Awarding monopoly franchises repeatedly: Are second-best block-rate tariffs attainable without regulation?

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Abstract

Under economies of scale, Demsetz's (1968) proposal of franchise bidding results, at best, in uniform prices approaching average cost. This paper questions the accepted belief that the auctioneer always needs to know the market demand function, if the concept is modified so as to allow for bids consisting of block-rate tariffs in order to increase welfare. Given a setting of repeated auctions, the auctioneer can apply a sequential mechanism to evaluate bids, instead of evaluating them in each auction independently. We characterize the conditions under which a second-best block-rate tariff for given thresholds is approached in equilibrium.

JEL-Classification: L51

Keywords: Block-rate tariffs; franchise bidding; regulation; second-best

I. INTRODUCTION

The idea of awarding monopoly franchises by auctions dates back at least to Chadwick (1859) and was rediscovered by Demsetz (1968). Given conditions of a natural monopoly, the government could award a franchise for the provision of a particular good to a single firm for a certain contractual period as a substitute for regulation. The franchise is awarded via competitive bidding. The firms willing to provide the good submit bids that take the form of the proposed uniform price which they would charge, in case they are awarded the franchise. The firm offering the lowest price wins the auction. At the end of every contractual period, a new auction starts.

It has often been criticized that franchise bidding does not result in marginal cost pricing under economies of scale and in the absence of government subsidies (see Telser, 1969). Since marginal cost prices maximize welfare on a particular market, as measured by the welfare criterion of total surplus, i. e. the sum of profits and aggregate consumer surplus, it is widely accepted that these prices should be the aim of a social planner from an efficiency perspective, at least if there are no distortions elsewhere in the economy, or if the particular sector is sufficiently separated from the other sectors.

A possible reply to this criticism of franchise bidding could lie in the requirement to submit bids consisting of two-part tariffs (see Demsetz, 1971), which increase total surplus compared to uniform prices. Since block-rate tariffs allow an even higher total surplus than two-part tariffs (see Willig, 1978), one might even think of inviting bids consisting of block-rate tariffs, where the thresholds are determined by the auctioneer. In this framework, the bid associated with the highest total surplus should be selected. Unfortunately, as has often been claimed, an adequate evaluation of the bids by the auctioneer seems, in general, only possible, if she knows the market demand function.

However, this argument is universally valid only if the evaluation takes place merely once, or independently of the evaluations in previous auctions. In this paper, we add to the existing literature by showing that the auctioneer, in a multi-period setting, could adapt a sequential mechanism described in Finsinger and Vogelsang (1981) to block-rate tariffs or to two-part tariffs. Then, a block-rate tariff maximizing total surplus for given thresholds of the tariff subject to a break-even constraint is approached in equilibrium, if there is either perfect competition at the bidding stage, or if the two most efficient bidders take part in each of the repeated auctions and have identical cost functions. In these settings, the auctioneer does not need to know the market demand function.

The plan of the paper is as follows. In Section II, we give a short account of the discussion in the literature on franchise bidding. We argue that the objections raised against franchise bidding are not as convincing as is often claimed. In Section III, we briefly review a compact way of characterizing the second-best block-rate tariff suitable for our purposes. Setting the stage for our analysis, we describe aggregate consumer surplus in Section IV. Afterwards, we develop a first-bid and a second-bid version of a sequential mechanism to implement the second-best block-rate tariff by adapting the approach described in Finsinger and Vogelsang (1981), and we demonstrate convergence to equilibrium under different conditions in Section V. In Section VI, we conclude.

II. A REVIEW OF THE DISCUSSION ON FRANCHISE BIDDING

Given conditions of a natural monopoly, on the surface, it seems that the case for the introduction of franchise bidding can be made in a straightforward way. Suppose the cost functions of the bidders exhibit economies of scale, and transaction costs can be neglected. With sufficiently many non-colluding firms at the bidding stage facing the same technology and production costs, the winner cannot expect to earn more than zero economic profit in the limit with least-cost production. Given stationary cost and demand conditions within the contractual period, the price would be bid down to the point at which the winning firm sets a price approaching average cost.[1]

However, there are, obviously, practical problems that are not included in this simplistic scenario. Franchise bidding as a governance structure for natural monopoly has frequently

[1] As the number of bidders approaches infinity, the bidding process attains prices as low as average cost in the limit (see Crew and Harstad, 1992).

been criticized from a transaction-cost perspective, above all by Williamson (1976) and Goldberg (1976).[2] In particular, it was argued that contractual incompleteness could be a relevant obstacle for franchise bidding, if long-term contracts are used. In this context, contract monitoring, enforcement, and renegotiation, or, in other words, regulation was often considered a necessity. At first sight, a possible answer to this criticism could lie in short-term contracts (see Posner, 1972), but short-term contracts may cause difficulties as well. If, in the event that the incumbent is displaced by a rival, an inaccurate valuation of the assets can be expected, the incumbent may be deterred from making investments in long-lived transaction-specific assets.[3] In addition, there could be assets which are not fully transferable between firms. If these assets are important, there exists a significant advantage of the incumbent over his rivals, and bidding may not really be competitive. Finally, in every round, sunk costs may have to be incurred over and over again, as the incumbent franchisee is displaced, which is socially wasteful (e. g., Neeman and Orosel, 2004). Given these problems, with a few exceptions, e. g. Laffont and Tirole (1987, 1988, 1993) and Riordan and Sappington (1987), franchise bidding has not been one of the major topics on the research agenda of regulatory economics for more than twenty years.

One of the reasons why Williamson (1976) could question franchise bidding was Demsetz's (1968) rather informal presentation of the idea. In the meantime, however, auction theory has advanced considerably, creating further possibilities for the use of auction mechanisms as an instrument of regulatory policy. A step into this direction is a path-breaking paper by Harstad and Crew (1999). In their model, compensation to the incumbent for asset transfer is moved from a contractual problem to a market mechanism. Furthermore, Sorana (2003) shows that the presence of durable specific assets per se does not have decisive effects on the competitive pressure of potential entrants, if bargaining over subcontracting or asset sales is efficient enough. Moreover, since Demsetz made his proposal, both the nature and the extent

[2] A survey of the empirical literature is given by Crocker and Masten (1996).

[3] Edlin and Reichelstein (1996) identified conditions under which first-best levels of specific investment can be attained even if contracts are incomplete.

of transaction-specific assets have changed in the network industries, making the problem of asset transfer less severe (see, e. g., Harstad and Crew, 1999). Finally, irrespective of technological changes, there have always been natural monopolies without relevant sunk costs, e. g. local postal delivery services and garbage collection. Thus, the main objections to franchise bidding as a governance structure for natural monopoly do not seem as compelling as is often claimed.

Therefore, an interesting area of research is the improvement of franchise bidding. In this paper, we make a suggestion for one possible improvement of the concept. We modify it as to allow for bids consisting of block-rate tariffs in order to increase welfare.

III. THE SECOND-BEST BLOCK-RATE TARIFF

A block-rate tariff is a nonuniform price schedule with a finite number, r, of rate steps, with $r > 1$. It consists of non-negative differentiated usage charges, $p_u^1,..., p_u^r$ and, possibly, of a non-negative access charge, p_a.[4] The differentiated usage charges are marginal prices for additional units of consumption. These marginal prices change, whenever certain levels of consumption, so-called thresholds, $\tau_1,...,\tau_{r-1}$, are reached. The access charge is a fixed amount per period which has to be paid for the opportunity of consuming a particular good at all, regardless of the quantity demanded, q. The marginal price schedule can be written as:

$$p_u(q) = \begin{cases} p_u^1; & 0 \le q < \tau_1 \\ p_u^2; & \tau_1 \le q < \tau_2 \\ \vdots & \\ p_u^r; & \tau_{r-1} \le q. \end{cases} \tag{1}$$

Define a block-rate tariff as second-best best, if it maximizes total surplus subject to a break-even constraint, given a single-product natural monopolist producing under economies of scale who is unable to identify individual consumers by type. Among the many possibilities of describing such a second-best block-rate tariff (see, e. g., Brown and Sibley, 1986; Laffont and Tirole, 1993; Wilson, 1993) a very compact characterization due to Borrmann

[4] If $r = 1$ and $p_a > 0$, a two-part tariff is given.

(2003) which follows the Ramsey principles of second-best pricing[5] and takes the thresholds of the block-rate tariff as given is convenient for our purposes.

Assumption 1.

Let there be a continuum of consumers whose types are identified by $\theta \in \Theta$ with $\Theta \subset \Re$. It is distributed according to a continuously differentiable function $F(\cdot)$, with $F'(\cdot) = f(\cdot)$.

Assumption 2.

The preferences of a consumer of type θ are quasilinear.

Assumption 3.

There are no consumption externalities and no transaction costs. Each of the consumers knows his future demand exactly.

Instead of thinking of the monopolist as providing one good, the firm is regarded as providing $r + 1$ goods with interrelated demands. Let the first good be "access", which is considered a necessary prerequisite for usage, i. e. consumption. Let the second good be "usage up to the first threshold, τ_1", the third good be "usage up to the second threshold, τ_2", etc., and let the last good be "usage beyond the last threshold, τ_{r-1}". The total quantities, $\boldsymbol{q}(\cdot)$, demanded of the $r + 1$ goods at prices, $\boldsymbol{p}$, are given by $\boldsymbol{q}(\boldsymbol{p}) = \left(q_a\left(p_a, p_u^1, \ldots, p_u^r\right), q_u^1\left(p_a, p_u^1, \ldots, p_u^r\right), \ldots, q_u^r\left(p_a, p_u^1, \ldots, p_u^r\right)\right)$. Maximizing total surplus, i. e. the sum of aggregate consumer surplus and the monopolist's profits, subject to a break-even constraint leads to two necessary conditions for optimality (Borrmann, 2003):

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5 As is well-known, the Ramsey (1927) principles of optimal taxation were applied to second-best pricing of multi-product natural monopolies by Boiteux (1956), Baumol and Bradford (1970), and Rohlfs (1979), among many others.

$$\begin{pmatrix} \frac{\partial q_a}{\partial p_a} & \frac{\partial q_u^1}{\partial p_a} & \cdots & \frac{\partial q_u^r}{\partial p_a} \\ \frac{\partial q_a}{\partial p_u^1} & \frac{\partial q_u^1}{\partial p_u^1} & \cdots & \frac{\partial q_u^r}{\partial p_u^1} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial q_a}{\partial p_u^r} & \frac{\partial q_u^1}{\partial p_u^r} & \cdots & \frac{\partial q_u^r}{\partial p_u^r} \end{pmatrix} \begin{pmatrix} p_a - \frac{\partial C}{\partial q_a} \\ p_u^1 - \frac{\partial C}{\partial q_u^1} \\ \vdots \\ p_u^r - \frac{\partial C}{\partial q_u^r} \end{pmatrix} = \left(-\frac{\lambda}{1+\lambda} \right) \begin{pmatrix} q_a \\ q_u^1 \\ \vdots \\ q_u^r \end{pmatrix}, \tag{2}$$

and

$$\begin{aligned} \Pi(\boldsymbol{p}) = {} & p_a q_a\left(p_a, p_u^1, \ldots, p_u^r\right) + p_u^1 q_u^1\left(p_a, p_u^1, \ldots, p_u^r\right) + \ldots + p_u^r q_u^r\left(p_a, p_u^1, \ldots, p_u^r\right) \\ & - C\left(q_a\left(p_a, p_u^1, \ldots, p_u^r\right), q_u^1\left(p_a, p_u^1, \ldots, p_u^r\right), \ldots, q_u^r\left(p_a, p_u^1, \ldots, p_u^r\right)\right) = 0, \end{aligned} \tag{3}$$

where $\Pi(\cdot)$ are the monopolist’s profits, $C(\cdot)$ the monopolist’s costs, and λ is the non-negative Lagrange multiplier of the maximization problem associated with the break-even constraint (3).

IV. A CHARACTERIZATION OF AGGREGATE CONSUMER SURPLUS

Now, we can develop a compact characterization of aggregate consumer surplus which is convenient for our purposes. Denote the utility-maximizing quantity of the second good, “usage up to the first threshold, τ_1”, of a type θ consumer in period t by $\overline{q}_{u,t}^{\theta,1}(\cdot)$, the utility-maximizing quantity of the third good, “usage up to the second threshold, τ_2”, of a type θ consumer in period t by $\overline{q}_{u,t}^{\theta,2}(\cdot)$, etc., and the utility-maximizing quantity of the last good, “usage beyond the last threshold, τ_{r-1}”, in period t by $\overline{q}_{u,t}^{\theta,r}(\cdot)$. All of the utility-maximizing quantities are functions of the usage charges in period t, $p_{u,t}^1, p_{u,t}^2, \ldots, p_{u,t}^r$. Following Assumption 2, which implies the absence of income effects, the individual willingness-to-pay, W^θ, in period t can be formulated as a function of $\overline{q}_{u,t}^{\theta,1}(\cdot)$, $\overline{q}_{u,t}^{\theta,2}(\cdot), \ldots, \overline{q}_{u,t}^{\theta,r}(\cdot)$. Assume that the individual willingness-to-pay function, $W^\theta(\cdot)$, is twice continuously partially differentiable with respect to $\overline{q}_{u,t}^{\theta,1}(\cdot)$, $\overline{q}_{u,t}^{\theta,2}(\cdot), \ldots, \overline{q}_{u,t}^{\theta,r}(\cdot)$, with the first partial derivatives being strictly positive and the second partial derivatives being strictly negative. Let the functions $\overline{q}_{u,t}^{\theta,1}(\cdot)$, $\overline{q}_{u,t}^{\theta,2}(\cdot), \ldots, \overline{q}_{u,t}^{\theta,r}(\cdot)$ be continuously partially differentiable with respect to

$p_{u,t}^{1}$, $p_{u,t}^{2}$,..., $p_{u,t}^{r}$, with the partial derivatives being strictly negative, and let $W^{\theta}(\cdot)$, $\overline{q}_{u,t}^{\theta,1}(\cdot)$, $\overline{q}_{u,t}^{\theta,2}(\cdot)$,..., $\overline{q}_{u,t}^{\theta,r}(\cdot)$ be monotonically increasing in θ.

Because of Assumption 3 a consumer of type θ is willing to participate in the market and to pay the access charge, $p_{a,t}$, in a specific period, if and only if his individual consumer surplus, $V^{\theta}(\cdot)$, i. e.

$$\begin{aligned} V^{\theta}\left(p_{a,t}, p_{u,t}^{1}, p_{u,t}^{2},..., p_{u,t}^{r}\right) &= W^{\theta}\left(\overline{q}_{u,t}^{\theta,1}(\cdot), \overline{q}_{u,t}^{\theta,2}(\cdot), \ldots, \overline{q}_{u,t}^{\theta,r}(\cdot)\right) \\ &\quad - p_{a,t} - p_{u,t}^{1}\overline{q}_{u,t}^{\theta,1}(\cdot) - p_{u,t}^{2}\overline{q}_{u,t}^{\theta,2}(\cdot) - \ldots - p_{u,t}^{r}\overline{q}_{u,t}^{\theta,r}(\cdot) \end{aligned} \tag{4}$$

is non-negative in that period. Let $\delta_{t}^{\theta}(\cdot)$ be a function indicating the combinations of access and usage charges, $p_{a,t}$, $p_{u,t}^{1}$, $p_{u,t}^{2}$,..., $p_{u,t}^{r}$, for which a type θ consumer is willing to pay

$$\delta_{t}^{\theta}\left(p_{a,t}, p_{u,t}^{1}, p_{u,t}^{2},..., p_{u,t}^{r}\right) = \begin{cases} 1 & \text{if } V^{\theta}\left(p_{a,t}, p_{u,t}^{1}, p_{u,t}^{2}, \ldots, p_{u,t}^{r}\right) \geq 0 \\ 0 & \text{otherwise.} \end{cases} \tag{5}$$

Thus, the individual demand of the second good, “usage up to the first threshold, τ_{1}”, of a type θ consumer in period t, $q_{u,t}^{\theta,1}(\cdot)$, may be written as

$$q_{u,t}^{\theta,1}\left(p_{a,t}, p_{u,t}^{1},..., p_{u,t}^{r}\right) = \delta_{t}^{\theta}\left(p_{a,t}, p_{u,t}^{1},..., p_{u,t}^{r}\right)\overline{q}_{u,t}^{\theta,1}\left(p_{u,t}^{1},..., p_{u,t}^{r}\right), \tag{6}$$

the individual demand of the third good, “usage up to the second threshold, τ_{2}”, of a type θ consumer in period t, $q_{u,t}^{\theta,2}(\cdot)$, can be described as

$$q_{u,t}^{\theta,2}\left(p_{a,t}, p_{u,t}^{1},..., p_{u,t}^{r}\right) = \delta_{t}^{\theta}\left(p_{a,t}, p_{u,t}^{1},..., p_{u,t}^{r}\right)\overline{q}_{u,t}^{\theta,2}\left(p_{u,t}^{1},..., p_{u,t}^{r}\right), \tag{7}$$

etc., and the individual demand of the last good, “usage beyond the last threshold, τ_{r-1}”, of a type θ consumer in period t, $q_{u,t}^{\theta,r}(\cdot)$, is given by

$$q_{u,t}^{\theta,r}\left(p_{a,t}, p_{u,t}^{1},..., p_{u,t}^{r}\right) = \delta_{t}^{\theta}\left(p_{a,t}, p_{u,t}^{1},..., p_{u,t}^{r}\right)\overline{q}_{u,t}^{\theta,r}\left(p_{u,t}^{1},..., p_{u,t}^{r}\right). \tag{8}$$

Let the number of consumers who are willing to participate in the market in period t, $N_{t}(\cdot)$, be a function of the access charge, $p_{a,t}$, and the usage charges, $p_{u,t}^{1}, p_{u,t}^{2}, \ldots, p_{u,t}^{r}$. Because of Assumption 1, the quantity of participating consumers depends continuously on these prices. In other words, the number of consumers is always sufficiently large, so that the quantity of participating consumers can be considered real-valued. $N_{t}(\cdot)$ may be written as

$$N_t\left(p_{a,t}, p^1_{u,t},..., p^r_{u,t}\right) = \int_{\Theta} \delta^{\theta}_t\left(p_{a,t}, p^1_{u,t},..., p^r_{u,t}\right) f(\theta) d\theta . \qquad (9)$$

Obviously, the aggregate demand of the first good, “access”, in period *t*, $q_{a,t}(\cdot)$, is identical with $N_t(\cdot)$:

$$q_{a,t}\left(p_{a,t}, p^1_{u,t},..., p^r_{u,t}\right) = N_t\left(p_{a,t}, p^1_{u,t},..., p^r_{u,t}\right). \qquad (10)$$

Furthermore, the aggregate demand of the second good, “usage up to the first threshold, τ_1”, in period t, $q^1_{u,t}(\cdot)$, is given by

$$q^1_{u,t}\left(p_{a,t}, p^1_{u,t},..., p^r_{u,t}\right) = \int_{\Theta} q^{\theta,1}_{u,t}\left(p_{a,t}, p^1_{u,t},..., p^r_{u,t}\right) f(\theta) d\theta , \qquad (11)$$

the aggregate demand of the third good, “usage up to the second threshold, τ_2”, in period t, $q^{\theta,2}_{u,t}(\cdot)$, can be described as

$$q^2_{u,t}\left(p_{a,t}, p^1_{u,t},..., p^r_{u,t}\right) = \int_{\Theta} q^{\theta,2}_{u,t}\left(p_{a,t}, p^1_{u,t},..., p^r_{u,t}\right) f(\theta) d\theta , \qquad (12)$$

etc., and the aggregate demand of the last good, “usage beyond the last threshold, τ_{r-1}”, in period t, $q^r_{u,t}(\cdot)$, may be written as

$$q^r_{u,t}\left(p_{a,t}, p^1_{u,t},..., p^r_{u,t}\right) = \int_{\Theta} q^{\theta,r}_{u,t}\left(p_{a,t}, p^1_{u,t},..., p^r_{u,t}\right) f(\theta) d\theta . \qquad (13)$$

Finally, aggregate consumer surplus, $V(\cdot)$, in period t is given by

$$V\left(p_{a,t}, p^1_{u,t},..., p^r_{u,t}\right) = \int_{\Theta} \delta^{\theta}_t\left(p_{a,t}, p^1_{u,t},..., p^r_{u,t}\right)\Big[W^{\theta}\left(\overline{q}^{\theta,1}_{u,t}(\cdot), \overline{q}^{\theta,2}_{u,t}(\cdot),..., \overline{q}^{\theta,r}_{u,t}(\cdot)\right)$$
$$- p_{a,t} - p^1_{u,t}\overline{q}^{\theta,1}_{u,t}(\cdot) - p^2_{u,t}\overline{q}^{\theta,2}_{u,t}(\cdot) - ... - p^r_{u,t}\overline{q}^{\theta,r}_{u,t}(\cdot)\Big] f(\theta) d\theta . \qquad (14)$$

V. A SEQUENTIAL MECHANISM TO APPROACH THE SECOND-BEST BLOCK-RATE TARIFF

Under economies of scale and in the absence of government subsidies, with Demsetz's (1968) concept of franchise bidding, at best, average cost prices above marginal cost are approached in the case of a single-product natural monopolist. However, bidding competition between potential multi-product monopolists does not lead to well-defined results at all. In the absence of collusion and transaction costs, it can be expected that the winner of the auction will not be able to earn more than zero economic profit in the limit with least-cost production, given sufficiently many firms at the bidding stage facing the same technology and production costs. Nevertheless, there are many price combinations resulting in zero economic profit. In order to solve this problem, Panzar and Willig suggested a sequential mechanism (orally in a discussion of Vogelsang and Finsinger, 1979), which is described in Finsinger and Vogelsang (1981). This sequential mechanism will be elaborated and adapted to block-rate tariffs in the following. Under conditions explained below, a second-best block-rate tariff is approached in equilibrium.

The mechanism is defined by Rules 1 and 2 (*first-bid version of the mechanism*), or, alternatively, by Rules 1 and 3 (*second-bid version of the mechanism*).[6] The bidding *firms* are characterized by Assumption 4. Assumption 5 specifies the properties of the *auctioneer*.

Rule 1.

At regular time intervals, $t = 1, 2, 3, \ldots$, an exactly defined monopoly franchise is repeatedly awarded via competitive bidding in procurement auctions without reserve price. The auctioneer determines thresholds, $\tau_1, \ldots, \tau_{r-1}$, of admissible block-rate tariffs prior to the bidding process. Given these thresholds, every bidder has to offer a price vector, $\boldsymbol{p}_t = \left(p_{a,t}, p_{u,t}^1, \ldots, p_{u,t}^r\right)$, consisting of a non-negative access charge, $p_{a,t}$, and non-negative differentiated usage charges, $p_{u,t}^1, \ldots, p_{u,t}^r$, which define a block-rate tariff at which he would be willing to supply the total quantities demanded in period t. Let the first good be “access”, the second good be “usage up to the first threshold, τ_1”, the third good be “usage up to the second threshold, τ_2”, etc., and let the last good be “usage beyond the last threshold, τ_{r-1}”. The total quantities demanded of the $r + 1$ goods by all consumers at these price vectors in period t are given by the demand correspondence

[6] The second-bid version is an extension of the sequential mechanism described in Finsinger and Vogelsang (1981). We will see later that, given identical cost functions of the most efficient bidders, it may be advantageous, if there are only few bidders.

$\boldsymbol{q}_t(\boldsymbol{p}_t) = \left(q_{a,t}\left(p_{a,t}, p^1_{u,t},..., p^r_{u,t}\right), q^1_{u,t}\left(p_{a,t}, p^1_{u,t},..., p^r_{u,t}\right),.., q^r_{u,t}\left(p_{a,t}, p^1_{u,t},..., p^r_{u,t}\right)\right)$. The monopoly franchise is then awarded to the firm with the bid that minimizes $\boldsymbol{p}_t\boldsymbol{q}_{t-1} = p_{a,t}q_{a,t-1} + p^1_{u,t}q^1_{u,t-1} + p^2_{u,t}q^2_{u,t-1} + ... + p^r_{u,t}q^r_{u,t-1}$. Thus, the criterion for awarding the monopoly franchise is the weighted sum of the access charge and the usage charges, where the weights are the quantities demanded of the $r + 1$ goods in the previous period t - 1. In the event of a tie, only one of these bidders is chosen by some predetermined allocative mechanism, e. g., a lottery.

Rule 2.

The winning bidder has to supply the total quantities demanded of the $r + 1$ goods in the contractual period at the price vector he bid.

Rule 3.

Alternatively, the winning bidder has to supply the total quantities demanded of the $r + 1$ goods in the contractual period at the price vector offered by the bidder with the second lowest $\boldsymbol{p}_t\boldsymbol{q}_{t-1}$.

Assumption 4.

The bidding firms maximize expected profits. Each firm assumes that it has at least one non-colluding competitor in the bidding process. At least two of the most efficient potential bidders take part in each of the repeated auctions. Firms are perfectly informed about their own cost functions and the market demand in period t, $\boldsymbol{q}_t(\boldsymbol{p}_t) = \left(q_{a,t}\left(p_{a,t}, p^1_{u,t},..., p^r_{u,t}\right), q^1_{u,t}\left(p_{a,t}, p^1_{u,t},..., p^r_{u,t}\right), ..., q^r_{u,t}\left(p_{a,t}, p^1_{u,t},..., p^r_{u,t}\right)\right)$, for all prices, $\boldsymbol{p}_t$, but they can neither observe the cost functions of the other bidders nor the individual demand of a type θ consumer in period t at prices $\boldsymbol{p}_t$. The cost functions of the bidding firms exhibit economies of scale. None of the bidding firms is financially constrained.

One point deserves particular attention. The assumption that none of the bidding firms is financially constrained is, for instance, fulfilled in case that capital markets are perfect.

Assuming the absence of financial constraints is crucial, since this ensures that bidders are indifferent between winning and losing at the respective least profitable bids they are willing to make (see Rothkopf, 2001).[7]

Assumption 5.

At the outset, the auctioneer does not have knowledge of the cost function of the bidder(s) with the most efficient technology, and of the market demand, $\boldsymbol{q}_t(\cdot)$, at prices $\boldsymbol{p}_t$, i. e. $\boldsymbol{q}_t(\boldsymbol{p}_t) = \left(q_{a,t}\left(p_{a,t}, p^1_{u,t}, ..., p^r_{u,t}\right), q^1_{u,t}\left(p_{a,t}, p^1_{u,t}, ..., p^r_{u,t}\right), ..., q^r_{u,t}\left(p_{a,t}, p^1_{u,t}, ..., p^r_{u,t}\right)\right)$. She only knows the quantities demanded of the $r + 1$ goods in the preceding period. The auctioneer assumes, however, that at least two non-colluding firms take part in the bidding process. Furthermore, the auctioneer presumes that stationary cost and demand conditions are given. In the beginning, she credibly commits herself to the mechanism, either according to Rules 1 and 2 (first-bid version of the mechanism), or according to Rules 1 and 3 (second-bid version of the mechanism), and she credibly promises not to exploit any knowledge gained in the current auction in one of the future auctions.

Proposition 1.

Given Assumptions 1-3 (consumers), 4 (firms) and 5 (auctioneer), Rules 1 and 2 (first-bid version of the mechanism), perfect competition at the bidding stage, as well as stationary cost and demand conditions, the sequence of the winning bids converges to the second-best block-rate tariff in the limit for given thresholds.

Proof of Proposition 1.

If it is common knowledge that perfect bidding competition is given, only zero economic profit can be expected by the bidders in the limit, with the number of bidders approaching infinity. Because of Assumption 4 (firms), a distinction between expected and actual

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[7] Models have been developed that consider bidders facing financial constraints, e. g. Che and Gale (1998).

quantities demanded and between expected and actual costs is unnecessary. Thus, the winning bidder's minimization problem can approximately be simplified as follows:

$$\underset{\left[p_{a,t},p_{u,t}^{1},p_{u,t}^{2},...,p_{u,t}^{r}\right]}{\text{Min}}\left[p_{a,t}q_{a,t-1}+p_{u,t}^{1}q_{u,t-1}^{1}+p_{u,t}^{2}q_{u,t-1}^{2}+...+p_{u,t}^{r}q_{u,t-1}^{r}\right] \tag{15}$$

subject to

$$\begin{aligned}\Pi(\boldsymbol{p}_t) = {} & p_{a,t}q_{a,t}\left(p_{a,t},p_{u,t}^{1},...,p_{u,t}^{r}\right)+p_{u,t}^{1}q_{u,t}^{1}\left(p_{a,t},p_{u,t}^{1},...,p_{u,t}^{r}\right)+...+p_{u,t}^{r}q_{u,t}^{r}\left(p_{a,t},p_{u,t}^{1},...,p_{u,t}^{r}\right)\\ & -C\left(q_{a,t}\left(p_{a,t},p_{u,t}^{1},...,p_{u,t}^{r}\right),q_{u,t}^{1}\left(p_{a,t},p_{u,t}^{1},...,p_{u,t}^{r}\right),...,q_{u,t}^{r}\left(p_{a,t},p_{u,t}^{1},...,p_{u,t}^{r}\right)\right)=0.\end{aligned} \tag{16}$$

The term $\boldsymbol{p}_t\boldsymbol{q}_{t-1}=p_{a,t}q_{a,t-1}+p_{u,t}^{1}q_{u,t-1}^{1}+p_{u,t}^{2}q_{u,t-1}^{2}+...+p_{u,t}^{r}q_{u,t-1}^{r}$ is minimal when $\left(\boldsymbol{p}_{t-1}-\boldsymbol{p}_t\right)\boldsymbol{q}_{t-1}$ is maximal, since $\boldsymbol{p}_{t-1}$ cannot be influenced by potential suppliers, when bidding at the beginning of period *t*. It is simply a constant for them.

It is well-known that the following relationship holds for all differentiable and convex functions, $f(\boldsymbol{x})=f(x_1,...,x_m)$, and for all $\boldsymbol{x}$, $\tilde{\boldsymbol{x}}$:

$$f(\boldsymbol{x})\geq f(\tilde{\boldsymbol{x}})+\sum_{i=1}^{m}\frac{\partial f(\tilde{\boldsymbol{x}})}{\partial x_i}\left(x_i-\tilde{x}_i\right). \tag{17}$$

According to Assumption 2 consumer preferences are quasilinear. Consequently, aggregate consumer surplus in period *t*, i. e. $V\left(p_{a,t},p_{u,t}^{1},p_{u,t}^{2},...,p_{u,t}^{r}\right)$, according to (14) is convex in $p_{a,t},p_{u,t}^{1},p_{u,t}^{2},...,p_{u,t}^{r}$.[8] This property of aggregate consumer surplus can be used. Applying (17) to aggregate consumer surplus in period *t* as well as in period *t - 1* yields:

$$V(\boldsymbol{p}_t)\geq V(\boldsymbol{p}_{t-1})+\frac{\partial V(\boldsymbol{p}_{t-1})}{\partial p_{a,t}}\left(p_{a,t}-p_{a,t-1}\right)+\frac{\partial V(\boldsymbol{p}_{t-1})}{\partial p_{u,t}}\left(p_{u,t}^{1}-p_{u,t-1}^{1}\right)+\ldots+\frac{\partial V(\boldsymbol{p}_{t-1})}{\partial p_{u,t}}\left(p_{u,t}^{r}-p_{u,t-1}^{r}\right). \tag{18}$$

Because of Assumptions 1 and 2, the set of marginal consumers who are indifferent between participation and non-participation in the market in period *t* is of measure *0* for a given access charge and given usage charges for all non-negative access and usage charges.

8 The convexity of consumer surplus in the absence of income effects is shown by Vogelsang and Finsinger (1979). Of course, their result holds for block-rate tariffs as well, if we take $V\left(p_{a,t},p_{u,t}^{1},p_{u,t}^{2},...,p_{u,t}^{r}\right)$ to be aggregate consumer surplus with quasilinear preferences, i. e. consumer surplus without income effects.

Given this result and Assumptions 1-3 (consumers), using the definition of the number of consumers willing to participate in the market in period *t*, $N_t(\cdot)$, and the definitions of the aggregate demands of the first good, second good, third good, etc., in period *t*, $q_{a,t}(\cdot)$, $q_{u,t}^{1}(\cdot)$, $q_{u,t}^{2}(\cdot),\ldots,q_{u,t}^{r}(\cdot)$, we obtain:

$$\frac{\partial V(\boldsymbol{p}_t)}{\partial p_{a,t}} = -\int_{\Theta} \delta_t^{\theta}\left(p_{a,t}, p_{u,t}^{1},\ldots, p_{u,t}^{r}\right) f(\theta)d\theta = -N_t\left(p_{a,t}, p_{u,t}^{1},\ldots, p_{u,t}^{r}\right) = -q_{a,t}(\boldsymbol{p}_t), \tag{19}$$

$$\frac{\partial V(\boldsymbol{p}_t)}{\partial p_{u,t}^{1}} = -\int_{\Theta} \delta_t^{\theta}\left(p_{a,t}, p_{u,t}^{1},\ldots, p_{u,t}^{r}\right) \bar{q}_{u,t}^{\theta,1}\left(p_{u,t}^{1},\ldots, p_{u,t}^{r}\right) f(\theta)d\theta$$

$$= -\int_{\Theta} q_{u,t}^{\theta,1}\left(p_{a,t}, p_{u,t}^{1},\ldots, p_{u,t}^{r}\right) f(\theta)d\theta = -q_{u,t}^{1}(\boldsymbol{p}_t), \tag{20}$$

$$\vdots$$

$$\frac{\partial V(\boldsymbol{p}_t)}{\partial p_{u,t}^{r}} = -\int_{\Theta} \delta_t^{\theta}\left(p_{a,t}, p_{u,t}^{1},\ldots, p_{u,t}^{r}\right) \bar{q}_{u,t}^{\theta,r}\left(p_{u,t}^{1},\ldots, p_{u,t}^{r}\right) f(\theta)d\theta$$

$$= -\int_{\Theta} q_{u,t}^{\theta,r}\left(p_{a,t}, p_{u,t}^{1},\ldots, p_{u,t}^{r}\right) f(\theta)d\theta = -q_{u,t}^{r}(\boldsymbol{p}_t). \tag{21}$$

This yields:

$$V(\boldsymbol{p}_t) \geq V(\boldsymbol{p}_{t-1}) + q_{a,t-1}\left(p_{a,t-1} - p_{a,t}\right) + q_{u,t\text{-}1}^{1}\left(p_{u,t-1}^{1} - p_{u,t}^{1}\right) + \ldots + q_{u,t\text{-}1}^{r}\left(p_{u,t-1}^{r} - p_{u,t}^{r}\right). \tag{22}$$

The term $q_{a,t-1}\left(p_{a,t-1} - p_{a,t}\right) + q_{u,t\text{-}1}^{1}\left(p_{u,t-1}^{1} - p_{u,t}^{1}\right) + \ldots + q_{u,t\text{-}1}^{r}\left(p_{u,t-1}^{r} - p_{u,t}^{r}\right)$ is obviously positive, as long as the second-best block-rate tariff has not been reached. Eq. (16) and (22) together imply that the increase of total surplus, $TS(\boldsymbol{p}_t)$, i. e. the increase of the sum of profits and aggregate consumer surplus, from one period to the next, $TS(\boldsymbol{p}_t) - TS(\boldsymbol{p}_{t\text{-}1})$, will be at least as large as $q_{a,t-1}\left(p_{a,t-1} - p_{a,t}\right) + q_{u,t\text{-}1}^{1}\left(p_{u,t-1}^{1} - p_{u,t}^{1}\right) + \ldots + q_{u,t\text{-}1}^{r}\left(p_{u,t-1}^{r} - p_{u,t}^{r}\right)$. Consequently, a monotonically increasing sequence of welfare levels, $TS(\boldsymbol{p}_t)$, subject to the zero economic profit constraint, i. e. Eq. (16), will be obtained. As Eq. (16) holds at every point in time and, therefore, the monotonic sequence $TS(\boldsymbol{p}_t)$ lies in a compact set, both the welfare levels and the prices converge. The only possible limit point is the second-best block-rate tariff, as characterized by Eqs. (2) and (3). ◻

A characteristic of the derivation of this result is its simplicity. It does not matter, whether the winning bidder adjusts his behavior to the fact that the auction is repeated or not. It is impossible for him to improve on his bidding strategy by attempting to use information revealed in previous auctions in the current auction, since the bids which maximize expected profits are identical in both cases.

How about the auctioneer? Initially, she does not have any knowledge of the cost function of the bidders with the most efficient technology, or of the market demand, according to Assumption 5 (auctioneer). From one period to the next, however, she gets to know further price combinations of the bidders with the most efficient technology that are associated with zero profit. Furthermore, she learns about the quantities demanded, and observes the process approaching the second-best block-rate tariff. Thus, she is able to learn a lot over time. Nevertheless, she cannot benefit from this knowledge either, since she has credibly committed herself to the mechanism at the outset. Thus, Assumption 5 (auctioneer) rules out any potential difficulties caused by moral hazard.

Proposition 2.

Given Assumptions 1-3 (consumers), 4 (firms) and 5 (auctioneer), Rules 1 and 3 (second-bid version of the mechanism), perfect competition at the bidding stage, as well as stationary cost and demand conditions, the sequence of the winning bids converges to the second-best block-rate tariff in the limit for given thresholds.

Proof of Proposition 2.

Straightforward and therefore omitted.

Unfortunately, Propositions 1 and 2 capture the essence of the problem only partly. Although there are some industries, where many bidders can be expected because of low entry barriers, e. g. garbage collection or the local delivery of mail, in theory, it is implausible to assume perfect competition at the bidding stage. How can there be perfect competition or, in other words, sufficiently many completely informed bidders at the bidding stage, without the auctioneer being completely informed about the cost and demand conditions as well, which would make the whole mechanism unnecessary? To be specific, with sufficiently many bidders, no firm would have any incentive not to reveal its private information about the market demand, if being asked by the auctioneer. Therefore, in the following, we consider the possibilities of attaining second-best block-rate tariffs, when only a few bidders take part in the repeated auctions. Thus, we do no longer assume that perfect competition at the bidding stage is given.

Proposition 3.

Given Assumptions 1-3 (consumers), 4 (firms) and 5 (auctioneer), Rules 1 and 3 (second-bid version of the mechanism), identical cost functions of the two (or more) most efficient bidders, as well as stationary cost and demand conditions, the sequence of the winning bids converges to the second-best block-rate tariff for given thresholds under optimal bidding strategies.

Proof of Proposition 3.

Assumption 4 (firms) states that each of the bidders is perfectly informed about his own cost function as well as the market demand in period t and assumes that he has at least one non-colluding competitor in the bidding process. A bidding firm, however, cannot observe the cost functions of the other bidders. So it cannot know whether it uses the most efficient technology or not. Thus, under the second-bid version of the mechanism, according to Rules 1 and 3, it is a dominant strategy for every firm to bid a price vector that would achieve zero economic profit under the first-bid version, according to Rules 1 and 2.[9] As the access price, $p_{a,t}$, and the usage prices, $p^{1}_{u,t}, p^{2}_{u,t}, \ldots, p^{r}_{u,t}$, which the winning bidder can charge are solely determined by the bid of the bidder with the second lowest $\boldsymbol{p}_t \boldsymbol{q}_{t-1}$, the winning bidder can

9 Given the private values according to Assumption 4 (firms), truth telling is a dominant strategy for a bidder in a sealed-bid Vickrey auction anyway (e. g., Wolfstetter, 1999). Notwithstanding, auction models have shown quite generally that a bidder's best response to rivals' strategies is to submit a bid at which he is indifferent between winning and losing (e. g., Milgrom, 1981; Levin and Harstad, 1986; Bikhchandani and Riley, 1991; Crew and Harstad, 1992).

choose his bid without regard of the bids of the other bidder(s). So the winning bidder's minimization problem under the second-bid version of the mechanism can be simplified in the same way as in the proof of Proposition 1:

$$\underset{\left[p_{a,t}, p_{u,t}^{1}, p_{u,t}^{2}, \ldots, p_{u,t}^{r}\right]}{\text{Min}} \left[p_{a,t} q_{a,t-1} + p_{u,t}^{1} q_{u,t-1}^{1} + p_{u,t}^{2} q_{u,t-1}^{2} + \ldots + p_{u,t}^{r} q_{u,t-1}^{r}\right] \tag{15}$$

subject to

$$\begin{aligned} \Pi(\boldsymbol{p}_t) = {} & p_{a,t} q_{a,t}\left(p_{a,t}, p_{u,t}^{1}, \ldots, p_{u,t}^{r}\right) + p_{u,t}^{1} q_{u,t}^{1}\left(p_{a,t}, p_{u,t}^{1}, \ldots, p_{u,t}^{r}\right) + \ldots + p_{u,t}^{r} q_{u,t}^{r}\left(p_{a,t}, p_{u,t}^{1}, \ldots, p_{u,t}^{r}\right) \\ & - C\left(q_{a,t}\left(p_{a,t}, p_{u,t}^{1}, \ldots, p_{u,t}^{r}\right), q_{u.t}^{1}\left(p_{a,t}, p_{u,t}^{1}, \ldots, p_{u,t}^{r}\right), \ldots, q_{u,t}^{r}\left(p_{a,t}, p_{u,t}^{1}, \ldots, p_{u,t}^{r}\right)\right) = 0. \end{aligned} \tag{16}$$

Given identical cost functions of the two (or more) most efficient bidders, the bids in the second-bid version of the mechanism are identical, which means that the winning bidder has to supply the good “access”, the good “usage up to the first threshold, τ_1”, the good “usage up to the second threshold, τ_2”, etc., and the good “usage beyond the last threshold, τ_{r-1}”, at the price vector that he submitted. In this case, the winning bidder is, of course, chosen by some predetermined allocative mechanism, according to Rule 1. Since, according to Assumption 4 (firms), at least two of the most efficient bidders take part in each of the repeated auctions, the remaining part of the proof of Proposition 1 applies. $\square$

Could any of the bidders improve on his bidding strategy by adapting his bid to the fact that the auction is repeated? This is impossible, as long as Assumption 4 (firms) holds. Only if a bidder takes the possibility of tacit or explicit collusion by (all of) the other bidder(s) into account, he can gain by raising his bid. Unfortunately, Assumption 4 (firms) does not seem to be particularly realistic, if there are and if there remain only two bidders in the course of several repeated auctions. In this case, it might seem more appropriate to expect some form of collusion. Therefore, the result of Proposition 3 appears to be relevant only, if there are not only two, but more bidders, and if the bidding firms cannot be sure whether the number of efficient bidders will rise in the following auction(s) or not.

If there are cost differences between the two most efficient bidders, we can only obtain a weaker result for the case that these bidders take part in each of the repeated auctions. In this situation, the sequence of the winning bids converges to the third-best block-rate tariff for given thresholds. The third-best block-rate tariff maximizes total surplus subject to the constraint that (one of) the firm(s) with the second-lowest costs would, hypothetically, just achieve zero economic profit, if this firm were the winner of the auction under optimal bidding strategies.

Proposition 4.

Given Assumptions 1-3 (consumers), 4 (firms) and 5 (auctioneer), Rules 1 and 3 (second-bid version of the mechanism), different cost functions of the two (or more) most efficient bidders, as well as stationary cost and demand conditions, the sequence of the winning bids converges to the third-best block-rate tariff for given thresholds under optimal bidding strategies.

Proof of Proposition 4.

Straightforward and therefore omitted.

There is, however, another problem which has to be solved. Unfortunately, the auctioneer usually does not exactly know the optimal thresholds. In other words, she does not know the precise definitions of the goods, for which bids are to be submitted. Thus, the mechanism cannot easily be implemented to determine the second-best block-rate tariff in general, i. e. the second-best block-rate tariff without given thresholds. At first sight, a possible answer might be to extend the mechanism and to delegate the task of setting the thresholds to the bidders. However, this does not really solve the problem. Even if they knew the optimal thresholds, there would still be the obstacle of the evaluation of bids. If the potential suppliers submitted bids which not only contain the access charge and the usage charges, but also the thresholds of the block-rate tariff, we would be in the situation that bidding competition would not lead to well-defined results at all. The auctioneer would not have a clear-cut criterion for the selection of the efficient supplier.

VI. CONCLUSION

As many of the practical problems with franchise bidding seem solvable in at least some of the network industries, it may become an interesting alternative to price regulation in the future. In this paper, we extended the concept of franchise bidding to bids consisting of block-rate tariffs for given thresholds, which enhances welfare. We presented a mechanism that approaches a second-best block-rate tariff with given thresholds in equilibrium by repeated Demsetz auctions, without the auctioneer having knowledge of the market demand. Mechanisms of this kind, notwithstanding their limitations, make franchise bidding more attractive compared to the benchmark of traditional-style regulation.

ACKNOWLEDGEMENTS

The author is indebted to Mélisande Cardona, Franz Diboky, Bernd Engelmann, Jörg Finsinger, Günter Knieps, Jürgen Siebel, Robert Wieser, Klaus Zauner, and many other colleagues for their helpful comments and suggestions. Earlier versions were presented at the WIPI Seminar, University of Vienna, 2003, at the Annual Meeting of the Austrian Economic Association in Klagenfurt, 2003, at the 36th Seminar in Transportation Research in Freiburg, 2003, at the Business & Economics Society International Conference in Rhodes, 2004, at the Interdisciplinary Research Seminar of the Department of Business, the Department of Finance, and the Department of Economics, University of Vienna, 2005, at the TILEC Seminar, Tilburg University, 2005, at a Colloquium at the University of Vienna, 2005, and at the Otto Beisheim Graduate School of Management, Vallendar, 2005. The usual caveat applies.

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