"Calling the Cards: Fears, Threats and Delegation in Infrastructure Regulation Games"

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ABSTRACT

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Abstract

Infrastructure regulation under asymmetric information on cost and effort-averse agents is revisited in this paper from the perspective of pragmatic implementations of regulatory regimes by political principals that have potentially non-aligned preferences. The political principal manipulates the independent regulator to leave rents to industry by two means; regulatory oversight by appeal courts and by imposing ex post participation constraints for yardstick regimes. First, along the lines of the law and regulation literature, we also assume that regulatory rulings can be appealed and repelled at high social costs if shown to be infeasible. By forcing the regulator to internalize these costs, the ex ante high-powered regimes are biased to provide higher information rents for a long period. Second, the yardstick regimes are powerful instruments to induce information revelation and productive efficiency under some conditions, one of them being a credible threat of bankruptcy. In our model, the weak political principal safeguards full participation from the full panel of firms by offering individual rationality constraints fulfilled ex post even under a yardstick regime, basically curtailing the regime to only offer upside gains. The framework presented in a stylized model shows that the fear for regulatory failure leads to welfare losses under all regimes, may distort choices of regulatory instruments and hampers information revelation. Some policy conclusions and analogies to the situation for the European economic regulation of electricity distribution system operators are given at the end of the paper.

1 Introduction

Regulation of essential infrastructure is not only an area of considerable academic interest, but also an everyday occupation for both administrators and operators mobilizing important resources for current and future use. An area of particular policy interest has been the economic energy infrastructure regulation, since it involves both technical and informational challenges for regulators that limit the potential for direct application of complex regu-
ulatory methodologies, such as the use of menus, repeated franchise auctions etc.

Our model is based on some interesting institutional details from the economic regulation of energy (electricity) distribution system operators. Following unbundling and deregulation of generation and retail, such as in Europe by the first IEM directive 96/92/EC in 1996, the distribution network remains a natural monopoly with high asset specific investments. In returns for meeting universal service obligations (USO), the regulated distributors finance their operations through tariffs from captive downstream clients. Government, or in the European case the European Commission, controls the regulated operations through a designated independent national regulatory authority (NRA). The competencies and methods of the NRA are defined by national laws implementing the community directives. The rulings of the NRA may be appealed in national administrative courts that may revoke rulings or, in exceptional cases, invalidate interpretations of laws and ordinances supporting methods and procedures exercised by the NRA.

The NRA assures non-discriminatory access to the network service, limits monopoly profits and assures sufficient provision of network services. Normally, the NRA defines the interaction with the firm through a concession instrument (e.g. Sweden) or operating license (UK, Netherlands). A concession for service in a defined geographical area is granted for a limited period that is potentially renewed, the concessionaire has full responsibility for all necessary investments and maintenance. A regulator can grant concessions to several operators and an operator can held multiple concessions from regulators, therefore the network size may vary among the operators.

Operating licenses enable the operator to perform services wherever assets are present, but do not define responsibilities geographically.

The concession-holding firms, the operators, form in European practice a pool of private, public and cooperatively owned firms of various judicial status. However, empirical evidence as well as economic intuition, suggest that a fair share of the operators have low intrinsic incentives for cost efficiency due to internal managerial incentive problems, lack of effective owner supervision, weak demand response and political risks of ratchet effects. This condition naturally induces the NRAs to specifically design regulatory instruments as to promote cost efficiency for the distribution networks\footnote{We restrict our motivation to the distribution utilities, as the behavior and regulatory challenges for transmission services are different and also involve more explicit incentive provision for asset investments, which is not characteristic for distribution.}.

Although the NRA may act in (relative) independence towards neutrality in regulatory procedure, the government and its branches may pursue objectives that favor some stakeholders by capture, vote-seeking or financial constraints. In particular, the government may limit the powers of the NRA to extract profits from (national) firms or to provoke restructuring of the sector. The means of governmental pressure are normally through the wording of laws and ordinances governing the NRA, expressing preferential statements (rarely) or prescribing/restricting the discretion of the NRA (common). The effectiveness of this implicit policy may be imperfect with respect to the original objectives.
This paper intends to shed some light on the limits for national regulatory delegation in a setting with potentially non-aligned political principals and effort-averse firms under asymmetric information. A stylized principal-agent model mimics the game between the political principal, the NRA and the operators in framework with moral hazard. (We follow the convention in principal-agent literature and denote for distinction an agent as “he” and a regulator as “she”).

The regulation is carried out in a two-stage system. In the first stage a common political principal chooses a regime from a discrete set of feasible regulation instruments (Cost of service, Revenue caps or Yardstick regime), which is common for all regulators. In the second stage each NRA parametrizes optimally the designated regime for the operators under her jurisdiction. The NRA can use verifiable information on network provision as well as collect ex post cost information for firms under its regulation. However, the optimal cost level is private information for the operators and cannot be directly elicited.

All operators face identical operating conditions but may differ in size and preferences for non-monetary information rents (cost of effort, "slack").

1.1 Literature review

The current paper draws on two streams of literature, the seminal readings on information economics and regulatory design for the theory and empirical work on the applications of incentive regulation within the studied sector: electricity distribution.

The rich literature on information and incentives can be differentiated with respect to incentive problem: moral hazard or adverse selection, and information access (full information or asymmetric information). Our focus is on moral hazard effects due to the specific application, leaving the adverse selection problems associated with concession renewal and firm heterogeneity to further work. The models then distinguish whether the behavior of the agent can be governed by the information effect, basically the objective function of the principal, or the participation constraint, basically a competitive or structural effect. The information properties of low-powered regimes along with poor incentives for efficiency are classic (cf. e.g. Laffont (1994) [16]) and supported by early work on specific low-powered regimes, such as the well-known distortions in the rate-of-return regulation (cf. Averch and Johnson (1962) [5]). The two principal remedying instruments are archetypical to the results in the area: a high-powered regime with some ex ante information support and a dynamic yardstick regime where information is generated by the agents. The yardstick model, attributed first to Shleifer (1985) [24], relates to seminal work by Holmstrom (1982) [12] where cardinal tournaments among firms reveal information as pseudo-competition, that can be used to assess individual firms. The role of the information material is underlined in Lazear and Rosen (1981) [18] and Green and Stokey (1983) [10] showing that relative performance evaluation in ordinal tournaments is valuable only when they offer information about common uncertainty. These results already focus at some potential empirical implementation problems that are relevant to our setting. In the model the regulator has a preference for consumers surplus (cf. Baron and Myerson (1982) [7]), no cost of
social funds is considered (cf. Laffont and Tirole (1986) [17]). Armstrong and Sappington (2004) [4] show that for a perfectly informed regulator both approaches in modeling the principal-agent relationship have a first best solution. Information is therefore crucial. The manager-owner compensation model in Hermalin (1992) [11] can be interpreted as high-powered bargaining, since the offer from the principal satisfies both a participation constraint for the owners and an incentive compatibility constraint for the agent that relates compensation to some exogenous correlated information. However, the Hermalin model explicitly addresses production risk sharing effects to limit slack, which is not used in our model due to consistency with the “weakness” hypothesis for the participation constraint in our model. Armstrong and Sappington (2005) [3] carry out a unified analysis on different regulatory models that address asymmetric information. Boyer and Laffont (2003) [8] provide a comprehensive model for regulatory design exploiting (pseudo)-competitive information (yardstick), production functions, product features as well as the threat of bankruptcy. Our work, is inspired on this latter point by exploiting the participation constraint to extract additional rent for the agent.

The energy sector has indeed been subject to the methods cited above with varying results. Littlechild (1983) [19] proposes a fixed revenue regime in order to address the weakness of the cost of service regime, the transfers to the operator is no longer directly dependent of cost information. A good overview of incentive regulation, that along the lines in this paper may not necessarily be strictly high-powered, is found in Joskow (1974) [15]. Pfeifenberger and Tye (1995) [22] discuss various ways of introducing yardstick competition in the regulation of utilities. Yardstick competition can be used both to achieve measures of efficient cost levels and to adjust for output characteristics under rate of return regulation. Sappington et al. (2001) [23] provide evidence of the popularity of incentive regulation (or performance-based regulation) with in electricity sector also in the US. Jamesb and Pollitt (2007) [13] show positive effects for incentive regulation for UK electricity distribution, although some alternative views are provided by Crouch (2006) [9] regarding the investment incentives. However, the European experience shows that high-powered regimes such as revenue-caps crucially depend on the precision of the models chosen and the commitment of the political principal to withstand from renegotiation. Nillesen and Pollitt (2007) [21] document how the Dutch NRA (Dte) revised the electricity distribution system revenue-cap four times in three years, leading to substantially higher information rents for the industry. The Dutch case also illustrates the “regulatory failure” hypothesis as it shows how a single appeal for a firm overthrows the entire regime, prompting a radical change from a national non-parametric model-based revenue-cap to a simple average-cost metric. The direct and indirect costs caused to the regulatory authority and the government by the judicial process have been very important, the welfare loss is reported in Nillesen and Pollitt (2007) [21] to 140 MEUR (or 7% of total revenues). Another European example of “regulatory failure” fears and subsequent rent extraction is found in Sweden. The Swedish NRA, EMI, developed and operated an engineering cost model to provide an exogenous individual cost target for electricity distributors (cf. Jamesb and Pollitt, 2008 [14]). However, the NRA faced massive appeals of the model-based rulings (200 appeals for 40 final rulings of 242 concession ar-
eas) and after both courts and the political principal (ministry) invalidated the incentive power of the model by canceling its outcome, the regulator suspended the model in 2008. De facto, the NRA is now operating a cost-of-service regulation, results in Agrell (2005) [1] also suggest that this may have been the outcome of the previous high-powered model, lacking credible backing from the political principal.

1.2 Contribution

The current model deviates from the classic mechanism design literature under asymmetric information in the sense that (i) we impose a discrete set of reimbursement schemes, (ii) we introduce a weak political principal that fears regulatory failure more than rent extraction and (iii) we assume limited liability for the agents. The first assumption does not exclude the design of incentive schemes with varying incentive power, through the use of relevant parameters, but it does exclude information revelation through the use of e.g. regulation through menus of contracts. However, this assumption relates to institutional practice, where the real-life complexity of multi-output service and heterogeneous service conditions render such schemes impractical or prohibitively costly to design. The second assumption is at the core of the paper, providing rather negative results regarding the social cost of safeguarding against regulatory failure under information asymmetry. We believe that this angle is original and relevant in the area of essential infrastructure regulation where the industry often paints terrifying scenarios (e.g. Californian blackouts) at the political level to discourage too drastic rent extractions. To this extent, the paper provides a complement to the normative literature on regulatory design and also provides some empirically testable hypotheses.

1.3 Outline

The outline of the paper is straightforward: the model is presented in section 2, section 3 contains the analysis of the incentive effects for the regimes studied, section 4 relates the proposition and contains a numerical illustration and section 5 closes the paper with some concluding comments.

2 The Model

We consider a set $\Omega$ of network operators with operator $i \in \{1,\ldots,N\}$ that provides services in a set of given jurisdiction $Y$ with $j \in \{1,\ldots,M\}$ and whose revenues are subject to regulatory approval. A jurisdiction can be interpreted as a label of a subset of $\Omega$. Is an element $i$ member of a single subset $\Omega_j$ it is denoted “national”, if it is a member of more than a single subset it is denoted “international.” In each jurisdiction the political principal exerts its influence by potentially restricting the choice of regimes and by allocating a share of the social cost $m_j$ of judicial rejections of the imposed regulation onto the regulator. The Court is not a strategic player but an action potentially chosen by the firm to challenge decisions made by an uninformed regulator on tariffs. Figure (1) distinguishes four instances, whereof the Regulator and the Operator form the center of the model.

All operators face the same production conditions and have therefore identical cost functions but the operators can be separated with respect to their
slack preferences. Operators have either low slack preference, denoted with \( \Omega' \) or high slack preference, denoted with \( \Omega'' \), whereby the slack preferences do not change among jurisdiction. The partitioning is not observable to the regulator. The network size per operator within a jurisdiction is normalized to \( N^i_j = 1 \ \forall i \). The total network size within a jurisdiction is denoted as \( \sum_{i \in \Omega_j} N^i_j = N_j \), total network size of an operator with \( \sum_{j \in \Upsilon} N^i_j = N^i \). In the following the calculation are explained for operators with low slack preference, the same calculations apply for operators with high slack preferences.

A risk-neutral regulator pools all demand for network services and acts as a proxy buyer on behalf of the captive consumers, whose demand is deterministic, observable and corresponds perfectly to the network size of each operator. The regulator has therefore complete information on the demand for network services but does not know the efficient cost of these network services. The regulator relies therefore on the cost that is reported by each operator for the provision of service.

2.1 The regulator’s problem

The risk-neutral regulator’s objective is to maximize (national) social welfare, the sum of net welfare from all networks in her jurisdiction. Each network operator \( i \) produces marginal social benefit \( b \) per network unit diminished by the transfer to the operator \( t^i_j(\cdot) \) and increased by as fraction \( \eta_j \leq 1 \) of the operators profit \( t^i_j(\cdot) - \tilde{c}^i_j \), if decided by the political principal. The demand is deterministic and common knowledge, as is the satisfactory performance of the service. The regulation is based on voluntary participation by the operators, the individual rational utility is normalized to zero for all operators. It is obvious that minimizing the transfer \( t^i_j(\cdot) \) without violating the individual rationality constraint maximizes social welfare.

\[
\begin{align*}
\max \quad W^i_j(t^i_j(\cdot)) &= \sum_{i \in \Omega_j} \left[ b - t^i_j(\cdot) + \eta_j (t^i_j(\cdot) - \tilde{c}^i_j) \right] N^i_j \\
\text{s.t.} \quad [t^i_j(\cdot) - \tilde{c}^i_j] &\geq 0 \quad \forall i \in \Omega_j
\end{align*}
\]

Figure 1: Model structure
The operator’s profit can be decomposed into the sum of transfer $t^i_j$ minus reported cost $\tilde{c}^*$ times the operator’s network size. The regulator’s problem can therefore be written as Lagrangian

$$L(t^i_j (.), \lambda^i_j) = \sum_{i \in \Omega} \left[ b - t^i_j (.) + \eta_j(t^i_j (.) - \tilde{c}^i_j) - \lambda^i_j(t^i_j (.) - \tilde{c}^i_j) \right] N^i_j$$

Under full cost information the individual rationality constraints are binding and the regulator sets the transfer to $t^i_j (.) = c^*$ for all operators. However, under asymmetric information the regulator does not know the optimal cost $c^*$ but relies on reported cost $\tilde{c}^i_j$ from the operator, which may be “padded” with an information rent (“slack”) $\tilde{c}^i_j(k^i_j) = (1+k^i_j)c^*$ to be explained below.

### 2.2 The operator’s problem

The operator is risk neutral and maximizes his utility, a weighted sum of operating profit and “slack”, whereby slack is less valued than profit $\theta' \in [0, 1]$. The slack represents lack of cost-reducing effort (good life) and on-the-job consumption of services and goods (non-monetary information rent) such as working conditions, business trips, offices, etc. In principle, it may also include excess compensation to non-managerial staff, representing lack of effort in labor bargaining. The slack preference is normally strict ($\theta < 1$) due to limitations in the type expenditure permitted. Further, there exists an ex ante commonly known upper limit to plausible operating cost $c^* + \tilde{K}$ per grid unit, above which the operator is costless detected as inefficient, providing a non-empty range for slack extraction as $k^i \in [0, \tilde{K}]$. The operator’s problem is then a compromise between cost reporting and slack extraction: $\tilde{c}^i_j = (1+k^i_j)c^*(1-\delta_j) + \sum_{j \in \Upsilon_i} (1+k^i_j)c^* \delta_j a^i_j$

$$\max \quad U^i(k^i_j, a^i_j) = \sum_{j \in \Upsilon_i} \left[ t^i_j (.) - (1+k^i_j)c^* + \theta'k^i_jc^* \right] N^i_j$$

s.t. \quad $\sum_{j \in \Upsilon_i} a^i_j = 1 \quad \forall j \in \Upsilon_i$

$$k^i_j \leq \tilde{K}$$

$$a^i_j \leq 1$$

$$k^i_j, a^i_j \geq 0$$

$$L(k^i_j, a^i_j, \mu^i_1, \lambda^i_1, \lambda^i_2, \lambda^i_3, \lambda^i_4) = \sum_{j \in \Upsilon_i} \left[ t^i_j (.) - (1+k^i_j)c^* + \theta'k^i_jc^* \right] N^i_j -$$

$$- \mu^i_1 \left[ \sum_{j \in \Upsilon_i} a^i_j - 1 \right] - \sum_{j \in \Upsilon_i} \lambda^i_1(k^i_j - \tilde{K}^i_j)$$

$$- \sum_{j \in \Upsilon_i} \lambda^i_2(a^i_j - 1) - \sum_{j \in \Upsilon_i} \lambda^i_3k^i_j - \sum_{j \in \Upsilon_i} \lambda^i_4a^i_j$$

Therefore the operator’s response in $k$ depends primarily on the incentive power of the regime. The operator adds maximum slack as long as monetary transfer from slack maximization exceeds utility loss from slack.

$$k^i_j = \begin{cases} \tilde{F}_j & \text{if } \frac{\partial L^i_{k^i_j}}{\partial k^i_j} \geq (1-\theta')c^* \\ 0 & \text{else} \end{cases}$$
The operator’s slack preference $\theta$ is therefore the key element for his best response, the higher the operators’ slack preference the more likely he is to be less efficient.

2.3 Government interaction

The government (political principal) delegates the task of regulation to the regulator, but limits the regulator’s discretion to three reimbursement mechanisms (regimes): Cost of service ($C$), Revenue cap ($R$) and Yardstick regime ($Y$). This policy corresponds to institutional and political practice in a field where the economic stakes are high and pragmatic concerns of regulatory predictability prevail. The political principal also forces the regulator to internalize (some part of) the cost of regulatory failure, $m$. Regulatory failure occurs in the game when the regulator, using a prescribed methodology, imposes a transfer (tariff level) $t_i$ that is lower than the optimal cost $c^*$. For the game, we let a third party (the court) determine with probability 1 whether a transfer is $t_i < c^*$ or not, the third party cannot decompose the operator’s reported cost further into its slack component and potential allocation component. The court In case of regulatory failure, the regulator pays the difference between the previous transfer and the operator’s reported cost $\tilde{c}_i - t_i$ and in addition carries the social cost $m_j$ (implicit the operators reported cost is $\tilde{c}_i(\cdot) = c^*$). We rule out nuisance suits by the operator by assuming that there is an arbitrary penalty for the operator if the court upholds the regulatory ruling (i.e. $t \geq c^*$).

In broad the interaction between government, regulator, operators and court can be outlined as in figure (2). The government limits the regimes to $\{C, R, Y\}$ and determines the social cost $m_j$. The regulator announces ex ante her parametrization of the regime. The operator accepts the regime, he decides on his cost (i.e. slack extraction), provides network services and reports his cost at the end of the period to the regulator. The regulator reimburses the operator ex post. The operator appeals in case of regulatory failure, as above. The final payment is assumed to come from captive clients, assuming away all issues related to downstream payment and distributional effects.
3 Hybrid regimes

The regulator may at most select from three types of regimes, the low-powered Cost of service, the high-powered Revenue cap and the pseudo-competitive Yardstick regime. She knows the network size and the number of the operators that are active in her jurisdiction. When designing the regime she must carefully find a trade off between an informed decision, that assured that the individual rationality constraint of the operator are respected and the setting of an incentive to produce fully efficiently, which maximizes social welfare as shown above. Under a pure Cost of service regime the individual rationality constraint is always respected because the regulator reimburses the operator’s reported cost, i.e. full participation and no risk of regulatory failure. However, any operator with non-zero slack preferences would exploit this regime to the highest plausible cost:

$$t^C(\tilde{c}_j^i) = \tilde{c}_j^i$$  \hspace{1cm} (4)

Under the remaining two pure regimes the individual rationality constraint is not always satisfied. For the Yardstick regime the cost observations for the other operators may be infeasible, leading to regulatory failure. In the Revenue cap regime, the regulator will gamble with a reimbursement level that either leaves positive information rents to the firm, or violates its individual rationality constraint with regulatory failure as a result.

The ex ante information for the regulator in the Revenue cap regime is modeled as a probabilistic belief on the distribution and first moments for the operator’s efficient cost, $c^*$. The Revenue cap offers a take-it-or-leave-it reimbursement $\hat{\beta}_j$ per network unit. To distinguish the regime from yardstick regimes and abstract from ratchet problems (Weitzman, 1980 [25]), we assume that the regulator commits not to collect or use any cost information ex post. Under these conditions, the high-powered regime makes the firm residual claimant for any reimbursement exceeding efficient cost, thereby inducing productive efficiency (but not necessarily welfare maximization).

$$t^R(\hat{\beta}_j) = \hat{\beta}_j$$  \hspace{1cm} (5)

The Yardstick regime (Shleifer, 1985 [24]) combines the objectives of information acquisition and incentives for cost reductions. The regulator collects all reported cost but calculates for each operator $i$ an average based on cost observations from all other operators (excluding operator $i$). This regime relies on the assumption that all operators face identical production conditions. Similar to the pure Revenue cap regime the regulator cannot be sure that the calculated reimbursement will respect all operators individual rationality constraint ex post.

$$t^Y(\tilde{c}_j^i, \tilde{c}_j^{-i}) = \frac{1}{N_j - 1} \sum \tilde{c}_j^{-i}$$  \hspace{1cm} (6)

Under pure regimes the operator either accepts or declines his participation. However, by implementing the court procedure the government implicitly forces the operator to participation by canceling the downside risk. The appeal procedure assures that the operator will always recover his efficient cost regardless of the proposed reimbursement of the regulator. This participation premium carries the social cost resulting from the “padding” made by
the regulator in the application of pure high powered regimes when internalizing the cost of regulatory failure. Consequently, the de facto regulatory situation under full participation (which, coincidentally, is the case in all empirical applications) is a hybrid regime where any application of high-powered regimes is combined more or less explicitly with a low-powered back-up option based on reported costs. The logical benchmark for the hybrid regimes is therefore the pure Cost of service regime.

3.1 Hybrid Revenue cap regime

Under a Revenue cap the regulator has a belief about the distribution of the optimal cost. The regulator is forced to a gamble with the risk of regulatory failure, $1 - F(\hat{\beta}) = Pr(\hat{\beta} < c^*)$, where and implementable Revenue cap regime and a (default) Cost of service are the two possible outcomes.

The operator’s reaction function follows from equation (3), i.e., the operator cannot influence the size of transfer by his own cost decision (effort). The operator’s utility in figure (3) illustrates the operator’s reaction to the regulator’s Revenue cap. If the Revenue cap is within the interval of the regulator that is also known by the operator beforehand, the operator behaves fully efficiently and maximizes slack otherwise. The operator trades off his gains from slack versus utility from monetary transfers, or information rent.

3.1.1 The regulator’s problem

The hybrid Revenue cap regime is outlined in figure (3). For a uniform distribution the regulator has a belief on $c^* \in [\underline{\beta}, \overline{\beta}]$. If $c^* \notin [\underline{\beta}, \overline{\beta}]$ the reimbursement to the operator corresponds to a reimbursement of a pure Cost of service regime with penalty incurred. In the regulator’s objective function there is no weight on the pure Cost of service regime. When the Revenue cap lies within the limits of the regulator’s belief, the welfare increases, because less weight is put on the penalty for a mismatch of the Revenue cap and the regulator incurs less inefficient cost from the operator. The welfare increases further with a growing $\hat{\beta}$. The welfare function does not reach its optimum at the operator’s efficient cost $c^*$ because the interval is not centered around $c^*$. When the welfare function surpasses its optimal point the savings from less payments for penalty and inefficient cost is offset by a high information rent to the operator.

The regulator maximizes an expected welfare function. In addition to the payment under a pure Cost of service regime the welfare is diminished by
penalty payments in case of regulatory failure.

\[
\max \quad E[W(\hat{\beta})] = \left[ b - F(\hat{\beta})[\hat{\beta} - \eta(\hat{\beta} - c^*)] - (1 - F(\hat{\beta}))[1 + \hat{k}c^*] - (1 - F(\hat{\beta}))(1 - F(\hat{\beta}))\right] - \\
(1 - F(\hat{\beta}))[(1 + \hat{\beta})c^*] - (1 - F(\hat{\beta}))(1 + k)c^* + f(\hat{\beta})m \\
\frac{\partial E[W(\hat{\beta})]}{\partial \hat{\beta}} = \left[ - F(\hat{\beta})(1 - \eta) - f(\hat{\beta})[\hat{\beta}(1 - \eta) + \eta c^*] \right] + f(\hat{\beta})(1 + k)c^* + f(\hat{\beta})m = 0 \\
\frac{\partial^2 E[W(\hat{\beta})]}{\partial^2 \hat{\beta}} = -(1 - \eta) \left[ F(\hat{\beta}')(\hat{\beta} - (1 + \hat{k})c^* - m) \right] 
\]

If \( F''(\cdot) > 0 \), then \( E[W(\hat{\beta})] \) is strictly concave. For convenience we assume \( F''(\cdot) > 0 \), which holds for any demand distribution with an increasing failure rate i.e., the hazard rate, \( f(\hat{\beta})/(1 - F(\hat{\beta})) \), is increasing. The normal and the uniform meet that condition. Therefore, there exists an unique optimal \( \hat{\beta} \) (Barlow (1963) [6]).

**Proposition 1** In a hybrid Revenue cap regime the optimal cap is:

\[
\hat{\beta}^* = c^* + \frac{\overline{\beta}}{1 - \eta} + \frac{m}{1 - \eta} - \frac{F(\hat{\beta})}{f(\hat{\beta})}
\]

**Proof.** This follows directly from the first order condition. The hybrid Revenue cap is composed by efficient cost plus the “discounted” payment for inefficient cost and penalty, diminished by the moral hazard rate. ■

3.1.2 Example: Uniform Distribution

For a uniform distribution with \( c^* \in (\beta; \overline{\beta}) \) the probability for a Revenue cap regime depends directly on the estimation of the cost norm \( \hat{\beta} \). If the regulator assumes an uniform distribution, we can write for the cumulative density function:

\[
Prob(\hat{\beta} \geq c^*) = F(\hat{\beta}) = \frac{\hat{\beta} - \beta}{\overline{\beta} - \beta}
\]

The derivative of the cumulative density function gives the probability density function. The quotient of these two functions gives us the monotone hazard rate.

\[
f(\hat{\beta}) = \frac{dF}{d\beta} = \frac{1}{\overline{\beta} - \beta}, \quad \frac{F(\hat{\beta})}{f(\hat{\beta})} = -(\overline{\beta} + \hat{\beta})
\]
Figure 3: Welfare and utility under a hybrid Revenue cap regime.
The hazard rate is then used to determine the cost norm and the cumulative density function.

\[
\hat{\beta}^U = \frac{1}{2} \left( c^* + \beta + \frac{\mathfrak{f} c^* + m}{1 - \eta} \right)
\]

\[
F(\hat{\beta}^U) = \frac{1}{2 \beta - \beta} \left( c^* - \beta + \frac{\mathfrak{f} c^* + m}{1 - \eta} \right)
\]

\[
E[W(\hat{\beta}^U)] = b - (1 + k)c^* - m + \frac{1}{(1 - \eta)(\beta - \beta)} \left[ \frac{(1 - \eta)(c^* - \beta) + kc^* + m}{2} \right]^2
\]

From the welfare function follows immediately that type and size of the operators do not influence the the of the operator do not influence welfare, because they are irrelevant for the determination of \( \hat{\beta} \).

**Proposition 2** Under a hybrid Revenue cap regime the regulator’s decision on \( \hat{\beta} \) is not influenced by the operators’ types \((\theta', \theta'')\), size \( q' \in \Omega', q'' \in \Omega'' \).

The hybrid Revenue cap is therefore not prone to the structure of the population of operators. Additionally, under full information the hybrid Revenue cap collapses to a pure Revenue Cap regime. The operators participation is thereby assured. The regulator’s preference for a hybrid Revenue cap versus a pure Cost of service regime cannot be altered by the government decision on the settlement variable \( m \).

**Proposition 3** Under perfect cost information \((\sigma = 0)\) the regulator sets \( \tilde{\beta} = c^* \). She prefers therefore a hybrid Revenue cap regime over a pure Cost of Service regime.

Under asymmetric information the regulator’s belief determines the hybrid Revenue cap. It is still robust to size and type of the operators but no longer robust to the government decision on \( m \).

**Proposition 4** Under noisy cost information \((\sigma > 0)\) for a sufficiently high \( m \) the regulator prefers a pure Cost of Service regime over a hybrid Revenue cap regime.

**Proof.** For all \( \frac{F(\cdot)}{F(\cdot)} \) there exists an \( m \) such that \( \frac{m}{1 - \eta} \geq \frac{F(\cdot)}{F(\cdot)} \) and the transfer under a hybrid revenue cap is bigger than under a pure Cost of service regime. ■

**Proposition 5** Under noisy cost information \((\sigma > 0)\) the operator’s information rent is monotonously increasing in \( m \).

**Proof.** Information rent is all transfer beyond efficient cost \( c^* \). From Proposition 2 follows: \( \partial \hat{\beta}^*/\partial m = \frac{1}{1 - \eta} > 1 \) ■

**Comment:** Under a hybrid regime the government influences indirectly the transfer to the operator. The limits for a too high increase in \( m \) is the regulator’s discretion to choose a different regime that is less exposed to government influence.

**Proposition 6** Under noisy cost information \((\sigma > 0)\) the operator’s information rent is decreasing in information precision for the regulator.
Proof. For a given \( m, \eta, k \) and decreasing \( \sigma \):
\[
\lim_{\beta \to c^*} \frac{F(\hat{\beta})}{f(\hat{\beta})} \to \infty
\]
The information rent is decreasing to zero. ■

Proposition 7 Under noisy cost information \((\sigma > 0)\) for a sufficiently imprecise belief in an uniform distribution the regulator prefers a pure Cost of Service regime over a hybrid Revenue cap regime.

Proof. For \( E[W(\hat{\beta})] > E[W(\hat{\beta}^U)] \Rightarrow \)
\[
E[W(\hat{\beta})] - E[W(\hat{\beta}^U)] = m - \frac{1}{(1-\eta)(\beta-\beta)} \left[ (1-\eta)(c^* - \beta) + kc^* + m \right]^2 > 0
\]
\[
\lim_{\beta \to \infty} \frac{1}{(1-\eta)(\beta \beta)} \left[ (1-\eta)(c^* - \beta) + kc^* + m \right]^2 = 0
\]

3.2 Hybrid Yardstick regime

The regulator announces his decision for a hybrid Yardstick regime at \( t-1 \). The operators accept the regime, because the hybrid Yardstick regime is designed in such a way that his rationality constraint is fulfilled ex post, thereby exists a thread of a future bankruptcy, because the regulator does not limit the regime to upside gains for all operators. The regulator collects reported cost information from all operators, then reimburses each operator individually whereby the calculated reimbursement is independent of the operator’s reported cost. In this particular hybrid Yardstick regime the incurred cost per network unit depends on the operator’s slack decision and on the operator’s cost allocation. The operator’s rationality constraint is fulfilled because in case of an infeasible reimbursement by the regulator the operator can appeal against this ruling at the court.

3.2.1 The operator’s reaction function

Operator’s \( i \) network size is normalized to \( N_j^i = 1 \) per country \( j \). Operator is either denoted “national”: \( |\Omega^i| = 1 \), or “international” with networks abroad \(-j\): \( |\Omega^i| > 1 \). All operators either minimize or maximize their slack. An international operator can split his cost into an “allocatable cost” fraction \((1-\delta)\) and a “floating cost” fraction and by setting \( a_j^i \) among the countries where he operates networks.

Within country \( j \) three structures of operators are possible: Either “purely national”, \( (\forall i \in \Omega_j : |\Omega^i| = 1) \), or “mixed” \( (\exists i \in \Omega_j : |\Omega^i| > 1) \) or “purely international” \( (\forall i \in \Omega_j : |\Omega^i| > 1) \).

We distinguish in table (1) the operators \( l \) and \( m \) further with respect to their slack preference with \( \theta^l > \theta^m \). By the decision for efficient (minimize slack) and inefficient cost (maximize slack) the operator influence whether they receive a payment above efficient cost as utility from slack or as monetary transfer. The reimbursement of each operator contains therefore four terms: The cost part that must remain in the country \( c^*(1-\delta)^2 \), floating

\footnote{The table does not contain this cost part, because it is irrespective of the operators slack decision.}
Table 1: Operator’s utility and Welfare under a hybrid Yardstick regime.

<table>
<thead>
<tr>
<th>Utility</th>
<th>( O^m )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \min )</td>
<td>( \frac{k_j^m}{k_j} \sum_{i \in \Omega_j \setminus j} \left[ \sum_{i \in \Omega_j \setminus j \in T^i} \left[ c^<em>(1 + k_i^m)\delta_{i-j} + c^</em>\delta_j \right] a_j^i \right] - c^*\delta_j a_j^m )</td>
</tr>
<tr>
<td>( \max )</td>
<td>( \frac{k_j^m}{k_j} \sum_{i \in \Omega_j \setminus j} \left[ \sum_{i \in \Omega_j \setminus j \in T^i} \left[ c^<em>(1 + k_i^m)\delta_{i-j} + c^</em>\delta_j \right] a_j^i \right] - c^*\delta_j a_j^m )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Welfare</th>
<th>( \Omega^m )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \min )</td>
<td>( \frac{k_j^m}{k_j} \left( \frac{\sum_{i \in \Omega_j \setminus j} \left[ \sum_{i \in \Omega_j \setminus j \in T^i} \left[ c^<em>(1 + k_i^m)\delta_{i-j} + c^</em>\delta_j \right] a_j^i \right]}{\sum_{i \in \Omega_j \setminus j \in T^i} \left[ c^<em>(1 + k_i^m)\delta_{i-j} + c^</em>\delta_j \right] a_j^i \right] ) + ( \frac{\sum_{i \in \Omega_j \setminus j} \left[ \sum_{i \in \Omega_j \setminus j \in T^i} \left[ c^<em>(1 + k_i^m)\delta_{i-j} + c^</em>\delta_j \right] a_j^i \right]}{\sum_{i \in \Omega_j \setminus j \in T^i} \left[ c^<em>(1 + k_i^m)\delta_{i-j} + c^</em>\delta_j \right] a_j^i \right] )</td>
</tr>
</tbody>
</table>

\( \Omega^m \) and \( \Omega^m \) are the minimum and maximum slack values, respectively, for \( k_j^m \) and \( \delta_j \). The \( \min \) and \( \max \) slack values are calculated based on the operator's utility function. The welfare function is a weighted sum of the utility and cost functions.
cost incurred abroad and allocated to country \( j \left\{ \sum_{i \in \Omega_j \setminus l} c^*(1 + k_{i-j}^j) \delta_{-j} a_{i-j}^j \right\} \), floating cost incurred country \( j \) and allocated to country \( j \) \( c^* \delta_j a_j^j \) minus floating cost allocated to country \( j \). The slack and cost allocation decision of one operator might lead to a negative utility of another operator, therefore all operators are exposed to the potential risk of bankruptcy, whereby the national operators are more limited in their cost allocation options, they always set \( a_j^j = 1 \). For the international operators, truth-telling would be an allocation of the floating cost in proportion to their cost size \( (a_j^i \in [0, 1] \) with \( a_j^i = \frac{(1 + k_{i-j}^j)}{\sum_{i \in \Omega_i \setminus l} (1 + k_{i-j}^j)} \) being truth-telling. The calculation is given for operator \( j \):

\[
E^Y[U_j(\cdot)] = p \left( \frac{1}{N_j} \sum_{i \in \Omega_j \setminus l} \left[ \sum_{-j \in T_i} c^*(1 + k_{i-j}^j) \delta_{-j} a_{i-j}^j \right] - c^* \delta_j a_j^j \right) q \\
+ p \left( \frac{1}{N_j} \sum_{i \in \Omega_j \setminus l} \left[ \sum_{-j \in T_i} c^*(1 + k_{i-j}^j) \delta_{-j} + c^*(1 + k_{i-j}^j) \delta_{j} + c^* (1 - \delta_j) \right] a_j^i \right) - c^* \delta_j a_j^j \right) (1 - q) \\
+ (1 - p) \left( \frac{1}{N_j} \sum_{i \in \Omega_j \setminus l} \left[ \sum_{-j \in T_i} c^*(1 + k_{i-j}^j) \delta_{-j} - c^* \delta_j a_j^j \right]+ (1 - p) \left( \frac{1}{N_j} \sum_{i \in \Omega_j \setminus l} \left[ \sum_{-j \in T_i} c^*(1 + k_{i-j}^j) \delta_{-j} + c^* (1 + k_{i-j}^j) \delta_{j} + c^* (1 - \delta_j) \right] a_j^i \right) - c^* \left( 1 + k_{i-j}^j \right) \delta_{j} a_j^j + \theta^j c^* \tilde{k}_{j} \right) q \\
+ (1 - p) \left( \frac{1}{N_j} \sum_{i \in \Omega_j \setminus l} \left[ \sum_{-j \in T_i} c^*(1 + k_{i-j}^j) \delta_{-j} + c^* (1 + k_{i-j}^j) \delta_{j} + c^* (1 - \delta_j) \right] a_j^i \right) - c^* \left( 1 + k_{i-j}^j \right) \delta_{j} a_j^j + \theta^j c^* \tilde{k}_{j} \right) (1 - q)
\]
\[
\frac{dE^Y[U_j(\cdot)]}{dp} = \left( \frac{1}{N_j} \sum_{i \in \Omega_j \setminus t} \left[ \sum_{j \in T^i} c^* (1 + k^i_{-j}) \delta_{-j} + c^* \delta_j \right] a^i_j \right) q \\
+ \left( \frac{1}{N_j} \sum_{i \in \Omega_j \setminus t} \left[ \sum_{j \in T^i} c^* (1 + k^i_{-j}) \delta_{-j} + c^* (1 + \bar{K}_j) \delta_j + c^* \bar{K}_j (1 - \delta_j) \right] a^i_j \right) \theta^i_j \] \\
- \left( \frac{1}{N_j} \sum_{i \in \Omega_j \setminus t} \left[ \sum_{j \in T^i} c^* (1 + k^i_{-j}) \delta_{-j} + c^* (1 + \bar{K}_j) \delta_j + c^* \bar{K}_j (1 - \delta_j) \right] a^i_j \right) \theta^i_j \]

\[
- \left( \frac{1}{N_j} \sum_{i \in \Omega_j \setminus t} \left[ \sum_{j \in T^i} c^* (1 + k^i_{-j}) \delta_{-j} + c^* (1 + \bar{K}_j) \delta_j + c^* \bar{K}_j (1 - \delta_j) \right] a^i_j \right) \delta_j \]

Operator’s \(O^m\) (and operator \(O^l\) respectively) best response is therefore dependent on the other operators’ preference for slack and decision for slack allocation. The higher his preference for inefficient cost the higher the weight on the maximization of slack. Note that only for \(\theta = 0\) and \(\theta = 1\) pure strategies are played, in all other cases mixed strategies are utility maximizing.

\[
q = \begin{cases} 
1 & \text{if } \delta_j a^i_j > \theta^i_j \\
0 & \text{else}
\end{cases} \quad (7)
\]

This implies that for \(q = 1\) the operator minimizes slack \(k^i_j = 0\) and for \(q = 0\) the operator maximizes slack \(k^i_j = \bar{K}_j = 0\).

**Proposition 8** For all structures an operator minimizes slack if \(\delta_j a^i_j > \theta^i_j\) \(\forall i\) is valid.

**Proof.** This follows directly from equation (7). \(\blacksquare\)

### 3.2.2 The regulator’s problem

The regulator knows the operators’ network size, reported cost and maximal slack allowance per network unit. Assuming that she also observes the partitioning of the operators, the expected welfare under a hybrid Yardstick regime is:
\[ E[W(.)] = N_j \left( b - c^\ast [1 + (1 - p)\bar{k}_{j\setminus l} + \bar{k}_{j\setminus m}(1 - q)](1 - \delta_j) \right) \]
\[ - \sum_{i \in \Omega_j} \left[ \sum_{-j \in \mathcal{T}_i} [c^\ast (1 + k_{-j}^l)\delta_{-j}] \right. \]
\[ + c^\ast [1 + (1 - p)\bar{k}_{j\setminus l} + \bar{k}_{j\setminus m}(1 - q)]\delta_j \]
\[ + \sum_{i \in \Omega_j} \min \left( \left[ \sum_{-j \in \mathcal{T}_i} [c^\ast (1 + k_{-j}^l)\delta_{-j}] \right. \right. \]
\[ + c^\ast [1 + (1 - p)\bar{k}_{j\setminus l} + \bar{k}_{j\setminus m}(1 - q)]\delta_j \] \[a_j^i - c^\ast \delta_j : 0 \right] (1 + m_j) \] (8)

It can be observed for the last line that the welfare depends on usual components of benefit from the networks and efficient cost for the provision of service, increased by transfers to operators that are recovered with \( \eta \) and decreased by full slack payment.

**Proposition 9** In a national structure, with symmetric slack preferences and operator’s indifference between money and slack (\( \theta^l = \theta^m = 1 \)) a hybrid Yardstick regime achieves the same welfare as a pure Cost of service regime.

**Proof.** For (\( \theta^l = \theta^m = 1 \)) follows from (7), \( p = q = 0 \) and for all national operators \( a_j^i = 1 \) and \( \sum_{-j \in \mathcal{T}_i} [c^\ast (1 + k_{-j}^l)\delta_{-j}] = 0 \). From (8) follows \( \sum_{i \in \Omega_j} \min \left( \sum_{-j \in \mathcal{T}_i} [c^\ast (1 + k_{-j}^l)\delta_{-j}] + c^\ast [1 + (1 - p)\bar{k}_{j\setminus l} + \bar{k}_{j\setminus m}(1 - q)]\delta_j \] \[a_j^i - c^\ast \delta_j : 0 \right] (1 + m_j) = 0 \), therefore \( E^Y[W(.)] = N_j(b - c^\ast [1 + \bar{k}_{j\setminus l} + \bar{k}_{j\setminus m}(1 - \delta_j) - N_j(c^\ast [1 + \bar{k}_{j\setminus l} + \bar{k}_{j\setminus m}]) \delta_j) + 0 = N_j(b - c^\ast + c^\ast \bar{k}_{j\setminus l}) = E^C[W(.)] \) ■

Implicit all players maximize slack.

**Proposition 10** In an international structure, with symmetric slack preferences and operator’s indifference between money and slack (\( \theta^l = \theta^m = 1 \)) a hybrid Yardstick regime achieves at least the same welfare as a pure Cost of service regime.

**Proof.** For (\( \theta^l = \theta^m = 1 \)) follows from equation (7), \( p = q = 0 \) and for all international operators \( a_j^i \in [0, 1] \).

For \( p = q = 0, a_j^i = 1 : E^C[W(.)] = N_j(b - c^\ast [1 + \bar{k}_{j\setminus l}]) \)
\[\sum_{i \in \Omega_j} \sum_{-j \in \mathcal{T}_i} [c^\ast (1 + k_{-j}^l)\delta_{-j}] + c^\ast (1 + \bar{k}_{j\setminus l})\delta_j = E^{hY}[W(.)] \]. For a decrease of \( a_j^i \) the probability of the payment of a penalty increases.

For \( p = q = 0, a_j^i = 0 : E^{hY}[W(.)] = N_j(b - c^\ast [1 + \bar{k}_{j\setminus l}]) \geq 0 = E^C[W(.)] \). When allocating all floating cost away, the cost of service regime does not recover the cost for providing the network services. ■

**Corollary 11** For symmetric slack preferences and operator’s indifference between money and slack (\( \theta^l = \theta^m = 1 \)) a hybrid Yardstick regime weakly dominates a pure Cost of service regime.

**Proposition 12** In a national structure, with symmetric slack preferences and no utility from slack (\( \theta^m = \theta^l = 0 \)) a hybrid Yardstick regime achieves the same welfare as a pure Yardstick regime.
Proof. For \((\theta^l = \theta^m = 0)\) follows from equation (7), \(p = q = 1\) and for all national operators \(a_{ij} = 1\) and \(\sum_{j \in \Upsilon} [c^*(1 + k^i_j)\delta_j] = 0\). □

**Proposition 13** In an international structure, with symmetric slack preferences and no utility from slack \((\theta^m = \theta^l = 0)\) a hybrid Yardstick regime achieves at least the same welfare as a pure hybrid Yardstick regime.

Proof. For \((\theta^l = \theta^m = 0)\) follows from equation (7), \(p = q = 1\) and for all international operators \(a_{ij} \in [0, 1]\).

For \(p = q = 1, a_{ij} = 1\) : \(E^{HY}[W()] = N_j(b - c^*[1](1 - \delta_j)) - N_j \delta_j + 0 = E^Y[W()]\). An increase in \(a_{ij}\) leads to a decrease in welfare. For \(p = q = 1, a_{ij} = 0\) : If all international operator allocate all floating cost abroad, efficient cost is not reimbursed and therefore no network service can be provided. \(E^{HY}[W()] = N_j(b - c^*[1](1 - \delta_j)) - N_j(c^* \delta_j)(1 + m_j) \geq 0 = E^Y[W()]\). □

**Corollary 14** For symmetric slack preferences and no utility from slack \((\theta^m = \theta^l = 0)\) a hybrid Yardstick regime weakly dominates a pure Yardstick regime.

Figure 4: Operator’s utility and welfare under hybrid Yardstick regime.
In figure (4) the case for operators with asymmetric slack preferences and equal network size is illustrated. The situation depicts a static situation, the ordinate is only indicative for the difference between two different $\theta$s. Operator $i$ has a higher preference for efficient cost than Operator $j$, therefore $i \in \Omega$ and $j \in \Omega$. The operators’ utility is described in the graph below (Note that the sections for $\theta = 0$ and $\theta = 1$ are magnified and would contain normally a single point). Operator $i$ has a lower slack utility and changes earlier than operator $j$ his strategy from slack maximization to slack minimization for an increase in $\theta$. Compared to table (1) in pure strategies, the operators are moving from the field bottom right to a the field top right and finally to the field top left.

**Proposition 15** Under a hybrid Yardstick regime welfare decreases monotonously in $\theta$.

The regulator pays therefore either transfers in the form of slack reimbursement or monetary transfer. Under a pure Cost of service regime the regulator reimburses slack, under Yardstick/Cost of service regime the regulator pays either for slack (operator $l$) or monetary transfers (operator $m$). From a welfare perspective (ignoring the preference variable $\eta$) the hybrid Yardstick regime is not welfare improving unless both operators ending up in playing both slack minimization and establishing thereby a pure Yardstick regime.

**Proof.** This follows form equation (8) and equation (7): For an increase in $\theta$ an operator is less likely to minimize slack, therefore the probability in equation (8) for slack maximization increases, which decreases welfare. ■

With increasing differences in network sizes with respect to the operators slack preferences the potential welfare effects from the application of a hybrid Yardstick regime becomes less predictable for the regulator. Nonetheless the Cost of Service regime remains the lower bound in achievable welfare.

## 4 Comparison and numerical illustration

The propositions can be related to each other in two dimensions: with respect to information about the operators’ true cost functions and with respect to the operators’ heterogeneity of the set of operators. In broad the propositions indicate that information and heterogeneity of the operators influence the regulators choice of the regulatory regime. Propositions 2 and 3 indicate that, the hybrid Revenue cap is robust against heterogeneity of the operators and under complete information the regulator will always prefer a Revenue cap over a Cost of service regime.

Propositions 4 and 5 indicate that under incomplete information the regulator’s decision is exposed to the influence of the political principal and the less informed the regulator is, the less welfare maximizing is a hybrid Revenue cap regime. Propositions 3.1.2 illustrates the influence of the regulator’s belief on her decision for the regimes.

Propositions ?? and 13 show how dependent the equilibrium under a hybrid Yardstick regime is to the operators’ preferences and thereby the regulator’s choice for a regime. Proposition 15 shows how heterogeneity in the operators’ preferences impacts the resulting welfare.
The influence of the political principal on the regulator’s preferences is illustrated in figure 6. For a uniformly distributed belief ($\mu = 2, \sigma = 5$), optimal cost $c^* = 3$ and welfare $b = 10$ the welfare under a hybrid Revenue cap is decreasing with an increase in $m$, even below a pure Cost of Service regulation.

The influence of the differences in $\theta$ is illustrated in figure 7. For symmetric network sizes an increasing difference in $\theta$ amongst the operators influences negatively welfare. For small differences the regulator would prefer a hybrid Yardstick regime over a hybrid Revenue cap and becomes for maximal difference $\Delta \theta = 1$ even indifferent between a pure Cost of Service regime and a hybrid Yardstick regime.

5 Conclusion

In Pfeifenberger and Tye (1995) [22] conclude their primer on incentive utility regulation by “Incentive mechanisms must be studied carefully before implementation to ensure successful achievement of the objectives” (p. 779). Part of this care is suggested to “restrict rewards and penalties to operationally and politically acceptable limits” (p. 778). In practice, there is international consensus (e.g. in the World Regulatory Forum’s Guidelines) that the accountability for infrastructure regulation rulings is implemented by granting regulated firms the possibility to appeal to administrative courts. Disregarding appeals on procedural grounds, empirical evidence in Europe shows that firms do exercise this right, that they do it strategically and that the results affect the scope and mode of regulation in some jurisdictions.

Our results show that imperfect means to constrain regulatory discretion by penalizing the regulator for sporadic violations of the participation constraint and “bail-out” options for inefficient firms from yardstick regimes seriously invalidate the effectiveness of the commonly used incentive mechanisms. Moreover, we have shown that an implicit cost-recovery commitment
Figure 6: Welfare under a hybrid Revenue cap and increasing cost of failure

by a political principal can be implemented through the regulator by simple parameters. Offering full participation turns all regimes in our model into “hybrids”, where a high-powered alternative competes with a low-powered shadow option. From a welfare perspective, this is naturally costly and this motivational and productive efficiency cost should be compared to the potential cost of structural change for owners and clients in the case full commitment would prevail.

The application, electricity distribution network regulation, is an example of an omnipresent infrastructure with high asset-specificity, large variations in ownership and governance practice among firms and likely high potential efficiency gains from structural, learning and motivational changes. It is also, which warrants the attention of the current model, a sector that in some countries successfully has branded the down-side of any high-powered regulation as threats to universal service obligations, security of supply, public safety or national environmental priorities. We argue that effectiveness of incentive regulation should be evaluated using a more careful analysis of the context into which the regime is implemented, not to mix the two effects (endorsement by political principal and information rent allocation of a given regime).

The current paper explores the limiting behavior of a weak principal (towards industry) that is a strong manager (towards the regulator). This assumption could be relaxed by limiting the competence of the political principal to allocate the cost of regulatory failure to to prescribe the regimes.
Some of the results, such as the mixed strategy equilibrium for the hybrid yardstick case, are indeed sensitive to this assumption, as even a limited penalty for the inefficient firm would enforce the static (Shleifer, 1985 [24]) and dynamic (e.g. Agrell et al., 2005) first-best equilibrium for the yardstick regime. Another assumption is the predictability of the judicial oversight, mechanically represented in our model. Introducing a probabilistic court in outcome and bias would likely change some results, but also introduce parameters that likely reduce the potential for empirical validation of the findings.

References


