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Regulation of network industries in the European Union and in Central and Eastern Europe

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Title:

REGULATION OF NETWORK INDUSTRIES IN THE EUROPEAN UNION AND IN CENTRAL AND EASTERN EUROPE

Abstract

Cost-based pricing has dominated the regulatory regime of network industries—and first of all, the regulation of the infocommunications sector—in the European Union since the early 1990s. When privatization of network industries began in Central and Eastern Europe (CEE), one of the main stumbling blocks on the road toward privately owned telecomm companies and postal services, energy producers and distributors, and other network industries was the lack of efficient and up-to-date industry regulations. From the mid-1990s, accessing countries that later became members of the EU, and other CEE countries that are still waiting for admission swiftly adopted the regulatory framework of the European Union. The EU has been striving for market opening and liberalization in these industries; it abolished industry regulation in several segments of the market of network industries. Now it applies so-called "cost-based pricing" in areas where regulation is still in place. CEE countries now use the same type of regulation as the advanced member states of the EU. But the regulatory capacity of most CEE countries is still far behind of their West European counterparts.

Experts of network industries advocate, and telecommunications, energy and other market regulators in various parts of the world practice, cost-based pricing for inter-firm network access services. Cost-based pricing is carried out under the assumption that the regulator has perfect information regarding the costs of producing the services. We show in this paper that—under fairly general conditions—cost-based pricing creates incentives for regulated firms *not to improve* their efficiency. We also show that cost-based pricing results in smaller consumer welfare than incentive regulation that takes into account the existence of information asymmetry between the regulator and the firm. A model of interconnection with adverse selection and moral hazard is presented.

JEL codes: D8, L14, L51
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REGULATION OF NETWORK INDUSTRIES IN CENTRAL AND EASTERN EUROPE

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INTRODUCTION

The European Union (EU) adopted cost-based pricing along with market liberalization of network industries starting in the early 1990s. Prices of different services have been based on long run incremental costs—in other words, on long run marginal costs (the so-called LLRIC principle). The EU has gone a long way since then and price regulation is limited to interconnection services in several network industries, first of all in telecommunications today. When privatization of network industries started in Central and Eastern Europe (CEE), one of the main stumbling blocks on the road toward privately owned telecomm companies and postal services, energy producers and distributors, and other network industries was the lack of efficient and up-to-date industry regulation. Since most network companies have been privatized to foreign-owned firms in CEE countries, the crucial issues of ownership and management were solved in a relatively painless manner. But the regulatory regimes of these emerging markets developed much slower than the changes in property rights occurred. The process speeded up when some of the CEE countries started the accession process to the European Union (EU) in the late 1990s. From that period on, accessing countries that later became members of the EU, and other CEE countries that are still waiting for admission swiftly adopted the regulatory framework of the European Union. The regulatory regime of the network industries has been a moving target also within the EU that rendered the adoption of the new regulations a fairly cumbersome process. The EU has been striving for market opening and liberalization of these industries; it abolished industry regulation in several segments of the market of network industries. Now it applies so-called "cost-based pricing" in areas where regulation is still in place. It is an overall trend in the EU that most market segments of network industries are liberalized. As a result, competition among network-based firms has become fairly intensive. A dominant position of a company in these markets – that creates the economic and legal basis for industry regulation along the EU directives – occurs less and less frequently. Observing this development, the EU abolished most price regulations. The only market segment where price regulation along with other measures is still in place is interconnection between networks and firms.

This paper deals with the regulation of interconnection prices for firms with interconnected networks. We discuss the features of cost-based pricing first. Then we turn to the analysis of feasible regulatory regimes under imperfect and asymmetric information.

The paper unites two separate lines of previous analyses. On the one hand, important works by Armstrong, Doyle and Vickers (1996), Armstrong (2002), Laffont, Rey and Tirole (1998a, b), Carter and Wright (1999, 2003) as well as studies by De Bilj and Peitz (2002), Peitz (2005) and numerous others address the issue of interconnection and termination charges under the assumption that the regulator has perfect information about the true costs of providing inter-firm network access services. On the other hand, the literature is equally extensive on the nature and consequences of asymmetric cost information between the regulator and the regulated firm. The seminal work on regulating a firm with unknown costs was written by Baron and Myerson (1982). Important contributions were made among others by Laffont and Tirole (2000) and Laffont and Martimort (2002).[1] However, we are not aware of any study that would have combined these two lines of investigation. Some authors did

[1] Armstrong and Sappington (2005) offer an overview of the issues of imperfect information in regulated industries.

not see the need for doing so. For example, Armstrong (2002) wrote: “While it is clear that imperfect regulatory knowledge of costs and the potential for cost reduction has an important impact on regulatory policy, the interaction of these features with the access pricing problem does not often seem to generate many new insights.” (p. 380) Believing that perfect regulatory knowledge was an adequate assumption, Armstrong then went on and proposed that the regulator should base inter-firm network access prices on “estimated efficient costs,” or costs computed from engineering models, or benchmarking.

The principle of cost-based pricing has long dominated regulatory approaches to pricing end user services. In addition to the major careers’ own cost models, North American regulators required the construction of elaborate service cost simulation models for various levels of service aggregation as early as the 1970’s. Cost-based price regulation has been adopted by the EU since the early 1990s. When, after opening up the market to competition in telecommunications and in other utilities markets, the regulation of inter-firm network access prices became a regulatory task of critical importance, cost-based pricing quickly found these industries as a new field of application. Regulators began to demand that network operators provide access to their network for other service companies for charges that are based on long run incremental costs.

Many difficulties are inherent in this approach. We show in this paper that cost-based pricing may signal incentives to firms *not to improve* the efficiency level of interconnection. The adverse effects of cost-based price regulation work through two channels. First, even if the regulator had perfect information about the service providers’ call termination costs (and based termination charges on those costs), service providers would not be induced to attain high efficiency for higher efficiency in network interconnection would not result in higher profits for them. This is a direct consequence of the complex cross-price effects in inter-firm services. Second, the adverse effect of cost-based pricing on the service providers’ efficiency is exacerbated if the regulator's information about the firms' cost is imperfect. We show that cost-based pricing can be extremely costly in terms of lost social welfare.

The shortcomings of the current regulatory schemes are further enhanced in CEE countries by the uncertain position and the feeble administrative capacity of the regulatory agencies. CEE governments extensively use the regulatory bodies to directly influence markets in their own short-term interests. Therefore, the activities of the regulatory agencies become over-politicized. In addition, these agencies frequently lack a well educated and experienced staff that is capable of uncovering the real issues in network markets and find feasible and efficient solutions. Most CEE countries try to imitate the regulatory solutions of the advanced member countries of the EU, without truly understanding the local conditions of the network markets. These regulatory agencies are frequently trapped by having insufficient information on the true costs and other operating conditions of the firms they try to regulate.

In reality, regulators can never perfectly know the true costs of network access services. More is involved than the informed party's unwillingness to disclose private information, or biases due to the unavoidable arbitrariness of some elements of cost allocation. The firm and the regulator may have some misperceptions about what the other party knows or infers from the information they both possess. For instance, a firm may assume, albeit mistakenly, that the regulator is also aware of some specific information about efficient operation that the firm previously acquired. Consequently, the firm would expect the regulator to incorporate this piece of information in his regulatory decision, although this will not, in fact, occur. Thus, the firm would adjust its output decision to a false assumption. Madarasz (2007) labelled this kind of assumption "information projection." The opposite may also happen. The firm may ignore important portions of cost accounting information and assume that the regulator is equally ignorant. According to Madarasz, this is "ignorance projection." Cost-based pricing may give rise to simultaneous cases of "information projection" and "ignorance projection". As a result, cost-based pricing may do more harm than good.[2]

Regulatory agencies also recognized recently some of the weaknesses of the cost-based regulatory design, and they started applying "bottom-up" benchmark models in their effort to find efficient prices. Bottom-up models establish the lowest feasible level of costs for each element of the network. Then they aggregate these cost components up to the level of end user services. We show in this paper that bottom-up benchmarking is not a solution for regulatory games, when one of the parties has private information. We use the example of the telecommunications industry, but our findings can be generalized for other network industries, where networks interconnect.

We shall demonstrate the adverse effects of cost-based pricing and the benefits of incentive regulation in the telecommunications industry. But our finding can be easily extended to other network markets. Our point of departure is a model of customers' choice between service providers similar to the one presented by Laffont, Rey and Tirole (1998a, b). We divert from their model at one important point: we assume that customers' valuation of network size and customers' demand for calls are additively separated. In addition, we relax Laffont et al.'s assumption of perfect information and develop a different model in which asymmetric information between service providers and regulators is assumed. Thus extended, the model enables us to analyze the critical aspects of network interconnection and call termination in different scenarios.

The regulatory model of interconnection with imperfect information conveys important policy implications. We demonstrate that incentive regulation gives the proper incentives to firms to improve efficiency, and it results in smaller social welfare loss than cost-based pricing or bottom-up cost accounting. Principal-agent models of price regulation are more

[2] Laffont and Tirole (2000) discuss several aspects of this problem.

“knowledge intensive” but less time consuming than cost accounting. Most importantly, a regulatory mechanism that takes into account the existence of asymmetric information between the regulator and the regulated firm induces cooperation between the contracting parties, while cost-based pricing inevitably brings about conflict between the regulator and the regulated firm.

The structure of the paper is as follows. The assumptions are outlined in section 2. The benchmark case of regulation with perfect information and cost-based pricing is presented in section 3. Section 4 is devoted to the description of a model of incentive regulation with two different effort levels and two efficiency types[3] of the regulated firms. We solve the model in section 5. The results are compared to those of other pricing policies, and the main conclusions are drawn in section 6.

1 ASSUMPTIONS

Two firms (denoted by subscripts 1 and 2) are assumed to operate in a market of telecommunications services. They offer differentiated services to subscribing end users and in doing so they compete in prices. For simplicity’s sake, end users do not migrate between service providers.[4] Subscribers initiate and receive intra-firm and inter-firm calls. Intra-firm calls are initiated and terminated in the same network, while inter-firm calls are terminated in the other network. There are three kinds of prices: *subscription* fees f_1 and f_2 that customers must pay in order to gain access to the network of firm 1 and 2, respectively; usage sensitive *intra-firm* calling prices p_1 and p_2; and usage sensitive *inter-firm* calling prices $\hat{p}_1$ and $\hat{p}_2$. Inter-firm calling prices $\hat{p}_1$ and $\hat{p}_2$ include *termination* charges a_1 and a_2, respectively. These are paid by each firm to the other firm for using the other firm’s network in order to terminate

[3] Low and high efficiency in producing interconnection (in our case: termination) services.
[4] On customers’ switching costs see Fudenberg and Tirole (2000) and Villas-Boas (1999).

inter-firm calls. There are no separate transit charges, since there are only two networks. All subscription and calling prices are unregulated. Termination charges are subject to regulation.

Subscribers have identical valuation $0 < V(s_i) < s_i$ for belonging to network *i* of size s_i, where s_i is the number (mass) of subscribers who subscribe to network *i*. s_i is normalized to one and it also denotes the market share of firm *i*. Hence for two firms: $s_1 + s_2 = 1$. For simplicity's sake, subscriber valuation is given by $V(s_i) = s_i V$.

A customer chooses between the two networks based on his/her valuation of network size and on the monetary utility $u(p, \hat{p}, f)$ he/she can gain from using the services of each network. We assume that the customer's valuation of network size and her/his monetary utility from using the network are additive in her/his total utility. The intuition behind this assumption is that a customer's decision of how many calls she will make depends only on the price of placing calls. Network size matters when a customer chooses her service provider for the size of the network will affect her utility through the intranet calling price she expects to pay. Her expectation is that the larger the network the lower this price becomes. Market shares will be functions of customers' total utility, and may be derived from a simple, slightly modified price competition model of consumer choice à la Hotelling.

The representative customer's demand for intranet calls is given by $d(p)$, while the mass of a customer's inter-firm calls is $\hat{d}(\hat{p})$. A subscriber's consumer surplus from a mass of $d(p)$ intranet calls is denoted by $v(p)$. It is assumed that $v'(p) \equiv -d(p)$. Similarly, a subscriber's consumer surplus from a mass of $\hat{d}(\hat{p})$ inter-firm calls is denoted $\hat{v}(\hat{p})$, and $\hat{v}' \equiv -\hat{d}(\hat{p})$ by assumption. We assume that customers' preferences for service providers, denoted θ, are uniformly distributed on the unit interval between firm 1 and firm 2: $\theta \in [0, 1]$. θ may be understood as the factor of substitution between network 1 and network 2. Thus, a subscriber's total utility from choosing network 1 or network 2 becomes:

(1)
$$U_1 = CS_1 = s_1 V + v_1(p_1) + \hat{v}_1(\hat{p}_1) - f_1 - \theta, \text{ or}$$
$$U_2 = CS_2 = (1 - s_1)V + v_2(p_2) + \hat{v}_2(\hat{p}_2) - f_2 - (1-\theta).$$

The marginal subscriber between network 1 and 2 will be the person for whom

(2) $$s_1 V + v_1(p_1) + \hat{v}_1(\hat{p}_1) - f_1 - \theta = (1 - s_1)V + v_2(p_2) + \hat{v}_2(\hat{p}_2) - f_2 - (1-\theta), \text{ or}$$

(3) $$v_1(p_1) + \hat{v}_1(\hat{p}_1) - f_1 - s_1(1-V) = v_2(p_2) + \hat{v}_2(\hat{p}_2) - f_2 - (1-s_1)(1-V).$$

The indifference condition in (2) gives

(4)
$$s_1 = \frac{v_1(p_1) - v_2(p_2) + \hat{v}_1(\hat{p}_1) - \hat{v}_2(\hat{p}_2) + f_2 - f_1}{2(1-V)} + \frac{1}{2}, \text{ and}$$
$$s_2 = 1 - s_1 = \frac{v_2(p_2) - v_1(p_1) + \hat{v}_2(\hat{p}_2) - \hat{v}_1(\hat{p}_1) + f_1 - f_2}{2(1-V)} + \frac{1}{2}.$$

Service providers operate with constant but different marginal costs in each segment of the service. Fixed costs are disregarded because they do not affect the optimal level of service. c_i^F denotes the additional (unit) cost of connecting a new subscriber to network i.[5] Firm i $(i = 1, 2)$ incurs total marginal cost of $c_i = c_i^O + c_i^T$ by providing on-net (intranet) calls to their own subscribers—where c_i^O denotes the marginal cost of call origination, while c_i^T labels the marginal cost of call termination—but the firm incurs only the unit cost c_i^T by terminating the off-net calls for subscribers of the other firm, respectively.

Firm i's total profit from serving a mass of s_i customers with on-net calls and a mass of s_j customers with inter-firm calls can be written as:

(5) $$\pi_i = \underbrace{s_i\left((p_i - c_i^O - c_i^T)d_i(p_i) + (\hat{p}_i - c_i^O - a_j)\hat{d}_i(\hat{p}_i) + f_i - c_i^F\right)}_{\text{profit from internal subscribers}} + \underbrace{s_j(a_i - c_i^T)\hat{d}_j(\hat{p}_j)}_{\text{profit from call termination for external customers}},$$

[5] By this we implicitly assume that service providers cannot extract all consumer surplus from new subscribers accessing their network.

where $a_i, \quad i = 1, 2$ denotes the call termination charge set by firm *i*. Total profit for the whole industry thus becomes:

(6)
$$\Pi = \pi_1 + \pi_2 = s_1\left(\left(p_1 - c_1^O - c_1^T\right)d_1(p_1) + \left(\hat{p}_1 - c_1^O - c_2^T\right)\hat{d}_1(\hat{p}_1) + f_1 - c_1^F\right) + \\ + s_2\left(\left(p_2 - c_2^O - c_2^T\right)d_2(p_2) + \left(\hat{p}_2 - c_2^O - c_2^T\right)\hat{d}_2(\hat{p}_2) + f_2 - c_2^F\right).$$

2 REGULATING INTERCONNECTION WITH PERFECT INFORMATION: COST-BASED PRICING FOR CALL TERMINATION

It is assumed to be in society's interest to control the firms' monopoly power over interconnection in order to foster competition in end user services. In fact, such regulation exists in numerous countries, where the regulator sets an upper limit on the call termination charge *a*. We assume that the regulator wants to maximize social welfare (*W*)—measured as total consumer surplus plus total industry profit—in the regulated segment of the market, subject to some constraints. The regulator's valuation over gross consumer surplus is concave with the usual properties: $W' > 0, \quad W'' \leq 0$. Thus, the regulator's objective function can be written as

(7) $W = s_1 CS_1 + s_1 CS_2 + \Pi$,

where Π is total industry profit as described in (6) and CS_i is the net consumer surplus enjoyed by a subscriber to network *i*.

When firms find the optimal calling prices $(p_i, \hat{p}_i)$ and subscription fee (f_i) by maximizing profits, they take into account the termination fee a_i that will be set by the regulator. Since the regulator knows how firms solve their optimization problem, she will use the profit maximizing prices of the firms to get the optimal termination fees that will maximize total social welfare.[6] The first order conditions of profit maximum in equation (5) are as follows:

(8) $$\frac{\partial \pi_i}{\partial p_i} = \frac{\partial s_i}{\partial p_i}\tilde{\pi}_i + s_i d_i + s_i\left(p_i - c_i^O - c_i^T\right)\frac{\partial d_i}{\partial p_i} = 0,$$

(9) $$\frac{\partial \pi_i}{\partial \hat{p}_i} = \frac{\partial s_i}{\partial \hat{p}_i}\tilde{\pi}_i + s_i \hat{d}_i + s_i\left(\hat{p}_i - c_i^O - a_j\right)\frac{\partial \hat{d}_i}{\partial \hat{p}_i} = 0,$$

(10) $$\frac{\partial \pi_i}{\partial f_i} = \frac{\partial s_i}{\partial f_i}\tilde{\pi}_i + s_i = 0,$$

where $\tilde{\pi}_i = \left(p_i - c_i^O - c_i^T\right)d_i + \left(\hat{p}_i - c_i^O - a_j\right)\hat{d}_i + f_i - c_i^F$ is firm *i*'s profit from one of its own customers. Using these conditions and the market share equation in (4) we have:

(11) $$p_i^* = c_i^O + c_i^T,$$

(12) $$\hat{p}_i^* = c_i^O + a_j,$$

(13) $$f_i^* = \frac{v_i(p_i) - v_j(p_j) + \hat{v}_i(\hat{p}_i(a_j)) - \hat{v}_j(\hat{p}_j(a_i)) + 2c_i^F + c_j^F}{3} + 2(1-V)$$

Substituting equation (13) into equation (4) yields the following market shares:

(14) $$s_i^* = \frac{v_i(p_i) - v_j(p_j) + \hat{v}_i(\hat{p}_i(a_j)) - \hat{v}_j(\hat{p}_j(a_i)) + c_j^F - c_i^F}{6(1-V)} + \frac{1}{2}.$$

Substituting equations (11) and (12) into the regulator's objective function in (7) gives:

(15)

$$W = s_1\left[\left(a_2 - c_2^T\right)\hat{d}_1 - c_1^F + v_1(p_1) + \hat{v}_1(\hat{p}_1(a_2))\right] + s_2\left[\left(a_1 - c_1^T\right)\hat{d}_2 - c_2^F + v_2(p_2) + \hat{v}_2(\hat{p}_2(a_1))\right],$$

where

[6] Our results would not change if the regulator established the cost-based termination fee at $a_i = c_i^T$ and firms maximized profits by knowing the regulated termination charges.

(15a)

$$\left(a_2 - c_2^T\right)\hat{d}_1 - c_1^F + v_1\left(p_1\right) + \hat{v}_1\left(\hat{p}_1\left(a_2\right)\right) = w_1, \text{ and}$$

$$\left(a_1 - c_1^T\right)\hat{d}_2 - c_2^F + v_2\left(p_2\right) + \hat{v}_2\left(\hat{p}_2\left(a_1\right)\right) = w_2$$

are consumer surpluses at the firms' profit maximizing prices of each subscriber in networks 1and 2, respectively.

Notice that $w_1 = w_2$ must hold, otherwise the regulator would alter the termination charges in a way that would direct customers away from the network that yields lower consumer surplus and toward the other network that offers higher consumer surplus per customer. For instance, if $w_1 > w_2$, then the regulator should reduce a_2, the termination fee she had set to firm 2 (and/or she should increase a_1) in order to direct customers away from network 2 and toward network 1. But a reduction of a_2 will reduce consumer surplus at network 1. The adjustment of termination fees continues until $w_1 = w_2$. From this result and from $s_1 + s_2 = 1$ it follows that a_i will maximize total social welfare in equation (15) if each consumer's total net surplus, $w_i = \left(a_j - c_j^T\right)\hat{d}_i - c_i^F + v_i\left(p_i\right) + \hat{v}_i\left(\hat{p}_i\left(a_j\right)\right)$ attains its maximum at a_i. The first order condition of social welfare maximum is

(16) $$\frac{\partial w_i}{\partial a_i} = \hat{d}_j + \left(a_i - c_i^T\right)\frac{\partial \hat{d}_j}{\partial a_i} - \hat{d}_j = 0,$$

which yields

(17) $$a_i = c_i^T$$

Based on the above results we can formulate an important proposition.

Proposition 1: *Cost-based pricing of call termination cannot be reconciled with competitive (unregulated) calling prices and subscription fees. Cost-based call termination prices will punish the more efficient firm for its market share and subscription fee will be smaller,* *consequently, its profit will be lower than in case this firm pretended to be less efficient. Thus, cost-based pricing of call termination will give the service providers a "perverse" incentive not to offer call termination at efficient costs.*

Proof: *It is easy to see from equation* (14), *that describes the market shares of the firms, that firm i's market share increases in its own termination charge* a_i, *but its market share is a decreasing function of the other firm's termination charge* a_j:

(18) $\frac{\partial s_i^*}{\partial a_i} > 0 \; and \; \frac{\partial s_i^*}{\partial a_j} < 0$.

Equation (17) *above shows the profit maximizing call termination charges. Since* $a_i < a_j$ *because* $c_i^T < c_j^T$ *by assumption, it follows from* (18) *that* $s_i^* < s_j^*$.

In addition, it can be seen from equations (11), (12) *and* (13), *which give the profit maximizing calling charges and subscription fees, that firms will earn positive profits only on subscription. It is obvious from equation* (13) *that firm i's profit maximizing subscription fee* f_i^* *increases in its own termination charge* a_i, *but it decreases in the other firm's termination charge* a_j:

(19) $\frac{\partial f_i^*}{\partial a_i} > 0 \; and \; \frac{\partial f_i^*}{\partial a_j} < 0$.

Consequently, if $a_i < a_j$ *because* $c_i^T < c_j^T$, *then* $f_i^* < f_j^*$. *Since* $\frac{\partial \pi_i}{\partial f_i} > 0$ *in the profit equation* (5), *it follows from* $f_i^* < f_j^*$ *that* $\pi_i < \pi_j$. *Q. e. d.*

3 REGULATION IN THE PRESENCE OF ADVERSE SELECTION AND MORAL HAZARD

The regulator and the regulated firms play a static game in our model, which is an extension of Chapter 7 in Laffont and Martimort (2002). The regulator has the right to offer a contract menu for the firms.[7] This "regulation game" has a unique Nash equilibrium in each case presented below. The firms themselves play another pricing game within the regulation game that also has a unique equilibrium as shown below.

The focus of our analysis is on the regulatory design for network interconnection (call termination), where the efficiency level of the termination service, c_i^T, constitutes the firms' private information. Each firm's efficiency level may have two different values: it may be "high," $\underline{c_i^T}$ or "low," $\overline{c_i^T}$, where the lower bar and the upper bar indicate low marginal cost (high efficiency) and high marginal cost (low efficiency), respectively. It follows from the definition of efficiency that $\underline{c_i^T} < \overline{c_i^T} \quad i = 1, 2$. The distance between firm *i*'s two efficiency levels is $\Delta c_i^T = \overline{c_i^T} - \underline{c_i^T}$.

The regulator does not know the true value of c_i^T but she knows that the firms' efficiency may be high with probability ν and it can be low with probability $(1-\nu)$ for both firms.[8] The probability distribution of the firms' efficiency type as well as the customers' demand functions is common knowledge.

Beside the companies' private information, regulation is hampered by the fact that the regulator cannot perfectly monitor the firms' effort level. This effort may be connected to the quality of service or to the firm's endeavor to improve on its efficiency level. There are two options to address the joint occurrence of adverse selection and moral hazard. Notably, we could assume that the firms' efficiency level is "given by nature" in the first place. This given, the companies decide how much effort to exert. Alternatively, the firms may first decide to

[7] It could be the other way around: the firms may design and offer the contract menu and the regulator may accept or reject their offer.
[8] Different probability distributions of the firms' efficiency type would complicate the analysis without adding new insight to the regulator's problem.

exert some level of effort. This would have a direct effect on their efficiency level. The efficiency level is then realized with some probability. We work with the latter assumption.[9] Assuming that the firms' effort (e) can be "high" or "low," $e \in \{e^h, e^\ell\}$,[10] we denote the firm's effort costs $\psi(e)$ as $\psi(e^h) = \psi$, and $\psi(e^\ell) = 0$, respectively.

The conditional probability of high efficiency if the firm exerted high effort is given as $\nu^h = P(i = h | e^h) = \frac{P(h \cap e^h)}{P(e^h)}$. The probability of low efficiency with high effort then becomes $1 - \nu^h$. Similarly, the conditional probability of high efficiency with low effort is ν^ℓ, hence the conditional probability of low efficiency with low effort becomes $1 - \nu^\ell$. We assume that the company is always capable of improving its efficiency level by exerting effort. But the actual realization of the efficiency level is a stochastic variable. When the company decides on effort—it may, for instance, invest in an efficiency enhancing technology—it cannot be certain that the effort will reap the expected efficiency level. We assume that the conditional probability of high efficiency is strictly increasing with effort: $\nu^h > \nu^\ell$. The difference between the conditional probabilities of high efficiency with respect to high and low efforts is $\Delta\nu = \nu^h - \nu^\ell$. We also assume that high effort is always socially optimal; i.e.

(20) $\Delta\nu(W^h - W^\ell) \geq \psi$,

where W^h and W^ℓ are total economic surpluses from interconnection (inter-firm call termination) with the firms' high and low effort, respectively. Before elaborating the model of incentive regulation we briefly present the regulatory contract with perfect regulatory information as a benchmark case.

[9] Our assumption is supported by empirical evidence in telecommunications and in road transport. The former approach would suit better to energy supply and to railway networks, where technology is more rigid and may be assumed to be fixed for longer periods of time.
[10] We could have assumed a continuous level of effort as we could have had a continuum of types, but it would have rendered the analysis technically more complex without adding to the important results. (See, for instance, Laffont and Martimort (2002), pp. 185–6.

We assume that the firms are *risk neutral* but they are protected by *limited liability*. Under such assumptions, it is not in the firms' interest to reveal their true type and exert high effort. But firms may be induced to reveal their type and exert high effort by the creation of an "information rent," which is allocated by the regulator between the regulated firms. Such an information rent can be financed from a "service provision fund." Firms may pay to or get payment from this fund. If firm *i* receives a transfer payment τ per customer, in addition to the termination fee it obtains from the other service provider for terminating inter-firm calls, then the firm's net utility per customer becomes

(21) $$u_i(\tau_i, a_i) = \tau_i - (c_i^T - a_i)\hat{d}_j .$$

The schedule of contracting between the firm and the regulator is as follows:

(1) "Nature" sets the probability distributions for the efficiency types and also for the output levels conditional on effort. The regulator and the firm learn these probability distributions.

(2) The regulator offers a contract menu $\left\{\left(\underline{\tau_i}, \underline{a_i}, \underline{\hat{d}_j}\right), \left(\overline{\tau_i}, \overline{a_i}, \overline{\hat{d}_j}\right)\right\}$ for each combination of effort level and efficiency type for each firm i $(i = 1, 2)$. The lower and upper bar variables stand for efficient outcomes and inefficient outcomes, respectively.

(3) The firm decides on its effort level without revealing the decision, which thus remains private information.

(4) Having selected an effort level, its efficiency type is set as a stochastic function of the firm's effort. (Notice, that even the firm is unable to know its efficiency type for sure).

(5) The firm delivers the interconnection (call termination) service, customers pay the termination charge as a fraction of the inter-firm calling price, and firms settle the net balance

of mutual interconnection charges among themselves according to the rule that has been specified by the regulator.

Additional contracting conditions are set for a firm by its participation constraint, limited liability constraints, and the adverse selection and moral hazard incentive constraints. We assume that the reservation utility of the firms, $\underline{u}_i^0(\underline{\tau}_i, \underline{a}_i), \overline{u_i^0}(\overline{\tau}_i, \overline{a}_i)$ equals zero for all efficiency types. The constraints are introduced below.

Participation constraint

Since the regulator intends to induce high effort by the firm by assumption, the participation constraint is associated only with high effort. It is

(22) $\nu^h \underline{u}_i + (1-\nu^h)\overline{u_i} \geq 0$.[11]

Limited liability constraints

We assume that the firm does not possess disposable assets to finance any loss. This is not as strong an assumption as it appears. We could allow a loss, say–*L,* which would affect our equations with a constant term, but it would not have any substantial effect on the model. The limited liability constraint of the firm with high efficiency is

(23a) $\underline{u}_i \geq 0$,

and the limited liability constraint of the firm with low efficiency is

(23b) $\overline{u_i} \geq 0$.

Adverse selection incentive compatibility constraints

[11] Notice that *u* does not have a superscript index. We assume that the regulator prefers high to low effort; consequently, participation must be ensured only for firms exerting high effort. When the superscript index is omitted, the variable or probability always refers to high effort.

These constraints ensure that the firm does not mimic another type of efficiency, which is different from its true type, because its utility cannot be higher with lying than with revealing the truth (its true efficiency level). (One may call these "Do not lie!" constraints.) The incentive constraints of the highly efficient firm are

(24a) $\underline{u_i} \geq \overline{u_i} + \Delta c_i^T \overline{\hat{d}_j}$,

while the incentive constraints for the firm with low efficiency become

(24b) $\overline{u_i} \geq \underline{u_i} - \Delta c_i^T \underline{\hat{d}_j}$,

where $\Delta c_i^T = \overline{c_i^T} - \underline{c_i^T}$, $i = 1, 2$ denotes the difference between high and low marginal costs of call termination.

Moral hazard incentive compatibility constraint

The moral hazard incentive constraint induces the firm to exert high effort provided that high effort is desirable for society. (One may call these "Do not cheat!" constraints.) In other words, the moral hazard incentive constraint ensures that the expected utility of the firm cannot be lower with high than with low effort. The incentive constraint is

(25) $\nu^h \underline{u_i} + (1 - \nu^h)\overline{u_i} - \psi \geq \nu^\ell \underline{u_i} + (1 - \nu^\ell)\overline{u_i} \Rightarrow \Delta\nu(\underline{u_i} - \overline{u_i}) \geq \psi$.

The regulator's objective function

Since the regulator does not possess perfect information about the firms, she must give up some of her benefits in order to induce effort and true revelation. The regulator's lost benefit becomes the firm's information rent. The information rent has two parts. The first part is the firm's limited liability rent, for the firms must be able to charge a higher interconnection fee than what the regulator would otherwise accept because of the firms' limited liability constraint. The second part is the "adverse selection" rent, which acts to induce true revelation of the firms' efficiency type. The regulator's objective function becomes

(26) $E(W) = \nu^h\left(\underline{W} - \underline{u}_1 - \underline{u}_2\right) + \left(1-\nu^h\right)\left(\overline{W} - \overline{u}_1 - \overline{u}_2\right)$

with constraints (22)–(25), where W is the social welfare function as given by equation (15).

The relevant constraints

The analysis of constraints reveals that we need to deal only with the limited liability constraints of the less efficient firm (23b), the adverse selection constraints of the efficient firm (24a), the moral hazard constraint (25), and the following *monotonicity constraint* (derived from the adverse selection constraints): $\underline{\hat{d}_j} \geq \overline{\hat{d}_j}$.[12]

The wider the gap between the regulated interconnection fee a and its first best optimum the larger the lost economic surplus will be. Consequently, the information rent of the inefficient type must be kept at minimum by the regulator. It then follows from the limited liability constraint of the inefficient firm that

(28) $\overline{u_i} = 0$ must hold.

The information rent of the efficient types will be affected by the relative strength of the effect of adverse selection and moral hazard. Different constraints may be binding depending on the probability distribution of efficiency types and effort level, and on the magnitude of the effort cost. The regulator faces a trade-off between the information rent, resulting from the adverse selection and limited liability constraints, and the allocative efficiency of the firm with different efficiency types. In certain cases, it makes sense for the regulator to distort the output level of the firm downwards and away from the first best level of output in order to save a portion of the information rent. We show that the downward distortion of output becomes smaller and smaller as the problem of moral hazard is exacerbated.

[12] Here we apply the results of Laffont and Martimort (2002), pp. 87.

4 OPTIMAL CONTRACT MENUS WITH DIFFERENT BINDING CONSTRAINTS

We need to discuss three different cases that are distinguished by the relative magnitude of the information rent and the effort cost. Notably, it will depend on the relative magnitude of the information rent and effort cost which constraints of the different efficiency types will be binding. We only present the first case in detail, when the information rent exceeds the effort cost. Then we outline only the final results of the other two cases, for the technical analysis goes along the same lines in all cases.

Case (a)

It is assumed that the information rent that a firm can extract with high efficiency is not less than the cost of inducing effort, that is, comparing (24a) and (25) we obtain:

(29) $$\Delta c_i^T \overline{\hat{d}_j^{SB}} \geq \frac{\psi}{\Delta \nu},$$

where the second best outcome of interconnection services is denoted by $\hat{d}_i^{SB}$.

The following result is obtained from (29):

If the cost of inducing effort of the efficient firm is smaller than the firm's information rent, then the adverse selection incentive constraint of the efficient firm (24a) *is binding:*

(30) $$\underline{u_i} = \Delta c_i^T \overline{\hat{d}_j}.$$

The first order conditions of the regulator's maximization problem yield optimal charges of call termination with different efficiency types. Substituting (28) and (30) into the regulator's objective function in (26) we get:

(31) $$E(W) = \nu^h \left(\underline{W} - \Delta c_1^T \overline{\hat{d}_2} - \Delta c_2^T \overline{\hat{d}_1} \right) + \left(1 - \nu^h\right)\left(\overline{W}\right)$$

The first order conditions of call termination charges yield:

$$(32)\quad \frac{\partial E(W)}{\partial \underline{a}_i} = \nu^h \left(\underline{a}_i - \underline{c}_i^T\right) \frac{\partial \underline{\hat{d}}_j}{\partial \underline{a}_i} = 0.$$

$$\frac{\partial E(W)}{\partial \overline{a}_i} = \nu^h \Delta c_i^T \frac{\partial \overline{\hat{d}_j}}{\partial \overline{a}_i} + \left(1-\nu^h\right)\left(\overline{a}_i - \overline{c_i^T}\right) \frac{\partial \overline{\hat{d}_j}}{\partial \overline{a}_i} = 0,$$

which sets the following termination fees:

$$(33)\quad \underline{a}_i = \underline{c}_i^T \text{ and } \overline{a}_i = \overline{c_i^T} + \frac{\nu^h}{1-\nu^h} \Delta c_i^T .$$

Our conclusion is that the different information rents that must be paid to high and to low types, respectively, differ to the extent that is sufficiently large to induce high effort of all firms. In such cases, the optimal contract menu looks the same as the contract that the regulator would offer in case of pure adverse selection.

Case (b)

It is assumed that the cost of inducing effort is higher than the information rent of the efficient type, but it is lower than this information rent would be if the output of the less efficient firm were not reduced below its first best level; i.e.,

$$(34)\qquad \Delta c_i^T \overline{\hat{d}_j^{SB}} < \frac{\psi}{\Delta \nu} \leq \Delta c_i^T \overline{\hat{d}_j^{FB}} ,$$

where $\overline{\hat{d}_j^{FB}}$ is the first best level of optimum output.

The adverse selection incentive constraint (24a) *and the moral hazard incentive constraint* (25) *will equally bind in case of the high efficient firm:*

$\underline{u}_i = \Delta c_i^T \overline{\hat{d}_j}$ *as in* (30) *and*

(35) $\underline{u_i} = \dfrac{\psi}{\Delta \nu}$,

so that equation (35) can be re-written as:

(36) $\Delta \nu \Delta c_i^T \overline{\hat{d}_j} - \psi = 0$,

and the regulator's objective function becomes:

(37) $E(W) = \nu^h \left(\underline{W} - \Delta c_1^T \overline{\hat{d}_2} - \Delta c_2^T \overline{\hat{d}_1} \right) + \left(1 - \nu^h\right)\left(\overline{W}\right) + \lambda \left(\Delta \nu \Delta c_1^T \overline{\hat{d}_2} + \Delta \nu \Delta c_2^T \overline{\hat{d}_1} - \psi \right)$

The first order conditions yield:

(38) $\underline{a_i} = \underline{c_i^T}$ and $\overline{a_i} = \overline{c_i^T} + \left(\dfrac{\nu^h}{1 - \nu^h} - \lambda \Delta \nu \right) \Delta c_j^T$

where $\lambda > 0$ is the Lagrange multiplier of equation (36).

The results indicate that exacerbated moral hazard results in a larger information rent of the efficient firm in case (b) than in case (a). The regulator cannot substantially reduce the information rent by deteriorating allocative efficiency, i.e., by reducing the level of service of the low efficiency type. Consequently, it is sensible to cut back the output of the less efficient firm to a lesser extent. As the first order conditions show, the efficient firm will produce at its first best optimum level. The regulator will distort the output level of the inefficient company downward as in case (a), but it follows from (38) that this distortion will be smaller now. Consequently, $\overline{a_i}$ is smaller now than in case (a), and the information rent of the efficient firm under case (b) will exceed the information rent of the same firm under case (a). The regulator must pay higher information rent for the gain in allocative efficiency.

Case (c)

It is assumed that the cost of inducing effort is larger than the information rent accrued by the efficient type:

(39) $$\Delta c_i^T \overline{\hat{d}_j^{FB}} < \frac{\psi}{\Delta \nu}.$$

The moral hazard constraint (25) *and the limited liability constraint* (23b) *are binding;* $\overline{u_i} = 0$ and $\underline{u_i} = \frac{\psi}{\Delta \nu}$.

The problem of moral hazard is so pervasive—the cost of inducing effort is so high—that it renders the reduction of the information rent of the more efficient type unfeasible by distorting the output level of the less efficient type downwards. Consequently, each type will produce at its first best level. The regulator's objective function in (26) becomes:

(40) $$E(W) = \nu^h \left(\underline{W} - \frac{\psi}{\Delta \nu} \right) + \left(1 - \nu^h\right) \overline{W}$$

Solving the first order conditions obtains:

(41) $$\underline{a_i} = \underline{c_i^T} \text{ and } \overline{a_i} = \overline{c_i^T}$$

Substituting the results of the three cases into the firm's profit functions in (6) the following proposition is formulated.

Proposition 2: *Cost-based pricing rewards low efficiency in call termination services in terms of profits, while incentive regulation provides the proper incentives to firms: the companies' higher effort to increase efficiency reaps larger profits.*

Proof: *Efficient types can charge lower, while inefficient types can charge higher termination fees with incentive regulation. But the adverse effect of termination charges will be* *compensated for the efficient type through the information rent it obtains. The source of this information rent is a direct transfer of revenues from the inefficient to the efficient firm.*

As the analysis demonstrates, incentive regulation does not come without a cost. The cost of inducing effort is inversely related to the allocative inefficiency of the firms with different efficiency types in mixed models if moral hazard precedes adverse selection.

An important question arises at this point. What is the magnitude of the *extra* welfare loss originating from the fact that the regulator pretends to be perfectly informed about the firms' costs and about the firms' effort although she is not? We shall answer this question by comparing social welfare under the worst case—case (c)—of incentive regulation to that of pretended perfect information and cost-based regulation. Proposition 3 asserts that incentive regulation results in larger social welfare than cost-based pricing.

Proposition 3: *If the regulator has imperfect and/or incomplete information about the firms' efficiency type and effort then incentive regulation of call termination fees will always result in larger social welfare surplus than cost-based pricing*.

Proof: *The regulator transfers the information rent* $\Delta c^T \bar{\hat{d}}$ *per customer to the efficient firm. This will be "the cost" of incentive regulation incurred by society. The return on incentive regulation is the extra consumer surplus compared to the consumer surplus of cost-based pricing. Contrary to cost-based pricing—where the efficient firm is induced to pretend that it is inefficient, as shown in section 2 above—incentive regulation induces true revelation of efficiency type that results in lower termination charges than those under cost-based pricing. Lower termination charges, in turn, lead to lower inter-firm calling prices, consequently, to a larger consumer surplus. The benefit of incentive regulation per customer becomes:*

$$(42)\quad \Delta\hat{v}\left(\hat{p}\left(a=c^T\right)\right)=\underline{\hat{v}}\left(\underline{\hat{p}}\left(\underline{a}=\underline{c}^T\right)\right)-\bar{\hat{v}}\left(\bar{\hat{p}}\left(\bar{a}=\overline{c^T}\right)\right).$$

At the same time, the increased consumer surplus under incentive regulation equals the change in consumer surplus because of a small decline in costs multiplied by the total difference in costs under cost-based pricing and incentive regulation:

$$(43)\quad \Delta\hat{v}\left(\hat{p}\left(a=c^T\right)\right)=\left|\frac{\partial\hat{v}\left(\hat{p}\left(a=c^T\right)\right)}{\partial c^T}\right|\Delta c^T,$$

where $\left|\frac{\partial\hat{v}\left(\hat{p}\left(a=c^T\right)\right)}{\partial c^T}\right|=\hat{d}$[13]*. That is, incentive regulation leads to larger welfare than cost-based pricing if*

$$(44)\quad \Delta\hat{v}\left(\hat{p}\left(a=c^T\right)\right)\geq\Delta c^T\bar{\hat{d}},$$

or

$$(45)\quad \left|\frac{\partial\hat{v}\left(\hat{p}\left(a=c^T\right)\right)}{\partial c^T}\right|\Delta c^T=\Delta c^T\hat{d}\geq\Delta c^T\bar{\hat{d}},$$

where $\bar{\hat{d}}$ *on the right-hand side is the demand for inter-firm calls facing the inefficient type at optimal prices, while* $\hat{d}$ *on the left-hand side is not a certain amount of demand for inter-firm calls, but a variable in the interval* $\left[\bar{\hat{d}},\underline{\hat{d}}\right]$*. Since* $\hat{d}\in\left[\bar{\hat{d}},\underline{\hat{d}}\right]\geq\bar{\hat{d}}$, (45) *will always hold. Q. e. d.*

Since the outbreak of the current worldwide financial and economic crisis, market regulation has become a fashionable topic of economic analysis. Some analysts push this idea to the extreme and demand government intervention in almost all areas of business life. At the other end, "free market fans" pretend that basically nothing serious happened that would require the revision of mainstream economics. We do not believe in the omnipotent nature of

[13] $\frac{\partial\hat{v}\left(\hat{p}\left(a=c^T\right)\right)}{\partial c^T}=\frac{\partial a}{\partial c^T}\frac{\partial\hat{p}}{\partial a}\frac{\partial\hat{v}\left(\hat{p}\left(a=c^T\right)\right)}{\partial\hat{p}}$, where $\frac{\partial a}{\partial c^T}=1$ from (41), $\frac{\partial\hat{p}}{\partial a}=1$ from (12) and $\frac{\partial\hat{v}\left(\hat{p}\right)}{\partial\hat{p}}=-\hat{d}$.

government regulation but we think that a fresh approach to regulation issues is required. Regulatory agencies exercise their activities based on questionable foundations. We have shown that the analytical tools of a more adequate regulatory regime – the scheme of incentive regulation – already exist and can be translated into sensible policy measures.

5 DISCUSSION AND CONCLUSIONS

Industry regulation has gone a long way from the rate-of-return type regulatory scheme through price cap to cost-based pricing during the past few decades. We demonstrated in this paper that cost-based regulation is still not the end of the road toward a sensible and efficient market regulation. Economics developed all the necessary analytical tools that could be applied in designing efficient regulatory schemes. This task is tedious to advanced countries but it is even more difficult for CEE countries that lag behind their developed peers in designing and implementing efficient market regulation. CEE countries also lack the administrative capacity to exercise effective market regulation. But they could turn this drawback into an advantage should they become the forerunners in designing and implementing incentive regulation.

The most important conclusion of our analysis is that incentive regulation does not have a perverse effect on the regulated firms' profit and efficiency, while cost-based regulation does have such an effect. Cost-based pricing of call termination ultimately rewards the less efficient types of regulated firms. In contrast, when the regulator offers the regulated firm an incentive-based contract menu, the efficient firm will earn higher profits, while the profit of the less efficient firm will be zero. These results suggest that incentive regulation puts an additional burden on the regulator, for she must reallocate a fraction of the termination charge between the less efficient and the most efficient firm. However, this difficulty may not materialize, since firms normally pay each other only the net balance of interconnection charges.

The regulator needs to compare and contrast three possible cases if adverse selection and moral hazard are both present. Regulated firms of both efficiency types provide their service at the first best, *Pareto*-efficient level in Case (c). The efficient type produces the first best level of output in all other cases as well, but the output level of the less efficient type is downward biased in Cases (a) and (b). In these cases, the regulator is forced to distort allocative efficiency in order to induce information revelation and high effort from any type of regulated firm.

The cost of inducing effort is larger, relative to the information rent, in Case (b) than in Case (a), and the regulator distorts the output level of the less efficient type downward to a lesser extent in Case (b) than in Case (a). As the cost of inducing effort keeps increasing, as in Cases (b) and (c), the downward distortion of the output level of the less efficient type becomes smaller and smaller. The service levels of firms of different efficiency types come closer and closer to their Pareto-efficient level as the benefit (what the firm can acquire in return for revealing private information) becomes smaller and smaller relative to the effort cost. Consequently, it is less and less necessary and sensible for the regulator to offer an information rent to the firm for information revelation. As the distortion of allocative efficiency becomes smaller, the interconnection charge is also reduced.

Efficient firms are induced to pretend to be inefficient if termination charges are cost-based. In incentive regulation, the regulator transfers a certain amount of information rent from total economic surplus in order to induce the efficient firm to reveal its true type. Then the efficient type will choose a contract from the contract menu offered by the regulator that is in line with its costs. As a result of true cost revelation, allocative efficiency among firms improves and consumer surplus increases.

We have also shown that a regulatory contract that is based on the unrealistic assumption of perfect regulatory information usually results in a larger welfare loss than incentive regulation that takes into account the imperfect nature of information. Cost-based pricing that attempts to extract detailed cost data from companies causes larger welfare losses in regulated services than incentive contracts that are built on the firms' voluntary information revelation.

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