Regulation by duopoly under political constraints

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January 30, 2004

Abstract

In a variety of economies, the past two decades have witnessed substantial privatisation and regulation of previously state-owned monopolies. An important question for policy makers in such situations is the design of the regulated industry: should it retain its monopoly status (as British Gas did) or should it face immediate competition? An important influence on this decision may be the degree of regulatory capture in the privatised industry. Accordingly, we adapt Auriol and Laffont's [3] model of regulated industry design to allow for this effect. We find that delegation to a benevolent regulator is welfare enhancing. A non-benevolent regulator (i.e. one open to capture) reduces welfare because he requires costly incentive payments and outputs are lower to reduce rents (thereby hurting consumers and firms). Auriol and Laffont's favouring of duopoly is strengthened in this case, which raises interesting questions about the optimality of regulated industry structures in a number of economies.
JEL Classification: L51, P16
Keywords: Regulation, industry design, capture

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1 Introduction

In a variety of economies, the past two decades have witnessed substantial privatisation and regulation of previously state-owned monopolies. This has been complemented by the introduction of independent regulators as a means of overseeing the newly created industries. An important question facing policy makers has been how should the post-privatisation industry be designed? Should it retain its monopoly status (as British Gas did) or should it face immediate competition (as did British Telecom)? However, the use of independent regulators immediately introduces a complication because the prospect of subsequent regulatory capture may influence the industry-design decision.

This matter is recognised by Armstrong, Cowan and Vickers [1], who note that it is difficult to be clear about the effects of possible political interference when deciding on the structure of regulated industries. Real world illustrations include the way in which political considerations may have influenced the post-privatisation structure of UK gas and the electricity industries in 1986 and 1990 respectively (see [2, 10, 12]). According to Joskow[7], part of the current Californian electricity crisis is explained by the way in which interest groups influenced the structure of the industry. In Mexico political restrictions impede the participation of private firms in natural gas production [4] and the reorganization of the electricity sector.

Similarly, the need to address concerns about capture of independent regulators (through amendments to the regulator's contract) has been recognised in a variety of reguatory settings, beginning with Laffont and Tirole (1993) who study the effect of capture in the regulation of a natural monopolistic industry in a complete constitution approach framework, whose results opened the discussion about the optimal institutional design. Laffont and Martimort (1998) who study collusion and delegation, where they discuss the internal organization of the firm, arguing that the comparison between a centralized and a decentralized hierarchical organization should be cast in terms of the agency costs associated with the different side-contracting games that agents play in these organizations. Boyer and Laffont (1999) who consider the issue for environmental regulation in a model of incomplete contracts, finding that constitutional constraints on the instruments of environmental policy may be desirable, even though they appear inefficient from a standard economic viewpoint. Their justification lies in the limitations they impose on the politicians' ability to distribute rents. Martimort (1999) who study the life cycle of regulatory agencies, where he analyses the dynamics of capture

under transactions costs, resulting in that the design of regulatory institutions play a role to increase the transaction costs of capture. Faure-Grimaud and Martimort (2003) who study the issue of regulatory inertia, where they look at the effects of regulatory independence on the stability of the regulatory framework, finding that even though regulatory independence enlarges collusive opportunities between regulated interest groups, it also constraints future governments creating a stabilisation effect.

Most of the works mentioned above, deal with the design of an optimal regulatory framework under situations like capture and renegotiation, and the impact of independent regulators over regulatory commitment. Our model form part of this literature, however, it contributes to it by incorporating the analysis of industry design under political economy constraints.Most of the developments in the political economy of regulation, deal with the design of an optimal regulatory framework under situations like capture and renegotiation, and the impact of independent regulators over regulatory commitment. Our model form part of this literature, however, it contributes to it by incorporating the analysis of industry design under political economy constraints.

Given the above observations, the current paper presents a model of industry design in the context of the potential for regulatory capture in the newly privatised industry. In particular, we take Auriol and Laffont's [3] model of industry design where a government chooses between allowing a monopoly or duopoly to produce a homogeneous product.[1] We amend this by recognising that the government may appoint a regulator because of the latter's expertise in discerning the characteristics of firms on the industry. The regulator is intended to report this information truthfully but may be captured by the industry and, therefore, choose not to do so. This must be borne in mind when the government decides whether the industry should be privatised as a monopoly or an oligopoly.[2] Thus, our paper serves two purposes: it addresses an issue of policy-relevance in many countries, and contributes to a growing recent literature on the relationship between optimal regulation and questions of political economy.

In Auriol and Laffont the decision to choose duopoly over monopoly is determined by two effects: a "sampling effect" and a "yardstick effect". The former allows the regulator to drop a potentially high-cost competitor; the latter permits him to benchmark the firms' price/output decisions. These are then weighed against the undesirability of duplicated fixed costs if the duopoly setting is chosen. We find that the introduction of political con-

[1] Dana [6] considers a similar issue in the context of product differentiation.

[2] Formally, we use a 'complete contract' model of capture: see Laffont [9]

straints alters the balance between these two effects in favour of a more competitive regulated industry. The reason for this is The reason for this is that, **in general, political economy constraints produce a strength of the sampling effect compared to asymmetric information, and if the capture parameter reduces monopoly quantities more than duopoly quantities the yardstick competition effect is positive and increasing with the level of capture.** We suggest that our results provide interesting insights into several industry design decisions: for example, the fact that Mexican natural gas distribution in two of the main cities of the country involves potentially competing duopolists despite obvious elements of natural monopoly[3] and the opposite design decision taken in the UK when British Gas was privatised, as well as the existence of parallel transmission lines in Germany and the USA and the duopoly policy followed in the in the British telecommunications industry.

The paper is organised as follows. Section 2 presents the basic model, sections 3 and 4 derive results for the monopoly and duopoly cases respectively. Section 5 compares both industry structures and finally section 6 concludes.

[3]Monterrey city has two main distribution lines Gas de Monterrey and CFE. Mexico City was divided into four zones for distribution, opening the possibility for oligopolistic competition in the future.

2 The model

An industry has been privatised and the Government (G) must decide whether it should operate as a monopoly or a homogeneous goods duopoly. Whatever the arrangement, an independent regulator (R) has been appointed to oversee the market. As we shall see, the firm(s) enjoy private information about the costs of production though R receives a signal about this and reports it back to G. This signal is noisy which raises the prospect of asymmetric information prevailing once it is received. As always (see Laffont and Tirole), a familiar information rent accrues to low-cost production under asymmetric information and this may create an incentive for R to collude with the firm(s) and report an uninformative signal to G despite having received a revealing one. Recognising this, G must design a suitable contract for R and our interest is in the effect this has on G's choice between a monopoly and duopoly industry structure. Thus, in setting out the model, we first look at the firm(s)'s output decision, then set out R's monitoring technology, before finally specifing G's problem.

2.1 Firms' output decisions

Consider, with Auriol and Laffont, a market that can be served by one or two firms, 1 and 2, selling homogeneous output. Consumption generates gross surplus $S(q^1 + q^2)$ for $q^i \geq 0$, $i = 1, 2$, for consumers, so $P(q) = S'(q)$ is the inverse demand function. Firm i faces costs given by $C^i(\beta^i, q^i) + K$, where $\beta^i \in [\underline{\beta}, \overline{\beta}]$ and K is identical for both firms. Output is chosen to maximise Firm i's rent, $U(\beta^i) = t + P(q)q^i - C^i(\beta^i, q^i) - K$ where t is a transfer from G and $q \equiv q^1 + q^2$.

Variable costs are observable, outputs are verifiable while β^i is private information for Firm i. However, the β^i's are correlated in a commonly understood way so it may be possible to infer something about them from observable information. To see this, let $\beta^i = \alpha b + (1 - \alpha)\epsilon^i, \alpha \in [0, 1], i = 1, 2$. Here, α is the correlation between β^1 and β^2, b is a common factor affecting costs and the ϵ's are stochastically independent random shocks. We let $b \in [\underline{b}, \overline{b}]$ and $v = \Pr(b = \underline{b})$. Given the above, the range of β^i, $i = 1, 2$ is $[\underline{\beta}, \overline{\beta}] = [\alpha\underline{b} + (1 - \alpha)\underline{\epsilon}, \alpha\overline{b} + (1 - \alpha)\overline{\epsilon}]$. Finally, the correlation parameter is defined as:

$$\alpha = \frac{\overline{\epsilon} - \underline{\epsilon}}{\overline{b} - \underline{b} + \overline{\epsilon} - \underline{\epsilon}}$$

Thus, with this assumption, when the firms discover their β's they can infer the value of the common factor b.

2.2 The Regulator (R)

Unlike models of regulation without the prospects of capture, R's role in the current setting is to discern information about the cost of production and relay this to G, who then sets industry structure and contracts for the firm(s). The supervision technology follows Laffont [9] involves R receiving signal $\sigma = \underline{\beta}$ with probability ζ, so R is fully informed, and a signal $\sigma = \emptyset$ with probability $(1-\zeta)$, in which case the signal is uninformative[4]. We shall consider two types of R: a benevolent one, who always reports the signal truthfully, and a self-interested one, who may choose not to do this.

2.3 The Government (G)

The Government offers contracts to the firm(S) of the following type: $t = K + U(B) + Bq - P(q)q$, with $\dot{U}(B) = -q(B)$ and $\dot{q}(B) \leq 0$, depending on whether the industry operates as a monopoly or a duopoly. **The contracts maximise welfare, given by[5]:**

$$W = V(q) + U(q) = S(q) + \lambda P(q)q - (1+\lambda)(Bq + K) - \lambda U(B) \quad (1)$$

[4]A footnote: notice that this information technology implies that when the true parameter is B=Bhigh the signal is equal to the empty set.

[5]**Where:** $V(q) = S(q) - P(q)q - (1+\lambda)t$ **is consumers' welfare and** $U(q) = t + P(q)q - Bq - K$ **is the firms' utility.**

Subject to incentive rationality and incentive compatibility constraints. The choice between monopoly and duopoly is then determined by which generates the highest *ex ante* welfare.

3 Regulation of monopoly

3.1 The benchmark case: Benevolent regulation

Suppose that the industry operates as a monopoly and that R reports the signal he receives truthfully; hence, G is fully informed when $\beta = \underline{\beta}$ but faces asymmetric information otherwise. As is familiar from Laffont and Tirole [8], full information means that G maximises equation (1) subject to $U(\underline{\beta}) = 0$: call the solution W^{FI}. Under asymmetric information, G maximises the expectation of equation (1) conditional on the information that is contained in the signal, subject to incentive compatibility and individual rationality constraints: call this $E_{(\beta \geq \underline{\beta} | \sigma = \emptyset)} W^{AI}$. Thus, in total, G maximises $\zeta W^{FI} + (1 - \zeta) E_{(\beta \geq \underline{\beta} | \sigma = \emptyset)} W^{AI}$ subject to incentive compatibility and individual rationality constraints.[6] The solution to this problem is

$$\frac{P(q_M^b(\beta))-\beta}{P(q_M^b(\beta))}=\frac{\lambda}{1+\lambda}\frac{1}{\eta(q_M^b(\beta))} + \frac{\lambda}{1+\lambda}\frac{F(\beta)}{f(\beta)}\frac{1}{P(q_M^b(\beta))}\frac{(1-\zeta)f(\sigma,\beta)}{\zeta f(\sigma)f(\beta)+(1-\zeta)f(\sigma,\beta)} \quad (2)$$

where $q_M^b(\beta)$ is the quantity produced by the monopolist under a benevolent R. Equation (2) is an amended Ramsey formula. To understand it, note that when $\zeta = 1$ we have the usual Ramsey expression associated with full information; when $\zeta = 0$, the final expression equals 1 and Ramsey formula is amended by inclusion of the hazard $\frac{F(\beta)}{f(\beta)}$. We can show that q_M^b is greater than the output arising under the asymmetric information in the monopoly case q_M^{AI}. **This is because under delegation to a benevolent R, some good types are expected to be discovered as such with probability ζ, therefore G is able to permit a higher level of q. Welfare under delegation dominates asymmetric information because the expected rents are lower under delegation compared to asymmetric information[7].**

[6]It is readily shown that this is larger than the asymmetric information welfare arising in the absence of delegation to R: see Laffont (REF). Thus, delegation is valuable to G.

[7]**This is a standard result shown in [9]**

3.2 Non-benevolent regulation

When R is self-interested, there are strong incentives for collusion with the monopolist. If R reports $\sigma = \emptyset$, when $\sigma = \underline{\beta}$ then the firm gets

$$U(\beta) = \int_{\underline{\beta}}^{\overline{\beta}} \int_{\underline{\beta}}^{\overline{\beta}} q_M(\beta) \frac{f(\sigma, \beta)}{f(\sigma)} d\beta d\beta$$

with probability $(1 - \zeta)$. The maximum amount of money that the firm is willing to offer to R is a bribe of $U(\beta)$ with a value to R of $kU(\beta)$, where $k = \frac{1}{1+\lambda_c}$ and λ_c is an exogenous transaction cost of the side-payment.

Now G must provide incentives to R to prevent this capture. In particular, a payment of $\hat{s} = kU(\beta)$ is required. With this, R is indifferent between truth and collusion and chooses the former, by assumption. The expected social cost is $\lambda\zeta\hat{s}$, because the payment occurs with probability ζ and has a social cost λ.

The Government now maximises

$$\begin{aligned} \max_{q(.)} \Bigg\{ \zeta \Bigg[\int_{\underline{\beta}}^{\overline{\beta}} [S(q_M(\beta)) + \lambda P(q_M(\beta))q_M(\beta) - (1+\lambda)(\beta q_M(\beta) + K)] dF(\beta) \Bigg] + \\ + (1-\zeta) \Bigg[\int_{\underline{\beta}}^{\overline{\beta}} \int_{\underline{\beta}}^{\overline{\beta}} \Bigg[S(q_M(\beta)) + \lambda P(q_M(\beta))q_M(\beta) \\ - (1+\lambda)(\beta q_M(\beta) + K) - \lambda q_M(\beta) \frac{F(\beta)}{f(\beta)} \Bigg] \frac{f(\sigma,\beta)}{f(\sigma)f(\beta)} \} dF(\beta) dF(\beta) \Bigg] \\ - \lambda\zeta k \int_{\underline{\beta}}^{\overline{\beta}} \int_{\underline{\beta}}^{\overline{\beta}} \Bigg[q_M(\beta) \frac{F(\beta)}{f(\beta)} \Bigg] \frac{f(\sigma,\beta)}{f(\sigma)f(\beta)}) dF(\beta) dF(\beta) \Bigg\} \end{aligned} \quad (3)$$

which yields another amended Ramsey formula:

$$
\begin{aligned}
\frac{P(q_M^{nb}(\beta)) - \beta}{P(q_M^{nb}(\beta))} &= \tfrac{\lambda}{1+\lambda}\frac{1}{\eta(q_M^{nb}(\beta))} + \\
&+ \tfrac{\lambda}{1+\lambda}\tfrac{F(\beta)}{f(\beta)}\frac{1}{P(q_M^{nb}(\beta))} \\
&(\tfrac{f(\sigma,\beta)}{\zeta f(\sigma)f(\beta)+(1-\zeta)f(\sigma,\beta)})\Big[1+\zeta[k-1]\Big]
\end{aligned} \tag{4}
$$

where $q_M^{nb}(\beta)$ is the monopoly output under a non-benevolent R. Several possibilities arise. To begin, suppose that $\lambda_c \simeq \infty$ so that $k \simeq 0$. Here, R is of maximum use because collusion is infinitely costly to the firm. Setting $k = 0$ in (4) returns (2) and $q_M^{nb} = q_M^b$. Further, $\zeta = 1$ returns the First-Best a of benevolent regulation with a revealing signal.

Second, when transactions costs $\lambda_c \simeq 0$ (so $k \simeq 1$), the situation is as if no delegation had taken place: collusion is so 'easy' that it cannot be prevented. For $k = 1$ equation (5) below is obtained and the final result still depends on ζ.

$$\frac{P(q_M^{nb}(\beta)) - \beta}{P(q_M^{nb}(\beta))} = \frac{\lambda}{1+\lambda}\frac{1}{\eta(q_M^{nb}(\beta))} +$$
$$+ \frac{\lambda}{1+\lambda}\frac{F(\beta)}{f(\beta)}\frac{1}{P(q_M^{nb}(\beta))}$$
$$\left(\frac{f(\sigma,\beta)}{\zeta f(\sigma)f(\beta) + (1-\zeta)f(\sigma,\beta)}\right) \tag{5}$$

For $\zeta = 0$ equation (5) reduces to that of monopoly under asymmetric information and $q_M^{nb} = q_M^b = q_M^{AI}$. However, for $\zeta = 1$, $q_M^b > q_M^{nb} \geq q_M^{AI}$ provided that $0 < \frac{f(\sigma,\beta)}{f(\sigma)f(\beta)} \leq 1$. In spite of facing a completely captured R, the probability of facing a good type makes G distort production less.

This result is consistent with Laffont[9], Laffont and Tirole[8] and Tirole[11]. As a response to the possibility of capture, G adopts two mechanisms[8]: (i) To give incentives to R with a positive expected social cost; and (ii) To reduce the stake of collusion. Which is done by increasing price and reducing the quantities produced ($q_M^{nb} \leq q_M^b$), since rents are increasing in quantities, the firm suffers from collusion as well.

[8]A third mechanism could be to increase the costs of collusion λ_c, but these have been considered exogenous in this model.

4 Delegation under duopoly

Auriol and Laffont[3] assume that R is able to observe α the correlation of β types, having three cases: 1) For $\alpha = 1$ the Cramer-McLean[3, 5] condition holds and no rents are given up to the most efficient firm. 2) For $0 < \alpha < 1$ R is able to cut rents provided that $\beta^i \in A_2$[9]. And 3) For $\alpha = 0$ there is no correlation between types and it is not possible to cut rents. Under duopoly only the sampling effect takes place.

In this section we drop this last assumption and we assume that G needs an informed R to have information about the correlation of types. Under this assumption with no R, asymmetric information entails G giving up expected rents equal to[10]:

$$\int_{\underline{\beta}}^{\overline{\beta}} U^i(\beta^i) dF(\beta^i) = \int_{\underline{\beta}}^{\overline{\beta}} \int_{\underline{\beta}}^{\overline{\beta}} q^i(B) \frac{F(\beta^i)}{f(\beta^i)} d\hat{F}(B) \tag{6}$$

Where $(i = 1, 2)$ stands for firm 1 and firm 2, and $B = (\beta^1, \beta^2)$. Thus, the only motivation for G in regulating by duopoly with no delegation comes from the sampling effect; that is, to have the most efficient monopoly at the cost of the duplication of fixed costs. However, with the use of an informed

[9] In that case given the stochastic structure assumed by Auriol and Laffont[3] the Cramer-MalLean condition does not hold.

[10] The idea is that with no R, although G can expect some correlation to exist, firms can always argue (in court) that correlation is zero, and G has no information to build a counterargument. Some difficulties for yardstick competition to be implemented come from this issue.

R, G is able to cut expected rents subject to the information technology available and the scope for discretionary behavior by R.

Following Laffont[9], we define the supervision technology as follows. G requires an informed R, in this case R is not able to see firms types directly, but a hard signal of the correlation of these types. Then: a) with probability ξ R observes $\sigma = \alpha$ and with probability z, $0 < \alpha \leq 1$. And b) with probability $(1 - \xi)$ R observes $\sigma = \emptyset$ and with probability $(1 - z)$, $\alpha = 0$[11]. If $\alpha = 0$ then $\sigma = \emptyset$ always.

4.1 Benevolent (R)

Proceeding as in the monopoly case, first we check whether R is useful. If R is benevolent, with probability (ξz) the Constitution is fully informed about α and with probability $(1 - \xi z)$ she is not informed. Notice that in this context, full information is more limited since R is not able to see the exact level of correlation, she can observe only an interval of it; in particular she is not able to see whether $\alpha = 1$ in which case she could be able to extract all Rents.

As before we have two cases. First, under full information welfare is defined as:

[11] Only the sampling effects takes place.

$$W^{FI} = \int_{\underline{\beta}}^{\overline{\beta}} [S(q^1(B) + q^2(B)) +$$
$$P(q^1(B) + q^2(B))(q^1(B) + q^2(B)) -$$
$$(1+\lambda)[\beta^1 q^1(B) + K + \beta^2 q^2(B) + K] -$$
$$\lambda U^1_{\sigma=\alpha}(\beta^1) - \lambda U^2_{\sigma=\alpha}(\beta^2)] d\hat{F}(B) \tag{7}$$

Notice that in our context, full information means the ability of R to observe a signal about the correlation between β^i and report it. We have defined

$$\int_{\underline{\beta}}^{\overline{\beta}} U^i_{\sigma=\alpha}(\beta^i) dF(\beta^i) = \int_{\underline{\beta}}^{\overline{\beta}} \int_{\underline{\beta}}^{\overline{\beta}} q^i(B) \frac{[F(\beta^i) - I_{A_2} F(a)]}{f(\beta^i)} d\hat{F}(B) \tag{8}$$

where as in Auriol and Laffont's[3] $I_{A_2} = 1$ when firm $i = 1$, respectively firm $i = 2$, is in A_2 and $I_{A_2} = 0$ otherwise. This event happens with probability (ξz).

Second, under asymmetric information there is no need to revise expectations since G is not able to cut rents according to expectations[12], so rents in this case are given by equation (6) and expected welfare under asymmetric information is:

[12]The only choice for G is to solve the asymmetric information program.

$$W^{AI} = \int_{\underline{\beta}}^{\overline{\beta}} \Big[S(q^1(B) + q^2(B)) +$$

$$P(q^1(B) + q^2(B))(q^1(B) + q^2(B)) -$$

$$(1+\lambda)[\beta^1 q^1(B) + K + \beta^2 q^2(B) + K]$$

$$-\lambda U^1_{\sigma=\emptyset}(\beta^1) - \lambda U^2_{\sigma=\emptyset}(\beta^2) \Big] d\hat{F}(B) \tag{9}$$

where:

$$\int_{\underline{\beta}}^{\overline{\beta}} U^i_{\sigma=\emptyset}(\beta^i) dF(\beta^i) = \int_{\underline{\beta}}^{\overline{\beta}} \int_{\underline{\beta}}^{\overline{\beta}} q^i(B) \frac{F(\beta^i)}{f(\beta^i)} d\hat{F}(B) \tag{10}$$

This event happens with probability $(1-\xi z)$. Thus, total expected welfare is given by:

$$\xi z W^{FI} + (1 - \xi z) W^{AI}$$

and R is useful since:

$$\xi z [W^{FI} - W^{AI}] =$$

$$\xi z \Bigg(\int_{\underline{\beta}}^{\overline{\beta}} \int_{\underline{\beta}}^{\overline{\beta}} \Bigg\{ \Bigg[q^1(B) \frac{I_{A_2} F(a)}{f(\beta^1)} + q^2(B) \frac{I_{A_2} F(a)}{f(\beta^2)} \Bigg] \Bigg\} d\hat{F}(B) \Bigg) \geq 0 \tag{11}$$

This means that when the most efficient firm is in A_1 then R is neutral to the yardstick competition effect, because there is no way to cut rents, due to the fact that there is no truncation of the hazard rate. For the most efficient firm being in A_2, delegation is always useful provided that $0 < \xi z \leq 1$, since R gives information about correlation and it permits G to cut rents[13].

With a benevolent R, G' optimization problem is:

$$
\begin{aligned}
\max_{q^1(.),q^2(.)} \int_{\underline{\beta}}^{\overline{\beta}} \int_{\underline{\beta}}^{\overline{\beta}} & [S(q^1(B) + q^2(B)) \\
& + \lambda P(q^1(B) + q^2(B))(q^1(B) + q^2(B)) \\
& - (1+\lambda)(\beta^1 q^1(B) + K + \beta^2 q^2(B) + K)] d\hat{F}(B) \\
& - \lambda \int_{\underline{\beta}}^{\overline{\beta}} \int_{\underline{\beta}}^{\overline{\beta}} q^1(B) \frac{[F(\beta^1) - \xi z I_{A_2} F(a)]}{f(\beta^1)} d\hat{F}(B) \\
& - \lambda \int_{\underline{\beta}}^{\overline{\beta}} \int_{\underline{\beta}}^{\overline{\beta}} q^2(B) \frac{[F(\beta^2) - \xi z I_{A_2} F(a)]}{f(\beta^2)} d\hat{F}(B)
\end{aligned} \tag{12}
$$

The solution is:

$$
\frac{P(q_D^b) - \min(B)}{P(q_D^b)} = \frac{\lambda}{1+\lambda} \frac{1}{\eta(q_D^b)} + \frac{\lambda}{1+\lambda} \frac{F \min(B) - \xi z I_{A_2}(\min(B)) F(a)}{f \min(B)} \tag{13}
$$

For $\xi z = 0$ the situation is as if there is no R; for $\xi z = 1$ we are back in the situation in which G can observe $0 < \alpha \leq 1$ as in Auriol and Laffont[3].

[13] Notice that delegation is useful as long as it provides information about cost correlation of firms, however the sampling effect exists independently of delegation and/or correlation.

4.2 Non-benevolent R

Once again, however, there is scope for collusion when R receives the signal about α. If $\sigma = \alpha$ and $0 < \alpha < 1$, then G can cut rents from equation (10) to equation (8)[14] for firm one or two.

So, for $0 < \alpha \leq 1$ there are incentives for R to report $r = \emptyset$ when she has observed $\sigma = \alpha$[15]. By doing this, if $\beta^1 \in A_2$ then the firm is able to keep:

$$\int_{\underline{\beta}}^{\overline{\beta}} U^1_{(\sigma=\emptyset)}(\beta^1) dF(\beta^1) = \int_{\underline{\beta}}^{\overline{\beta}} \int_{\underline{\beta}}^{\overline{\beta}} q^1(B) \frac{F(\beta^1)}{f(\beta^1)} d\hat{F}(B)$$

and the same for firm 2. Under these circumstances the firm can pay to R up to:

$$\hat{s} = \int_{\underline{\beta}}^{\overline{\beta}} \int_{\underline{\beta}}^{\overline{\beta}} q^1(B) \frac{I_{A_2} F(a)}{f(\beta^1)} d\hat{F}(B)$$

For R, the value of the bribe is $k\hat{s}$, as before.

In order to avoid collusion G can give a transfer to R which has expected social value of $\lambda\xi zk\hat{s}$, since λ is the social cost of the transfer and ξz is the probability of the transfer to take place. G maximizes expected social welfare:

[14] For $\alpha = 1$ rents are zero

[15] Notice that the observation of the correlation parameter is still hard information for G in the sense that R cannot change the information received, in particular if she has observed $\sigma = \emptyset$, she cannot say that she has observed $\sigma = \alpha$.

$$\max_{q^1(.),q^2(.)} \xi z W^{FI} + (1-\xi z)W^{AI} - \lambda \xi z k \hat{s} \tag{14}$$

and the result is:

$$\frac{P(q_D^{nb}) - \min(B)}{P(q_D^{nb})} = \frac{\lambda}{1+\lambda}\frac{1}{\eta(q_D^{nb})} + \frac{\lambda}{1+\lambda}\frac{F\min(B)}{f\min(B)P(q_D^{nb})} + \frac{\lambda}{1+\lambda}\frac{\xi z I_{A_2}(\min(B))F(a)}{f\min(B)P(q_D^{nb})}[k-1] \tag{15}$$

We can define two extreme cases:

1. When the transaction costs are very large, for example in the extreme case that $\lambda_c = \infty$, $k = 0$, G is as if it were facing a benevolent R, equation (13).

2. In the other extreme if $\lambda_c = 0$, then $k = 1$ there are no transaction costs of capture. It is too easy for the firm to capture R that it is better for G not to avoid capture. In that case the solution is as that with no R:

$$\frac{P(q_D^{nb}) - \min(B)}{P(q_D^{nb})} = \frac{\lambda}{1+\lambda}\frac{1}{\eta(q_D^{nb})} + \frac{\lambda}{1+\lambda}\frac{F\min(B)}{f\min(B)P(q_D^{nb})} \tag{16}$$

Again as in the monopoly case, in response to collusion G: 1) Gives, at an expected social cost, incentives to R to avoid collusion. 2) Reduces the stake of collusion by reducing q_D due to the fact that rents are increasing in quantities. Consumers and firms are damaged by the risk of collusion. The first best in this framework (which is in reality a second best) is attained when $\xi z = 1$ and $k = 0$. Since G is able to maximize the cutting of rents for $\beta^1 \in A_2$, respectively $\beta^2 \in A_2$.

5 The comparison

5.1 Level of duplication of fixed costs

Auriol and Laffont [3] obtained four pricing equations shown in table (1), next page. Taking those equations and looking at the quantities produced under each industry structure and informational environment, they are able to determine the level of duplication of fixed costs that R could permit, due to the reduction in rents under duopoly structure.

Introducing delegation in an asymmetric information environment we also obtained four pricing equations shown in table (2).We intent to follow Auriol and Laffont's procedure to determine the level of duplication of fixed costs that G is able to permit under a non-benevolent R. Therefore, we study the

Table 1: Auriol and Laffont equations.

MFI[a]	$\frac{P(q_M^*)-\beta}{P(q_M^*)} = \frac{\lambda}{1+\lambda}\frac{1}{\eta(q_M^*)}$
MAI[b]	$\frac{P(q_M)-\beta}{P(q_M)} = \frac{\lambda}{(1+\lambda)}\frac{1}{\eta(q_M)} + \frac{\lambda}{(1+\lambda)}\frac{F(\beta)}{f(\beta)}\frac{1}{p(q_M)}$
DFI[c]	$\frac{P(q_D^*)-\min(B)}{P(q_D^*)} = \frac{1}{1+\lambda}\frac{1}{\eta(q_D^*)}$
DAI[d]	$\frac{P(q_D)-\min(B)}{P(q_D)} = \frac{1}{1+\lambda}\frac{1}{\eta(q_D)} + \frac{1}{1+\lambda}\frac{F(\min(B))-I_{A_2}(\min(B))F(a)}{f(\min(B))P(q_D)}$

[a] Monopoly Full Information.
[b] Monopoly Asymmetric Information.
[c] Duopoly Full Information.
[d] Duopoly Asymmetric Information.

Table 2: Delegation equations.

M-BR[a]	$\frac{P(q_M^b(\beta))-\beta}{P(q_M^b(\beta))} = \frac{\lambda}{1+\lambda}\frac{1}{\eta(q_M^b(\beta))} + \frac{\lambda}{1+\lambda}\frac{F(\beta)}{f(\beta)}\frac{(1-\zeta)f(\sigma,\beta)}{\zeta f(\sigma)f(\beta)+(1-\zeta)f(\sigma,\beta)P(q_M^b(\beta))}$
M-NBR[b]	$\frac{P(q_M^{nb}(\beta))-\beta}{P(q_M^{nb}(\beta))} = \frac{\lambda}{1+\lambda}\frac{1}{\eta(q_M^{nb}(\beta))} + \frac{\lambda}{1+\lambda}\frac{F(\beta)}{f(\beta)P(q_M^{nb}(\beta)}(\frac{(1+\zeta[k-1])f(\sigma,\beta)}{\zeta f(\sigma)f(\beta)+(1-\zeta)f(\sigma,\beta))})$
D-BR[c]	$\frac{P(q_D^b)-\min(B)}{P(q_D^b)} = \frac{\lambda}{1+\lambda}\frac{1}{\eta(q_D^b)} + \frac{\lambda}{1+\lambda}\frac{F\min(B)-\xi z I_{A_2}(\min(B))F(a)}{f\min(B)P(q_D^b)}$
D-NBR[d]	$\frac{P(q_D^{nb})-\min(B)}{P(q_D^{nb})} = \frac{\lambda}{1+\lambda}\frac{1}{\eta(q_D^{nb})} + \frac{\lambda}{1+\lambda}\frac{F\min(B)}{f\min(B)P(q_D^{nb})} + \frac{\lambda}{1+\lambda}\frac{\xi z I_{A_2}(\min(B))F(a)}{f\min(B)P(q_D^{nb})}[k-1]$

[a] Monopoly Benevolent R .
[b] Monopoly Non-benevolent R.
[c] Duopoly Benevolent R.
[d] Duopoly Non-benevolent R.

quantities produced in each industry structure. Through this procedure we expect to determine the effects that delegation and capture have over the level of permissible duplication of fixed costs, and with that the likelihood for G of selecting duopoly over monopoly when capture is present.

From Auriol and Laffont [3] we have the duplication of fixed costs as[16]:

[16] To derive the duplication of fixed costs they use the following results: $q_D^* = q_M^* \min(\beta^1, \beta^2)$. And $q_D = q_M$ if $\beta \in A_1$, $q_D > q_M$ if $\beta \in A_2$.

$$K^{AI} = \int_a^{\overline{\beta}} (q_D^{AI}(\beta)) - q_M^{AI}(\beta)) \frac{F\min(B)}{f\min(B)} dF\min(B) +$$
$$\int_{\underline{\beta}}^{\overline{\beta}} \left[q_M^{AI}(\beta) + \frac{\lambda}{1+\lambda} q_M^{AI}(\beta) \left(\frac{d(\frac{F(\beta)}{f(\beta)})}{d\beta} \right) \right] [F\min(B) - F(\beta)] d\beta \quad \text{(AL.5)}$$

After doing some remarks about different restrictive conditions of the model[17], their main conclusion is that, in general, asymmetric information favours the duopolistic structure when the market structure is chosen ex-ante.

In our case, the level of duplication of fixed costs under asymmetric information and non-benevolent R is defined as:

$$K^{nb} = \int_a^{\overline{\beta}} [q_D^{nb}(\beta) - q_M^{nb}(\beta)] \frac{F\min(B)}{f\min(B)} dF\min(B) +$$
$$+ \int_{\underline{\beta}}^{\overline{\beta}} [q_M^{nb}(\beta) + \frac{\lambda[1+\zeta[k-1]]}{1+\lambda} q_M^{nb} \left[\frac{d(\frac{F(\beta)}{f(\beta)})}{d\beta} \left(\frac{f(\sigma,\beta)}{\zeta f(\sigma) f(\beta) + (1-\zeta) f(\sigma,\beta)} \right) \right.$$
$$\left. + \frac{d(\frac{f(\sigma,\beta)}{\zeta f(\sigma) f(\beta) + (1-\zeta) f(\sigma,\beta)})}{d\beta} (\frac{F(\beta)}{f(\beta)}) \right] (F\min(B) - F(\beta)) d\beta \quad (17)$$

As expected, the duplication of fixed costs in this context is affected again by the yardstick competition effect under non-benevolent R Y^{nb}, (first

[17] In their framework an extra condition for duopoly to dominate monopoly as the decision taken by R about industry structure, is that the yardstick competition effect to dominate the weakening of the sampling effect under asymmetric information, relative to full information.

integral in equation (17)) and the sampling effect under non-benevolent R S^{nb}, (second integral in the same equation). Both effects are now affected, directly and indirectly, by the value of the parameters; therefore, we need to analyze analise, not only the direct change in Y^{nb} and S^{nb} for changes in the parameters, but also the change in quantities when the parameters change. The sampling effect, as in Auriol and Laffont's model, is divided in two parts: the quantity effect and the rent effect. However, unlike in that the model, the rent effect is now affected by additional terms coming from the conditional probabilities and the parameters[18] ζ and k. Therefore, equation (18) provides the condition for the sampling effect under a non-benevolent R to dominate the sampling effect under asymmetric information and no delegation.

[18]Notice that the term in big brackets for the sampling effect is the derivative of the hazard rate (which is positive by assumption) times the weighted conditional probability $g(\beta < \overline{\beta}|\sigma = \emptyset)$, plus the derivative of the conditional probability with respect to β, times the hazard rate. The derivative of the weighted conditional probability with respect to β may be negative as the probability of $\beta = \overline{\beta}$ given that $\sigma = \emptyset$ increases as β increases. This could make the rent effect to be negative since the hazard rate grows very fast. An explanation of a negative rent effect is the following: given that some good types are discovered as such, the change of the conditional probability of $\overline{\beta}$ given $\sigma = \emptyset$ is negative; this produces a negative rent effect since being the firm already efficient there is a waste in letting two firms to serve the market since the next firm is less efficient. There is no cost saving.

$$\int_{\underline{\beta}}^{\overline{\beta}} [q_M^{nb}(\beta) - q_M^{AI}(\beta)][F\min(B) - F(\beta)]d\beta \geq$$

$$\frac{\lambda}{1+\lambda}\int_{\underline{\beta}}^{\overline{\beta}} \Bigg[q_M^{AI}(\beta)\Bigg(\frac{d(\frac{F(\beta)}{f(\beta)})}{d\beta}\Bigg)$$
$$- [1+\zeta[k-1]]q_M^{nb}\Bigg[\frac{d(\frac{F(\beta)}{f(\beta)})}{d\beta}\Bigg(\frac{f(\sigma,\beta)}{\zeta f(\sigma)f(\beta) + (1-\zeta)f(\sigma,\beta)}\Bigg) +$$
$$\frac{d(\frac{f(\sigma,\beta)}{\zeta f(\sigma)f(\beta)+(1-\zeta)f(\sigma,\beta)})}{d\beta}(\frac{F(\beta)}{f(\beta)})\Bigg]\Bigg](F\min(B) - F(\beta))d\beta \tag{18}$$

For the yardstick effect, it is necessary to check the effects that the different values of the parameters have over q_M^{nb} and q_D^{nb}, we found that for $q_D^{nb} > q_M^{nb}$ equation (19) must hold. From our analysis we found that the yardstick effect could be negative for some values of the parameters. However, if the strengthening of the sampling effect under non-benevolent R dominates the weakening of the yardstick effect under non-benevolent R, the optimal contract still permits the duplication of fixed costs.

$$\int_a^{\overline{\beta}} \frac{F(\beta)}{f(\beta)}\frac{1}{P(q_M^{nb}(\beta))}(\frac{f(\sigma,\beta)}{\zeta f(\sigma)f(\beta) + (1-\zeta)f(\sigma,\beta)})\Big[1+\zeta[k-1]\Big] \geq$$
$$\int_a^{\overline{\beta}} \Bigg[\frac{F\min(B)}{f\min(B)P(q_D^{nb})} + \frac{\xi z I A_2 F(a)}{f\min(B)P(q_D^{nb})}[k-1]\Bigg]\frac{F\min(B)}{f\min(B)}dF\min(B) \tag{19}$$

As a general result we have that when the yardstick competition effect is positive, then G decision is biased towards duopoly since, for λ small enough and $q_M^{nb} > q_M^{AI}$, under delegation to a non-benevolent R the sampling effect is always strengthened compared to asymmetric information. Under certain values of the parameters the yardstick competition effect could be negative, however, G can still admit a positive level of duplication of fixed costs if the strengthening of the sampling effect under non-benevolent R compared to asymmetric information is bigger than the weakening of the yardstick competition effect. However, given the complexity of the relationships a numerical simulation is required to get a better picture of our conclusions.

5.2 Numerical simulation

We pursued a numerical simulation, assuming an exponential distribution function for the β types. We developed from it the required conditional and marginal distribution functions. The results are shown in tables (3), (4) and (5), in the next pages.

From table (3), we can observe that the duplication of fixed costs increases as capture increases for a given level of productivity γ, where $1/\gamma$ is the average productivity. However, for a high level of productivity, the level of duplication of fixed costs is reduced drastically, presenting even negative

Table 3: Duplication of fixed costs non-benevolent R[a]

	$\gamma = 0.25$	$\gamma = 0.5$	$\gamma = 0.75$	$\gamma = 1$	$\gamma = 1.5$
k=0	2.7126	3.835	4.1433	3.7411	-2.5750
k=0.2	2.7667	3.9539	4.3626	4.1286	-1.3552
k=0.5	2.8476	4.1317	4.6902	4.7007	0.4656
k=0.7	2.9014	4.2500	4.9078	5.0910	1.6736
k=0.8	2.9283	4.3090	5.0163	5.2824	2.2759
k=0.9	2.9552	4.3679	5.1247	5.4735	2.8770
k=1	2.9821	4.4268	5.2329	5.6642	3.4770

[a] The parameter k represents the level of capture. For the simulation $F(\beta)$ is assumed to be exponential, so γ is the parameter of the exponential cumulative distribution function, $\frac{1}{\gamma}$ is the average marginal cost. The higher γ the lower the marginal cost.

Table 4: Condition for S^{nb} to dominate S^{AI}[a]

	$\gamma = 0.25$	$\gamma = 0.5$	$\gamma = 0.75$	$\gamma = 1$	$\gamma = 1.5$
k=0	0.2964	0.3467	0.3203	0.3075	1.2648
k=0.2	0.3003	0.3587	0.3404	0.3329	1.2867
k=0.5	0.3060	0.3763	0.3692	0.3684	1.3107
k=0.7	0.3098	0.3877	0.3876	0.3904	1.3209
k=0.8	03116	0.3933	0.3965	0.4008	1.3242
k=0.9	0.3135	0.3989	0.4053	0.4108	1.3264
k=1	0.3153	0.4043	0.4139	0.4206	1.3275

[a] The parameter k represents the level of capture. For the simulation $F(\beta)$ is assumed to be exponential, so γ is the parameter of the exponential cumulative distribution function, $\frac{1}{\gamma}$ is the average marginal cost. The higher γ the lower the marginal cost.

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Table 5: Condition for strengthening of S^{nb} to dominate the weakening of Y^{nb}[(a)]

	$\gamma = 0.25$	$\gamma = 0.5$	$\gamma = 0.75$	$\gamma = 1$	$\gamma = 1.5$
k=0	0.0702	-0.3996	-0.3932	-1.1625	-6.8657
k=0.2	0.1243	0.0792	-0.1739	-0.7751	-5.6459
k=0.5	0.2052	0.2570	0.1538	0.9334	-3.8251
k=0.7	0.2591	0.3752	0.3714	0.1874	-2.6171
k=0.8	0.2860	0.4342	0.4799	0.3788	-2.0148
k=0.9	0.3130	0.4932	0.5883	0.5698	-1.4137
k=1	0.3398	0.5520	0.6965	0.7606	-0.8137

[a] The parameter k represents the level of capture. For the simulation $F(\beta)$ is assumed to be exponential, so γ is the parameter of the exponential cumulative distribution function, $\frac{1}{\gamma}$ is the average marginal cost. The higher γ the lower the marginal cost.

numbers for low levels of capture.

In table (4), we observe the condition for the sampling effect under non-benevolent R to dominate the sampling effect under asymmetric information. In our example, the condition holds for any value of k and γ.

Finally, in table (5), we corroborate that the strengthening of the sampling effect under non-benevolent R dominates the weakening of the yardstick effect under non-benevolent R. We found that, for a given level of productivity, the strengthening of the sampling effect increases its power as capture increases. However, for a given level of capture, an increase in productivity produces a non-linear effect in the condition. In any case, when productivity is very high the weakening of the sampling effect dominates and the monopolistic structure is preferred.

6 Conclusions

In this paper we have analysed regulation by duopoly under political economy constraints, we have built our model on Auriol and Laffont's model of regulation by duopoly and Laffont's model of capture under a complete contract approach with hard information. First, we introduced delegation and later we allowed for a non-benevolent R.

We found that delegation to a benevolent R increases welfare under monopoly and duopoly structures. Furthermore, a benevolent R increases quantities under both structures so that there is a strengthening of the sampling effect and a positive yardstick competition effect. The resulting implication is that the level of duplication of fixed costs is increased compared to asymmetric information.

Under a non-benevolent R there is a reduction in welfare compared to the benevolent case, since G has to give incentives to R to deliver true information. The reduction in welfare comes from three sources: the social cost of the incentive payments, the reduction in consumer surplus due to the reduction in quantities and the reduction in producer surplus due to the reduction in rents. Consumers and firms suffer from capture.

It is not straightforward to derive analytical conclusions about the overall effects of capture on the desirable level of duplication of fixed costs. However, we have seen that for certain values of the parameters there is a strengthening of the sampling effect compared to asymmetric information and if capture reduces monopoly quantities more than duopoly quantities the yardstick competition effect is positive and increasing with the level of capture. In such a case, duopoly dominates monopoly as the level of capture increases. Thus, political economy strengthens Auriol and Laffont's findings that duopoly is the welfare-dominant industry structure. The results of the numerical simulation support our observations.

Our model abstracts from a number of issues and, as such, raises several questions for future research. For instance, why have countries like England and France allowed duopolistic structures in their telecommunication sectors, or Germany and USA allowed for duplication of fixed costs in some natural gas transmission lines? Does it mean that there is more capture in those countries, than for example in some developing economies that preserved monopolistic structures in those sectors?

One interesting possibility is that the 'stake of collusion' is higher in more developed countries. Alternatively, perhaps these countries governments are more constrained by their constituencies, so that they face more pressures to set the optimal contract. In less developed countries, governments with less pressures are more discretionary and are able to avoid the optimal contract.

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