Regulation by duopoly under political constraints

José Eduardo Mendoza Contreras
Department of Economics. University of Surrey.
Guildford, Surrey GU2 7XH UK.
(mece64@hotmail.com)

Neil Rickman
Department of Economics. University of Surrey, and CEPR.
Guildford, Surrey GU2 7XH UK.
(N.Rickman@surrey.ac.uk)

Francesc Trillas
Departament d'Economia i Història Econòmica
Universitat Autònoma de Barcelona
08193 Bellaterra, Barcelona (SPAIN)
(francesc.trillas@uab.es)

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Abstract

We extend Auriol and Laffont (1992)’s comparison of regulating monopoly and oligopoly to allow for the possibility of regulatory capture. A benevolent regulator reduces allocative distortions under asymmetric information but these need to be increased when the regulator is non-benevolent. This is because reducing output lowers information rent and makes it easier for the Government to ‘buy off’ the regulator. As capture becomes easier, we show that most (but not all) forces favour the choice of duopoly, and we provide a sufficient condition for this bias to be unambiguous. By suggesting that the effects of capture may be diluted by suitable industry design our results may be of interest in post-privatisation settings and in developing economies.

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1 Introduction

In a variety of economies, the past quarter century has witnessed substantial restructuring of previously state-owned monopolies. This has been complemented by the introduction of independent regulators as a means of overseeing these 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 et al. (1994), who note that it is difficult to be clear about the effects of possible political interference when deciding on the structure of regulated industries. Despite this, however, the literature on the political economy of regulation has little to say about such structural issues since all of it (to our knowledge) focuses on monopolistic situations. Although there has been a lot of progress in modelling interest groups, capture; the political effects of asymmetric information; separation of powers; checks and balances; the life cycle of regulators or delegation into independent regulators, all these contributions are set in a framework with only one firm. We take a first step into modelling the political economy of sectors that combine liberalization and regulation, by analyzing the choice of duopoly or monopoly in an industry subject to regulation (by yardstick competition in the case of duopoly). In fact, the scope for this combination of delegated regulation, structural issues and (possibly) downstream capt-
ture is somewhat wider than in the regulated utilities. For instance, federal structures may exhibit central powers that are less under the influence of national or local firms whereas these are powerful *vis-à-vis* state governments. Thus, the European Commission has been consistently more pro-consumer and pro-competition than the member state governments, who have been more inclined to protect their national champions. In the US, it can be argued that the federal agencies of energy and telecommunications have been more active promoting liberalization and restructuring than the states. Similar effects can operate through pressure from international organizations in developing countries who may, themselves be captured by domestic industry. Any federal legislature with healthy party competition and large majorities needed for changes to (say) industrial structures may be prone to capture problems at the level of delegated decisions. Finally, as the transactions costs of capture varies across industries, the level of capture varies across industries as well. For instance, in some industries consumers are better informed (telecoms vs vehicle inspections or retail rather than whole sales markets) and may count with watchdogs institutions. In those situations we would expect the transactions costs of capture to be higher, so that the regulatory agencies should be less prone to be captured. The level of capture varies across countries as well as the level of corruption, measured for example by Transparency International.

A number of other authors have considered issues relating to independent regulation and capture. Laffont and Tirole (1993) and Laffont (2000) set out a general model of capture where the regulator is delegated the task of collecting information about the regulated firm’s performance by a principal
'Government') who, otherwise, has incomplete information about this. The Government ultimately designs the revelation mechanism for the firm. Here, capture involves changing the regulator’s feedback in return for a share of the information rents arising from the Government’s subsequent asymmetric information problem. Subsequent authors have built on this framework to analyse the trade-offs between centralised and decentralised decision making (in terms of agency costs: Laffont and Martimort (1998)), environmental lobbying (Boyer and Laffont (1999)), the life-cycle of regulatory agencies (Martimort (1999)) and regulatory inertia (Faure-Grimaud and Martimort (2003)). In addition, Laffont (2005) surveys literature on the potential for capture of independent regulators in developing economies, suggesting that a separation of regulatory powers may be beneficial here (see also Laffont and Martimort (1999)). As mentioned above, however, all of these papers assume that a monopolistic industry is being modelled and, as such, overlooks the important opportunity that Government may have to set the ‘rules of the game’ by first determining industry structure. As we show, this may be important because, as the prospects of capture increase, (duopoly) competition may help to alleviate its effects.

We build on Auriol and Laffont (1992)’s paper that considers regulated industry design in a non-capture setting with a homogeneous product (see Dana (1993) for a model with heterogeneous outputs). The Government itself regulates the industry having initially decided (by backwards induction) on a monopoly/duopoly structure. It has asymmetric information about production costs which may, in the duopoly setting, be correlated. This allows for partial rent extraction under duopoly (the “yardstick effect”). Duopoly also
generates the benefit of lower costs (in expectation) because there are more firms to sample from (the “sampling effect”). Comparison between the two structures is ambiguous, however, because of the fixed costs that are duplicated in the duopoly setting. In our model, having decided upon structure, the Government uses a regulator and capture may arise. The Government responds to this risk in two ways. First, it offers the regulator a contract that ‘buys off’ the incentive to collude with the firm(s). Second, it reduces the size of the required ‘buy-off’ payment by lowering output relative to the non-capture case. Thus, as mentioned above, the structural decision can help influence the effects of subsequent capture. We find that, as capture becomes more probable, it seems increasingly likely that duopoly will be favoured, though (as yet) we cannot confirm this analytically.

Laffont (2005) argues convincingly that in developing countries the transaction costs of capture are lower (so there is more capture) and the cost of public funds is higher. To the extent that the results of the model we present in the next pages vary with these two parameters (the transaction costs of capture and the cost of public funds), the model fits into the analysis of regulation in developing countries pioneered by Laffont.

The paper is structured as follows: the next section sets out the model; Sections 3 and 4 look at regulation under monopoly and duopoly respectively; In Section 5, we examine the effects of capture on the threshold level of fixed costs that determines the choice between our two industry structures and finally section 6 concludes the paper.
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. A familiar (see Laffont and Tirole (1993)) 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 signal. Recognising this, G must design a suitable contract for R.

Borrowing from Auriol and Laffont (1992), the firms, 1 and 2, sell a homogeneous output ($q_1$ and $q_2$), generating gross surplus $S(Q)$ for $Q = q_1 + q_2$, so $P(Q) = S'(Q)$ is the inverse demand function. Firm $i$ faces costs given by $C_i = \beta_i q_i + K$ where K is a fixed cost equal for both firms. Output is chosen to maximise Firm $i$’s rent, $U(\beta^i) = t + P(Q)q_i - \beta^i q_i - K$, where $t$ is a transfer from G.

The two firms’ cost parameters ($\beta^i, i = 1, 2$) contain a common element ($b \in \{\underline{b}, \overline{b}\}$) and an independently distributed shock ($\epsilon^i \in [\underline{\epsilon}, \overline{\epsilon}]$), where $Pr(b = \underline{b}) = v$ and $\epsilon^i$ is cumulatively distributed $H(\epsilon^i)$. We then have $\beta^i = \alpha b + (1 - \alpha)\epsilon^i$, with larger values of $\alpha$ denoting greater correlation amongst the firms types. The range of cost parameters is $[\underline{\beta}, \overline{\beta}] = [\alpha \underline{b} + (1 - \alpha)\underline{\epsilon}, \alpha \overline{b} + (1 - \alpha)\overline{\epsilon}]$. The cost parameters are distributed as follows: $\hat{F}(\beta^1, \beta^2)$ is the joint
cumulative distribution function; \( \hat{f}(\beta^1, \beta^2) \) is the joint density; \( F(\beta^i) \) is the marginal cumulative distribution function of \( \beta^i \); and \( f(\beta^i) \) is the marginal density. These are all common knowledge.

This set-up means that the firm(s) always enjoy some private information about their cost conditions.\(^1\) Notice that in the monopoly case, the firm report any cost parameter \( \beta \in [\underline{\beta}, \overline{\beta}] \) with \( F(\beta) \) and \( f(\beta) \).

In the duopoly case rents can be extracted using the correlation parameter. In order to avoid the Crémer-McLean result\(^2\), \( \alpha \) is specialised to:

\[
\alpha = \frac{\overline{\epsilon} - \underline{\epsilon}}{\overline{b} - \underline{b} + \overline{\epsilon} - \underline{\epsilon}} \tag{1}
\]

In fact, given (1), the range \([\underline{\beta}, \overline{\beta}]\) can be divided into two since \( \alpha \overline{b} + (1 - \alpha)\overline{\epsilon} = \alpha \underline{b} + (1 - \alpha)\underline{\epsilon} \equiv a \). Auriol and Laffont call the range \([\underline{\beta}, a]\) “\( A_1 \)” and \((a, \overline{\beta})\) “\( A_2 \)”—see Figure 1. This is important because it means that something about Firm \( i \)’s costs can be inferred from Firm \( j \)’s reports. In particular, if \( j \) reports \( \beta^j \in A_1 \), it is clear that both firms have \( b = \underline{b} \); and similarly for a report of \( \beta^j \in A_2 \).\(^3\)

As a result of the above, a measure of yardstick competition can be used to reduce rents under duopoly. This is because reports of \( \beta^i \in A_1 \) immediately allows \( G \) to truncate the distribution of possible types at \( a \) and restrict informational rents—unlike in the monopoly case. An extreme example of this

\(^1\)The presence of uncertainty replaces the role of cost-reducing effort in Laffont and Tirole (1993).

\(^2\)Under specific circumstances, this condition enables the regulator to extract all the informational rents from any level of correlation of types between firms. See Auriol and Laffont (1992) and Cremer and McLean (1985).

\(^3\)In equilibrium, both firms expect the other to report truthfully so it will be clear that an inconsistent report will generate immediate discovery. If \( G \) threatens substantial penalties for such inconsistency, it will not take place.
Figure 1: Disjoint productivity intervals

\[ \alpha b + (1 - \alpha) \xi = \alpha \bar{b} + (1 - \alpha) \bar{\xi} \]

occurs when \( \alpha = 1 \) as this generates complete correlation between the firms’ costs (see Cremer and McLean (1985)). More generally, however, we have \( \alpha < 1 \) so that this prospect does not arise.

Finally, we describe the timing of events. The government (G) chooses industry structure (monopoly or duopoly) on the basis of the expected outcome under contracts and production. The chosen firm(s) then sink their fixed costs \( (K) \) and learn their cost parameters \( (\beta^i) \). The regulator (R) then receives a signal about these costs which he may (or may not) pass on to G truthfully, who then designs contracts \( \{t(\beta), C(\beta)\} \) on the basis of this information. Firms choose contracts, production takes place, payments (under the contracts) take place and the game ends.

We begin by setting out and solving the monopoly case—in section 3 duopoly is introduced. We first look at the monopolist’s output decision, then set out R’s monitoring technology, before finally specifying G’s problem.
3 Regulation in the monopoly cases

3.1 The Monopolist (M)

A monopolist’s (M) output (Q) generates gross surplus S(Q), so \( P(Q) = S'(Q) \) is the inverse demand function with \( P'(Q) = S''(Q) < 0 \), for \( Q > 0 \). Production costs are given by \( \beta Q + K \), where \( \beta \in [\underline{\beta}, \overline{\beta}] \).\(^4\) Output is chosen to maximise M’s rent, \( U(\beta) = t + P(Q)Q - \beta Q - K \) where \( t \) is a transfer from G. Variable costs are observable, output is verifiable and \( \beta \) is private information for M; this creates the potential for delegating information gathering to a regulatory agent.

3.2 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 report this to G, who then sets industry structure and contracts for the firm(s). The supervision technology follows Laffont (2000): it involves R receiving a signal \( \sigma = \beta \) with probability \( \zeta \), so R is fully informed, and a signal \( \sigma = \emptyset \) with probability \( (1 - \zeta) \), in which case the signal is uninformative. 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.\(^5\)

\(^4\)Auriol and Laffont also examine a model with increasing costs.

\(^5\)Note that \( \zeta = 1 \) creates First Best (i.e. full-information) conditions when R is benevolent.
3.3 The Government (G)

The Government offers a contract of the following type to M: \( t = K + U(\beta) + \beta Q - P(Q)Q \), where the transfer payment \( t \) is set to recover the fixed \( K \) and variable costs \( \beta Q \) plus a rent \( U(\beta) \), in excess of sales revenue. The contract maximises expected social welfare, given by:

\[
W = \int_{\hat{\beta}}^{\bar{\beta}} [V(Q) + U(Q)]dF(\beta)
\]

\[
= \int_{\hat{\beta}}^{\bar{\beta}} [S(Q) + \lambda P(Q)Q - (1 + \lambda)(\beta Q + K) - \lambda U(Q)]dF(\beta)
\] (2)

where, \( V(Q) = S(Q) - P(Q)Q - (1 + \lambda)t \) is consumers’ net welfare, \( U(Q) \) is M’s rent (given above) and \( \lambda \) is the social cost of public funds. Given asymmetric information about \( \beta \), (2) is maximised subject to incentive compatibility constraints\(^6\):

\[
\dot{U}(\beta) = -Q(\beta)
\] (3)

\[
\dot{Q}(\beta) \leq 0
\] (4)

\[
U(\bar{\beta}) \geq 0
\] (5)

equation 5 is the individual rationality constraint.

3.4 The benchmark case: Benevolent regulation

Suppose that R reports the signal he receives truthfully; hence, G is fully informed when \( \sigma = \beta \) (i.e. with probability \( \zeta \)) but otherwise faces asymmetric

\(^6\)It is also required \( q_{M}(a^-) \geq q_{M}(a^+) \) from the discontinuity of the hazard rate of substitution at point \( a \) in figure 1. See Auriol and Laffont (1992).
information. As is familiar from Laffont and Tirole (1993), full information means that $G$ maximises equation (2) subject to $U(\beta) = 0$: call this monopoly welfare with full information $W_{FM}^{FI}$. Under asymmetric information, $G$ maximises equation (2) subject to (3)–(5): call this monopoly welfare of asymmetric information $W_{FM}^{AI}$. Thus, in total, $G$ solves $\max_{Q(\beta)} \zeta W_{FM}^{FI} + (1 - \zeta)W_{FM}^{AI}$ subject to (3)–(5), where

$$W_{FM}^{FI} = \int_{\beta}^{\overline{\beta}} [S(Q(\beta)) + \lambda P(Q(\beta))Q(\beta) - (1 + \lambda)(\beta Q(\beta) + K)]dF(\beta)$$

$$W_{FM}^{AI} = \int_{\beta}^{\overline{\beta}} [S(Q(\beta)) + \lambda P(Q(\beta))Q(\beta) - (1 + \lambda)(\beta Q(\beta) + K) - \lambda U(\beta)]dF(\beta)$$

Let the solution to this problem be $Q_{FM}^{b}$. This solution ($Q_{FM}^{b}$) is implicitly given by

$$\frac{P(Q_{FM}^{b}(\beta)) - \beta}{P(Q_{FM}^{b}(\beta))} = \frac{\lambda}{(1 + \lambda)\eta(Q_{FM}^{b}(\beta))} + \frac{\lambda}{1 + \lambda} \frac{F(\beta)}{(1 - \zeta)F(\beta)}$$

Equation (6) is an amended Ramsey formula. When $\zeta = 1$ we have the usual Ramsey expression associated with full information (with costly transfers). Values of $\zeta < 1$ create an asymmetric information problem for $G$ (with the problem worsening as $\zeta$ falls and $R$ becomes less useful in overcoming the problem; indeed $\zeta = 0$ returns Auriol and Laffont’s result with asymmetric information and no delegation). In this case, a further allocative distortion arises because of the need to provide information rent. The extent of the price increase is determined by the hazard rate $(F/f)$ which trades off the

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7The solution technique is standard: some manipulation of (3) enables substitution for $U(\beta)$ while the remaining constraints are readily confirmed to be satisfied at this solution (see Mendoza-Contreras (2005)).
number of firms who would experience the distortion \( f(\beta) \) with the likely number having their rent cut \( F(\beta) \). From the above discussion, we deduce:

**Result 1** Monopoly quantities produced under asymmetric information with no regulator \( (Q^A_M) \) are less than or equal to monopoly quantities produced under asymmetric information with a benevolent regulator \( (Q^b_M) \). In turn, these are less than or equal to First Best (full information quantities \( (Q^*_M) \)).

This result is intuitive. The presence of a benevolent regulator enables \( G \) to avoid the asymmetric information problem with positive probability. In anticipation of this, there is less need to remove information rents by (the usual mechanism of) lowering output levels.

### 3.5 Non-benevolent regulation

Now it is possible that \( R \) will cheat when receiving the signal \( \sigma \). As a result, we need to calculate \( R \)’s potential gains from such behaviour. If \( R \) reports \( \sigma = \emptyset \) when \( \sigma = \beta \) then \( M \) receives \( U(\beta) = \int_\beta^\gamma Q(\beta) dF(\beta) \). Accordingly, this is the maximum that \( M \) will offer to bribe \( R \) and influence his report to \( G \).

This has a value of \( kU(\beta) \), where \( k \) reflects the costs of reaching such a deal (thus, higher values of \( k \) imply that capture is ‘easier’). In particular, let \( k = \frac{1}{1+\Delta} \) and \( \Delta \) is an exogenous transaction cost of the side-payment.

\( G \) must now provide incentives to \( R \) to prevent capture. Therefore a payment of \( k\hat{s} = kU(\beta) \) is required. With this, \( R \) is indifferent to truth or collusion and we assume that he selects the former. The expected social cost
is $\lambda \zeta k \delta$. The Government now solves

$$
\max_{Q(\beta)} \zeta [W_M^F - \lambda k \delta] + (1 - \zeta) W_M^A
$$

subject to (3)–(5). The solution, $Q_M^{nb} (\beta)$, is implicitly given by the amended Ramsey formula:

$$
\frac{P(\zeta) - \beta}{P(Q_M^{nb} (\beta))} = \frac{\lambda}{(1 + \lambda) \eta (Q_M^{nb} (\beta))} + \frac{\lambda}{1 + \lambda} [1 - \zeta (1 - k)] \frac{F(\beta)}{f(\beta) P(Q_M^{nb} (\beta))}
$$

(7)

Several possibilities arise. To begin, suppose that transactions costs are high ($\Delta \simeq \infty$) so that $k \simeq 0$. Here, $R$ is of maximum use because collusion is infinitely costly to the firm. Setting $k = 0$ in (7) returns (6) and $Q_M^{nb} = Q_M^{b}$. Further, when $k = 0$, $\zeta = 1$ returns the First-Best while $\zeta = 0$ returns $Q_M^{AI}$. Next, when $\Delta \simeq 0$ (so $k \simeq 1$), the situation is as if no delegation had taken place: collusion is too 'easy' to be prevented. For $k = 1$ we have $Q_M^{nb} = Q_M^{AI}$, that is, a totally captured regulator does not do better than asymmetric information. Employing the implicit function theorem on (7) yields

$$
\frac{\partial Q_M^{nb}}{\partial k} = \frac{\zeta F(\beta)}{f(\beta) P'(Q_M^{nb})} \leq 0
$$

since $P'(Q_M^{nb}) < 0$ by assumption. Thus we have

**Result 2** For a given type of non-benevolent regulator ($\zeta$), $Q_M^{nb} \leq Q_M^{b}$.

This result can be explained as follows. In response to the possibility of capture, $G$ adopts two mechanisms: (i) the provision of incentives to $R$ and,

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8 A third mechanism could be to increase the costs of collusion $\Delta$. 

12
because this has a social cost, (ii) the lowering of the gains available from collusion. The latter is done by increasing price and reducing the quantities produced ($Q_{nb}^M \leq Q_{M}^b$), since rents are increasing in quantities.\footnote{Thus, M also suffers from collusion in equilibrium.}

4 Delegation under duopoly

4.1 Duopoly with a benevolent regulator

The regulator’s monitoring technology is analogous to that in Section 2. With probability ($\zeta$), R observes a signal $\sigma = (\beta^1, \beta^2)$, while with probability $(1 - \zeta)$ he observes nothing, so $\sigma = \emptyset$. Therefore, as in the monopoly case, G maximises the expectation of duopoly welfare under full information and asymmetric information. Thus, G solves $\max_{q_1(B),q_2(B)} \zeta W_{FI}^D + (1 - \zeta)W_{AI}^D$, for $B = \{\beta^1, \beta^2\}$, subject to incentive compatibility and individual rationality constraints. The former is given by

$$\dot{U}^i(\beta^i) = -E_{(\beta^j | \beta^i)} q_i(B), \quad i,j = 1, 2, \quad i \neq j \quad (8)$$

This resembles (3) but, now, rent must evolve according to the anticipated effect of Firm $j$ on $i$’s output (and, thus, rent). As usual, given (8), individual rationality reduces to

$$U^i(\beta^i) \geq 0, \quad i = 1, 2 \quad (9)$$
The welfare functions are given by

\[
W_{DF}^{FI} = \int_{\beta_2}^{\beta_1} \left[ S(Q(B)) + \lambda P(Q(B))Q(B) - (1 + \lambda) \sum_{i=1}^{2} (\beta^i q^i + K) \right] d\hat{F}(B)
\]

\[
W_{DA}^{FI} = \int_{\beta_2}^{\beta_1} \left[ S(Q(B)) + \lambda P(Q(B))Q(B) - (1 + \lambda) \sum_{i=1}^{2} (\beta^i q^i + K) - \lambda \sum_{i=1}^{2} U^i(\beta^i) \right] d\hat{F}(B)
\]

We now consider the solution to the above programme. Since only the most efficient firm will actually produce in this (homogeneous goods, linear costs) industry, the firms marginal cost will be \(\min\{B\}\) (with associated distributions \(F_{\min}(B)\) and \(f_{\min}(B)\)). Further, from our discussion in Section 3.3, we must recognise the discontinuity in Firm \(i\)'s rent that results from being in either \(A_1\) or \(A_2\) in Figure 1. Let \(I_{A_2}(\beta^i)\) be an indicator function with \(I_{A_2}(\beta^i) = 1\) if \(\beta^i \in A_2\), and 0 otherwise. Denoting the solution to the programme as \(Q^b_D(B)\), this is implicitly given by

\[
\frac{P(Q_D^b) - \min\{B\}}{P(Q_D^b)} = \frac{\lambda}{1 + \lambda \eta(Q_D^b)} + \frac{\lambda}{1 + \lambda (1 - \zeta)} \frac{F_{\min}(B) - I_{A_2}(%(\min\{B\})F(A)}{f_{\min}(B)P(Q_D^b)}
\]

(10)

Again, this is a modified Ramsey formula; one modification emerging from the asymmetry of information that results when \(R\) receives an uninformative signal (with probability \(1 - \zeta\)), the other coming from whether \(G\) can use yardstick competition to help overcome the asymmetry in this case: this happens when \(I_{A_2} = 1\) because the lower truncation of the \(\beta\) distribution helps to reduce the benefits of distorting output because there is a smaller number of efficient firms who would earn information rent. As in the monopoly case, a fully informed benevolent regulator (\(\zeta = 1\)) returns the First Best (full infor-
mation) outcome. When R is uninformed, we need to examine the final (‘distortion’) term in (10) when \( \min \{ B \} = \hat{\beta} \in A_1 \) and when \( \min \{ B \} = \tilde{\beta} \in A_2 \). For \( \min \{ B \} \in A_1 \), it is clear from (10) and (6) that \( Q^b_M = Q^b_D \). By contrast, when \( \min \{ B \} \in A_2 \), we have \( Q^b_D > Q^b_M \). This latter result is the yardstick effect brought about by having a probability of giving away information rent that is reduced to \( F_{\min}(B) - F(a) \) to trade off against the costs of distortion, \( f_{\min}(B) \). Setting \( \zeta = 0 \) returns asymmetric information output under duopoly. Inspection of (10) shows that these outputs are generally below those under some quality of delegation: as with monopoly, the prospects of R addressing the asymmetric information problem allows G to impose less distortion on quantities.

**Result 3** Duopoly quantities under delegation to a benevolent regulator are greater than or equal to monopoly quantities under benevolent regulation and duopoly quantities under asymmetric information.

### 4.2 Duopoly with a non-benevolent regulator

Once again there is scope for collusion when R receives the signal about \( \beta \). If \( \sigma = \beta \) and R reports this then G pays to the most efficient firm no rent. This firm is better off if R reports \( \emptyset \). With this report it can get an expected rent given by: \( \int_{\hat{\beta}}^\beta \int_{\hat{\beta}}^\beta q(B) \frac{F(\beta) - I(a)(\beta)F(a)}{f(\beta)} d\hat{F}(B) \), which reflects the fact that there is some probability (captured in \( \hat{F}(B) \)) that this firm is the most efficient. This is the maximum amount \( \hat{s}(i|\beta^i = \min \{ B \}) \) that the firm can pay to R, which has a value for him: \( k\hat{s}(i|\beta^i = \min \{ B \}) \), where \( k \) is defined as before.

As in the monopoly case, G gives a transfer which has an expected so-
cial value across the competing duopolists and therefore maximizes expected social welfare:

$$
\max_{q^1, q^2} \zeta W^F_D + (1 - \zeta) W^A_D - \lambda \zeta k \sum_{i=1}^{2} \hat{s}(i) \beta^i = \min\{B\} 
$$

(11)

subject to incentive compatibility (8) and individual rationality (9) constraints. From the first order conditions, we get the price-markup equation for duopoly under a non-benevolent regulator as:

$$
\frac{P(Q^b_D) - \min(B)}{P(Q^A_D)} = \frac{\lambda}{1 + \lambda \eta(Q^b_D)} + \frac{\lambda}{1 + \lambda} \left[1 - \zeta(1 - k)\right] 
\left(\frac{F \min(B) - I_{A_2}(\min(B)) F(a)}{f \min(B) P(Q^b_D)}\right) 
$$

(12)

We can define two extreme cases. First, when the transaction costs are very large (e.g. $\Delta = \infty, k = 0$), G effectively faces a benevolent R, as in equation (10). Second, at the other extreme, $\Delta = 0$ so $k = 1$ and there are no transaction costs of capture. It is too easy for the firm to capture R and impossible for G to avoid capture. In this case the solution is as that with no R. The above analysis provides the intuition for the following result:

**Result 4** Duopoly quantities under a non-benevolent $R$ lie in the range $Q^b_D \geq Q^A_D$, furthermore they decrease with the level of capture. This is confirmed by:

$$
\frac{\partial Q^b_D}{\partial k} = \frac{F(\min(\beta) - I_{A_2}(\min(\beta)) F(a)}{f(\min(B))} \zeta P'(q^b_D) \leq 0
$$
since $P'(Q_D^{nb}) < 0$.

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 is attained when $\zeta = 1$ together with $k = 0$ or when $\alpha = 1$ alone. Since G is able to maximize the cutting of rents for $\beta^1 \in A_2$, respectively $\beta^2 \in A_2$.

The contribution of this section has been to analyse the scope of capture in a duopolistic structure, something that as we have mentioned in the introduction, to our knowledge has not been done by the literature before. In the next section we will compare this result with those obtained by the literature in the study of capture under a monopolistic structure, in order to find the effect of capture on the optimal decision taken by G.

5 Monopoly and duopoly compared

Our interest in this section is in the choice between monopoly and duopoly structures. Following Auriol and Laffont, a convenient way to address this is to identify the level of fixed cost ($K$) which just makes G indifferent between these two options. We focus on the non-benevolent regulator. The relevant value of $K$ ($K^{nb}$, say) is the solution to $E[W_{M}^{nb}] = E[W_{D}^{nb}]$. Some
straightforward algebra (see Mendoza-Contreras (2005)) shows that

\[
K^{nb} = \int_a^\beta \left[ Q^{nb}_D(\beta) - Q^{nb}_M(\beta) \right] F_{\min}(B) \frac{f_{\min}(B)}{dF_{\min}(\beta)} dF_{\min}(B)
\]

\[
+ \int_\beta^{\bar{\beta}} \left[ Q^{nb}_M(\beta) + \frac{\lambda}{1 + \lambda} [1 - \zeta(1 - k)] Q^{nb}_M \frac{d(F(\beta))}{d\beta} \right] 
\times (F_{\min}(B) - F(\beta)) d\beta
\]

(13)

For values of \( K > K^{nb} \) any gains associated with duopoly are outweighed by the duplication of fixed costs. We now examine the components of \( K^{nb} \).

It is possible to decompose \( K^{nb} \) into a yardstick effect (\( Y^{nb} \)) and a sampling effect (\( S^{nb} \)). In turn, the latter can be decomposed into an output effect (\( O^{nb} \)) and a rent effect \( U^{nb} \); i.e. \( S^{nb} = O^{nb} + U^{nb} \). We now have the following results:

\[
\frac{\partial Y^{nb}}{\partial k} = \int_a^\beta \left[ \frac{\partial Q^{nb}_D}{\partial k} - \frac{\partial Q^{nb}_M}{\partial k} \right] F(\min(\beta)) \frac{f(\min(\beta))}{f(\min(\beta))} dF(\min(\beta))
\]

\[
= \int_a^\beta \zeta \left[ \frac{F(\min(\beta)) - IA_2(\min(\beta)F(a))}{f(\min(\beta))P'(Q^{nb}_D)} - \frac{F(\beta)}{f(\beta)P'(Q^{nb}_M)} \right] F(\min(\beta)) dF(\min(\beta)) \geq 0
\]

(14)

This is the effect discussed in the previous section: the presence of two firms allows G to call for less distortions in output and, in turn, to increase welfare.

\[
\frac{\partial O^{nb}}{\partial k} = \int_\beta^{\bar{\beta}} \frac{\partial Q^{nb}_M}{\partial k} (F(\min(\beta)) - F(\beta)) d\beta \leq 0
\]

(15)

This is intuitive: the smaller the project is (as it happens under easier capture), the less benefit arises from the possibility of sampling a lower cost
The effect of easier capture on the rent effect is ambiguous. On one hand, under duopoly, the distribution of $\beta$ is more favourable (due to sampling) and, therefore $G$ anticipates giving away less information rent. As capture becomes easier, and output falls, there is less benefit from this effect (this is the negative effect in (16)). On the other hand, we can interpret $1 - \zeta(1 - k)$ as the ‘quality’ of $R$ in terms of its success in saving rent for $G$. As $k$ approaches 0, $R$ is more effective on $G$’s behalf and the sampling effect is maximized (this is the positive effect in (16)).

Clearly, although easier capture appears likely to increase the $G$’s preference for duopoly, the final effect above means that we cannot be certain of this. We can, however, state the following result (which follows directly from (15) and (16)):

**Result 5** A sufficient condition for easier capture (higher $k$) to increase the range of fixed costs over which duopoly is favoured is

$$\frac{\partial O_{nb}}{\partial k} + \frac{\partial U_{nb}}{\partial k} \geq 0$$

which requires

$$\xi Q^{nb}_M + [1 - \xi(1 - k)]\frac{\partial Q^{nb}_M}{\partial k} \geq 0.$$
Table 1: $K^{nb}$ (Exponential pdf)

<table>
<thead>
<tr>
<th>$\lambda$ = 0.5</th>
<th>$\gamma = 0.5$</th>
<th>$\gamma = 0.75$</th>
<th>$\gamma = 1.5$</th>
<th>$\lambda$ = 0.3</th>
<th>$\gamma = 0.5$</th>
<th>$\gamma = 0.75$</th>
<th>$\gamma = 1.5$</th>
<th>$\lambda$ = 0.1</th>
<th>$\gamma = 0.5$</th>
<th>$\gamma = 0.75$</th>
<th>$\gamma = 1.5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$k$ = 0</td>
<td>3,059.4</td>
<td>3,495.0</td>
<td>4,872.0</td>
<td>3,263.0</td>
<td>3,743.8</td>
<td>5,202.0</td>
<td>3,692.4</td>
<td>4,158.6</td>
<td>5,751.0</td>
<td>3,602.4</td>
<td>4,158.6</td>
</tr>
<tr>
<td>$k$ = 0.2</td>
<td>3,090.1</td>
<td>3,520.0</td>
<td>4,918.0</td>
<td>3,286.1</td>
<td>3,762.8</td>
<td>5,236.0</td>
<td>3,612.7</td>
<td>4,167.1</td>
<td>5,766.0</td>
<td>3,612.7</td>
<td>4,167.1</td>
</tr>
<tr>
<td>$k$ = 0.4</td>
<td>3,120.9</td>
<td>3,546.6</td>
<td>4,964.0</td>
<td>3,309.2</td>
<td>3,781.8</td>
<td>5,271.0</td>
<td>3,622.9</td>
<td>4,175.5</td>
<td>5,781.0</td>
<td>3,622.9</td>
<td>4,175.5</td>
</tr>
<tr>
<td>$k$ = 0.6</td>
<td>3,151.7</td>
<td>3,751.0</td>
<td>5,010.0</td>
<td>3,332.3</td>
<td>3,800.8</td>
<td>5,305.0</td>
<td>3,633.2</td>
<td>4,184.1</td>
<td>5,797.0</td>
<td>3,633.2</td>
<td>4,184.1</td>
</tr>
<tr>
<td>$k$ = 0.8</td>
<td>3,182.4</td>
<td>3,596.0</td>
<td>5,056.0</td>
<td>3,355.3</td>
<td>3,819.9</td>
<td>5,339.0</td>
<td>3,643.5</td>
<td>4,192.5</td>
<td>5,812.0</td>
<td>3,643.5</td>
<td>4,192.5</td>
</tr>
<tr>
<td>$k$ = 1</td>
<td>3,213.1</td>
<td>3,622.0</td>
<td>5,102.0</td>
<td>3,378.4</td>
<td>3,838.9</td>
<td>5,374.0</td>
<td>3,653.7</td>
<td>4,201.0</td>
<td>5,827.0</td>
<td>3,653.7</td>
<td>4,201.0</td>
</tr>
</tbody>
</table>

In order to illustrate our analysis, we end with a numerical example of the effects we have identified above. To perform this, we assume that $F(\beta) = 1 - e^{-\gamma \beta}$ (i.e. an exponential cumulative distribution), so that the probability distribution function is $f(\beta) = \gamma e^{-\gamma \beta}$ with $E(\beta) = 1/\gamma$, and that inverse demand is of the (linear) form $P = 1000 - 0.5Q$. We calculate $K^{nb}$ for values of $k$ from 0 to 1 (at intervals of 0.2) and for $\lambda = \{0.5, 0.3, 0.1\}$. We also allow for different values of $\gamma$ since $1/\gamma$ is the expected value of $\beta$ so that higher $\gamma$ implies lower marginal costs. Table 1 presents the results. It is clear from the table that increasing $k$ raises $K^{nb}$ for all values of $\lambda$ and $\gamma$ studied: thus, easier capture favours duopoly here, as we would broadly expect. As $\lambda$ falls, this effect is more pronounced because it is cheaper for G to set the optimal structure. Both these sets of results are robust to various expected values of $\beta$ (changes in $\gamma$).

6 Conclusions

The design of post-privatisation industries has been an important concern for policy makers over the last twenty-five years. An additional feature of this issue has been the use of independent regulators to oversee the result-
ing industries. As several authors have noted, this independence raises the prospect of capture and, in turn, can influence the conditions under which regulation takes place. The current paper applies this insight to the question of designing post-privatisation industries.

Our results show that delegation to a benevolent regulator has the beneficial effect of reducing allocative distortions under asymmetric information: this occurs under monopoly and duopoly and arises because of the information gathering benefits from delegation. Under a non-benevolent regulator, a complication arises because of the need to distort outputs in order to limit incentives for collusion between firm(s) and regulator. These distortions are (generally) smaller than under asymmetric information, however, and are also no larger under duopoly than under monopoly. As a consequence, our results suggest that there is a welfare bias towards duopoly when there is a serious prospect of capture (a strengthening of Auriol and Laffont (1992)'s own result without capture), though further work is needed to establish the limits to this.

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 has taken a light regulation approach on its natural gas industry, allowing 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? This seems potentially counter-intuitive. One interesting possibility may be that developed countries’ governments are more
constrained by their constituencies and this, combined with a lower social cost of transfers, makes them more willing to implement the optimal contract. In less developed countries, on the other hand, governments with less pressures and higher social costs of public funds are more discretionary and have more incentives to avoid the optimal contract as in Laffont (2005). It seems likely that case studies will prove helpful in addressing these more detailed questions. An interesting case study here may be Mexico, where there is a wide range of examples of industry design under the pressure of powerful interest groups, and a not so strong institutional framework. The Mexican Government privatised or gave exploitation rights in favour of certain interest groups that created national or regional private monopolies in industries such as telecommunications, airports, seaports, rail, natural gas, roads, etc. Introducing competition in those sectors has been an extremely difficult task for the Federal Competition Commission, in such a way that the performance in those industries has become one of the main obstacles to reform the Mexican energy sector. Some future agenda for research may be to endogenise the transaction costs of capture following the work of authors such as Grossman and Helpman (1996), Martimort (1999), Bardhan and Mookherjee (1999), and Devarajan and Zou (2000). Finally, as Motta (2004) points it out capture affects competition agencies as well. A captured competition agency may permit anticompetitive mergers, that the Government would like to avoid, so that a natural extension of this paper could be to analyse merger decisions under the scope of capture. We hope that our analysis has highlighted an important link between industrial and regulatory design.
References


