GOVERNANCE AND THE EFFICIENCY OF ECONOMIC SYSTEMS
GESY

Discussion Paper No. 320

Using Forward Contracts to Reduce Regulatory Capture

Felix Höffler*
Sebastian Kranz**

*Department WHU - Otto Beisheim School of Management, Burgplatz 2, 56179 Vallendar
E-mail: felix.hoeffler@whu.edu
**Bonn Graduate School of Economics, University of Bonn, Adenauerallee 24-26, 53113 Bonn, Germany.
E-mail: skranz@uni-bonn.de

February 2010

Financial support from the Deutsche Forschungsgemeinschaft through SFB/TR 15 is gratefully acknowledged.

Sonderforschungsbereich/Transregio 15 · www.sfbtr15.de
Universität Mannheim · Freie Universität Berlin · Humboldt-Universität zu Berlin · Ludwig-Maximilians-Universität München
Rheinische Friedrich-Wilhelms-Universität Bonn · Zentrum für Europäische Wirtschaftsforschung Mannheim

Speaker: Prof. Dr. Urs Schweizer. · Department of Economics · University of Bonn · D-53113 Bonn,
Phone: +49(0228)739220 · Fax: +49(0228)739221

Using Forward Contracts to Reduce Regulatory Capture

Felix Höffler[1] and Sebastian Kranz[2]

February 2010

Abstract

A fully unbundled, regulated network firm of unknown efficiency level can undertake unobservable effort to increase the likelihood of low downstream prices, e.g., by facilitating downstream competition. To incentivize such effort, the regulator can use an incentive scheme paying transfers to the firm contingent on realized downstream prices. Alternatively, the regulator can force the firm to sell the following forward contracts: the firm pays the downstream price to the owners of a contract, but receives the expected value of the contracts when selling them to a competitive financial market. We compare the two regulatory tools with respect to regulatory capture: if the regulator can be bribed to suppress information on the underlying state of the world (the basic probability of high downstream prices, or the type of the firm), optimal regulation uses forward contracts only.

Keywords: Incentive regulation, regulatory capture, virtual power plants

JEL-Classification: L43, L51, K23, L94

[1]WHU - Otto Beisheim School of Management -, Burgplatz 2, 56179 Vallendar, felix.hoeffler@whu.edu, +49 (0)261 6509 220. Research affiliate, Max Planck Institute for Research on Collective Goods, Bonn.

[2]Bonn Graduate School of Economics, University of Bonn, Adenauerallee 24-26, 53113 Bonn, Germany. skranz@uni-bonn.de. I thank the Deutsche Forschungsgemeinschaft for financial support through SFB/TR 15.

1 Introduction

In many liberalized network industries (like energy or telecommunications) it is often only the network as a monopolistic bottleneck that remains subject to strict regulation. This paper focuses on the regulation of an "unbundled" network operator (i.e., the network firm is not active downstream) which provides an essential input for the downstream market. While the bottleneck monopolist does not directly set final market prices, its actions (investments and operational decisions) can have substantial influence on downstream prices, e.g. by reducing downstream firms' costs or by increasing downstream competition.

A typical contract providing incentives for such actions would be to pay the network firm monetary transfers that decrease in (downstream) market prices. A problem of such outcome contingent transfers (i.e., transfers conditioning on realized downstream prices) is that downstream prices are stochastic and influenced by a multitude of factors. Thus the expected transfers to the network operator strongly depend on the regulator's assessment of the underlying distribution of downstream prices. This gives rise to the danger of regulatory capture: the network operator can receive rents by influencing the regulator to make a biased assessment that favors higher payments to the firm.

At the same time, in many industries, liquid financial markets exist (e.g. electricity wholesale markets), in which forward contracts for the final product are traded. Thus, there are financial investors who also hold information on the underlying distribution of downstream prices. The question of our paper is: Can an incentive regulation use the information of the financial market to avoid the problem of regulatory capture?

The basic idea is that the network operator can be forced to auction off a fixed quantity of forward contracts, which create the obligation to make future payments that are increasing in future downstream prices. From an incentive point of view, it is irrelevant whether lower downstream prices increase a network firm's profits because of higher transfers from the regulator, or because of lower payments to the buyers of the forward contracts. However, forward contracts can reduce the problem of regulatory capture, since the network operator's auction revenues depend on the financial investor's assessment of expected downstream prices, not on the regulator's assessment; and in our framework, bribing the regulator can in principle increase profits, while trying to manipulate the financial market is never profitable.

To make this precise, we build on the framework proposed by Laffont and Tirole (1991), with a benevolent legislator, and a corruptible regulator, who may receive information about the state of the world (the "baseline probability of high downstream prices"). It is well understood that a regulation based solely on outcome contingent transfers must leave rents to the firm to avoid that the regulator is bribed to suppress information.

Compared to this, a regulation using forward contracts can fully avoid costly rents if the financial market received the same information as the regulator. Independent of the regulator's assessment, the firm is forced to sell the contracts to the competitive financial market, which provides incentives to exert effort. The firm receives the expected value of the contracts, based on the financial market's information. Since the regulator does not influence payments, there is no point in bribing him. Bribing the financial market also is never profitable: any gain from bribing (e.g., selling the contract above value), would require an offsetting payment to the financial counterparty.

The superiority of forward contracts is less straightforward if the firm can be of different types, and if the type is revealed to the regulator and to the financial market with some probability only. Due to standard reasoning, outcome contingent transfers imply an information rent for the efficient type. Surprisingly, with forward contracts, not only the efficient type, but also the inefficient type receives a rent. If the type is not revealed, the financial market will pay only an average price for the contracts, implying that the inefficient type makes losses in the financial market transaction. To ensure participation, the regulator has to cover this potential loss with an additional transfer. Hence, in the presence of adverse selection, the use of forward contracts requires additionally transfers that depend on the regulator's announcement (whether the firm's type was revealed, or not). The firm now has an incentive to bribe the regulator to suppress this information, and also forward contracts imply costly rents, which also the inefficient type receives. However, rents are unambiguously lower with forward contracts, compared to using outcome contingent transfers only.

This main result is derived under the assumption of symmetric information between the financial market and the regulator. By analyzing alternative informational setup, we find that our results are robust against changes in the assumption on the distribution of information. We also investigate imperfections in financial markets, like market power or transaction costs, that cause auction revenues to be below the expected payments of forward contracts. Relying on forward contracts is then not always optimal. Finally, we discuss the opportunities and limitations of regulation schemes that condition regulatory transfers on the ex post realization of the auction proceeds.

Forward contracts have been intensively discussed in the literature, mainly with a focus on forward contracting by firms producing a final product. Under Cournot competition, forward contracting tends to reduce the final product's price (Bushnell (2007), Allaz and Vila (1993)), while under Bertrand it tends to increase the price (Mahenc and Salanie (2004)). Our analysis differs from this discussion since, (i) we look at contracting by an intermediary (the network firm), (ii) the amount of contracts is not a choice variable of the firms, but imposed by the regulator, and (iii) our focus is on the issue of regulatory capture.

Several papers have analyzed forward contracting arrangements that are imposed by a regulator in the energy industry (e.g. de Frutos and Fabra (2009), Fabra and Toro (2005), or, for "virtual power plants", Schultz (2009)). Also these papers' contribution is to understand the impact of such contracts on the strategic interaction in the final product market, while we investigate the contracts being used to mitigate regulatory capture by the network firm.

The positive theory of regulation has for a long time recognized and discussed the problem of regulatory capture (see Stigler (1971) and Peltzman (1976)). Levine and Forrence (1990) provide an overview of the different perspectives on regulation, the "public interest" view and the "capture" view. Bó (2006) discusses more recent literature and includes also empirical results on regulatory capture.

The analysis of corruptible agents goes back to the three tier principal-supervisor-agent model proposed by Tirole (1986), which later was explicitly applied as a government-regulator-regulated firm model by Laffont and Tirole (1991) (and summarized in Laffont and Tirole (1993), Ch. 11). This literature usually focuses on the interaction of optimal regulation and incentive contracts between the legislator and the regulator, which influence the cost of bribes. Although we also use a three tier model, to focus our analysis on the role of forward contracts, we abstract from incentive contracts between legislator and regulator and make the simplifying assumption that the costs of bribes are exogenously given.

Finally, our paper is also related to Faure-Grimaud (2002). He focuses on the question how the use of stock price information in regulation might substitute information gathering by the regulator and can solve problems of a regulator to commit long term. While our focus is different (we look for solutions for the problem of regulatory capture, while he looks for solutions to the asymmetric information problem), the spirit of the papers is similar: The idea is to use the financial market as a third party to solve a contracting problem.

The remainder of the paper is organized as follows. For further motivation, section two discusses applications of forward contracts in the energy industry. Section three starts the basic analysis by investigating first a pure moral hazard problem. Section four completes the basic analysis by additionally investigating adverse selection and provides the main result. Section five considers different informational assumptions, the case of transaction costs in auctions, and regulatory rules that condition on the auction proceeds. Section six concludes.

2 Forward contracting in the regulation of the energy industry

In the energy industry, in many countries (e.g., UK, Sweden, Netherlands) network operators are indeed fully vertically unbundled, i.e., do not have any activities upstream (e.g., electricity generation) or downstream (wholesale or retail of electricity), but are focused on transport and distribution of energy. Nevertheless, these network companies influence the downstream market prices of electricity or gas. They affect the barriers to entry, and thereby the level of actual or potential competition, for instance by the speed with which they hook up power plants of new entrants to the electricity grid. Another important way to influence downstream prices are investments in electricity interconnectors between different countries which increase for cross-border competition. The interconnector facilitates potential entry and can symmetrically reduce prices in both countries even if the interconnector will not be used in equilibrium. Borenstein, Bushnell, and Stoft (2000) show formally that "the social value of transmission capacity may not be closely related to the actual flow that occurs on the line" (p. 320). Therefore, any regulation remunerating the network operator for investments using only access prices for the actual flow may provide little incentives to undertake the interconnector investment.

Many regulators are concerned about sufficient investments into the national grids, including interconnectors. To provide investment incentives, European regulator frequently use "investment budgets", which allow network firms additional revenues from all network users if they undertake network extensions. As these revenues are unrelated to the actual usage of the new infrastructure they can be interpreted as a transfer to the network operator financed by a general tax on network usage.[3] These investment budgets are of considerable size: in the UK, the energy regulator Ofgem accepted an investment budget up to 2012 of £ 3.8 bn. (about Euro 4.5 bn., and thereby almost half the book value of the existing infrastructure),[4] in Germany the regulated investment budget in 2008 was Euro 8.6 bn.[5]. Although these

[3] For instance, in the German energy regulation, an "investment budget" increases the so-called "long-term unavoidable cost" and thereby increases the revenue cap of the firm (see "Anreizregulierungsverordnung, § 11 (2) no. 6"). Essentially, this means that all network users, not only those actually using the new infrastructure, have to pay higher access charges to the network operator.

[4] See UK regulator Ofgem (2008), Transmission Access Review - Initial Consultation on Enhanced Transmission Investment Incentives, Ref. 175/08, 19.12.2008, p. 5 and p. 8.

[5] See German regulator "Bundesnetzagentur", Press Release 07.07.2008. The four transmission grid companies received the major share of Euro 6.2 bn. That the firms applied for considerable higher volumes can be taken as evidence that the regulated return is indeed attractive, i.e., there is a rent connected to the investment budget.

are not outcome contingent transfers in the strict sense of the theory,[6] the magnitude of the transfers makes it likely that regulatory capture can be an issue.

At the same time, electricity (and to some extent also natural gas), is tradable in liquid wholesale markets, including all sorts of electricity future contracts. Thus, there exists a financial market with experience in trading forward contracts.

The energy industry already knows regulatory instruments similar to the ones proposed in our paper. When the Spanish electricity market was liberalized, "Competition Transition Costs" where introduced, which essentially were transfers from the state to the firms which were decreasing in the electricity price, thereby providing incentives for price reducing actions. The same effect could have been achieved by providing the firms with put options for electricity with a given (high) strike price. In 1998, these "Competition Transition Costs" payments amounted to Euro 633.5 mn. (Fabra and Toro (2005)).

Related institutions are the already mentioned "virtual power plants". In many competition cases,[7] firms with market power were obliged to sell (virtual) capacity in a competitive process. The buyer of the capacity can buy electricity at a predetermined price $\overline{p}$. The payment (or transfer) to the firm then comes from the private investors and (under perfect competition for the capacity) equals the difference between the future electricity price which the investors expect and $\overline{p}$. The buyer of virtual power plant capacity essentially buys a call option on electricity with a strike price $\overline{p}$.

Our forward contracts can be thought of as a combination of these two tools. Like in the Spanish example, the contracts provides an incentive to help to reduce prices, and like in the "virtual power plant" cases, the regulated firm is forced to sell contracts of an amount specified by the authorities to the financial market, and can keep the proceeds of this auction.

[6] It is rather a "cost plus" regulation. However, at least long term, it would be hard to justify such large investment budgets without some positive effect on downstream markets, e.g. intensified cross-bored competition. Therefore, there probably is some implicit outcome contingency of the investment budgets.

[7] In particular in merger cases, e.g., the merger between EdF and EnBW (EU Commission, Case No COMP/M 1853), or the merger between Nuon and Reliant (Dutch Competition Authority, NMa, Press Release 03-49, as of 11-27-2003). Other cases involve virtual power plants as remedies in sector specific regulation, e.g., when Electrabel became the default supplier in Belgium. For details and further cases see Schultz (2009).

3 A Model of Pure Moral Hazard

3.1 Optimal regulation without financial contracts

To formulate our ideas, we restrict attention to a very stylized model of a network industry. A network operator ("firm") provides an essential input for a downstream market. The price in the downstream market is stochastic, but influenced by the firm. For simplicity, we assume that the downstream market price p can take on only two values, $p \in \{p_L, p_H\}$, where $p_L < p_H$. The probability of a high price is:

$$\Pr(p = p_H) = x + \eta(1 - e), \tag{1}$$

and the probability of a low price is $1 - \Pr(p = p_H)$.

The network operator chooses between two unobservable effort levels $e \in \{0, 1\}$ where high effort $e = 1$ corresponds to costly actions that reduce the probability of a high downstream price. Effort costs are unobservable and equal to ce, with $c > 0$. Non-observability reflects that, e.g., for building an interconnector to foster cross-border competition, also the remaining grid requires additional investments (due to changed flows, following Kirchhoff's law), and that it is not easy to disentangle which grid investments are caused by the interconnector expansion, and which are due to "normal" business. The parameter $\eta \geq 0$ measures how strongly the firm's effort decreases the probability of high prices.

The parameter x denotes the baseline probability of high prices. It measures factors like expected demand conditions, which influence the expected downstream prices. The baseline probability of high prices is itself a random variable that can either be high or low: $x \in \{x_H, x_L\}$ with $0 < x_L < x_H < 1 - \eta$. The ex-ante probability of a low baseline probability is given by α_x. The mean of the baseline probability is denoted by $x_M = \alpha_x x_L + (1 - \alpha_x) x_H$.

There are two layers of regulation, a benevolent (but uninformed) legislator, and a better informed (but corruptible) regulator. The regulator has to provide an assessment of the state of the industry, and the legislator specifies ex-ante a rule that maps the regulator's assessment into a specific regulation. The regulator receives a signal $\widehat{x} \in \{x_L, x_M, x_H\}$ about the baseline probability, where $\widehat{x} = x_L$ and $\widehat{x} = x_H$ mean that the regulator gets evidence that reveal the baseline probability x (which happens with probability ϕ_x), while a signal $\widehat{x} = x_M$ means that the regulator gets no information about the baseline probability (which happens with probability $(1 - \phi_x)$).

The regulator's assessment consists of an announcement $\widetilde{x} \in \{x_L, x_M, x_H\}$ of his signal. The regulator can suppress evidence but cannot fake it, i.e. he can state $\widetilde{x} = x_M$ if $\widehat{x} = x_L$ or

$\widehat{x} = x_H$, but he cannot state $\widetilde{x} = x_L$ or $\widetilde{x} = x_H$ if $\widehat{x} = x_M$. The firm receives the same signal as the regulator (we later discuss alternative informational assumptions). If the regulator got evidence of a low or high baseline probability, the firm can bribe him to suppress the evidence by announcing $\widetilde{x} = x_M$. A bribe costs the firm a fixed amount $b_x > 0$. If the regulator is not bribed, he reveals truthfully $\widetilde{x} = \widehat{x}$.[8]

A regulation is simply a pair of (possibly negative) outcome contingent transfers $(t_L, t_H) \in \mathbb{R}^2$ that the regulated firm receives when a low or a high market price is realized. The legislator designs a regulation rule, that maps the regulator's assessment $\widetilde{x}$ into a regulation. This means a regulation rule describes ex-post transfers ($t_L(\widetilde{x})$,$t_H(\widetilde{x})$) that depend on the regulator's assessment and the realized market prices.

The legislator maximizes a welfare criterion

$$W = S(p) - ce - \beta t - \gamma B, \tag{2}$$

where $S(p)$ is a combined measure of consumer surplus and the profits of downstream firms, t denotes the transfers to the firm, and B are the bribes. The parameter β, $\beta > 0$, denotes shadow cost of public funds to finance the transfers. The legislator dislikes bribes, $\gamma > 0$, for instance, because resources used for bribes can not be used as efficiently as legal money (e.g., only be transferred to and spend in a foreign country). We take the other "operational" profits of the firm as given, and normalize it to zero.

The timing and information structure are as follows. First, the legislator chooses a regulatory rule $(t_L(\widetilde{x}), t_H(\widetilde{x}))$. Then nature draws the baseline probability of high prices x and the corresponding signal $\widehat{x}$. The signal $\widehat{x}$ is revealed to the regulator and the firm and the firm then decides whether to bribe the regulator to suppress evidence. Afterwards the regulator makes his assessment $\widetilde{x}$. The firm can then accept or reject the resulting regulation. If the firm rejects, it gets an outside payoff of 0 and welfare is also 0. If the firm accepts, it decides on its pro-competitive effort e. Finally, the market price p realizes and transfers according to the regulation are conducted. Figure 1 provides an overview.

We focus on "essential" services, i.e., we assume in all what follows that the legislator never wants that the firm does not participate. Furthermore, to avoid uninteresting cases, we always assume that the benefit from the pro-competitive action ($e = 1$) is sufficiently large that the legislator always wants to induce it.

[8] While Laffont and Tirole endogenize the cost of bribes by allowing the legislator to write incentive contracts for the regulator, we assume that costs of bribes are exogenously given.

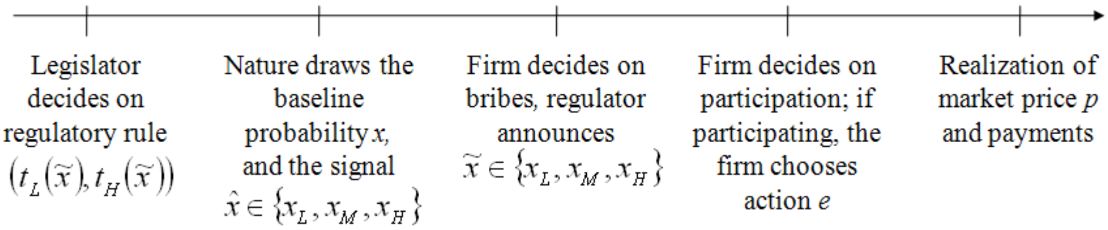

Figure 1: Regulation using only outcome contingent transfers

For any given regulation (t_L, t_H), we denote by

$$\Delta_t = t_L - t_H \tag{3}$$

the difference of the transfers under low and high market prices. The variable Δ_t can be interpreted as a bonus that the firm receives from the regulatory transfers if low prices realize. The incentive constraint that the firm chooses high effort $e = 1$ requires that the expected gain from higher transfers exceeds the cost of high effort, i.e.

$$\eta \Delta_t \geq c \tag{4}$$

The firm's participation constraint is given by

$$t_H + (1 - \widehat{x})\Delta_t \geq c. \tag{5}$$

Since the legislator does not observe the signal $\widehat{x}$, the relevant transfers can only be based on the regulator's assessment $\widetilde{x}$. If bribes were not possible, the lowest transfers t_H that always ensure participation would be given by

$$t_H = c - (1 - \widetilde{x})\Delta_t. \tag{6}$$

Under this rule, the only potentially profitable form of bribes is to induce omission of evidence for a low baseline probability, i.e. bribing the regulator to state $\widetilde{x} = x_M$ if $\widetilde{x} = x_L$. The firm could then obtain a rent of $(x_M - x_L)\,\Delta_t - b_x$ from bribery. Since bribes are welfare reducing, it is optimal for the legislator to avoid the bribe by leaving the firm a rent in case $\widetilde{x} = x_L$ is announced. The minimum rent, the legislator has to leave to the network firm to avoid bribes is given by

$$R_x(\widehat{x}|\Delta_t) = \begin{cases} \max\{(x_M - x_L)\,\Delta_t - b_x, 0\} & \text{if } \widehat{x} = x_L \\ 0 & \text{otherwise} \end{cases}. \tag{7}$$

Proposition 1 *There is a welfare optimal regulation rule with following structure: The bonus for low prices is set to*

$$\Delta_t = \frac{\eta}{c}$$

and $t_H(\widetilde{x})$ is set such that bribes will not be paid and the firm gets his minimum rents of $R_x(x|\Delta_t)$.

Proof. Setting $\Delta_t = \frac{\eta}{c}$ ensures $e = 1$. Let

$$t_H(\widetilde{x}) = c + (1 - \widetilde{x})\Delta_t + \begin{cases} \max\{(x_M - x_L)\,\Delta_t - b_x, 0\} & \text{if } \widehat{x} = x_L \\ 0 & \text{otherwise} \end{cases} .$$

This implies the rents of (7), which are the minimum rents possible, due to the following arguments: (i) Conditioning on the announcement is optimal: The rule is either conditional on the regulator's announcement, or independent of the announcement. If it is independent, to guarantee participation in all cases, including $\widehat{x} = x_H$, the lowest transfers to the firm satisfy $x_H t_H + (1 - x_H)\,t_L - c = 0$. Conditioning on the announcement as described in the proposition yields lower costly rents if $\widehat{x} = x_H$, because then no misreporting is possible and the participation is guaranteed already if $x_M t_H + (1 - x_M)\,t_L - c = 0$ holds. (ii) It is optimal to avoid bribes. Consider a rule conditioning on the regulator's announcement. Now assume, that it would be worthwhile for the firm to bribe the regulator under this rule, and this would in some state $\widehat{x}_i$ yield a payoff $\Pi(\widehat{x}_i, \widetilde{x} \neq \widehat{x}_i) > \Pi(\widehat{x}_i, \widetilde{x} = \widehat{x}_i)$. Then, a rule adding $\Pi(\widehat{x}_i, \widetilde{x} \neq \widehat{x}_i) - \Pi(\widehat{x}_i, \widetilde{x} = \widehat{x}_i) - b_x$ to $\Pi(\widehat{x}_i, \widetilde{x} = \widehat{x}_i)$ takes away the incentive to bribe, leaves rents unaltered, but avoids the welfare reducing bribes. (iii) Consider an alternative conditional regulatory rule that yields lower rents. Since rents are zero under the proposed rule for $\widehat{x}_H$ and $\widehat{x}_M$, this would imply that rents are lower for $\widehat{x}_L$, but this would not be bribe free and therefore not optimal according to (ii). ■

3.2 Optimal regulation with forward contracts

We now introduce regulations that can force the firm to sell forward contracts in an auction. We restrict attention to simple forward contracts of the form that for every forward contract sold, the firm will in the future, i.e., after the realization of the downstream price, have to pay the buyer of the contract the downstream price p. The regulatory rule determines the quantity q of forward contracts that has to be auctioned off and it determines the transfers to be paid to the firm. The regulatory rule is not allowed to condition on the outcome of the auction (we discuss this assumption in Section 5.3).

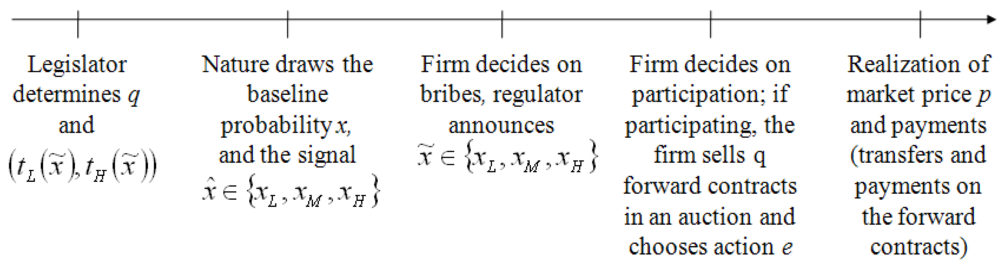

Figure 2: Regulation using outcome contingent transfers and forward contracts

There are several risk-neutral, perfectly competitive financial investors who commonly learn the signal $\widehat{x}$. Since the financial market is competitive, total auction revenues are equal to expected returns, which, under a regulatory rule that induces high effort, are given by

$$A = q(\widehat{x}p_H + (1 - \widehat{x})p_L). \tag{8}$$

We define by

$$\Delta_f = q(p_H - p_L) \tag{9}$$

the amount that the firm has to pay less to the buyers of the forward contracts if the downstream price p_L instead of p_H realizes. The variable Δ_f can be interpreted as a bonus that the firm receives from the forward contracts if low prices realize. Figure (2) summarizes the timing for the case that forward contracts are used.

In contrast to outcome contingent transfers, a regulation using forward contracts can solve the moral hazard problem without causing any costly rents.

Proposition 2 *The following regulatory rule achieves the first-best welfare optimal outcome: The quantity of forward contracts q is independent of the announcement $\widetilde{x}$ and chosen such that*

$$\Delta_f = \frac{\eta}{c}.$$

Regulatory transfers are independent of the realized price and the regulator's announcement and are characterized by

$$\Delta_t = 0, \text{ and } t_H(\widetilde{x}, \theta) = -c.$$

There are never bribes and the firm always gets zero expected rents.

Proof. It is straightforward to check that the described regulation satisfies the incentive compatibility condition and the participation constraint of the firm. Furthermore, the return on bribes is zero. ■

The intuition why the first best outcome can be achieved is simple. We assumed that the financial market is as well informed as the firm, hence – like with regulation using no forward contracts – there is no asymmetric information problem. The difference to the previous case is that the incentives are provided by the financial market interaction, which rules out that bribes can create profits. Since there are no payments depending on the regulator's behavior (the regulator is dispensable under this kind of regulation), bribing the regulator makes no sense.

Note that there is no coalition of the network firm and financial investors that could jointly benefit by possible bribes from the network firm to the investors that shall induce too high or too low bids in the auction. That is because the auction revenues do not influence the regulatory payments or the future payment obligations from the sold forward contracts. Bribing a bidder to pay too much in the auction, would require as a compensation for the overpaying bidder exactly the additional proceeds from the auction. Bribing a bidder to make lower bids makes no sense as this would directly reduce the profits of the network firm.

4 Optimal regulation with private information by the firm

Since it might well be that the firm has private information, we add to the previous analysis a problem of adverse selection. We assume that the firm has private information about a parameter θ that influences the distribution of prices. The probability of high prices is

$$\Pr(p = p_H) = x + \theta + \eta(1 - e). \tag{10}$$

The parameter θ can take two values, $\theta \in \{\theta_L, \theta_H\}$, with $0 < \theta_L < \theta_H < 1 - x_H - \eta$. We refer to θ_L as an efficient type and to θ_H as an inefficient type.[9] The ex-ante probability of an efficient type θ_L is α_θ and we denote the expected value of θ by $\theta_M = \alpha_\theta \theta_L + (1 - \alpha_\theta)\, \theta_H$. The financial market and the regulator only observes a signal $\widehat{\theta}$ that can take one of the values $\{\theta_L, \theta_M, \theta_H\}$, where $\widehat{\theta} = \theta_L$ and $\widehat{\theta} = \theta_H$ indicate evidence of an efficient and of an inefficient type, respectively, while $\widehat{\theta} = \theta_M$ indicates no evidence of a type. Evidence of the type is obtained with probability ϕ_θ, irrespective of whether $\theta = \theta_L$, or $\theta = \theta_H$.

The regulator's assessment now consists of a pair of announcements $(\widetilde{x}, \widetilde{\theta})$ that can disclose evidence of the baseline probability x and of the firm's type θ. For simplicity, we assume that

[9] An alternative interpretation would be that the firm has superior information on the baseline probability of high prices, which would then be $(x + \theta)$.

the firm has to bribe separately for concealing evidence of x and θ, with bribing costs of b_x and b_θ, respectively. Again we restrict attention to the case that it is welfare optimal that the firm always accepts the regulation and chooses high effort.

It is instructive to first analyze the firm's minimal rents due to private information on the type under a regulatory rule that does not use forward contracts, i.e. $\Delta_t > 0$ and $\Delta_f = 0$. If the firm's type is not revealed, $\widehat{\theta} = \theta_M$, the participation constraint has to hold for the inefficient type θ_H, i.e. an efficient type θ_L can ensure itself a rent of $(\theta_H - \theta_L)\Delta_t$. If the regulator receives a signal that reveals an efficient type, $\widehat{\theta} = \theta_L$, the possibility of a bribing the regulator to conceal this evidence guarantees the efficient firm a rent of $\max\{(\theta_H - \theta_L)\Delta_t - b_\theta, 0\}$. An inefficient type receives no rent.

Let us now consider the opposite case, where forward contracts are used, but the regulatory transfer does not depend on the realized downstream prices, i.e., $\Delta_t = 0$ and $\Delta_f > 0$. In contrast to the case without private information, it is now no longer true that the regulatory transfer has only to capture the cost c of the efficient action. Now, the transfer must be higher in case that the firm's type is not revealed to the financial market and to the regulator.

Imagine the firm is of the inefficient type, but this is not revealed, i.e., $\theta = \theta_H$ and $\widehat{\theta} = \theta_M$. The financial market will only pay the average price for the forward contract, $p_H(\widehat{x} + \theta_M) + p_L(1 - (\widehat{x} + \theta_M))$, while the firm knows that its expected payments per contract will be higher, namely $p_H(\widehat{x} + \theta_H) + p_L(1 - (\widehat{x} + \theta_H))$. Thus, the inefficient type would face a loss of $(\theta_H - \theta_M)\Delta_t$, and it will participate only if it receives a "reimbursement payment" of $(\theta_H - \theta_M)\Delta_t$ to cover this loss from the interaction with the financial market. Thus, in case that the type is unknown to the regulator, the regulator must pay a flat transfer of $(\theta_H - \theta_M)\Delta_t + c$. This implies that, if the firm turns out to be inefficient, it receives no rent (zero profits), while it does receive a rent if it is efficient. The rent equals $(\theta_H - \theta_M)\Delta_f + (\theta_M - \theta_L)\Delta_f = (\theta_H - \theta_L)\Delta_f$. The first term is the reimbursement payment (which ex post turns out to be unnecessary), the second term is the profit the efficient firm makes when trading with an uninformed financial market.

The reimbursement payment required for the case that the type of the firm is not revealed provides incentives to bribe the regulator in the cases where the type is revealed. If it is revealed, the interaction with the financial market yields zero expected profits for both types, and no reimbursement payment is required. If no bribing was possible, this would imply that the participation constraint for both types would already be satisfied by a flat transfer of consisting of c only (to cover the effort cost).

However, if manipulating the regulator is possible, both types can now gain from bribing the regulator to announce "no information" $\left(\widetilde{\theta}=\theta_m\right)$, which would then trigger the reimbursement payment.[10] To avoid this, the firm must receive a rent also in the case that the type is revealed. A flat transfer of $\max\{(\theta_H-\theta_M)\Delta_f-b_\theta,0\}+c$ exactly offsets the incentive for obtaining (surreptitiously) the reimbursement payment. This implies that with forward contracts, not only the efficient type receives a rent (like in the case of outcome contingent transfers), but also the inefficient type.

By adding up the rents of the two cases (i) $\Delta_t=0$ and $\Delta_f>0$; (ii) $\Delta_t>0$ and $\Delta_f=0$, we can derive that, generally, the minimum rents from the adverse section problem are:

$$R_\theta(\widehat{\theta},\theta|\Delta_t,\Delta_f)=\begin{cases}(\theta_H-\theta_L)(\Delta_t+\Delta_f) & \text{if } \widehat{\theta}=\theta_M \text{ and } \theta=\theta_L\\ 0 & \text{if } \widehat{\theta}=\theta_M \text{ and } \theta=\theta_H\\ \max\{(\theta_H-\theta_L)\Delta_t+(\theta_H-\theta_M)\Delta_f-b_\theta,0\} & \text{if } \widehat{\theta}=\theta_L \text{ and } \theta=\theta_L\\ \max\{(\theta_H-\theta_M)\Delta_f-b_\theta,0\} & \text{if } \widehat{\theta}=\theta_H \text{ and } \theta=\theta_H\end{cases}. \tag{11}$$

If the type of the firm is not revealed (the first two lines with $\widehat{\theta}=\theta_M$), the rent is just the usual information rent for the efficient type (line 1), while it is zero for the inefficient type. If the type is revealed, the firm will receive rents in order to prevent it from bribing the regulator to suppress the information received, which is just the sum of the rents for the extreme cases that use either price contingent transfers, or forward contract. If the firm's type is known to be efficient, the firm gets a rent from either type of regulation. However, if the firm is inefficient, a rent is generated only from the reimbursement payment stemming from the use of financial contracts.

In addition, the firm still gets the rents from the option to bribe the regulator not to disclose a low baseline probability if $\widehat{x}=x_L$. Due to our assumption that the regulator has to be bribed separately for concealing evidence of the baseline probability and of the firm's type, also the rents are additive. Thus, the total minimum costly[11] rents as functions of Δ_t and

[10] If this happened, the auction revenues to be expected due to this announcement and the actual auction revenues would differ. This does not matter in the framework proposed since we assumed that the regulatory rule can not condition on the auction revenues. We discuss regulations that condition on the auction revenues in Section 5.3.

[11] Ex post, the firm's rent and the costly rent can differ. This happens if $\widehat{\theta}=\theta_M$: if $\widehat{\theta}=\theta_M$ and $\theta=\theta_L$, the costly rent is only the reimbursement payment, $(\theta_H-\theta_M)\Delta_f$, while the rest of the firm's rent, $(\theta_M-\theta_L)\Delta_f$, is paid by the financial market, i.e., is only a transfer between firms. This loss is exactly offset by the financial market's profit if $\widehat{\theta}=\theta_M$ and $\theta=\theta_H$. This profit is financed by the transfers (the reimbursement payment) from the regulator to the firm, i.e., in this case, ex post, the firm's rent (which is zero) falls short of the socially costly transfers. Ex ante, due to the zero profit condition for the financial market, costly rents and the firm's rent must be identical.

Δ_f are given by

$$R(\widehat{x}, \widehat{\theta}, \theta | \Delta_t, \Delta_f) = R_x(\widehat{x} | \Delta_t, \Delta_f) + R_\theta(\widehat{\theta}, \theta | \Delta_t, \Delta_f). \tag{12}$$

To satisfy the incentive constraints for high effort we need $\Delta_f + \Delta_t \geq \frac{\eta}{c}$. Even though positive values of Δ_f can yield positive rents of for an inefficient type, it turns out that ex-ante expected rents are minimized by setting $\Delta_f = \frac{\eta}{c}$ and $\Delta_t = 0$, i.e., optimal regulation uses forward contracts only.

Proposition 3 *There is always an optimal regulatory rule with $\Delta_t = 0$, and $\Delta_f = \frac{\eta}{c}$. Total welfare is strictly increasing in the cost of bribes b_θ, as long as b_θ is sufficiently low.*

Proof. Maximization of expected total welfare maximization is in our set-up equivalent to minimization of the ex-ante expected rents of the firm. Following the arguments above, we find that the lowest ex-ante expected rents that guarantee participation of the firms are given by

$$\begin{aligned} E\left[R(\Delta_f, \Delta_t)\right] =& \alpha_x \phi_x R_x(x_L) + (1-\alpha_\theta)\phi_\theta R_\theta(\theta_H, \theta_H) \\ &+ \alpha_\theta \phi_\theta R_\theta(\theta_L, \theta_L) + \alpha_\theta(1-\phi_\theta) R_\theta(\theta_M, \theta_L) \\ =& \alpha_x \phi_x \max\{(x_M - x_L)\Delta_t - b_x, 0\} \\ &+ (1-\alpha_\theta)\phi_\theta \max\{(\theta_H - \theta_M)\Delta_f - b_\theta, 0\} \\ &+ \alpha_\theta \phi_\theta \max\{(\theta_H - \theta_L)\Delta_t + (\theta_H - \theta_M)\Delta_f - b_\theta, 0\} \\ &+ \alpha_\theta (1-\phi_\theta)\left(\theta_H - \theta_L\right)\left(\Delta_t + \Delta_f\right) \end{aligned} \tag{13}$$

For the case $(\theta_H - \theta_M)\Delta_f - b_\theta < 0$ it is evident that choosing $\Delta_f = \frac{\eta}{c}$ and $\Delta_t = 0$ minimizes the expected rents, since the second term in the sum drops out. Consider the case that $(\theta_H - \theta_M)\Delta_f - b_\theta \geq 0$, implying that

$$\begin{aligned} E\left[R(\Delta_f, \Delta_t)\right] &= \alpha_x \phi_x \max\{(x_M - x_L)\Delta_t - b_x, 0\} \\ &+ \Delta_f\left(\phi_\theta\left(\theta_H - \theta_M\right) + \alpha_\theta\left(1-\phi_\theta\right)\left(\theta_H - \theta_L\right)\right) \\ &+ \Delta_t \alpha_\theta\left(\theta_H - \theta_L\right) \\ &= \alpha_x \phi_x \max\{(x_M - x_L)\Delta_t - b_x, 0\} \qquad (14) \\ &+ \left(\Delta_f + \Delta_t\right)\alpha_\theta\left(\theta_H - \theta_L\right). \qquad (15) \end{aligned}$$

Then, a marginal increase in Δ_f increases the expected rents by

$$\frac{\partial E\left[R(\Delta_f, \Delta_t)\right]}{\partial \Delta_f} = \alpha_\theta(\theta_H - \theta_L), \tag{16}$$

while a marginal increase in Δ_t increases the expected rent by:

$$\frac{\partial E\left[R(\Delta_f, \Delta_t)\right]}{\partial \Delta_t} = \alpha_\theta(\theta_H - \theta_L) + \frac{\partial R_x(\widehat{x}|\Delta_t, \Delta_f)}{\partial \Delta_t}. \tag{17}$$

i.e., it increases rents by the same amount (if $\frac{\partial R_x(\widehat{x}|\Delta_t, \Delta_f)}{\partial \Delta_t} = 0$), or (otherwise, which happens if b_x is sufficiently small) strictly more. Hence, it is always optimal to set $\Delta_t = 0$ and $\Delta_f = \frac{\eta}{c}$.

■

We know from Proposition 2 that forward contracts tend to be better suited to solve the moral hazard problem. It is not obvious, however, that the superiority of forward contracts still holds in the presence of an additional adverse selection problem, since forward contracts create rents not only for the efficient type, but also for the inefficient type, while outcome contingent transfers yield rents only for the efficient type.

The proof of Proposition 3 shows that forward contracts are as well suited to solve the adverse selection problem as outcome contingent transfers. Imagine that $\Delta_f = \Delta_t = \frac{1}{2}\frac{\eta}{c}$ (we already know that for incentive compatibility we need $\Delta_f + \Delta_t = \frac{\eta}{c}$). In that case, ex-post rents due to outcome contingent transfers occur less frequently (only if the firm is an efficient type), but if they occur, they are higher than the rents due to forward contracts. To ensure participation, the rents due to outcome contingent payments need to cover the difference between the efficient and the inefficient type, $(\theta_H - \theta_L)\,\Delta_t$, while the reimbursement payment required with forward contracts needs to cover only the difference between the "average" type and the low type only, $(\theta_M - \theta_L)\,\Delta_f$. Increasing the weight on Δ_f therefore has two opposing effects (less weight on those rents which occur only with some probability, but lower level of ex post rents if both types of rents occur), which exactly offset each other with respect to the rent caused by adverse selection. However, with outcome contingent transfers, we additionally need to pay rents R_x to solve the moral hazard problem, which makes forward contracts the preferred regulatory tool.

5 Robustness

5.1 Alternative Information assumptions

So far we assumed an information advantage of the firm on its type, while the financial market and the regulator are symmetrically informed about the baseline probability, and they receive the same information about the type. This symmetry assumption might be violated in various ways.

Regulator holding superior information One might argue that the regulator has superior knowledge about the firm's type θ compared to the financial market, since the regulator can force the firm to reveal certain information (e.g., cost information). Although such information is frequently protected as a business secret, the regulator can publish it in some aggregated form which might be sufficient for the financial market to infer important information about the firm's type.

To analyze the case where the regulator holds superior information, assume that only the regulator can get a signal $\widehat{\theta}$ about the network firm's type θ, while the financial market never obtains direct evidence of the type. If and only if the regulator announces evidence for a low or high type, i.e. $\widetilde{\theta} \in \{\theta_L, \theta_H\}$, the type is also be revealed to financial investors. As before, we assume that the regulator cannot make up evidence, but may hide information.

For the following arguments assume $\Delta_t = 0$ and $\Delta_f = \frac{\eta}{c}$, and assume that the financial market believes that the regulator announces truthfully.[12] Consider the case that the regulator gets a signal for an inefficient firm, i.e. $\widehat{\theta} = \theta_H$. In contrast to the case that the financial market is informed, the inefficient firm can no longer benefit from bribing the regulator to suppress this information. As long as the financial market remains uninformed about the type, the firm's auction proceeds will fall short of the expected payments of the firm. This loss is exactly equal to the reimbursement payment, which the firm can obtain by bribing the regulator. Thus, an inefficient type does not obtain a rent in this case.

Consider now the case that an efficient type is revealed to the regulator, i.e. $\widehat{\theta} = \theta_L$. Bribing the regulator produces two kinds of returns. First, the firm receives the reimbursement payment of $(\theta_H - \theta_M)\Delta_f$. Second, the financial market remains uninformed, and the efficient firm can realize the profit from interacting with an uninformed financial market, which equals, $(\theta_M - \theta_L)\Delta_f$. To avoid bribes, the regulation must require that if the regulator announces that the type is efficient, the firm must receive a flat transfer of $max\left\{(\theta_H - \theta_L)\Delta_f - b_\theta\right\} + c$.

This yields exactly the same rents from the adverse selection problem as a regulation relying only on outcome contingent transfers, $\Delta_f = 0$ and $\Delta_t = \frac{\eta}{c}$, where by the same arguments as before, only the efficient type receives the usual information rent of $(\theta_H - \theta_L)\Delta_f$ and the inefficient type never receives any rent. While rents from the adverse selection problem are again identical, the additional rent required to solve the moral hazard problem tips the regulatory regime in favor of using forward contracts only.

Financial market holding superior information Alternatively, one might argue that financial

[12] Under optimal regulations the firm will have no incentives to bribe. Then consistent beliefs for financial investors are that the regulator's announcements are truthful.

market participants have superior information compared to the regulator, e.g., due to better paid and more able personnel, availability of international comparisons etc. If the financial market has better information about the baseline probability than the regulator, neither the optimal regulation nor the firms expected rents change. Outcome contingent transfers are not affected by this alternative informational assumption. Forward contracts again solve the moral hazard problem without cost, while the cost from solving the adverse selection problem are the reimbursement payments (paid to both types), which must be such that the firm participates even in the (still possible) case that the financial market interaction leads to a loss for the inefficient firm. (This case has just become less likely since the type is known now more frequently known by the financial market, ensuring zero profit from the financial market interaction).

Although the financial market is better informed here, involving them in the regulation by using forward contracts does not reduce the rents. This could happen only if the financial market would always perfectly recognize an inefficient type (and if the regulator knows this); then the regulation could reduce the fixed transfer. The result that only perfect information of the financial market can reduce the rent is due to our assumption that the firm delivers an essential service, i.e., the participation constraint must always hold. If this assumption would be relaxed, superior information by financial markets can be beneficial more generally.

The firm holding inferior information Another potentially plausible case is that the financial market is even better informed about the future downstream prices than the firm itself. This might be due to the fact that the firm is a firm that focuses only on the network part, while the financial players can easily collect information also about the spot market and can analyze the information in a very effective way.

An easy way to fit this into our analysis would be to add a mean preserving error term θ_{FM} into the probability of high prices, $\Pr(p_H) = x + \theta + \eta(1-e) + \theta_{FM}$, $E[\theta_{FM}] = 0$. The financial market knows the realization of θ_{FM}, while the regulator and the firm do not know it. If we maintain all other assumptions from the previous section, such inferior information of the firm does not change the result of Proposition 3. Competition in the financial market will ensure that the profit from the financial market interaction is zero (in expectation), given the information of the financial market. What changes compared to the previous analysis is that the firm has to calculate with an expected profit from the financial market interaction, based on its knowledge about the own type, instead of being able to exactly predict this profit. Since we assumed that the firm is risk neutral, this does not matter for the firm's behavior.

5.2 Costly auctions

So far we assumed that there were no costs associated with auctioning off the forward contracts. However, there can be several reasons why auction revenues might be lower than expected income from the forward contracts, e.g. financial market participants might have market power (i.e., buyer power vis a vis the firm), they might be risk averse, or there might be technological transaction costs. Consider the case that auction revenues are only a fraction $(1-k)$ of the expected income:

$$A = (1-k)q\left((\widehat{x}+\widehat{\theta})p_H + (1-\widehat{x}-\widehat{\theta})p_L\right), \tag{18}$$

where $k \in \mathbb{R}$ is an exogenous transaction cost parameter. Let K denote the expected total transaction cost of the auctions:

$$K = kqp_M, \tag{19}$$

where $p_M = (x_M + \theta_M)p_H + (1 - x_M - \theta_M)p_L$ is the ex-ante expected market price. By the definition of Δ_f, $q = \Delta_f / (p_H - p_L)$. A marginal increase in Δ_f then leads to a marginal increase in expected total transaction costs by

$$\frac{\partial K}{\partial \Delta_f} = \frac{\partial K}{\partial q}\frac{\partial q}{\partial \Delta_f} = k\frac{p_M}{p_H - p_L}. \tag{20}$$

Since this is positive, it immediately follows that if the legislator attaches a negative welfare weight to the transaction costs, the use of forward contracts therefore becomes less attractive. A very high negative weight or a large size of the transaction costs parameter k can easily make it optimal to fully abstain from using forward contracts.

However, even if the legislator attaches no negative welfare weight to the transaction costs (e.g., because they reflect buyer power of the financial market, and the legislator is indifferent with respect to transfers between the firm and the financial market), the presence of transaction costs can make forward contracts less attractive, since the firm has to be reimbursed for the lost auction revenues by higher fixed transfers.

For the optimal choices of Δ_t and Δ_f, the adverse selection problem again plays no role. By the last section's arguments, from an ex-ante perspective outcome contingent transfers and financial contracts are equally vulnerable to bribes to conceal evidence on the type (see (15) in the proof of Proposition 3). What matters are (i) the rents due to the moral hazard problem, i.e., the rents the firm can achieve by bribing the regulator to omit evidence of a low baseline probability x_L if outcome contingent transfers are used (the term (14) in the proof of Proposition 3), and (ii) the additional effect of transaction cost, $\frac{\partial K}{\partial \Delta_f}$.

The first effect favors the use of forward contracts, the second makes them less attractive. The first effect is absent if bribing the regulator for misreporting the baseline probability is too costly, i.e., if $(x_M - x_L)\frac{\eta}{c} \leq b_x$. In that case, only the second effect is present and it is optimal not to use any forward contracts, i.e. to set $\Delta_t = \frac{\eta}{c}$ and $\Delta_f = 0$.

If the first effect is present, i.e., $(x_M - x_L)\frac{\eta}{c} > b_x$, then it follows that is optimal to use forward contracts if and only if

$$\frac{\partial K}{\partial \Delta_f} \leq \alpha_x \phi_x \left(x_M - x_L\right), \tag{21}$$

where the left hand side is just the first effect, and the right hand side is the second effect, i.e., the marginal impact of a change of Δ_t on (14). Using (20) this implies:

$$k \leq \phi_x \alpha_x (1 - \alpha_x)(x_H - x_L)\frac{p_H - p_L}{p_M}. \tag{22}$$

Using forward contracts is beneficial only if the first effect (the expected negative impact of bribes to omit evidence for a low baseline probability) is sufficiently large; condition (22) clarifies what this exactly means. Using forward contracts is beneficial if (a) the baseline probability is frequently known, i.e. ϕ_x is large, (b) the uncertainty about the baseline probability, measured by $\alpha_x(1-\alpha_x)$, is large, and (c) if the spread in the baseline probabilities $(x_H - x_L)$ is large; finally, (d) a large normalized spread in downstream prices $\frac{p_H - p_L}{p_M}$ makes the use of forward contracts more beneficial, because forward contracts can then more effectively provide incentives for high effort.

According to (14), for small values of Δ_t, up to the threshold $\frac{b_x}{x_M - x_L}$, the first effect is not present and Δ_t does not cause any costly rents. The "bonus" Δ_t is just too small to make bribing the regulator profitable, and therefore, no rent has to be granted to avoid the bribe. Thus, $\Delta_t > 0$ should be used, since this can reduce Δ_f, where the latter is costly due to the transaction cost. For larger values of Δ_t it is no longer true that it is cheaper to provide incentives by substituting Δ_f by Δ_t. We just derived that given $k > 0$ and provided that condition (22) holds, incentives are cheaper to provide by using Δ_f instead of Δ_t. Therefore, in this case the optimal regulation has the structure $\Delta_t = \frac{b_x}{x_M - x_L}$ and $\Delta_f = \frac{\eta}{c} - \Delta_t$. Consequently, with positive transaction cost in the auction, which lead to auction proceeds falling short of the expected value of the forward contracts, it can become optimal to use both instruments, forward contracts and outcome contingent transfers.[13]

[13] If the auction was not costly, the legislator would be indifferent between choosing forward contracts only, $\Delta_f = \frac{\eta}{c}$ and $\Delta_t = 0$, or choosing $\Delta_t = \frac{b_x}{x_M - x_L}$ and $\Delta_f = \frac{\eta}{c} - \Delta_t$, thus, choosing the former is optimal as claimed in Proposition 3. If transaction costs can be saved, the latter is strictly preferred by the legislator, as discussed in this section.

Whether it is a sensible assumption that auction revenues are in expectation smaller than expected payments, depends on the application. Auction revenues might also exceed expected payments if there are many counterparties that want to buy forward contracts as an insurance against high future prices, i.e. $k < 0$ could then be a sensible assumption. For instance, electricity retailers might want to buy insurance against increasing wholesale prices. This means there is a positive willingness to pay for forward contracts on the wholesale price on energy. A firm that is forced to auction off such contracts may earn a positive premium in the auction, which makes the use of forward contracts more attractive.

5.3 Regulatory payments that condition on auction proceeds

The use of forward contract is attractive because it helps to benefit from the information held by financial markets. In principle, this information could be elicited from the financial market more easily in an "information revelation auction". By selling just a few forward contracts, the financial market's information about the state of the world could be inferred from the auction proceeds. Optimal incentive provision could then rely on price contingent transfers whose average level is calibrated by the revealed information from the auction instead of relying on the potentially biased assessment of the regulator.

The drawback of such a mechanism is that it invites manipulation of the auction by the firm. It could easily be profitable to bribe one financial market participant to pay a high price for the contract in the good state of the world (i.e., low baseline probability of high prices), which would then lead the regulatory rule to implement the (high) payments of the bad state of the world. Since in this case the firm would be the only counterparty of a "bribed" financial market participant, the firm can fully compensate the bidder for having overpaid, and keep the profit from the favorable regulation.[14]

Another way of relating the regulatory rule to the auction proceeds is to reduce regulatory transfers in case auction revenues are lower than predicted given the regulator's assessment. This could rule out the incentives of an inefficient network firm to bribe the regulator to suppress information about the type. The network firm could no longer capture the "re-imbursement" transfer, if this transfer will only be paid if auction proceeds are as low as

[14] The effect of bribing financial market participants is fundamentally different here to the case where (only) forward contracts are used. Here, manipulating the auction outcome will trigger transfers paid by the regulator to the firm, which provides the coalition of the firm and the bribed financial market participant with additional funds. If only forward contracts are used, any bribe is a zero sum interaction between the firm and the bribed financial market participant.

predicted.

However, such a mechanism heavily exploits our simplifying assumption that auction proceeds can be higher than predicted only if the regulator has been bribed. Consider the case where there are some transaction cost k in the auction. It might well be the case that k is known only to the financial market (e.g., the degree of market power), while it is stochastic from the perspective of the legislator, the regulator, and the firm. In that case, it will no longer be possible to identify whether certain (e.g. "too high") realizations of the auction proceeds are due to a mis-announcement of a bribed regulator, or due to a low realization of k.

However, in general, having some sort of penalty for the case the auction revenues deviate significantly from what had to be expected from the regulator's announcement might be sensible. This would then further improve the results from using forward contracts, compared to outcome contingent transfers.

6 Conclusion

We have analyzed to which extent the use of forward contracts can be beneficial for regulating a network firm providing an essential input for the production of a good, which is competitively traded. We found that simple forward contracts can solve moral hazard problems of the firm just as good as outcome contingent transfers; their additional benefit rest on the idea that they can better solve the problem of regulatory capture, since financial markets can hardly be bribed to manipulate a regulatory rule in favor of the regulated firm. If in addition to a moral hazard problem also adverse selection problems are present, it remains optimal to use forward contracts only, although the first best can no longer be achieved.

Three basic elements of the underlying problem drive the result that forward contracts can improve regulation: First, there must be a moral hazard problem on the side of the regulated network firm, which in practice would typically be an investment problem. Second, there must be a significant danger of regulatory capture. Third, the problem of regulatory capture is reduced using a competitive, transaction cost free financial market for the final product. Only where such markets are established, forward contracts have unambiguously positive effects.

In terms of practical implementation, the main application one might think of is the energy industry. In many regional markets, liquid spot markets for electricity, and also sometimes for natural gas, exist. In many countries, network firms are (or are planned to be) fully separated from any downstream activity, while at the same time, regulators face the challenge to provide incentives for these regulated firms to invest in the network. Hence, the energy industry would be the most natural candidate to use such contracts. Since regulatory policy has not only to care about investment decision, in practical terms it will probably not be optimal to solely use forward contracts. However, our analysis suggests that at least as a complementary tool, their use should be considered.

References

Allaz, B., and J.-L. Vila (1993): "Cournot Competition, Forward Markets and Efficiency," *Journal of Economic Theory*, 59(1), 1–16.

Bó, E. D. (2006): "Regulatory Capture: A Review," *Oxford Review of Economic Policy*, 22(2), 203–225.

Borenstein, S., J. Bushnell, and S. Stoft (2000): "The Competitive Effects of Transmission Capacity in a Deregulated Electricity Industry," *The RAND Journal of Economics*, 31, 294–325.

Bushnell, J. (2007): "Oligopoly Equilibria in Electricity Contract Markets," *Journal of Regulatory Economcis*, 32, 225–245.

de Frutos, M.-A., and N. Fabra (2009): "How to Award Pro-Competitive Forward Contracts. The Case of Electricity Auctions," mimeo, Universidad Carlos III de Madrid.

Fabra, N., and J. Toro (2005): "Price Wars and Collusion in the Spanish Electricity Market," *International Journal of Industrial Organization*, 23, 155–181.

Faure-Grimaud, A. (2002): "Using Stock Price Information to Regulate Firms," *Review of Economic Studies*, 69, 169–190.

Laffont, J.-J., and J. Tirole (1991): "The Politics of Government Decision-Making: A Theory of Regulatory Capture," *Quarterly Journal of Economics*, 106(4), 1089–1127.

——— (1993): *A Theory of Incentives in Procurement and Regulation*. MIT Press, Cambridge, MA.

Levine, M. E., and J. L. Forrence (1990): "Regulatory Capture, Public Interest, and the Public Agenda: Toward a Synthesis," *Journal of Law, Economics and Organization*, 6, 167–198.

Mahenc, P., and F. Salanie (2004): "Softening Competition Through Forward Contracting," *Journal of Economic Theory*, 116, 282–293.

Peltzman, S. (1976): "Toward a More General Theory of Regulation," *Journal of Law and Economics*, 19(2), 211–240.

Schultz, C. (2009): "Virtual Capacity and Competition," mimeo, University of Copenhagen.

Stigler, G. J. (1971): "The Theory of Economic Regulation," *Bell Journal of Economics and Management Science*, 2(1), 3–21.

Tirole, J. (1986): "Hierarchies and Bureaucracies: On the Role of Collusion in Organizations," *Journal of Law, Economics and Organization*, 2(2), 181–214.