and among practitioners, that regulating those firms is a task made particularly difficult by the extent of private information. Since regulators are viewed to be at an informational disadvantage with respect to firms, regulatory schemes must be designed to elicit hidden information. This task appears even more daunting in a dynamic context. Repeatedly eliciting private information from regulated firms introduces additional difficulties when regulators cannot fully commit to future regulation (Laffont and Tirole 1988, 1990). In contrast, when regulatory commitment is absolute, the dynamic incentive problem becomes essentially static (see Baron and Besanko, 1984). The impossibility to fully commit to future regulatory schemes seems the right assumption to make both on empirical grounds (for instance in the U.K., regulatory contracts, although unusually long, typically do not last for more than 5 to 7 years) and from a theoretical point of view. For instance, it seems difficult to ban pareto improving renegotiation.

Nowadays, the picture of regulated industries has drastically changed. Almost all regulated firms evolve in a competitive framework or under the threat of possible entry by competitors. It has already been argued that such an evolution makes the task of regulators easier (e.g. Shleifer 1985, and Armstrong, Cowan and Vickers 1994): competitors are likely to have some information (maybe private) about the incumbent's private information and regulators should find a way to extract this additional information in order to be less at an informational disadvantage than absent competition.[1] This paper presents a novel argument: not only can competition make the task of regulators less difficult but it can also make regulators better at performing it.

It is well known that in a repeated regulatory framework, regulators may suffer from the ratchet effect: if a firm at a given period indicates that its costs are low, the regulator has an incentive to impose more stringent regulatory constraints later on. Anticipating this effect, the firm is more reluctant initially to reveal its greater efficiency since by not doing so, it can enjoy extra rents in the present as well as in the future. It is also known that in a *static* framework regulators can extract information more easily if the market is shared with other firms and if information across firms is correlated. Along the lines of Crémer and McLean (1985, 1988) or McAfee and Reny (1990), one can design transfers for a firm reporting a high cost level that depend on the competitor's cost report in such a way that they leave no rent to a true high cost firm while simultaneously penalizing a low cost firm for lying about its type.[4] This is possible because a high cost firm and a low cost firm face different cost distributions for their competitor if one assumes that competing firms' costs are interdependent.

We first extend this result to a dynamic setting by showing that regulators can implement first best outcomes at every period. Second, we show that this is possible with a sequence of short term contracts. Commitment is not an issue because even if the lack of it does prevent the regulator from simply offering the repetition of the optimal static correlated mechanism, the regulator can design initial transfers that still induce full revelation of costs in the first period, without giving up rents. Thus, neither the extent to which private information can be screened nor the efficiency of the contracting solution depend on the assumption of perfect commitment. Similarly, the difference between spot contracting and long-term

[1] Yardstick mechanisms are now used in regulation over a wide range of markets. Examples are Medicare's reimbursement policy of hospitals (Dranove 1987), the regulation of electricity supply (Kumbhakar and Hjalmarsson 1998), of the water industry (Cowan 1997) and of telecommunications (FCC 1997).

[4] The discussion implicitly considers the case of a binary cost distribution.

contracting with renegotiation disappears.[5] The ratchet effect is washed out by the use of correlated mechanisms. This result is shown to hold true for any time horizon, any discount factor and any degree of correlation.
We then investigate what limitations are likely to make long term contracting worthwhile when firms' information is correlated. We first show that long-term contracts allow the regulator to implement repeated yardstick competition even if she is unable to commit not to renegotiate those long-term contracts. This has the additional benefit of reducing the variability of per-period transfers, making it easier to satisfy limited liability constraints. We also show that long term contracting allows the regulator to extract all rents using the sole *threat* of future entry by competitors with correlated cost structures and that this threat remains powerful even without commitment not to renegotiate. These last results will not hold if only short term contracting is possible. Notice that in any case, the regulator inability to commit not to renegotiate is of no consequence.

Some limitations of yardstick mechanisms have been analyzed by Dalen (1998) and Sobel (1999) in a setting where firms can invest into cost reductions. These papers show that an ex-ante regulatory scheme using yardstick mechanisms can achieve the full-information outcome only if the regulator can commit to such a scheme before investments are undertaken. In contrast, if she cannot commit to a scheme the regulator will expropriate all of a firm's rent by using a correlated mechanism which in turn dilutes investment incentives. Our analysis concentrates on a dynamic interaction instead where firms are regulated repeatedly. Although correlated mechanisms might be inefficient in solving hold-up type problems as in this literature, we show they perform well when dealing with the ratchet effect.

Beyond regulatory settings, we believe our results to be relevant for several contract theory applications. The fact that correlated mechanisms implement first best outcomes has often been viewed as troublesome for contract theory because it introduces a discontinuity between the case of uncorrelated and correlated information. In the former situation, the principal can only implement a second best allocation that can be very inefficient relative to the outcome under full information, whereas in the latter the first best obtains, no matter how weak correlation is.[6] This paper shows that a situation in which agents' private information is correlated starkly departs from the situation of uncorrelated information in another respect: in a correlated world, the inability of a principal to commit to long term contracts does not matter. Our findings may thus have implications for the literature on the Coase conjecture (as in Hart and Tirole 1988), a manifestation of the lack of commitment of a durable goods monopolist, which could turn out to be not so severe if consumers have correlated valuations. They may also matter for the theory of organizations. For instance, Olsen (1996) makes the point that integration of several units in one firm may be suboptimal if aggregation increases the scope for ratcheting. This conclusion could be reversed if subdivisions have correlated private information. Another range of applications regards the structure of supervision. Typically, a supervisor in charge of overseeing an agent observes a signal correlated with the agent's private information. The dynamics of supervision could be free of ratcheting as the commitment of the principal would not be an issue.

A standard criticism of yardstick mechanisms is that they impose substantial risk on the privately

[5] Rey and Salanie (1996) characterize conditions under which either spot contracting or short term (two-period) contracting can implemement the long-term renegotiation-proof optimum in a setting with only one agent. They show that the conditions needed for the former are considerably more stringent.

[6] To our knowledge, only two approaches have attempted to bridge the gap between the two settings. Using the fact that with very small correlation, truth telling requires submitting agents to highly risky bets, Robert (1991) and Kosmopoulou and Williams (1998) show that the usefulness of correlated mechanisms vanishes when correlation goes to zero if agents are risk averse and/or if a bound on the magnitude of transfers is imposed (see also Demougin and Garvie 1991). Laffont and Martimort (2000) and Faure-Grimaud, Laffont and Martimort (2001) have shown that correlation can help agents to collude which may prevent the principal from making use of correlated mechanisms.

informed parties, or may conflict with the limited liability of those parties. A first reading of our results is that, if correlation is to be taken seriously, implications of lack of regulatory commitment should be studied in environments where agents have non linear preferences[7] or cannot be penalized by too negative transfers. Beyond this minimal interpretation, we believe the relevance of such criticisms to be limited in our context. Regulated firms tend to be large public firms with many fully diversified shareholders (institutional investors, pension funds etc.) and so should not be expected to be too risk averse. For instance, Enron's preferences have not been suspected of exhibiting risk aversion. Large regulated firms are also less likely to be in breach of limited liability even when substantial penalties are imposed on them. As of today, the State of California is trying to induce the Federal Energy Regulatory Commission to impose a \$9billion fee on electricity companies, including the bankrupted Enron. This would be a large negative transfer.

We first present a simple model of regulation. Section 3 shows that first best regulation can be implemented by a sequence of short term contracts. Section 4 presents two extensions. First, we consider limits on negative transfers. Second, we analyze regulation of an incumbent firm that operates under the threat of future entry. A final section contains conclusions about the interplay of deregulation and competition.

2 The Model

Consider a Baron-Myerson model of procurement as follows:

∘ Agents: two firms $i = \{1, 2\}$ have to produce a quantity q^i of consumption good. The cost of production for each firm is $\theta^i q$. Hence, the total cost of producing $q = q^1 + q^2$ units is $\theta^1 q^1 + \theta^2 q^2$. This production generates a consumer surplus of $R(q^1, q^2)$.

∘ Information: for both firms, assume θ^i takes value in $\{\theta_1, \theta_2\}$, with $\Delta\theta \equiv \theta_2 - \theta_1 > 0$. We assume that the exact realization of θ^i is private information to firm i. It is common knowledge that these random variables are drawn from a discrete probability distribution $(p_{nk})_{n,k=1,2}$, where p_{nk} is the probability that firm i's cost is equal to θ_n and firm j's cost is equal to θ_k.[8] We denote by $\rho \equiv p_{11}p_{22} - p_{12}p_{21}$ the correlation coefficient and we make the convention that $\rho > 0$, i.e. types are positively correlated.

∘ Contracts: to regulate this activity, an agency offers contracts to firms which specify a monetary transfer t^i to each firm, and a quantity to be produced q^i. We focus on direct mechanisms, where each firm is asked to make a report about its type.[9] We denote by $q^{i\tau}_{nk} \equiv q^{i\tau}(\hat{\theta}_n, \hat{\theta}_k)$ and $t^{i\tau}_{nk} \equiv t^{i\tau}(\hat{\theta}_n, \hat{\theta}_k)$, the production implemented and the transfer to firm i at time τ, when firm i reports $\hat{\theta}_n$ and firm j reports $\hat{\theta}_k$.

∘ Timing: there is an initial period 0, in which firms' costs are realized, and $T - 1$ periods of production, indexed by τ. We denote by δ the common factor used to discount payoffs that accrue later in time. The sequence of events unfolds as follows:

[7] To the best of our knowledge, the entire literature on regulation has retained risk neutrality as the most appropriate assumption (one exception being Laffont and Rochet 1998).

[8] This formulation implies that firms are symmetric, i.e. $p_{nk} = p_{kn}$. There would be no qualitative change in the results if we assumed firms to be asymmetric.

[9] Without commitment, the Revelation Principle cannot be used to ensure that restricting attention to direct mechanisms is without loss of generality. However, we are going to characterize contracts that implement the first best so that there is no need to consider more general mechanisms.

i) Period 0
- firms receive private information about their costs.

ii) Periods $1 \leq \tau \leq T-1$
- each period the regulator makes a contract offer which, unless specified otherwise, is valid for period τ only.
- firms simultaneously accept or reject this contract. If one rejects, no production takes place for this period and no transfers are paid.
- firms make reports to the regulator, production and transfers take place.

Denoting by λ the cost of public funds, the intertemporal expected utilities of the different players are:

- for firm i of type θ_n :

$$EU_n^i \equiv \sum_{\tau=1}^{T} \sum_{k=1}^{2} \delta^{\tau-1} \frac{p_{nk}}{p_{n1}+p_{n2}} \left(t_{nk}^{i\tau} - \theta_n q_{nk}^{i\tau}\right)$$

- for the regulator:

$$EW \equiv \sum_{\tau=1}^{T} \sum_{n,k=1}^{2} \delta^{\tau-1} p_{nk} \left(R(q_{nk}^{1\tau}, q_{kn}^{2\tau}) - (1+\lambda)\left(t_{nk}^{1\tau} + t_{kn}^{2\tau}\right) + u_{nk}^{1\tau} + u_{kn}^{2\tau}\right)$$

where $u_{nk}^{i\tau} \equiv t_{nk}^{i\tau} - \theta_n q_{nk}^{i\tau}$. Absent asymmetric information, the regulator would set $u_{nk}^{i\tau} = 0$ and would choose first best quantities $q_{nk}^{i\tau} \equiv q_{nk}^{i*}$, for all $1 \leq \tau \leq T-1$, so that marginal benefit of production equals marginal (social) cost:

$$\frac{\partial R(q_{nk}^{1*}, q_{kn}^{2*})}{\partial q^1} = (1+\lambda)\theta_n \quad (1)$$

$$\frac{\partial R(q_{nk}^{1*}, q_{kn}^{2*})}{\partial q^2} = (1+\lambda)\theta_k. \quad (2)$$

3 The Optimal Sequence of Short Term Contracts

We start by observing that the problem is not trivial when parties can only write short term contracts: it is *not* the case that the first best can be implemented at every period by just repeating the optimal static yardstick contract. If firms and regulators cannot commit to long term contracts, the repetition of the optimal static contract is not implementable because the beliefs of the parties change over time: as long as some information is revealed, firms' information about their competitor is modified and so are the conditions for participation and incentive compatibility. However, we now construct an equilibrium where the regulator can circumvent her lack of commitment and still implement the first best outcome in all periods, with full separation of types.

Suppose that indeed the regulator can achieve full separation in the first period and assume that she has received a report of (θ_n, θ_k). Then, starting with any period $\tau > 1$, the regulator faces no more incentive constraints. Still, the subsequent short term contracts have to be individually rational, i.e.: $u_{nk}^{i\tau} \geq 0$.

The optimal short term contract entails setting

$$q_{nk}^{i\tau} \equiv q_{nk}^{i*} \text{ and } t_{nk}^{i\tau} = \theta_n q_{nk}^{i*}, \tag{3}$$

resulting in zero rent at every period $\tau > 1$ for a firm that has reported truthfully in the first period. Although sufficient for efficiency, it is worth noting that the condition on transfers is not necessary, as will become clear later.

Coming back to the first period, a firm i with type θ_1 will truthfully reveal its type iff:

$$\begin{aligned} p_{11}u_{11}^{i1} + p_{12}u_{12}^{i1} \quad \geq \quad & p_{11}\left(t_{21}^{i1} - \theta_1 q_{21}^{i1}\right) + p_{12}\left(t_{22}^{i1} - \theta_1 q_{22}^{i1}\right) \\ & + (\delta + \delta^2 + ... + \delta^{T-1})\Delta\theta(p_{11}q_{21}^{i*} + p_{12}q_{22}^{i*}), \end{aligned} \tag{4}$$

as pretending in the first period that its costs are high results in the firm saving $t_{2k}^{i\tau} - \theta_1 q_{2k}^{i*} = \Delta\theta q_{2k}^{i*}$ forever. A firm i with type θ_2 will reveal its cost iff:

$$p_{21}u_{21}^{i1} + p_{22}u_{22}^{i1} \geq p_{21}\left(t_{11}^{i1} - \theta_2 q_{11}^{i1}\right) + p_{22}\left(t_{12}^{i1} - \theta_2 q_{12}^{i1}\right) \tag{5}$$

This second incentive constraint uses the fact that a θ_2 firm that understates its first period cost can refuse to produce in any subsequent period (the "take the money and run" strategy as identified by Laffont and Tirole 1988, 1993). Remark that if we assume a slightly stronger commitment power by firms, namely, that they can be asked to commit to produce for several periods, an additional negative term $-\frac{1-\delta^T}{1-\delta}\Delta\theta(p_{21}q_{11}^{i*} + p_{22}q_{12}^{i*})$ will appear on the right-hand-side of (5): by pretending to be a low cost firm, the high cost firm commits itself to produce a high quantity and receives a low compensation for all consecutive periods. Since this makes it easier to satisfy the incentive constraint, showing that the first-best can be achieved under spot contracting automatically proves the same result for renegotiation-proof long-term contracts.[10]

Given that in a separating equilibrium firms obtain no rents in future periods, such a contract will be individually rational for firm i in period 1 iff:

$$p_{n1}u_{n1}^{i1} + p_{n2}u_{n2}^{i1} \geq 0 \qquad \forall n = 1, 2 \tag{6}$$

Setting the first period quantities to their first best levels, the principal leaves no rents to the firms and ensures their acceptance of the contract by choosing:

$$u_{11}^{i1} = u_{12}^{i1} = 0, \tag{7}$$

$$u_{21}^{i1} = \frac{-p_{22}}{\rho}\frac{1-\delta^T}{1-\delta}\Delta\theta(p_{11}q_{21}^{i*} + p_{12}q_{22}^{i*}), \quad u_{22}^{i1} = \frac{p_{21}}{\rho}\frac{1-\delta^T}{1-\delta}\Delta\theta(p_{11}q_{21}^{i*} + p_{12}q_{22}^{i*}) \tag{8}$$

This utility profile satisfies the previous dynamic incentive constraints. We can now state our main result:

[10] Incentive constraints are constructed with 'passive' beliefs by the regulator following a "take the money and run" strategy. After a firm's claim in period $\tau = 1$ that it is of type θ_1 and its subsequent refusal to produce for some periods $\tau > 1$, the regulator should continue to believe that the firm is indeed of type θ_1 and thus should offer the efficient allocation (defined in (3)) for this type. We claim that these beliefs are the only ones consistent with equilibrium behavior in the continuation game starting from period 2. This is because any more favorable offer by the regulator after an observed shut-down would also attract the low cost type. Since this type earns zero rent in the equilibrium of the continuation game, this firm does not suffer from a shut-down but would benefit from convincing the regulator that it is actually a deviating high cost type. In order to prevent such an imitation by the low cost type, the regulator has to maintain unchanged beliefs off the equilibrium path.

Theorem: *There is a sequence of short term contracts that implements the first best in any period, for any value of δ and any $\rho \neq 0$. Hence, regulatory commitment is irrelevant.*

Proof: The previous utility profiles leave no rent at any period to the firms. Then maximization of the expected welfare per period is obtained by choosing first best quantities.

It should be clear to the reader that although derived with a binary cost distribution, the result is more general: whenever the regulator can extract all rents in a static framework, her commitment ability is irrelevant in a dynamic setting.[11]

It is indeed true that the lack of commitment of the regulator subjects her to some "ratcheting": she cannot refrain from using in subsequent periods what she has learned in the first. It is also true that this effect creates an extra incentive for firms to misreport their types in the first period. But the yardstick mechanism is powerful enough to make sure that regardless of the size of the extra rents that a firm can secure in future periods, the regulator can recoup them in the first one. This is achieved by increasing the loss a firm would make in the first period, if it were to hide its type, given that the other firm does not and that types are correlated. As the time horizon increases, future gains of initially misreporting an efficient type increase. However the principal can still recoup them, but the risk to which the firm is exposed (here $u_{22}^{i1} - u_{21}^{i1}$) has to increase to maintain incentive compatibility. Notice however that after this first period, the mechanism provides full insurance for all remaining periods. As mentioned in the introduction, concerns about risk aversion seem misplaced in a regulatory setting and have always been ignored by the literature. We investigate the robustness of our result to the introduction of a lower bound on transfers in the following section.

The mechanism has a simple interpretation: firms obtain cost reimbursement (cost-plus-regulation) except possibly in the first period when high costs are reported. Such a firm is put to the test: if the other firm claims that its costs are low, a penalty is imposed. If the other firm also reports high cost, costs are reimbursed and firms receive an extra payoff. This extra transfer is calculated to cover a high production cost in expectation, where the expectation is taken conditionally on the firm telling the truth, i.e. conditional on high cost. But it is also chosen in such a way that a deviating low cost firm receives an expected negative payoff. This is possible since the conditional distribution when a firm has a low cost differs from the one when its cost is high.

Notice that the optimal contract just described is consistent with the observation that yardstick contracts are rarely used in practice, while cost-plus-regulation seems pervasive. The model can provide some justification for this fact as here yardstick mechanisms are used only initially, when a firm claims high cost. After that we should only observe cost-plus-regulation. It is enough to put the firm to the yardstick test once.

4 The Value of Long Term Contracting

We now explore the possibility that long term contracting may achieve more than a sequence of short term contracts in environments where the usefulness of yardstick mechanisms is limited. We study

[11] We refer the reader to Crémer and McLean (1985, 1988) for such conditions. Only in the two type case considered here is non independence sufficient. Otherwise, first best implementation requires the conditional distribution matrix to have full rank.

two such limitations: the first one introduces lower bounds on transfers that can be imposed on firms, the second is concerned with situations where although there are no competitors initially, there is the possibility of entry in the future. We show that even with such constraints, the impossibility of regulators to commit not to renegotiate regulatory contracts does not matter.

4.1 Lower Bound on Transfers and Regulatory Commitment

Considering the previous sequence of short term contracts, a high cost firm is subject to some risk as the first period transfers it receives along the equilibrium path are:

$$t_{21}^{i1} = \theta_2(p_{11}q_{21}^{i*} + p_{12}q_{22}^{i*}) - \frac{p_{22}}{\rho}\frac{1-\delta^T}{1-\delta}\Delta\theta(p_{11}q_{21}^{i*} + p_{12}q_{22}^{i*}), \tag{9}$$

$$t_{22}^{i1} = \theta_2(p_{11}q_{21}^{i*} + p_{12}q_{22}^{i*}) + \frac{p_{21}}{\rho}\frac{1-\delta^T}{1-\delta}\Delta\theta(p_{11}q_{21}^{i*} + p_{12}q_{22}^{i*}) \tag{10}$$

Consider now the possibility of a lower bound on transfers that can be imposed on a firm. For instance, firms may be protected by limited liability so that we need $t_{nk}^{i\tau} \geq K$ with $K < 0$. Strictly negative transfers can be imposed without violating the firm's limited liability when the firm has several activities and some sources of revenues may not be covered by regulation.[12]

The previous contract is feasible only if:

$$K \leq \theta_2(p_{11}q_{21}^{i*} + p_{12}q_{22}^{i*}) - \frac{p_{22}}{\rho}\frac{1-\delta^T}{1-\delta}\Delta\theta(p_{11}q_{21}^{i*} + p_{12}q_{22}^{i*}),$$

which is equivalent to

$$\frac{\frac{1-\delta^T}{1-\delta}\Delta\theta(p_{11}q_{21}^{i*} + p_{12}q_{22}^{i*})}{\theta_2(p_{11}q_{21}^{i*} + p_{12}q_{22}^{i*}) - K} \leq \frac{\rho}{p_{22}}. \tag{11}$$

Thus, for the previous contract to work we need ρ not too small. Observe that implementing the first best under this limited liability constraint may be more difficult in a dynamic setting than in a static one: the condition is more stringent the higher the number of periods (the left hand side of (11) increases with T, $T = 1$ corresponding to the static condition). However this reasoning is incomplete as it does not distinguish between the different commitment possibilities.

To see why, let us consider first the case where the regulator could fully commit to future contracts. The repeated interactions give the possibility for the regulator to spread penalties over time. For instance, the regulator can at each period offer the same production levels and the same utility profiles as before except for:

$$u_{21}^{i\tau} = \frac{-p_{22}}{\rho}\Delta\theta(p_{11}q_{21}^{i*} + p_{12}q_{22}^{i*}), \quad u_{22}^{i\tau} = \frac{p_{21}}{\rho}\Delta\theta(p_{11}q_{21}^{i*} + p_{12}q_{22}^{i*}) \qquad \forall\tau,$$

The difference with the previous sequence of contracts is that now a high cost firm is subject to a transfer scheme that results in either a negative or a positive utility *in every period,* depending on the report of the other firm. This contract gives the same expected welfare to the regulator as the one of Theorem 1. It also satisfies all the previous constraints. Firms are guaranteed a non negative utility

[12] Demougin and Garvie (1991) provide a detailed analysis of the static case.

in expectation. Incentive constraints are also satisfied as a low cost firm that would deviate in $t = 1$ would expect:

$$p_{11}\left(\Delta\theta q_{21}^{i*} - \frac{p_{22}}{\rho}\Delta\theta(p_{11}q_{21}^{i*} + p_{12}q_{22}^{i*})\right)\left(1 + \delta + \delta^2 + ... + \delta^{T-1}\right)$$
$$+p_{12}\left(\Delta\theta q_{22}^{i*} + \frac{p_{21}}{\rho}\Delta\theta(p_{11}q_{21}^{i*} + p_{12}q_{22}^{i*})\right)\left(1 + \delta + \delta^2 + ... + \delta^{T-1}\right),$$

which is equal to the right hand side of (4). Similarly a high cost firm has no incentive to deviate.

To implement the long term contract the regulator must be able to prevent the "take the money and run strategy" by imposing penalties to a firm that first reports low costs and then stops to produce. Also, the long term contract should prevent a firm which has reported high cost while the competitor reported low cost to exit the market. Therefore, with full commitment, the first best can be implemented whenever:

$$\frac{\Delta\theta(p_{11}q_{21}^{i*} + p_{12}q_{22}^{i*})}{\theta_2(p_{11}q_{21}^{i*} + p_{12}q_{22}^{i*}) - K} \leq \frac{\rho}{p_{22}}, \tag{12}$$

which is identical to the static condition.

This contract where a high cost firm is subject to a yardstick contract at every date is renegotiation-proof. If the firm reveals low cost, the regulator is happy to repay its cost at every period. If the firm initially reports high cost, the regulator repays less than those if the competitor reports low cost, while he repays more if both firms claim high cost. Importantly, the regulator does so in every period. Then, in the first case, the regulator does not want to renegotiate. The firm would like to leave, but the long term contract can have a clause that forbids exit. In the second case, the regulator would like to repay less but the firm refuses to renegotiate.

This optimal renegotiation-proof long term contract cannot be implemented by a sequence of short term contracts. If both firms report high cost in the first period, in future periods, the regulator would not offer a payment that leaves firms with positive rents and so $u_{22}^{i\tau} > 0$ is not implementable for $\tau > 1$. Similarly, if firms announce different cost, the high cost firm prefers to leave the market, since it cannot be forced to receive a negative utility in consecutive periods. In other words, $u_{21}^{i\tau} < 0$ is not implementable for $\tau > 1$.

The regulator's lack of commitment can be circumvented by asking her to pay a high reimbursement in the first period if both firms report high cost as detailed in (10). Such a scheme is feasible since there is no restriction on the *positive* transfers from the regulator to the firm. In all ensuing periods both high cost firms are simply reimbursed their cost. In contrast, the firm's lack of commitment remains a binding constraint due to the bound on negative transfers. In fact, only the sequence of short term contracts of Theorem 1 is subgame perfect so the condition for their implementability when transfers are constrained remains (12).

Putting these observations together gives the following result:

Proposition 1 *Suppose that there exists a lower bound K on the transfers that firms can be asked to pay. Then, whenever the regulator can implement the first best with full commitment, she can do so with long term contracts even if she cannot commit not to renegotiate. For some correlation values a sequence of short term contracts fails to achieve the same outcome.*

Proof: It has already been argued that a long term contract with renegotiation implements the first best whenever full commitment does too. Comparing (11) and (12), whenever (11) is satisfied so is (12) but the converse is not true.

Constraining the yardstick mechanisms to satisfy some limited liability condition does not necessarily make regulatory commitment relevant. First it remains true that some form of lack of commitment is always without consequence: whenever the regulator can implement the first best with full commitment, she can do so with long term contracting and renegotiation. Indeed, long term contracting allows the regulator to impose smaller punishments per period, but for a longer period of time. This is not undone by renegotiation possibilities. Second, there is a welfare loss if the regulator cannot write long term contracts but only for intermediate values of correlation. For these values, the regulator would like to submit the firm who reports high costs to a sequence of yardstick contracts. The impossibility to do so comes from the firm's lack of commitment: a low cost firm that would first deviate could "take the money and run" as it would refuse the yardstick contract which would give it a negative expected utility.

4.2 The Threat of Future Entry

Although many regulated firms have come to share their core markets with newcomers, most of the time the entry process is not over: there remains scope for further entry. We want to investigate the case where instead of being subject to current competition, regulated firms operate under the threat of future entry. We show that in such a situation, a sequence of short term contracts fails to implement the first best, while again there is no loss in having the regulator unable to commit not to renegotiate.

To make this point, we suppose that initially there is only one firm, the incumbent I. We consider the potential entry of one new firm (E) in the future: there is at least a date τ' where firm E enters with probability π.[13] If entry takes place, we assume that E's cost is correlated with the incumbent's. The set-up is as in section 2 except that consumer surplus is written as $R(q^I)$ if only the incumbent is in the market and as $R(q^I, q^E)$ after entry. To keep the analysis in line with the preceding sections, we assume that new entrants are also regulated.[14] For simplicity, we neglect to study the asymmetric information problem between the entrant and the regulator, that is, we do not analyze the optimal contract that allows the regulator to elicit E's cost. A discussion of this problem can be found after the next proposition. Finally we assume now no constraints on feasible transfers.

With full commitment, one can construct a long term contract that leaves no rents to the incumbent. Consider for instance the following contract: the regulator offers a cost plus contract to the incumbent unless entry takes place. If E enters, an incumbent who has reported high cost is submitted to a yardstick contract, calculated so that it imposes expected penalties to a deviating low cost firm high enough to exceed all future rents. We then show:

Proposition 2 *It is enough that there is at least one period in the future where an entrant with correlated cost may enter to implement the first best with a long term contract. This contract is renegotiation-*

[13] Of course, having either entry for sure or multiple entry would not invalidate our results.

[14] We make this assumption to keep some symmetry in the model and to ease the exposure of the argument. If entrants are not regulated, they will possibly enjoy more rents but the impact on the incumbent and the conclusions regarding regulatory commitment will be unchanged.

proof so that the inability of the regulator to commit not to renegotiate is irrelevant. Short term contracting cannot achieve this result.

Proof: see appendix.

There is more than one way to implement the first best with a renegotiation-proof long-term contract as one could submit the high cost incumbent to yardstick contracts for several periods of time (and spread penalties over time as previously). But the contract above is quite simple: the regulator offers a cost plus contract unless the incumbent demands a high cost reimbursement. Then, if entry takes place, the incumbent is put to the test: it receives a transfer that depends on the entrant's cost report. This is renegotiation-proof as it implements the first best along the equilibrium path. For such a contract to work the regulator must be able to prevent the take-the-money-and-run strategy. Otherwise, a deviating low cost incumbent could report high cost and exit the market upon entry of E to avoid being put to the yardstick test. The long term contract has to stipulate penalties for such a behavior, and those are obviously renegotiation-proof.

In fact, there is even a mechanism which is immune to the threat of the take-the-money-and-run strategy: the regulator asks in the first period the incumbent to report a cost level. If the incumbent reports low cost, it gets it reimbursed at every period. If the incumbent reports high cost, it has to pay a fee F initially and then it has its variable cost reimbursed, $\theta_2 q$, at the high cost level. If entry takes place and if the new entrant has high cost, the regulator repays F plus some premium to the incumbent. One can always find F and a premium so that a high cost firm breaks even on average while a low cost firm does not, if it deviates by pretending its costs are high. This contract is implemented even if the regulator cannot commit not to renegotiate and the firm cannot commit not to quit the market at some time in the future.

Consider now a sequence of short term contracts. The first contract described (with future penalties) cannot be implemented with short term contracts because if the regulator cannot specify future penalties to ban exit, a firm can leave the market whenever its expected payoff per period is negative. A low cost firm would then prefer to report high cost and take advantage of the higher reimbursement as long as entry does not occur, and then possibly leave upon entry. Similarly, the second contract described which makes use of an initial fee is not implementable absent long term contracting because we need the regulator to repay a high cost firm following a future entry of a high cost competitor.

In summary, with future competition it is the *simultaneous* inability of both parties to write long term contracts that prevents implementation of the first-best with a sequence of short-term contracts, in contrast to the above subsection where we studied the implication of lower bounds on transfers and where only the firm's lack of commitment mattered.

Notice that here we abstract from discussing the incentive problem for the entrant. The regulator cannot use the *incumbent's* announcement to costlessly extract the entrant's information since the incumbent's cost are known along the equilibrium path. More interestingly, there is a role for sequential entry in this situation. If there is a date $\tau'' > \tau'$ at which a second entrant may enter, the regulator can put the first entrant in exactly the same position as the incumbent before. Therefore, the entrant's private information can be extracted at no cost, except for the last possible entrant (a last mover advantage!). In this perspective, more competition is socially desirable because it delays the rents that have to be given up in order to have the last entrant reveal its cost truthfully. If the pool of potential entrants is larger, welfare goes up by a discounting effect. This argument could be taken as supportive

of the view that instead of being substitute, regulation and competition could complement each other.

4.3 Conclusion

This paper has shown that the dynamics of contracting when agents' private information is correlated strongly differs from the uncorrelated case. This has several implications for regulation. First, it implies that the lack of commitment of regulators to future contracts may have little consequence, a view that strongly departs from existing ones. Second, it provides an explanation for the relatively excessive use (from the viewpoint of incentive theory) of cost-plus-regulation and the minor role played by yardstick mechanism in practice: we show in a dynamic setting that cost-plus-contracts are chosen in every period but one. Third, it suggests that regulation becomes more efficient with competition not only because informational asymmetries are reduced but also because regulatory shortcomings can be circumvented. This paper can provide arguments to challenge the view that the development of competition should necessarily reduce the role of regulators. If indeed more competition reduces the need for regulation, it is shown here that it can also increase its marginal benefits. The overall effect in practical issues is to be determined.

Some further extensions may be considered. At a theoretical level, the recent papers by McLean and Postlewaite (2001, 2001) show that the amount of rent left to agents with correlated private information can be made arbitrarily small if an agent's 'informational size' is vanishing. Their setting differs from ours as they analyze a situation in which an agent receives a private signal correlated with the true state of nature (for example the cost state in our regulatory setting) that affects all agents' utilities simultaneously. Intuitively, an agent is "informationally small" if his signal adds little to the information contained in the aggregate of the other agents' signals. Agents might become informationally small as the number of agents increases, holding fixed the accuracy of each agent's signal. In our framework this could mean that implementing first best regulation can be achieved with relatively little variance in transfers even for small degree of correlation, as the number of competitors in a regulated market increase.

Appendix

Proof of Proposition 3:

Consider a cost plus contract for the incumbent I at every period but possibly at date τ' if E enters. The quantities that I is asked to produce in every period are the first-best levels. These are q_n^{I*} if I has cost θ_n and is alone in the market, i.e. the consumer surplus is $R(q^I)$, and q_{nk}^{I*}, if I has cost θ_n, E has cost θ_k and the market is shared, i.e. the consumer surplus is $R(q^I, q^E)$. Following entry at date τ', a high cost incumbent's transfer payments are $\{t_{2k}^{I\tau'}\}_{k=1,2}$, depending on the cost announcement of the entrant, whereas a low cost incumbent receives his cost.

To check that such a contract implements the first best, notice that a θ_1 incumbent's incentive constraint is satisfied if we can find transfers $t_{21}^{I\tau'}$ and $t_{22}^{I\tau'}$ such that:

$$\begin{aligned} 0 \quad \geq \quad & \textstyle\sum_{\tau<\tau'} \delta^{\tau} \Delta\theta q_2^{I*} \\ & + \delta^{t'} \left[(1-\pi) \Delta\theta q_2^{I*} + \pi \left(p_{11} \left(t_{21}^{I\tau'} - \theta_1 q_{21}^{I*} \right) + p_{12} \left(t_{22}^{I\tau'} - \theta_1 q_{22}^{I*} \right) \right) \right] \\ & + \textstyle\sum_{\tau>\tau'} \delta^{\tau} \left[(1-\pi) \Delta\theta q_2^{I*} + \pi \left(p_{11} \Delta\theta q_{21}^{I*} + p_{12} \Delta\theta q_{22}^{I*} \right) \right] \end{aligned} \tag{13}$$

Indeed, an incumbent firm with low cost obtains zero rent at every period for truthfully reporting its type. Pretending otherwise results in a positive rent of $\Delta\theta q_2^{I*}$ in every period before entry takes place, since the incumbent is a monopolist in the market. Now at date τ', if entry does not take place, the incumbent remains a monopolist and produces that same level forever. If entry does take place, the incumbent is offered a yardstick contract at that date only. In all subsequent periods the incumbent shares the market with the entrant and receives an expected rent of $p_{11}\Delta\theta q_{21}^{I*} + p_{12}\Delta\theta q_{22}^{I*}$. Remark, that we could have also constructed a mechanism which submits the incumbent to yardstick competition for a longer period of time, as in the section on bounded transfers. The incentive constraint of a θ_2 incumbent is trivially satisfied as lying would result in negative rents at every period. So we simply need the two participation constraints to be satisfied, and given the cost plus contract at every period but τ', only the high cost participation remains to be checked. This constraint reduces to:

$$p_{21} \left(t_{21}^{I\tau'} - \theta_2 q_{21}^{I*} \right) + p_{22} \left(t_{22}^{I\tau'} - \theta_2 q_{22}^{I*} \right) \geq 0 \tag{14}$$

Whenever $p_{11}p_{22} - p_{12}p_{21} > 0$, (13) and (14) can both be made binding with appropriate transfers $t_{21}^{I\tau'}$ and $t_{22}^{I\tau'}$, leaving no rents to any type of firm.

This contract is renegotiation-proof: the regulator can forbid a possibly deviating low cost firm to exit the market if entry takes place, to avoid being subjected to the yardstick contract. Since along the equilibrium path the first best is implemented there is no scope for renegotiation.

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