Yardstick competition, franchise bidding and collusive incentives*

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Abstract

Yardstick competition is an incentive regulatory tool which allows the regulator to introduce virtual competition into locally monopolistic industries(Shleifer[1985]). As with any competitive environment, regulated firms may be incited to collude, thereby undermining the efficiency of yardstick competition. In this paper, we study incentives to collude among firms regulated under such a scheme through an infinitely repeated game with two perfectly symmetric firms and by considering some conditions that are propitious to collusion. We find that collusion is harder to sustain when the regulator rewards the truth-telling firm. We also show that, under the condition that the monopoly rights are granted for a sufficiently long period of time, the use of franchise bidding mechanisms to attribute the markets before regulating them using yardstick competition makes collusion relativey harder to sustain when compared to the case where the regulator uses only yardstick competition. We argue therefore that collusion should be harder to sustain under yardstick competition when a franchise bidding mechanism is also used. This result pleads for the use of franchise bidding together with yardstick competition to attribute a temporary monopoly.

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Introduction

As Klein and Gray[1997] noted, reforms seeking to privatize network industries may not be able to bring about long lasting public benefits if governments do not account for problems that are linked to the monopoly segment of the privatized industry. Yardsick competition, a means by which competition may be introduced into locally monopolistic industries (Shleifer[1985]) such as water distribution, public transportations etc., may be a tool for the government or a regulator to address this problem. Under the type of regulation, competition is created because each regulated firm's payments would depend on its performance relatively to that of its peers.

Yardstick competition has been used in various sectors by various countries to introduce competition where market competition is not viable. For instance, the US Medicare Program is essentially a form of yardstick competition (Shleifer[1985], Dranove[1987]). Yardstick competition is also applied in the Japanese railway sector (Mizutani[1997], Okabe[2004]) , the Norwegian bus industry (Dalen and Gomez-Lobo[2003]), and the UK water sector (Cowan[1997]) among others.

As with any competitive environment, yardstick competition could lead to collusive behaviour among firms. Collusion would then undermine the efficiency that such a scheme seek to introduce into the industry in the first place. Notably, the public benefits of introducing competition into such industries could be offset by collusion among the firms. However, collusion among regulated firms under yardstick competition has received relatively little attention in the literature. To the best of our knowledge, this issue has been studied theoretically by Tangerås[2002], and Laffont and Martimort[2000]. The objective of both studies is to characterize the optimal collusion proof yardstick competition. To this end, the authors used a mechanism design framework, where collusion is sustained through a side contract with side transfers among the colluding firms enforced by a benevolent third party. This modelization, noted the authors, can be seen as a short cut to modelizing a collusion that is sustained through a repeated game framework.

They are then able to derive the trade off between incentives and allocative efficiency, given that the regulator has to account for collusion proofness in yardstick competition. The major difference between the two articles resides in that firms may or may not be in possession of private information when writing the collusive side agreement, and consequently, the regulator may exploit internal incentive problem of the collusive side agreement, as in Laffont and Martimort[2000]'s setting.

In this paper, it is also our aim to study how collusive incentives are created or altered when a regulator uses yardstick competition in locally monopolistic markets. However, we will rather focus on self-enforcing collusion[1] using an infinitely repeated game framework. Collusion is more likely if the collusive agreement is easier to sustain without having any recourse to any external third parties under an infinitely repeated game framework. We will also adopt some assumptions that are deemed favorable to sustain collusion. Indeed, when collusion is not sustainable under very favourable conditions, then it would probably be harder to sustain it under more adverse circumstances. One of such condition is that the regulated firms are perfectly correlated. Indeed, one may argue that collusion among asymmetric firms is more difficult to sustain in absence any side payments. According to Cabral[2000], Jacquemin and Slade[1989] and Rothschild[1999], increasing heterogeneity in terms of costs among firms makes coming to a collusive agreement harder[2]. On top of this, we will consider grim trigger strategy games *à la* Friedman[1978].

We will also check into the case to see how collusive incentives are altered when franchise bidding is used simultaneously with yardstick competition to regulate locally monopolistic industries. Some economists have indeed suggested the idea that monopoly right attributed through franchise bidding

[1]We restrict attention to this class of collusion for several reasons: first of all, regulated firms operate in geographically separated areas. This would possibly render explicit collusion harder. Besides, it seems unlikely that judiciairy instances would enforce explicit collusive agreements. Moreover, when collusion is supported by an explicit agreement, the regulator, or the competition authorities, may disposed of other instruments such as leniency programs or whistle-blowing to deter collusion.

[2]For instance, Cabral[2000], in p. 138, states that "*Collusion is normally easier to maintain among few and similar firms*".

could help to destabilize collusion under yardstick competition.

We find that even in an infinitely repeated game, perfectly correlated firms may have some incentives to defect from the collusive strategy under some circumstances. This is true if the regulator may promise high compensation to encourage defecting strategies from firms, in which case yardstick competition can deliver the full information outcome. However, a reward too high may not be realistic, which prompts us to study the introduction of franchise bidding as a tool to destabilize collusive incentives among the firms. We find that this will be the case if the monopoly rights to operate in a market is granted for a sufficiently long period of time, and firms that are regulated using yardstick competition throughout the period for which the monopoly rights are granted are “moderately patient”. Intuitively, this is because firms are not able to credibly commit to share the markets when markets are put up for bids, as they are tempted by the perspective of monopoly rents stemming from both markets should they be able to operate in both the markets. This, in turn, renders collusion harder to sustain when they are regulated by yardstick competition. We also find that the use of franchise bidding may contribute to sustain collusion when firms are very impatient. This is due to the fact that impatient firms can more easily share the markets when the monopoly rights are put up for bids.

Note that it is not in our intention to study the optimal yardstick competition scheme or franchise bidding schemes, nor it is our aim to study the optimal trade off between various schemes.

The paper will be organized as follows: we will begin by setting up a simple static model. The full information case is derived as a benchmark and we show how yardstick competition allows the regulator to extract information rents and promote efficiency. We then study collusive incentives when yardstick competition is used repeatedly to regulate firms in the third section. In the fourth section, we will see how the sustainability of collusion is altered when the regulatory uses an additional franchise bidding mechanism to attribute monopoly rights for the markets while using yardstick competition to regulate firms when they detain the monopoly rights.

1 The static model

1.1 Technology and preferences

We assume that there are two regional monopolies under the supervision of a regulator. In each region, market demand is inelastic and, for simplicity's sake, we will suppose that there is a unit demand which generates a gross consumer surplus $S/2$ in each of the market. Furthermore, we suppose that the gross consumer surplus in each market is such that production will always be desired. This is a rather mild assumption, especially when one is dealing with industries that produces essential infrastructure goods such as water, electricity etc.

Each region is being served by a local firm i, $i = 1, 2$ whose technology is characterized by the following cost function:

$$C_i = \beta_i - e_i$$

Costs depend on an exogeneous productivity parameter β_i and on an effort term. Through putting in an amount of effort, the firms could bring down their costs. We shall suppose that $e_i \geq 0$. However, as the saying goes, "the best of all monopoly profits is a quiet life"(Hicks[1935]), it is therefore natural to think that efforts are costly in terms of disutility to the firms which are operating in monopolistic markets. We note this disutility of efforts by:

$$\phi(e_i), \text{ with } \phi \geq 0, \phi' > 0, \phi'' > 0$$

Thus disutility of efforts is always non negative. It is increasing in effort at an increasing rate.

Since these regional markets are monopolistic in nature, we assume that there is a national regulator already in place to supervise the local firms. The regulator, however, is confronted with an asymmetric information position: he does not exactly know the firms' productivity level β_i nor is he able to monitor efforts e_i of the firms in bring down costs. He can only observe the realized cost of each firms C_i. He is, however, able to disagregate the costs into their components through a adequately designed incentive contract.

While it seems more realistic to assume that the firms' costs would depend on some industry-wide factors and local conditions, for simplicity's sake, we will rather assume that only industry-specific conditions impact on each firm's production costs, that is:

$$\beta_i = \beta, \qquad \forall i = 1, 2$$

This assumption implies that the two firms in the model are prefectly correlated.

Furthermore, let us assumed that β can take two values: $\overline{\beta}$ with probability $1 - v$ and $\underline{\beta}$ with probability v, with $\overline{\beta} > \underline{\beta}$ so that productivity in the industry is high when $\underline{\beta}$ is realized.

We suppose that the regulator will totally compensate the firms for their production costs C_i, while at the same time makes a net transfer t_i to each firms for serving the market. This is an accounting convention usually adopted in the regulatory economics literature. Hence, we can write each firm's rent as

$$U_i = t_i - \phi(e_i)$$

Assuming that the regulator seeks to maximize total social welfare. Since markets are geographically separated, total social welfare in the economy is the sum of social market in each market:

$$\mathscr{W} = S - (1+\lambda)\sum_i(\beta_i - e_i + \phi(e_i)) - \lambda \sum_i U_i$$

where λ is the shadow costs of public funds (Laffont and Tirole[1993]). This notion captures the idea that in order to use 1 monetary unit, public autorities need to raise $(1 + \lambda)$ monetary units.

1.2 Timing of the static game

In the static game, we suppose that the firms will first observe the realized β and it is their private information. The regulator then announces the regulatory contract based on yardstick competition. Refusing to participate in the market(s) leaves the firms with a level of utility U_i^o, which captures the firms' outside options. Without loss of generality, we normalized this utility of reservation to 0. As assumed above, consumer surplus generated by the good is such that its production is always desired. As such, the contracts that the regulator offers must at least satisfy the firms reservation utility. Should the firms choose to participate in the market(s), the regulator will ask for reports of their costs. According to their reports, gross transfers are paid out to the firms as specified in the regulatory contract and each firm meets its designated target.

2 Regulation with yardstick competition

In this section, we will first derive the full information case as a benchmark before studying the use of yardstick competition in an asymmetric information case.

2.1 The full information case

We will now derive the full information case as a benchmark before studying yardstick competition under asymmetric information. When the regulator can fully observe the firms' private information, the choice of the firm is irrelevant given that both firms are symmetric.

In the full information case, the regulator will set the price such as a firm i will be totally reimburse of its costs and costs reducing efforts: $t_i^{FI} = \phi(e^{FI})$, $C^{FI} = \beta_i - e^{FI}, \beta_i \in \{\underline{\beta}, \overline{\beta}\}$. On top of that, cost reduction that is required on the firm i, $i = 1, 2$, will be such that the marginal cost of cost reduction is equal to the marginal benefit of cost reduction. Formally, the first best level of efforts e^{FI} is such that $\phi'(e^{FI}) = 1$.

Note that under full information, the regulator will leave the firms with no rents because rents are costly. Allocation efficiency and production efficiency can be achieved, since the regulator shares the same information as the firms.

2.2 The asymmetric information case and yardstick competition

Let us now turn to the case where the regulator can observe the firms' realized costs, but does not know the true value of β_i nor monitors the level of effort . The regulator, however, knows the distribution of the β_i. Appealing to the revelation principle, we could restrict our attention to direct revelation mechanisms, where the regulator commits to some transfer and the cost target according to firms' direct reports on their β_i. In a nutshell, we could characterize the direct revelation mechanism in our case as the pair $\{t(\tilde{\beta}_i), C(\tilde{\beta}_i)\}_{\tilde{\beta}_i \in \{\underline{\beta}, \overline{\beta}\}}$, where $\tilde{\beta}_i$ is firm i's report on the industry-wide productivity parameter, $C(\tilde{\beta}_i)$ is the cost target for report $\tilde{\beta}_i$ and $t(\tilde{\beta}_i)$ is the transfers associated with report $\tilde{\beta}_i$.

In the event that the regulator ignores his asymmetric information position and proposes the full information contract, and that $\overline{\beta}$ is realized, it is straightforward to show that a regulated firm will have an incentive to truthfully report $\overline{\beta}$: cheating on the regulator will left the firm with negative rents. On the contrary, when $\underline{\beta}$ is realized, a firm reporting $\tilde{\beta}_i = \overline{\beta}$ would have utility:

$$\begin{aligned} U_i(\tilde{\beta}_i = \overline{\beta}, \underline{\beta}) &= \phi(e^{FI}) + (\overline{\beta} - e^{FI}) - (\underline{\beta} - e^{FI} + \Delta\beta) - \phi(e^{FI} - \Delta\beta) \\ &= \phi(e^{FI}) - \phi(e^{FI} - \Delta\beta) \end{aligned}$$

that is $U_i(\tilde{\beta}_i = \overline{\beta}, \underline{\beta}) > 0$. The firm will therefore have incentives to cheat on the regulator with an untruthful report. In doing so, it would gain in rents amounting to $\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)$. Notice here that the informational rents that accrues to the efficient type firm is measured in terms of economy of disutility of efforts given its superior technology. In order to ensure truthful revelation of β_i, the regulator will have to design a mechanism that allows him to solicit the firms' private information. One of such mechanisms is yardstick competition as the regulated firms are perfectly correlated.

Under yardstick competition, the firms' payoffs will be conditionned on their own report and the report of the other firm. Let us note $(t_i(\tilde{\beta}_i, \tilde{\beta}_j), C_i(\tilde{\beta}_i, \tilde{\beta}_j))$ the transfer/cost contract for firm i when it reports $\tilde{\beta}_i$ while its counterpart reports $\tilde{\beta}_j$. Given that the productivity parameter is perfectly correlated, and that firms do not have any incentive to report $\underline{\beta}$ when the realized productivity parameter is $\overline{\beta}$, any incompatible reports will allow the regulator to know that: (i) the true realized productivity parameter is $\underline{\beta}$, and; (ii) the firm reporting $\tilde{\beta}_i = \overline{\beta}$ is lying.

Suppose that the regulator proposes the following mechanism adapted from Auriol[1993,2000] and Laffont and Auriol[1992][3]: (i) if the reports of both firms are compatible, i.e. $\tilde{\beta}_i = \tilde{\beta}_j$, $i = 1, 2$, the regulator would think that $\tilde{\beta}_i$ is realized. He could therefore fix the transfer at $t_i(\tilde{\beta}_i, \tilde{\beta}_i) = \phi(\tilde{\beta}_i - C_i(\tilde{\beta}_i, \tilde{\beta}_i))$, and reimburses $C_i(\tilde{\beta}_i, \tilde{\beta}_i) = \tilde{\beta}_i - e_i$, with $\tilde{\beta}_i = \{\underline{\beta}, \overline{\beta}\}$. Seeking to maximize welfare, and given that the firms' private information is "screened", the level of costs that he reimburses will be such that $C_i(\tilde{\beta}_i, \tilde{\beta}_i) = \tilde{\beta}_i - e^{FI}, i = 1, 2$ and transfers would therefore be $t_i(\tilde{\beta}_i, \tilde{\beta}_i) = \phi(e^{FI})$; (ii) if reports of both firms are incompatible, i.e. $\tilde{\beta}_i \neq \tilde{\beta}_j$, $i = 1, 2$, then the regulator will assume that the true realization of the productivity parameter is $\underline{\beta}$. Therefore, he reimburses $\underline{\beta} - e^{FI}$ in order to maximize social welfare. The rationale behind the regulator's choice is given above. The regulator may decide to punish the cheating firm and/or compensate the true-telling firm, and therefore transfers are set $t_i(\overline{\beta}, \underline{\beta}) = \phi(\underline{\beta} - C_i(\underline{\beta})) - P$, and/or $t_i(\underline{\beta}, \overline{\beta}) = \phi(\underline{\beta} - C_i(\underline{\beta})) + A$, with $i \neq j, i = 1, 2$, and $A, P \geq 0$ being respectively the amount of compensation (resp. fine) that the regulator imposes on the truth-telling (resp. lying) firm.

[3] In fact, the authors here proposes using a large amount of fine to dissuade any dissimulation. Here, we consider as well the role of a compensation.

Under the mechanism above, a firm i's level of utility can be rewritten as a fonction of its own report, the report of the other firm j, and the cost and transfer specified in the contract according to the reports:

$$U_i(\tilde{\beta}_i, \tilde{\beta}_j, \beta_i) = t_i(\tilde{\beta}_i, \tilde{\beta}_j) + C_i(\tilde{\beta}_i, \tilde{\beta}_j) - C(\beta_i) - \phi(e_i), \quad i \neq j, i, j = 1, 2$$

Table 1 (resp. table 2) gives the firms' level of utility according to different strategy profiles when the realized productivity parameter is $\overline{\beta}$, i.e. the firms are of the inefficient (resp. efficient) type. Proposition 2 resumes the outcome of the game.

Proposition 1. *Under yardstick competition, it is possible for the regulator, on conditioning the transfer to a firm on the reports of the other firm, to achieve the full information outcome. When the regulator uses a punishment based yardstick competition, i.e. $P > 0, A = 0$, then truthful reports is a (Bayesien-)Nash equilibrium. On the contrary, if the regulator uses a compensation based yardstick competition, for $[\phi(e^{FI}) - \phi(e - \Delta\beta)] \leq A \leq [\phi(e^{FI} + \Delta\beta) - \phi(e^{FI})]$, truthful reports is an equilibrium in dominant strategy.*

Proof. See appendix. □

Firm 1 / Firm 2	Reports $\underline{\beta}$	Reports $\overline{\beta}$
Reports $\underline{\beta}$	$\phi(e^{FI}) - \phi(e^{FI} + \Delta\beta)$, $\phi(e^{FI}) - \phi(e^{FI} + \Delta\beta)$	$\phi(e^{FI}) - P - \phi(e^{FI} + \Delta\beta)$, $\phi(e^{FI}) + A - \phi(e^{FI} + \Delta\beta)$
Reports $\overline{\beta}$	$\phi(e^{FI}) + A - \phi(e^{FI} + \Delta\beta)$, $\phi(e^{FI}) - P - \phi(e^{FI} + \Delta\beta)$	0, 0

Table 1: Payoff matrix when the realized productivity parameter is $\overline{\beta}$

Note that truth telling is not the unique (Bayesian-)Nash equilibrium[4]. We note, however, that it is possible for the regulator to implement truth-telling

[4]This has been shown in previous study of asymmetric information. See for instance Demski and Sappington[1984]. Previous studies on yardstick competition have limited to show that truth-telling as a Bayesian Nash equilibrium, when the other agent(s) are telling the truth. Auriol[2000] has nevertheless shown that implementing yardstick competition

Firm 2 \ Firm 1	Reports $\underline{\beta}$	Reports $\overline{\beta}$
Reports $\underline{\beta}$	0, 0	$-P$, A
Reports $\overline{\beta}$	A, $-P$	$\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)$, $\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)$

Table 2: Payoff matrix when the realized productivity parameter is $\underline{\beta}$

as a dominant strategy equilibrium. Under a dominant strategy implementation, firms' utility under yardstick competition has a prisoner dilemma's structure.

We see that the value of yardstick competition lies in the fact that the correlation between the firms' private information provides the regulator with an additional instrument to solicit their private information. When firms' private information are perfectly correlated, the regulator is able to obtain this information without giving up any informational rents, and achieve the full information equilibrium[5].

3 Repeated interactions and collusive incentives

In most cases, the production of a regional monopoly good is hardly static. Demand for the good will persist over time, and industrial conditions may change as well from period to period. In a way, the firms will almost always be "in business" and repeatedly interact with the regulator. In order to account for this aspect of the contractual relationship between the regulator and the firms, we will assume that the above static game is infinitely

through a menu of linear contracts can deliver the first best outcome in that firms will have incentives to undertake the full information level of cost-reducing effort and receive no informational rents as a dominant strategy equilibrium under a more general setting. This contrasts the result derived from a game of simultaneous revelation.

[5] In fact, Crémer and McLean[1985,1988], among others, have shown that any correlation, however mild, in agents' private information would allow for the principal to extract all rents.

repeated. We assume furthermore that, changes from period to period ars captured by the industry-wide productivity parameter. In other words, during each regulatory review, the nature will choose between $\overline{\beta}$ and $\underline{\beta}$ before revealing it to the firms, with probability $(1-v)$ and v respectively. Here we have assumed that industry-wide productivity realizations are independent over time[6]. We will further assume that the regulator proposes the same static contract period over period.

3.1 Collusive strategies and firms' utility

From table 1 and table 2 it is easy to see that firms can gain from colluding and coordinating in their reports to the regulator: firms have an incentive to report truthfully when $\overline{\beta}$ is realized, but both firms have an interest to report $\overline{\beta}$ when $\underline{\beta}$ is realized. The question, however, both firms will have an incentive to submit a false report in this case. Indeed, collusive contracts are illegal and are not enforceable by formal institutions. As such, collusion is all the more plausible if the collusion is *self-enforcing*, when firms repeatedly interact with each other (through the regulator here). In other words, in order to evaluate the plausibility of collusion, one needs to study the incentives of firms to defect from the collusion strategy. Consequently, collusion will be all the more likely the easier the firms can sustain the collusive agreement. We adopt a grim trigger strategy framework (Friedman[1979]) to study this issue. This should facilitate any collusive initiative. Under such a configuration, firms start by playing the collusion strategy until there is a defection. When a firm defects from the collusive strategy, all firms will revert back to playing their truth-telling strategy. We define defection by a firm i as here firm i reporting truthfully its private information.

The timing of the static game with collusion is illustrated by figure 1. We have allowed for a stage where firms can decide to collude or not to collude in the game. However, as we have mention earlier, since firms cannot rely on an

[6]This assumption allows us to abstract ourselves from side issues due to the fact that if the productivity parameter should be time dependent, there will only be asymmetric information during the first period of the game.

explicit contract to enforced a coordinated collusive strategy. The collusive "agreement" at this stage must be self enforceable, in the sense that firms must rely on the fact that neither firm has any incentives to defect from this collusive agreement. On top of that, firms are perfectly symmetric in our model. As such, it is not essential that firms do meet to coordinate during this stage: both firms can easily identify the collusive strategy to play should they want to collude[7]. Since no agreement reached at this stage can be enforced by a third party, our model can apply to the case where collusion is tacit, and to the case that collusion is explicitly coordinated, but is unable to be enforced as an explicit contract[8]. What matters here is that the collusive strategy must be self-enforceable.

Note as well that the time when this stage occurs (relatively to the realization of β) is without consequence in our analysis as firms are perfectly correlated[9].

We suppose that firms have a discount factor equals to δ. Under a trigger strategy framework, firm i discounted expected utility when both firms continously play their collusive strategy is therefore:

$$U_i^c = \sum_{t=0}^{\infty} \delta^t v[\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)] = \frac{v}{(1-\delta)}[\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)]$$

and discounted expected utility for firm i after a deviation from the collusion would yield:

$$U_i^d = vA + \sum_{t=1}^{\infty} \delta^t \times 0$$

if the regulator proposes some compensation when reports are incompatible. We have supposed that when A is such that when $\overline{\beta}$ is realized, firms have

[7]We do however recognize that in order to collude under yardstick competition, firms may have to coordinate on their regulatory accounting. As such, collusion may be more complex in reality, and the collusive strategy may be harder to identify. We abstract ourselves from this coordination problem, and suppose that firms are able to identify the means to manipulate their regulatory accounts in order to collude. Our framework can then allow us to study if firms will indeed stick to the agreed-upon manipulations.

[8]That is, a contract that can be enforced by a third party, for instance, some judiciairy institutions.

[9]The major difference between the fact that the firms coordinate before β is realized and after β is realized, is that in the former case, renegotiations may be necessary after β is realized when firms are not perfectly correlated. In the latter case, the collusive "agreement" must take into account asymmetry information between the firms when firms are not perfectly correlated and when they cannot observed each other's information.

no interest to report $\underline{\beta}$ to receive the compensation, that is $A \leq [\phi(e^{FI} + \Delta\beta) - \phi(e^{FI})]$. In the event that the regulator prefers to only punish firms whenever reports are incompatible, then we will have $U_i^d = 0$. We can now evalute collusive incentives of the firms under the various yardstick competition scheme.

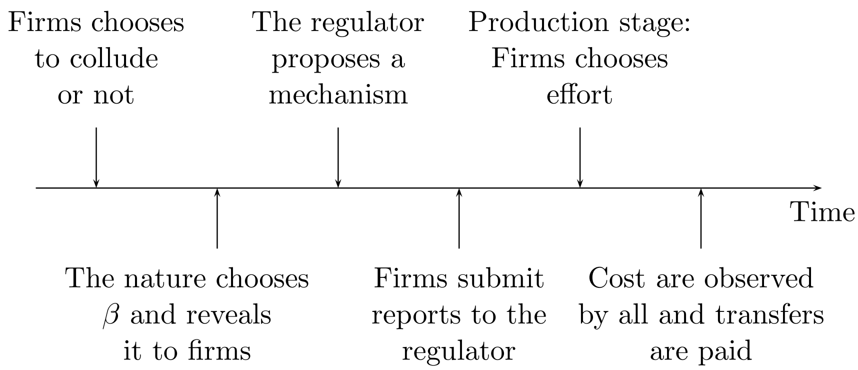

Figure 1: Timing of the game with collusion

3.2 Yardstick competition and collusive incentives

Collusion is sustainable through a trigger strategy game if and only if the expected discounted utility from continuing to collude is larger than the expected discounted utility for a firm should it defect :

$$U_i^c \geq U_i^d$$

We could easily see that if the regulator relies only on punishing firms in the event of incompatible reports to achieve truth-telling, firms will never have any incentive to defect. Indeed, when a punishment-based scheme is used, a defecting firm i's expected utility is $U_i^d = 0$. Collusion is sustainable if and only if:

$$\frac{1}{(1-\delta)} v[\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)] \geq 0$$

which is always verified given our assumptions. Collusion is therefore always sustainable.

More generally, if the regulator decides to compensate the firm reporting $\underline{\beta}$ when reports are not compatible, collusion under a grim trigger strategy game is sustainable if and only if the discounted expected utility when both firms play a collusive strategy is greater than the discounted expected utility for a defecting firm:

$$\frac{1}{(1-\delta)}v[\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)] \geq vA$$

Or, in terms of a critical threshold discount factor, which we will denote δ^*, collusion among the firms is sustainable whenever firms' discount factor is such that:

$$\delta \geq \delta^* = \frac{A - [\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)]}{A}$$

As expected, one could easily see that the higher the compensation that the regulator sets, the higher the critical threshold discount factor should be in order for firms to sustain collusion. Indeed, one could easily check that the threshold discount factor is increasing in the amount of compensation, albeit at a decreasing rate[10]. Firms will have to be more patient in order to sustain the collusion when the compensation in case of incompatible reports is high. Impatient firms may find it more interesting to defect from collusion. Implementation of yardstick competition as a dominant strategy equilibrium (with respect to an implementation in terms of (Bayesian-)Nash equilibrium) would thus seem to allow the regulator to reduce the likelihood of an eventual collusion between the regulated firms.

We can resume these observations in the following proposition:

Proposition 2. *When the regulator uses a punishment based yardstick competition, then collusion is always sustainable. Collusion is less likely the higher the compensation is and/or the lower firms' discount factors are. High compensations are possible when the difference between the two level of productivity is large.*

At this point, one should keep in mind that the compensation has to satisfy $A \leq [\phi(e^{FI} + \Delta\beta) - \phi(e^{FI})]$, so that when $\overline{\beta}$ is realized, firms will not have

[10] $\frac{\partial \delta^*}{\partial A} = [\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)]A^{-2} > 0$ and $\frac{\partial^2 \delta^*}{\partial A^2} = -2[\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)]A^{-3} < 0$.

any incentives to report $\underline{\beta}$ for the sake of the compensation. This suggests that there is an upper bound on the amount of compensation that a regulator could use. Suppose now that the regulator fixes $A = [\phi(e^{FI} + \Delta\beta) - \phi(e^{FI})]$, then the threshold discount factor could be rewritten as:

$$\delta^* = 1 - \frac{\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)}{\phi(e^{FI} + \Delta\beta) - \phi(e^{FI})}$$

We see that the threshold discount factor is increasing in $\Delta\beta$[11].

This suggests that when $\Delta\beta$ is large, it will be easier for the regulator to discourage any collusive incentives. Indeed, the larger is the difference between the productivity parameter, the higher a compensation the regulator can use to tempt firms to defect. As such, in order to sustain the collusive outcome, both firms will have to be more patient. This suggests as well that when the difference in the productivity parameter is small, the threshold discount factor will be lower as $\frac{\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)}{\phi(e^{FI} + \Delta\beta) - \phi(e^{FI})}$ will be closer to unity. The regulator will have a lesser margin to tempt the firms away from behaving collusively. Firms can afford to be less patient to sustain the collusive pact.

3.3 Detering collusion under repeated yardstick competition

As one can see, in a repeated game framework, collusion may be enforced through repeated interactions between the firms in absence of any third party enforcement of the collusive contract. In order for the regulator to deter collusion, yardstick competition based on compensation when reports differ should be preferred. Indeed, collusion is sustainable whatever the firms' discount factor when the regulator decides to punish in the event of incompatible reports. Even when the regulator uses a compensation based scheme, collusion may be sustainable, depending on firms' discount factor and on $\Delta\beta$. When $\Delta\beta$ is low, it would be harder for the regulator to deter collusive behaviour, while if $\Delta\beta$ is higher enough, the regulator could propose a high compensation, making the collusive agreement harder to sustain.

[11] See appendix A.2 for proof.

Even so, there may be limits to the capacity of the regulator to discourage collusive behaviour. Indeed, even if there is no upper bound on the amount of compensation (to prevent firms from reporting $\underline{\beta}$ when $\overline{\beta}$ is realized), the regulator still has to set an amount of compensation A that is at least as high as the discounted rents that firms can expect from future ongoing collusion. This amount could be quite high, if firms are patient enough, and it may not be credible, or even possible, for the regulator to commit itself to such high amounts of compensation for various political or economic reasons.

One will however notice that the likelihood of collusion depends as well on firms' discount factor. This suggest another means for the regulator to prevent collusion, should $\Delta\beta$ be too low and/or should he be limited in his capacities to commit to too high a compensation: he could try to influence this parameter instead. Indeed, the discount factor could be reinterpreted as the probability that the contractual relationship will continue into the following period. Indeed, the regulator is probably able to decide whether to renew a firm's contract for the following period. One means to this end may be the regulator stochastically decides during each period if each firms contracts will be renewed. Such a mechanism seems implausible for obvious reasons.

Another way to this end, much more plausible, is for the regulator to use a franchise bidding mechanism to attribute the markets (Demsetz[1968]). Such a mechanism may introduce some uncertainty as to whether the contractual relationship will be renewed in the following period, thereby destabilizing collusive incentives. While the idea of using franchise bidding in complement with yardstick competition to deter collusion has been already suggested in the literature (see Bouf and Péguy[2001] for the railway sector for instance), we believe however that our interpretation of it being a tool to influence firms' discount factor is new to the literature. However, it should be noted that when franchise bidding mechanisms are used, the regulator will not have unilateral control over the renewal of a firm's contract. This would rather result from the bids submitted by the firms and institutional rules organizing the franchise bidding mechanism. Firms may act strategically in their bids, and collusion may not become harder to sustain. We propose to study in further detail such the impact of having this supplementary mechanism on firms' collusive incentives in the coming sections.

4 Franchise Bidding, yardstick competition and collusive incentives

As mentioned, using franchise bidding in complement to yardstick competition might be a way for the regulator to influence the firms' discount factor. However, when franchise bidding is used, the regulator can no longer unilaterally terminate a contract with a firm. Whether the contractual relationship will end depends on the franchise bidding mechanism and behaviour of participating firms. As such, it is not straightforward to think that collusive incentives may be destabilized when such a mechanism is in place. We will now turn to study the impact that such a mixture of franchise bidding and yardstick competition can have on collusive incentives. We describe first the timing of the stage game, before turning to study sustainability of a collusion when this stage game is infinitely repeated.

4.1 Timing of the static game

Since the regulator now uses a franchise bidding mechanism to attribute the market, and then applies some sort of regulation, we will model the static game as a multi-stage game. Figure 2 shows the timing of the game when the regulator first uses franchise bidding to attribute the market and then regulates the markets using yardstick competition only during one period ($n = 1$).

In the first stage of the game, franchise bidding is used to attribute the markets simulteneously and independently. The regulator will announce the number of periods $n + 1$ that the monopoly rights will be granted, and how the markets will be regulated during these periods when firm(s) detain(s) the monopoly right. Each market is attributed to the firm with the lowest costs, or equivalently, announces the lowest productivity parameter. When an *ex æquo* arises, the regulator attributes one market to each firm[12].

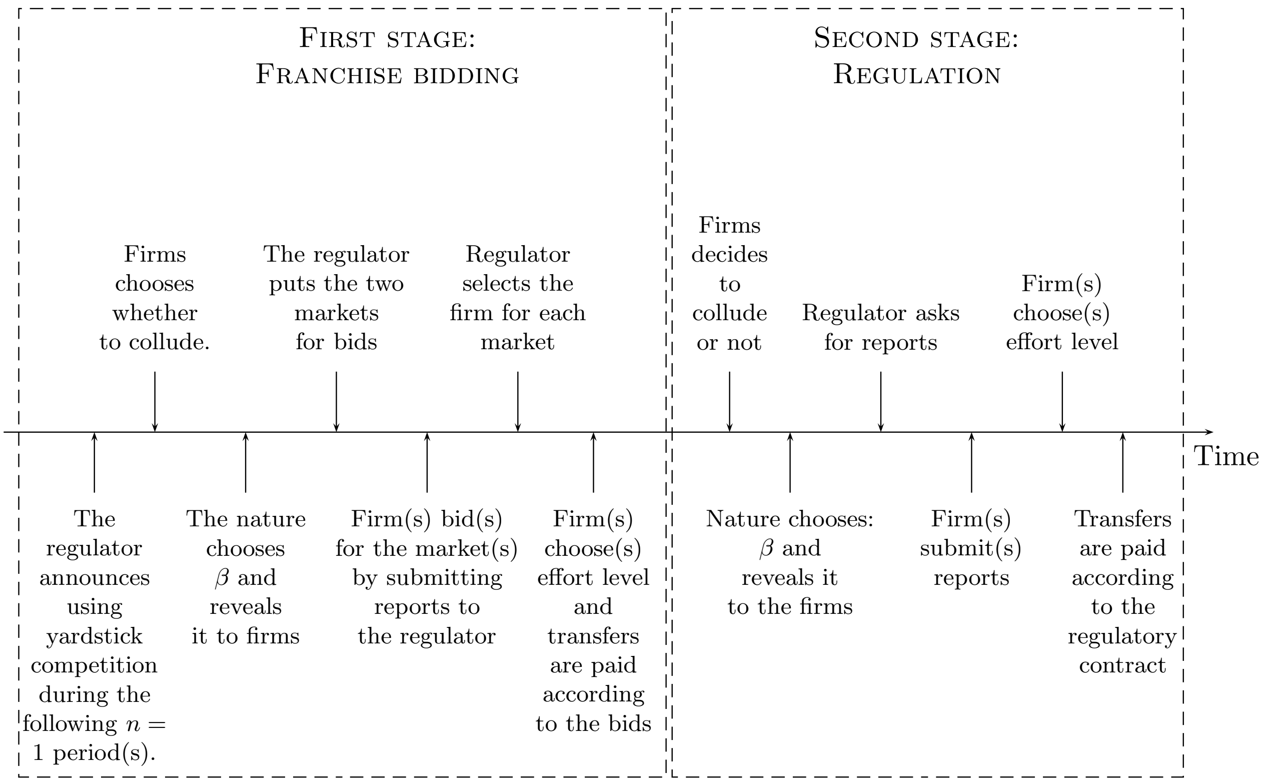

Figure 2: Timing of the two stage game with franchise bidding

In the coming stages of the game, since the productivity parameter changes, the regulator will use yardstick competition as discussed above to regulate the firm(s) operating in markets. Notice that we have allow for the firms to behave collusively at the beginning of each stage, should there be any need or interest for the firms to coordinate their reports (either on bids or on costs reports).

[12]In the event of an *ex æquo*, we do not use the usual rule of attributing an market with a probability of 0.5 found in the literature. The reason being that since the regulator may wish to use yardstick competition during the second stage of the game, it seems natural that he chooses to let both firms operate each in one market when an *ex æquo* arises.

In order to study the sustainability of an implicit collusion, the above multi-stage game is infinitely repeated. More specifically, franchise bidding is used to attribute the monopoly rights to operate in a markets by the regulator for $n+1$ periods, and $n+1$ is announced by the regulator. Regulation using yardstick competition is then administered during the n periods on firm(s) which detain(s) the monopoly rights to operate in the markets after the franchise bidding stage. When the monopoly rights expire during the end of the n^{th} period, the markets are then put up for bids again under a franchise bidding mechanism, followed by another n periods of regulation, *ad infinitum*. Note that we have supposed that the periods for which the monopoly rights are granted are the same at every franchise bidding stage. For simplicity's sake, we suppose as well that the monopoly rights will be granted for the same length of time for each market, and that these rights are put up for bids at the same moment.

4.2 Collusion strategies and firms' utility

Before studying the sustainability of a collusive pact, let us first discuss what is meant by a collusive pact when the regulator uses a franchise bidding mechanism to attribute the monopoly rights to operate in a market, and then uses yardstick competition to regulate the markets throughtout the duration of the monopoly rights.

Several "types" of collusive agreements between the regulated firms may arise: firms may agree to only share the markets collusively, coordinate on their reports only, or try to collude by sharing the markets and coordinating on their reports when they are being regulated through yardstick competition. In the following discussion, we will define the collusive pact as the third type of strategy, i.e. firms will agree to share the markets during the bidding stages and coordinate their reports when they are being regulated under yardstick competition. In other words, under the collusive agreement, firms must report that their private information is $\overline{\beta}$ whatever the true realization of their productivity parameter.

The reason why we consider such a type of collusive agreement is that such a strategy should leave firms with the higest expected utility when ethy collude, when one compares it with the payoff goven by the two other types of collusive strategy. Presumably, when firms collude, this is basically what they hope to achieve. In this case the expected discounted utility of a firm i under collusion is simply $U_i^c = \frac{v}{(1-\delta)}[\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)]$. Firms' defecting strategies will be discussed later on when we consider the different possible configuration allowed by an additional franchise bidding mechanism to attribute the markets.

4.3 Collusion under franchise bidding

Let us start by supposing that the regulator only uses franchise bidding to grant the monopoly rights. As the firms' private information changes from period to period independently, the regulator will only grant these rights for a market during one period[13].

When a franchise bidding mechanism is used to attribute the markets, the firms' payoff as a function of their bids, or reports on their private information under a one-shot game will be given by the table 3 and table 4. Indeed, if a firm does not win a market, its utility is then equal to its outside option, here 0, and if a firm truthfully reveals its private information, it will have no informational rents. Proposition 3 resumes the outcome of the game.

Proposition 3. *When using a franchise bidding mechanism to attribute the markets simulatneously, truthful bids in which the firms reveal their private information is a (Bayesian-)Nash equilibrium under the static game. When the game is infnitely repeated, the firms can sustain the collusive market strategies whatever the discount factor.*

[13] Indeed, since we have not supposed any costs for organizing the franchise bidding procedures, and the the firms' productivity parameter changes independantly from period to period, the best that a regulator can do is to attribute the monopoly rights for one period.

Proof. See appendix. □

Firm 1 / Firm 2	Reports $\underline{\beta}$	Reports $\overline{\beta}$
Reports $\underline{\beta}$	$\phi(e^{FI}) - \phi(e^{FI} + \Delta\beta)$, $\phi(e^{FI}) - \phi(e^{FI} + \Delta\beta)$	0, $2[\phi(e^{FI}) - \phi(e^{FI} + \Delta\beta)]$
Reports $\overline{\beta}$	$2[\phi(e^{FI}) - \phi(e^{FI} + \Delta\beta)]$, 0	0, 0

Table 3: Payoff matrix when the realized productivity parameter is $\overline{\beta}$ under a static franchise bidding mechanism

Firm 1 / Firm 2	Reports $\underline{\beta}$	Reports $\overline{\beta}$
Reports $\underline{\beta}$	0, 0	0, 0
Reports $\overline{\beta}$	0, 0	$\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)$, $\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)$

Table 4: Payoff matrix when the realized productivity parameter is $\underline{\beta}$ under a static franchise bidding mechanism

Note however the proposition above is derived under the assumption that the regulator attributes both markets at the same time and that monopoly rights to operate in each market is attributed for one period of time. Moreover, we do not study the optimal contract that the regulator uses to attribute the markets, and more specifically, we have not accounted for the fact that the regulator could optimally trade-off incentives and collusion-proofness by granting the monopoly rights for some longer periods. As such, proposition 3 should be interpreted with care.

4.4 Market sharing collusion under franchise bidding and yardstick competition

Let us assume now that after an initial franchise bidding stage, yardstick competition is being applied during n stages before the market is reattributed again. We will start by studying the sustainability of the market sharing part of the collusive agreement. To do this, suppose that the game starts at the stage where monopoly rights are being put up for bids.

In this case, an infinitely repeated market sharing strategy would yield the same sum as above, i.e. $\frac{1}{(1-\delta)}v[\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)]$. Defection here could be easily understood as firms bid truthfully, in the sense that they will report the true realization of the productivity parameter[14]. A defection would therefore allow the defecting firm to operate in both markets for n subsequent period during which yardstick competition is applied, given that the other firm plays the collusive market sharing strategy in the franchise bidding game. Expected discounted utility for the defecting firm under grim trigger strategies would yield:

$$\begin{aligned} & 2v[\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)][\delta + \delta^2 + \ldots + \delta^n] \\ &= \frac{\delta(1-\delta^n)}{1-\delta} 2v[\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)] \end{aligned}$$

This is simply the sum of rents that the firm which has defected touches during the franchise bidding stage, and during the successive regulation stages when it is the only firm operating in the two markets, and rents resulting from the truth-telling strategy after defection.

If there are n sucessive stages of yardstick competition, then the market sharing collusive agreement is sustainable if and only if:

$$\frac{1}{(1-\delta)}v[\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)] \geq \frac{\delta(1-\delta^n)}{1-\delta} 2v[\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)]$$

which yields

$$\frac{1}{(1-\delta^n)} \geq 2\delta$$

Figure 3 shows the curves of 2δ and $f(\delta, n) = \frac{1}{(1-\delta^n)}$ according to some values of n, i.e. $n = 1, 2, 5, 10$, and $n = 35$, for $\delta \in]0, 1[$. The dashed line represents 2δ, while the solid lines represent $f(\delta, n)$. For values of δ where the dashed

[14] In fact, firms may want to defect by reporting $\underline{\beta}$ whatever the realization of the true industry-wide productivity parameter. Indeed they could be tempted by the prespective of temporary informational rents when operating in both markets during subsequent periods when yardstick competition is used.

line lies above the solid lines, collusion is sustainable, as the inequality above is satisfied. On the contrary, collusion is not sustainable for values of δ where the solid lines lay below the dashed line. The critical threshold factor that sustain collusion for a given n is given by the intersections between a curve and the dashed line.

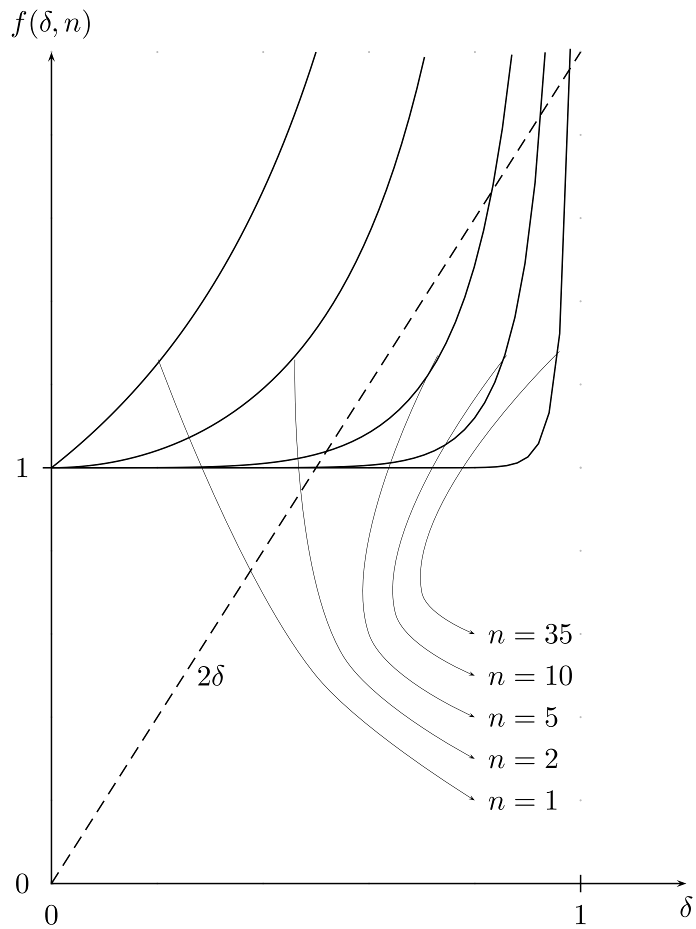

Figure 3: Values of $f(\delta, n)$ according to n

One could draw two principal observations from figure 3: first of all, n is small, collusion is always sustainable. Indeed, one could see that for

$n = 1$ and $n = 2$, 2δ will always be greater than $f(\delta, 1)$ and $f(\delta, 2)$ in the relevant range for δ. As n goes up, the value of δ for which the solid curve will start to lay below the dashed line decrease, meaning that collusion becomes harder to sustain for the corresponding values of the discount factor. Notice also that in our case, we have two critical threshold value for which collusion is sustainable. Indeed, the solid line will intersection again with the dashed line for high values of δ. After this second intersection between the lines, one can see that the solid lines will lay above the dashed line again, meaning that collusion as defined above is once again sustainable. This suggests therefore that instead of one critical threshold discount factor (as in a classical analysis of collusion sustainability), here we have two critical threshold discount values: collusion will be sustainable only either when firms are very patient, or when they are very impatient! For "intermediate" values of discount factor, collusion will be harder to sustain.

Notice as well that the range of values for which collusion is harder to sustain seems to be increasing in the length of time during which the monopoly rights are attributed: the longer the monopoly rights will be granted, the interval of δ for which collusion is harder to sustain becomes larger. We will first resume these results in the following proposition before giving an intuition of these results.

Proposition 4. *Under a grim trigger strategy framework, self-enforcing collusion to share the markets is harder to sustain when* (*i*) *the monopoly rights are granted for a sufficiently long period of time;* (*ii*) *the regulator uses yardstick competition to regulate the firms during the period for which the monopoly rights are granted; and* (*iii*) *firms are "moderately" patient. However, if firms are very patient or if they are very impatient, this will have no effects on firms' ability to sustain collusion.*

The intuition for the results above is as follows: let us first observe that a defection during the bidding stage allows the defecting firm to win the monopoly rights to operate during $n+1$ periods as the unique monopolist in both of the markets. In the succesive n periods where yardstick competition is applied, the defecting firm, being the unique firm on both the markets, can coordinate its reports to the regulator. Under yardstick competition, it would be in the defecting firm's best interests to report as being the $\overline{\beta}$-type whatever the truthful realization of the industry-wide productivity parameter. The defecting firm could thus expect positive informational rents from *both* markets, whereas under the collusive agreement, the firm could only benefit from informational rents stemming from *one* market. As such, all things being equal, the longer the monopoly rights are granted, the more interesting defection is for the firms.

However, under grim trigger strategies, a defection will result in firms playing non cooperatively once the monopoly rights have expired and markets are re-attributed again. A defecting firm will therefore stand to "lose" all informational rents from *one* market from the moment when monopoly rights are re-attributed until the end of time. When deciding to stick to the collusion agreement or to defect, a firm will have to trade off these rents. If firms are very patient, the perspective of ongoing informational rents assured by the collusive agreement would tend to outweight near future rents steming from defection. Therefore, patient firms will tend to stick to the collusive agreement. However, as n increases (the monopoly rights are granted for a longer period of time), the amount of informational rents stemming from *both* markets becomes more important, and firms will have to be all the more patient in order to collude. This explains why the upper threshold critical discount factor will increase with the duration of the monopoly rights.

Remember that if firms are very impatient, they could sustain the collusive agreement as well. To understand the reason behind this lower threshold discount factor, notice that a defection implies for the defecting firm to forego the informational rents during bidding stage when monopoly rights are attributed. In the event that a firm decides to respect the collusive agreement, it will be able to benefit from informational rents stemming from one market during this stage. Therefore, if firms are very impatient, they may not want to forego these rents during the bidding stage by defecting. It will therefore be in these firms' interest to respect the collusive agreement so that they will not need to forego the rents during the bidding stage.

In a nutshell, our results suggest that yardstick competition could be a means through which the regulator could discourage collusive initiatives from firms when monopoly rights are attributed through a franchise bidding mechanism. This is the case only when the monopoly rights are granted for a sufficiently long period of time, and for firms that are moderately "patient". While it is true that the same result could be achieved in the case where no regulation is used during the length of time that the monopoly rights are in force, regulation under the form of yardstick competition may be desired in this case. Indeed, should both firms decide to defect during this bidding stage, each firm will be granted the monopoly rights for a market after the bidding stage, and yardstick competition could allow the regulator to save informational rents when compared to the case where there is no regulation.

4.5 Collusion under yardstick competition in presence of franchise bidding

Let us now look at how firms' collusive incentive is altered under yardstick competition, given their ability to enforce the market sharing side of the collusive agreement. In order to do this, let us assume that at the beginning of the game, both firms are operating each in one regional market and they are being regulated under yardstick competition. The firms' monopoly rights are temporary and they will be put up for bids in some near future. The position in time that this discussion will take place is illustrated in figure 4 by the hashed box.

Since the firms' market rights will be re-attributed through a franchise bidding in the future, one could reasonably expect that the sustainability of false reports under yardstick competition would depend on firms' ability to stick to the collusive agreement when markets are being re-attributed. As we have seen earlier, it would seem that if the monopoly rights are granted for a sufficiently long period of time, then the market sharing side of the collusive contract will be relatively harder to sustain. When the market sharing side of the collusive pact is harder to sustain, we could reasonably

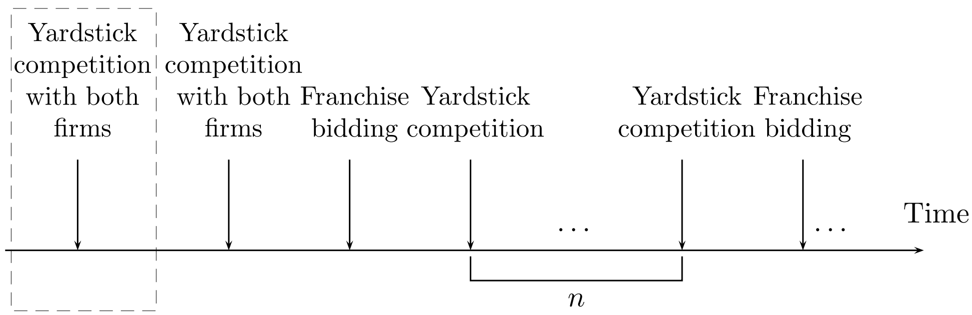

Figure 4: Temporal position of the stage of yardstick competition

expect firms to give less weight to the amount of expected discounted utility stemming from collusion when firms share the markets and coordinate on false reports during the subsequent regulation periods after monopoly rights are re-attributed through franchise bidding. In other words, the expected discounted collusive rents under grim trigger strategy would be smaller, as firms are not sure that their counterparts will behave in conformity with the collusive pact to share markets. This collusive rents should be smaller as the franchise bidding stage draws nearer. When the regulator compensates the "more productive" firm in the event of incompatible reports under yardstick competition, defection would therefore be relatively more interesting for the firms. In other words, with the same amount of compensation A, collusion under yardstick competition, when monopoly rights are temporary and they are granted through a franchise bidding mechanism for a sufficiently long period of time and when firms' are "moderately" patient, will be relatively more difficult to sustain for firms than when these rights are granted once and for all and when the regulator only relies on yardstick competition. A firm is considered to be "moderately" patient when their discount factor falls within the interval between the two critical threshold discount factor conditioning to the duration of time for which the monopoly rights are enforced.

Needless to say, if firms are very patient, or very impatient, then they will be able to sustain collusion during yardstick competition. The supplementary franchise bidding mechanism that attributes monopoly rights will have no consequence on the firms' collusive incentives.

Interestingly, when one compares the use the a franchise bidding mechanism in conjonction with yardstick competition with the case where only a compensation-based yardstick competition is applied, the supplementary franchise bidding can in fact help sustain collusion. Indeed, remember that collusion is easier to sustain the more patient the firms are when only a compensation-based yardstick competition is used. As we have seen above, in the case where an additional franchise bidding mechanism is used to attribute the monopoly rights, collusion during the regulation periods can become easier to sustain when firms are very impatient too! Consequently, when firms are very impatient, a regulator should avoid using a supplementary franchise bidding mechanism to attribute monopoly rights: a compensation-based yardstick competition should suffice in this case to discourage collusion.

To sum up, the joint use of franchise bidding and yardstick competition could make collusion between firms harder to sustain when the monopoly rights are attributed for a sufficiently long period of time and when firms are "moderately" patient . In this case, firms will find it harder to share the markets collusively, and this in turn would have an impact of future collusive rents after monopoly rights are attributed. Anticipating this, collusive rents would weight relatively less under yardstick competition, and defection could be more tempting for the regulated firms when they operate each in a market. Therefore firms may find it harder to sustain a collusion under yardstick competition by reporting a false productivity parameter. Otherwise, collusion in the form of misreports under yardstick competition is sustainable when firms are either very patient or very impatient. In the latter case, franchise bidding might in fact contribute to make collusion easier to sustain.

5 Conclusion

Yardstick competition is a regulatory tool through which the regulator can create some virtual competition between firms that operate in similar locally monopolistic markets. One of its merits is that informational rents need not be given up *ex post* when the regulator tries to solicit firms' private information. We have seen that if firms expect each other to report truthfully, then imposing some punishment in the event of incompatible reports suffices to induce truthful revelation. Otherwise, if the regulator wants to be sure of achieving truthful revelation, then compensations are needed.

As with any competitive environment, firms may stand to gain from behaving cooperatively. In order to evaluate the plausibility of such a behaviour, we have used a infinitely repeated game framework with grim trigger strategies. This is because we believe that any collusion that may arise in our case needs to be self-enforcing. Explicit collusive contracts signed between firms are unlikely to be enforced by a third party. Thus, collusive behaviour is all the more likely when it can be self enforcing. To this end, we constructed a model for perfectly symmetric firms, and we show that when yardstick competition is repeatedly used, the bigger the difference between the favorable and unfavorable productivity of the firms, the easier it will be for the regulator to promise compensations high enough to deter collusion. With high compensations, collusion is harder to sustain.

It may not be credible for a regulator to commit to high compensations. Without credible commitment on compensations, collusion would be easy to sustain, and therefore likely to occur. We suggest franchise bidding may be used to bring down the compensation needed to deter collusion. This is because franchise bidding can be seen as a way for the regulator to influence firms' discount factor, and therefore making collusion harder to sustain. However, should the regulator introduces a supplementary franchise bidding procedure, firms may behave collusively and share the markets. We show that this will not be the case when the markets are not put up for bids too often, and if firms are neither too patient or too impatient. The advantage of using yardstick competition in this case is that *ex post*, the regulator can actually save up costly rents while providing incentives *ex ante* for firms to fight for the markets. When market sharing is harder to sustain for the firms, we argue that collusion under yardstick competition will be harder to sustain as well. We have also shown that the use of franchise bidding might in fact contribute to help sustain collusion. The latter is true when firms are very impatient.

Our analysis does have limits, and the most important of which might be that we have oversimplified the stakes that firms could have in order to grab all the markets. Indeed, a winning firm that operates in a market could benefit in terms of technology and information with compare to a firm that stays "out of business" until the next bidding stage. There should be an asymmetry between a firm that operates and a firm that has not for some time (Williamson[1976]). Therefore, winning both markets would imply for the winning firm more important rents in all sucessive bidding stage and regulation stage. This might erode all the more any collusive incentive during the bidding stage. This could be an important factor that we have not consider, all the more as industries that we are considering here (water distribution, railways operations etc.) are often characterized by very long term contracts.

We have neither account for the fact that regulatory procedures and franchise bidding are costly to put in place, nor any resulting trade off between duration, rents, allocative efficiency and costs of the various policies. For instance, Yvrande-Billon[2005], citing a CERTU[2003] report, mentions that the costs for preparing a bid in the French urban transport sector could amount to 30,000 euros for a small network and 500,000 euros for a large one. A regulator might therefore want to tolerate certain inefficiency and allow some collusion in order to avoid the costs.

All this said, we believe that our results would help to recognized that collusion is no simple matter in real life. Even under very strong and favourable conditions for collusion, we have shown that such a behaviour can still be deterred by the regulator. When firms are asymmetric, and when there are some asymmetry information between them, collusion under yardstick competition could be harder to sustain. Moreover, the use of various instruments can contribute as they can discourage any collusive initiatives.

Therefore, before recommending the use of one or several instruments, one should clearly and carefully evaluate the impact of such instruments on firms' collusive incentives.

References

[1] Emmanuelle Auriol, *Monopole ou duopole: l'effet de comparaison*, Annales d'Economie et de Statistique **31** (1993), 1–31.

[2] ———, *Concurrence par comparaison: un point de vue normatif*, Revue Economique **51** (2000), 621–634.

[3] Emmanuelle Auriol and Jean-Jacques Laffont, *Regulation by duopoly*, Journal of Economics and Management Strategy **1** (1992), no. 3, 507–533.

[4] Dominique Bouf and Pierre-Yves Péguy, *Is yardstick competition desirable for western european railways?*, International Journal of Transport Economics **28** (2001), no. 2, 205–227.

[5] Luis M. B. Cabral, *Introduction to industrial organization*, MIT Press, Cambridge, MA, 2000.

[6] CERTU, *La dévolution des services publics de transport urbain: La délégation de service public*, Certu Dossier 144 **1** (2003).

[7] Simon Cowan, *Competition in the water industry*, Oxford Review of Economic Policy **13** (1997), 83–92.

[8] Jacques Crémer and Richard P. McLean, *Optimal selling strategies under uncertainty for a discriminating monopolist when demands are interdependent*, Econometrica **53** (1985), no. 2, 345–362.

[9] ———, *Full extraction of the surplus in bayesian and dominant strategy auctions*, Econometrica **56** (1988), no. 6, 1247–1257.

[10] Dag Morten Dalen and Andres Gómez-Lobo, *Yardsticks on the road: Regulatory contracts and cost efficiency in the norwegian bus industry*, Transportation **30** (2003), 371–386.

[11] Harold Demsetz, *Why regulate utilities?*, Journal of Law and Economics **11** (1968), 55–66.

[12] Joel S. Demski and David E.M. Sappington, *Optimal incentive contracts with multiple agents*, Journal of Economic Theory **33** (1984), 152–171.

[13] David Dranove, *Rate-setting by diagnosis related groups and hospital specialization*, Rand Journal of Economics **18** (1987), no. 3, 417–427.

[14] James W. Friedman, *A non-cooperative equilibrium for supergames*, Review of Economic Studies **38** (1971), 1–12.

[15] John Hicks, *Annual survey of economic theory: The theory of monopoly*, Econometrica **3** (1935), no. 1, 1–20.

[16] Alexis Jacquemin and Margaret E. Slade, *Cartels, collusion, and horizontal merger*, Handbook of Industrial Organization (Richard Schmalensee and Robert D. Willig, eds.), vol. 1, North Holland, Amsterdam, 1989, pp. 415–473.

[17] Michael Klein and Philip Gray, *Competition in network industries – where and how to introduce it*, Public Policy Journal (1997), no. 104.

[18] Jean-Jacques Laffont and David Martimort, *Mechanism design with collusion and correlation*, Econometrica **68** (2000), no. 2, 309–342.

[19] Jean-Jacques Laffont and Jean Tirole, *Using cost observation to regulate firms*, The Journal of Political Economy **94** (1986), no. 3, 614–641.

[20] ______, *A theory of incentives in procurement and regulation*, MIT Press, 1993.

[21] Fumitoshi Mizutani, *Empirical analysis of yardstick competition in the japanese railway industry*, International Journal of Transport Economics **24** (1997), 367–392.

[22] Masaru Okabe, *New passenger railway fares*, Japan Railway and Transport Review (2004), no. 37, 4–15.

[23] Robert Rothschild, *Cartel stability when costs are heterogeneous*, International Journal of Industrial Organization **17** (1999), 717–734.

[24] Andrei Shleifer, *A theory of yardstick competition*, The RAND Journal of Economics **16** (1985), no. 3, 319–327.

[25] Thomas P. Tangerås, *Collusion-proof yardstick competition*, Journal of Public Economics **83** (2002), no. 2, 231–254.

[26] Oliver Williamson, *Franchise bidding for natural monopolies: In general and with respect to catv*, Bell Journal of Economics **7** (1976), no. 1, 73–104.

[27] Anne Yvrande-Billon, *The attribution process of delegation contracts in the french urban transport sector: Why is competitive bidding a myth?*, Annals of Public and Cooperative Economics (forthcoming) (2005).

A Appendix

A.1 Proof for proposition 1

In order for truth telling to be a (Bayesian-)Nash equilibrium of the game, we must have for firm i:

$$U_i(\overline{\beta},\overline{\beta},\overline{\beta}) \geq U_i(\underline{\beta},\overline{\beta},\overline{\beta}), \qquad i=1,2 \tag{1}$$

$$U_i(\underline{\beta},\underline{\beta},\underline{\beta}) \geq U_i(\overline{\beta},\underline{\beta},\underline{\beta}), \qquad i=1,2 \tag{2}$$

where $U_i(\tilde{\beta}_i,\tilde{\beta}_j,\beta)$ is the utility of firm i when it submits a report $\tilde{\beta}_i$ and firm j submits a report $\tilde{\beta}_j$ in the event that β is realized, $\tilde{\beta}_i,\tilde{\beta}_j,\beta \in \{\underline{\beta},\overline{\beta}\}$. The above constraints state that firm i will not have any incentive to deviate from reporting the true productivity parameter, given that firm j reports truthfully.

Under the proposed mechanism, these contraints, for a firm i, can be rewritten as:

$$\begin{aligned} 0 &\geq \phi(e^{FI}) + A - \phi(e^{FI}+\Delta\beta), \qquad i=1,2 \\ 0 &\geq -P \end{aligned}$$

Thus, truth-telling is a Nash equilibrium when $P \geq 0$ and $A \leq \phi(e^{FI}+\Delta\beta)-\phi(e^{FI})$. In particular, the first set of inequality is verified when $A = 0$, as $\phi(e^{FI}) - \phi(e^{FI} + \Delta\beta) < 0$. As such, in order to have truth-telling as a (Bayesian-)Nash equilibrium, it suffices to punish firms whenever reports are incompatible. The equilibrium outcome will have both firms reporting truthfully, and the regulator need not apply any punishment, and the full information outcome is achieved.

We note, however, that it is possible for the regulator to implement truth-telling as a dominant strategy equilibrium. To this end, P and A would have to satisfy the following contraints:

$$
\begin{array}{rcll}
U_i(\overline{\beta},\overline{\beta},\overline{\beta}) & \geq & U_i(\underline{\beta},\overline{\beta},\overline{\beta}), & \quad i=1,2 \\
U_i(\overline{\beta},\underline{\beta},\overline{\beta}) & \geq & U_i(\underline{\beta},\underline{\beta},\overline{\beta}), & \quad i=1,2 \\
U_i(\underline{\beta},\underline{\beta},\underline{\beta}) & \geq & U_i(\overline{\beta},\underline{\beta},\underline{\beta}), & \quad i=1,2 \\
U_i(\underline{\beta},\overline{\beta},\underline{\beta}) & \geq & U_i(\overline{\beta},\overline{\beta},\underline{\beta}), & \quad i=1,2
\end{array}
$$

These contraints give rise to the following inequalities:

$$
\begin{array}{rcl}
A & \leq & \phi(e^{FI}+\Delta\beta)-\phi(e^{FI}) \\
P & \leq & 0 \\
P & \geq & 0 \\
A & \geq & \phi(e^{FI})-\phi(e^{FI}-\Delta\beta)
\end{array}
$$

Therefore, if the regulator wants to implement truth-telling as a dominant strategy equilibrium, he will need to set $P = 0$, and compensates any firms that report $\underline{\beta}$ whenever reports are incompatible. The compensation should be such that $[\phi(e^{FI}) - \phi(e - \Delta\beta)] \leq A \leq [\phi(e^{FI} + \Delta\beta) - \phi(e^{FI})]$. There will exist such a range for A, as $\phi(e^{FI} + \Delta\beta) > \phi(e^{FI}) > \phi(e^{FI} - \Delta\beta)$. Given that $\phi''(\cdot) > 0$, $\phi(e^{FI} + \Delta\beta) - \phi(e^{FI}) > \phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)$.

A.2 The threshold discount factor and $\Delta\beta$ under an infinitely repeated yardstick competition

Let $d(\Delta\beta) = [\phi(e^{FI}+\Delta\beta)-\phi(e^{FI})]-[\phi(e^{FI})-\phi(e^{FI}-\Delta\beta)]$ be the difference between $\phi(e^{FI}+\Delta\beta)-\phi(e^{FI})$ and $\phi(e^{FI})-\phi(e^{FI}-\Delta\beta)$. We will first show that $d(\Delta\beta)$ is increasing in $\Delta\beta$ at an increasing rate:

$$\frac{\partial d(\Delta\beta)}{\partial\Delta\beta} = \phi'(e^{FI}+\Delta\beta) - \phi'(e^{FI}-\Delta\beta) > 0$$

as $\phi''(\cdot) > 0$. Moreover,

$$\frac{\partial^2 d(\Delta\beta)}{\partial(\Delta\beta)^2} = \phi''(e^{FI}+\Delta\beta) + \phi''(e^{FI}-\Delta\beta) > 0$$

It follows that $[\phi(e^{FI}+\Delta\beta)-\phi(e^{FI})]$ increases faster in $\Delta\beta$ than $[\phi(e^{FI})-\phi(e^{FI}-\Delta\beta)]$. Furthermore, we have $\frac{\phi(e^{FI})-\phi(e^{FI}-\Delta\beta)}{\phi(e^{FI}+\Delta\beta)-\phi(e^{FI})} < 1$ since $[\phi(e^{FI}+\Delta\beta)-\phi(e^{FI})] > [\phi(e^{FI})-\phi(e^{FI}-\Delta\beta)]$. As such $\frac{\phi(e^{FI})-\phi(e^{FI}-\Delta\beta)}{\phi(e^{FI}+\Delta\beta)-\phi(e^{FI})}$ is decreasing in $\Delta\beta$ and therefore $1-\frac{\phi(e^{FI})-\phi(e^{FI}-\Delta\beta)}{\phi(e^{FI}+\Delta\beta)-\phi(e^{FI})}$ is increasing in $\Delta\beta$.

A.3 Proof for proposition 3

It is easy to see that in the static game, truthful revelation is a Bayesian-Nash equilibrium. Indeed we show that the following constraints are satisfied:

$$\begin{aligned} U_i(\overline{\beta},\overline{\beta},\overline{\beta}) &\geq U_i(\underline{\beta},\overline{\beta},\overline{\beta}), \qquad i=1,2 \\ U_i(\underline{\beta},\underline{\beta},\underline{\beta}) &\geq U_i(\overline{\beta},\underline{\beta},\underline{\beta}), \qquad i=1,2 \end{aligned}$$

which yields:

$$\begin{aligned} 0 &\geq 2[\phi(e^{FI})-\phi(e^{FI}+\Delta\beta)] \\ 0 &\geq 0 \end{aligned}$$

for both firms. For the first constraints, under our assumption, $\phi(e^{FI}+\Delta\beta)] > \phi(e^{FI})$, so that $2[\phi(e^{FI})-\phi(e^{FI}+\Delta\beta)]$ is always negative. As such, when a firm expects the other to truthfully reveal its private information, it will have an interest to reveal its private information.

In the infinitely repeated version of the game, under a grim trigger strategy, a collusive market sharing strategy is sustainable if and only if:

$$U_i^c \geq U_i^d$$

where U_i^c is firm i's expected discounted utility under a collusive market sharing strategy and U_i^d is firm i's expected discounted utility when it defects. In our case, $U_i^c = \frac{1}{(1-\delta)} v[\phi(e^{FI}) - \phi(e^{FI} - \Delta\beta)] > 0$ while $U_i^d = 0$, thus the collusive market sharing strategy is always sustainable for all values of δ when the regulator attribute the markets repeatedly after every period using a franchise bidding mechanism.