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Entry auctions and strategic behavior under cross-market price constraints

James J. Anton[a,*], James H. Vander Weide[a], Nikolaos Vettas[a,b]

[a]*The Fuqua School of Business, Duke University, Box 90120, Durham, NC 27708-0120, USA*
[b]*Department of Economics, University of Athens, Athens 10559, Greece*

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Abstract

We examine how universal service provisions and price restrictions across markets impact strategic entry and pricing. We develop a simple multi-market model with an oligopolistic (profitable) urban market and entry auctions for (unprofitable) rural service. Cross-market price restrictions induce a firm operating in both markets to become a 'softer' competitor, thus placing the firm at a strategic disadvantage. When we account for entry incentives and strategic bidding, the downstream strategic disadvantage becomes advantageous, leading to higher prices and profits. Price restrictions may also put outside firms, even relatively inefficient ones, at a strategic advantage.

JEL classification: D4; L1; L5; L96

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1. Introduction

We observe many regulated market environments in which the variation of prices across markets and market segments is restricted. Typically, these price restrictions are associated with universal service goals and they arise when the

*Corresponding author. Tel.: +1 919 6607754; fax: +1 919 6842818.
E-mail address: james.anton@duke.edu (J. Anton).

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price differentials expected to prevail in an unregulated setting are deemed unacceptable by policymakers. Familiar examples of industries with universal service requirements are postal delivery, railroad transport and telecommunications; related cross-market price constraints are also observed in a variety of other markets.[1] Liberalization in many regulatory environments, however, has exposed profitable markets to entry and competition. As discussed by Laffont and Tirole (2000) and others, liberalization has raised important questions regarding the coexistence of price constraints across markets, competition, and the goal of universal service, as many markets and segments are inherently unprofitable on a stand-alone basis.[2]

In a classic analysis, Leontief (1940) develops the theory of multi-market monopoly under cross-market price restrictions. Armstrong and Vickers (1993) introduce competition and examine the effects of price discrimination when an incumbent firm faces a (price-taking) entrant in a profitable market while the incumbent also serves customers in a separate market. A ban on price discrimination across the incumbent's markets, which is often part of a universal service requirement, causes the incumbent to be less aggressive in response to entry. The ban on price discrimination also has a significant impact on the scale of entry in equilibrium. We also examine the impact of cross-market price constraints (a ban on price discrimination) but introduce strategic interaction between competitors.

We focus on the issue of firm selection for a second, inherently unprofitable, 'rural' market and the strategic linkage to a profitable 'urban' market where there is oligopolistic competition. In particular, we examine the use of an auction to determine which firm will supply the unprofitable rural market. As discussed by Armstrong (2000) and Laffont and Tirole (2000), there is significant policy interest in the potential for awarding the right to serve markets via auctions in which bidders compete on requested subsidy levels.

We analyze the strategic implications of universal service requirements and related cross-market price restrictions with a simple model involving oligopoly competition and two markets. Oligopoly competition takes place in a profitable urban market and the resulting urban market price determines the ceiling (under

[1] Universal service provisions exist in several other markets (e.g., a Federal subsidy program was established following deregulation in the Airlines industry to support 'Essential Air Service' to rural, regional airports in the US). In general, cross-market price restrictions arise in a variety of contexts and, even when no formal entry auctions exist, strategic entry incentives may be affected: in international trade, anti-dumping provisions involve a comparison of prices across countries (Prusa, 1994); in pharmaceutical markets, countries often employ global reference pricing and link their domestic prices to those observed abroad (Lanjouw, 1997); and systems like Medicaid involve most-favored-customer rules (Scott Morton, 1997).

[2] According to Laffont and Tirole (2000), p. 218, ''Universal service is a knotty and explosive problem. It has been (or will be) a central issue in the political debate surrounding regulatory reform in all network industries and in most countries.''

universal service) for the rural market price. The strategic element that matters for our analysis is that urban market firms can influence or manipulate the relevant prices via their strategic choices. A homogeneous good duopoly with quantity-setting (as in Cournot competition) has this property and, for simplicity, we adopt this as the mode for strategic choice in the urban market.[3]

The rural market is inherently unprofitable due to a large fixed cost. Thus, no firm would independently seek to enter this market. Supply in this market is determined by the outcome of bidding in an upstream auction in which one firm becomes the single supplier to the rural market. Bids take the form of subsidy requirements and the selected firm is the low bidder (smallest subsidy).

The model provides a simple equilibrium framework for assessing the strategic implications of universal service requirements. First, we examine the direct impact of cross-market price constraints under universal service on prices, quantities and profits in each of the urban and rural markets. Next, we employ these market outcomes to analyze the bidding incentives for the rural market auction. The advantage of this approach is that market structure and bidding outcomes are endogenously determined by the underlying demand and cost structure. Finally, we extend the analysis to examine bidding competition and market structure when 'outside' firms (i.e., not active in the urban market) also bid in the rural market auction.

Our main results are as follows. With regard to direct effects on the two markets, we find that universal service requirements create a strategic link between the urban and rural market. This link arises because a firm that supplies both markets would like to set a rural price in excess of the oligopolistically determined urban price and, as a result, the reaction function of this firm shifts in the direction that makes this firm a 'softer' competitor in the urban market. The shift, which is downwards under quantity-setting, leads to higher equilibrium prices in both markets relative to unconstrained oligopoly competition. The 'softer' firm benefits in the rural market but it suffers in the urban market as the competing firm expands and earns higher profits. Thus, a firm supplying both markets is at a strategic disadvantage relative to an urban market competitor.

Equilibrium bidding and the resulting subsidy in the rural market auction must reflect this strategic disadvantage. Since a firm would prefer to 'lose' the rural auction and gain the stronger position in the urban market, the equilibrium subsidy contains a premium to compensate for the strategic disadvantage. As a result, once the subsidy is included, both firms earn higher profits relative to those under pure oligopoly competition in the urban market. The key insight is that the higher price under universal service leads to greater joint profits for the competitors and the auction, via the subsidy, allows a share of these gains to accrue to the firm that

[3] We also discuss how our results extend to other settings, such as differentiated price-setting (Bertrand) competition and quality competition.

supplies both markets. Thus, the strategic disadvantage created by universal service requirements is advantageous for urban market competitors once we account for the equilibrium incentives to bid for the rural market.

The presence of outside firms in the rural market auction affects bidding and the resulting market structure in several important ways. The critical feature is that an outside firm cannot directly affect the urban market price and, consequently, when an outside firm wins the auction, the strategic link between prices in the two markets disappears. This has an important implication for bidding incentives as the identity of the winning firm now matters to an incumbent urban market firm when it loses the rural auction. Among other results, we show when this leads to a less efficient outside firm winning the rural market auction.

Our analysis rests upon a price link across markets and is therefore closely related to the general issue of multimarket oligopoly. The idea that production in one market can affect strategic incentives in another market is emphasized by Bulow et al. (1985). The strategic link in our analysis, however, does not arise as a consequence of cost or demand interrelationships across markets. Indeed, we abstract away from any such interrelationship in order to focus exclusively on the strategic implications of the price restriction.

DeGraba (1987) also recognizes how cross-market price constraints can make firms softer competitors. The focus is different, however, as DeGraba shows that once firms become softer (price) competitors they may adjust their locations and, as a result, prices may decrease when a cross-market price constraint is present. In addition, he does not examine entry incentives, a primary consideration in our analysis.[4]

Our analysis involves an entry auction for determining the rural market supplier. Consequently, the issue of whether a multimarket oligopoly arises (an insider wins the auction) or not (an outsider wins) is determined endogenously. Further, the valuations of insiders and outsiders with respect to the rural market feature external effects: a losing bidder is affected by the identity of the winning bidder. Thus, our entry auction is related to recent work on auctions and, in particular, Jehiel and Moldovanu (1996, 2000) who examine bidding under external effects. In our case, the asymmetry of external effects is because an urban market insider prefers that a competing insider wins the auction rather than an outsider.

The basic model is described in Section 2 and analyzed in Section 3. In Section 4, we examine bidding when outside firms can participate. Section 5 discusses welfare effects. We consider extensions and conclude in Section 6.

[4] Our paper is also related to the problem of introducing competition into regulated markets (see Biglaiser and Ma, 1995; De Fraja, 1997; Laffont and Tirole, 1993; Wolinsky, 1997, who also provide additional references).

2. The Model

There are two markets, U (urban) and R (rural) and two firms, A and B. Demand in the U market is $D^{U}(p) = 1 - p$ and in the R market $D^{R}(p) = b(1 - p)$, where p is the market price and $b > 0$. Thus, while both markets have a common price intercept of $p = 1$, the slope coefficient of b allows rural demand to be smaller or larger than urban demand. In many situations, we expect the rural market to be the smaller market.[5]

The fixed cost of any given firm is $F^{U} > 0$ in market U and $F^{R} > 0$ in market R. There is a constant marginal cost $c \geq 0$, and this is the same for both firms and both markets.[6] Naturally, we assume that $c < 1$ so that, ignoring fixed costs, it is always profitable (and efficient) to supply some amount to each market.

2.1. Benchmarks

Consider first the case where the two firms compete in a Cournot fashion in the U market. Standard arguments yield a unique equilibrium with quantities $q^{c} = (1 - c)/3$, price $p^{c} = (1 + 2c)/3$, and per-firm profit

$$\pi^{c} = (1 - c)^{2}/9 - F^{U}. \tag{1}$$

We assume that the fixed cost in the U market is sufficiently low to allow $\pi^{c} > 0$.

Consider now a monopolist operating only in market R. The monopolist would maximize $Q(1 - Q/b) - cQ$ by choosing output $b(1 - c)/2$ with price $(1 + c)/2$ and profit

$$\Pi^{M} = b(1 - c)^{2}/4 - F^{R}. \tag{2}$$

We assume that F^{R} is sufficiently large that $\Pi^{M} < 0$. This assumption implies the need for subsidies if the government wants consumers in this market to be served.

2.2. The game

We consider a simple complete information game with the following timing.

1. Firms A and B choose bids s^{A} and s^{B}. These bids represent lump-sum subsidies that the firms ask from the government in order to serve market R.

[5] The analysis, which extends readily to linear demands with different intercepts, is streamlined by specifying a common intercept since this eliminates cases in which the price constraint does not bind.

[6] We assume that marginal cost is the same in order to focus on the effects of differences in demand and fixed costs across markets. Such differences are often substantial in reality.

2. The lowest bidder (smaller subsidy required) wins, receives a subsidy equal to the winning bid, incurs the fixed cost F^R and becomes a monopolist in the R market. 'Ties' among symmetric bidders are resolved by a coin toss and ties in other cases are resolved by awarding the rural market to the bidder with the highest payoff.[7] The price in the R market is determined as in 4 below.

3. Firms A and B choose quantities q_A and q_B for the U market. The price in the U market is then determined as $p^U = 1 - q_A - q_B$.

4. The monopolist in the R market can then choose a price that cannot exceed the price determined in the U market, that is, $p^R \leq p^U$.

5. Each firm's payoff is the sum of its profits in the two markets, including any subsidies.

We solve for a subgame perfect equilibrium of this game, focusing on pure strategy equilibria in the bidding stage.[8]

3. Analysis

We proceed from the end of the game-tree back towards the beginning.

3.1. Step 1: pricing in the R market

As we show below, the $p^R \leq p^U$ constraint is binding in equilibrium. In other words, the monopoly price in the R market is higher than the equilibrium price in the U market when one firm operates in both markets. Thus $p^R = p^U$.

[7] In a complete information setting, auction equilibria typically involve a tie either because bidders are symmetric or because the bidder with the strongest strategic position bids so that the next strongest bidder is indifferent between winning and losing. Our tie breaking rule follows the literature (see, e.g., Milgrom, 1987).

[8] Some remarks about the model are appropriate at this point. First, the adopted timing of events is the one that makes the cross-market constraint operate in a natural way. An alternative sequencing would be to have the firm that operates in both markets choose the quantities it supplies in each market at the same time that the other firm chooses its U market quantity. However, this would create the problem of how to impose the price constraint in the R market. Second, the multi-market firm should not be viewed as a price-taker in the R market. Given the cross-market price constraint, the firm is free to set any price in the R market up to the ceiling. More importantly, the ceiling is endogenous with respect to the firms' actions: the multi-market firm can and does adjust its U market choices to raise the ceiling price for the R market. Finally, the Cournot structure for the U market only serves to streamline the analysis and allows us to consider a homogeneous good for which the cross-market price constraint is unambiguous (R market buyers purchase the same good at the same price as U market buyers). As an alternative strategic mode, we could employ price setting (differentiated Bertrand). While, as noted below, this does not alter the basic strategic link between the U and R markets, it does introduce additional issues such as how to interpret the cross-market price constraint when products are differentiated.

3.2. Step 2: quantities supplied in the U market

Denote by q_1 the quantity supplied in the U market by the firm that only operates in the U market and by q_2 the quantity supplied in the U market by the firm that operates in *both* markets. Given the quantities supplied in the U market, the prices are $p^R = p^U = 1 - q_1 - q_2$. Then, market profits gross of fixed costs and subsidies are: for the firm that operates in both markets $[(1 - q_1 - q_2)q_2 - cq_2] + [(1 - q_1 - q_2)b(q_1 + q_2) - cb(q_1 + q_2)]$ or, equivalently, $(1 - q_1 - q_2 - c)[q_2 + b(q_1 + q_2)]$, and for the firm that operates only in the U market $(1 - q_1 - q_2 - c)q_1$.

We can then derive the reaction functions

$$r^1(q_2) = \frac{1 - c - q_2}{2} \quad \text{and} \quad r^2(q_1) = \frac{1 - c - q_1}{2} - \frac{bq_1}{2(1 + b)}, \tag{3}$$

which yield the equilibrium quantities

$$q_1^* = (1 + b)\frac{1 - c}{3 + 2b}, \quad q_2^* = \frac{1 - c}{3 + 2b}, \tag{4}$$

and equilibrium price

$$p^* \equiv 1 - q_1^* - q_2^* = \frac{(1 + b)(1 + c) + c}{3 + 2b} = p^U = p^R. \tag{5}$$

It is now easy to check that the price constraint is indeed binding:

Remark 1. *p^* is lower than the monopoly price in the R market.*

This follows directly from a comparison of p^* with the monopoly price $(1 + c)/2$ upon noting that $c < 1$. We now summarize how the outcome in the urban and rural markets under the price constraint compares with the benchmark of Cournot outcomes in the urban market. A direct comparison of the appropriate terms shows that:

Proposition 1. *Relative to the Cournot outcome,* (*i*) *when one of the U market firms also operates in the R market, equilibrium in the U market involves a higher price and lower aggregate quantity*: $p^* > p^c$ *and* $q_1^* + q_2^* < 2q^c$, *and* (*ii*) *the firm that operates in both markets supplies a lower quantity in the U market while the firm that operates only in the U market supplies a higher quantity*: $q_2^* < q^c < q_1^*$.

Intuitively, the firm that operates in both markets would like to relax the R market price constraint and, as a result, it would like a higher price in the U market. To accomplish this, it is willing to supply a lower (than the Cournot level) quantity in the U market. In other words, the firm that operates in the U market is now ‘softer’ (relative to Cournot competition). This is evident from the fact that

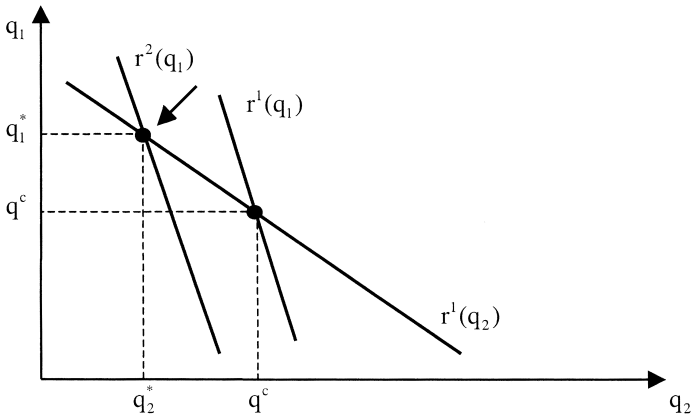

Fig. 1. Equilibrium quantities in the Urban market compared to the equilibrium with no cross-market constraints.

the reaction function r^2 lies below the reaction function under Cournot competition (see Fig. 1 and Eq. (3)). The U market competitor (firm 1) benefits from this effect and supplies a larger quantity.

Now, the equilibrium profit for the firm that operates only in the U market is

$$\pi_1^* = (p^* - c)q_1^* - F^{\mathrm{U}} = \frac{(1+b)^2}{(3+2b)^2}(1-c)^2 - F^{\mathrm{U}} \tag{6}$$

and profit for the firm that operates in both markets is

$$\begin{aligned}\pi_2^* &= (p^* - c)[q_2^* + b(1-p^*)] - F^{\mathrm{U}} - F^{\mathrm{R}} \\ &= \frac{(1+b)^3}{(3+2b)^2}(1-c)^2 - F^{\mathrm{U}} - F^{\mathrm{R}}.\end{aligned} \tag{7}$$

A direct comparison of (1), (6) and (7) yields the following result.

Lemma 1. *The profit of the firm that operates in both markets is lower than the per-firm U market Cournot profit and this, in turn, is lower than the profit of the firm that operates only in the U market*:

$$\pi_2^* < \pi^c < \pi_1^*. \tag{8}$$

The firm that operates in both markets has negative profit in the R market once we account for the fixed cost of F^{R}. Further, this firm supplies smaller quantity to the U market and has a lower profit there than its competitor. Thus $\pi_2^* < \pi_1^*$. $\pi^c < \pi_1^*$ follows from the fact that the firm that operates only in the U market increases both its price and its quantity when its competitor enters the R market.

Now, $\pi_2^* < \pi^c$ is true for two reasons. First, firm 2 has a loss in the R market. In addition, firm 2's profit in the U market decreases when it enters the R market. Note that when 2 enters the R market the quantity it supplies to the U market decreases but the price increases. Direct calculations show that its U market profit drops from π^c to $(p^* - c)q_2^* - F^U = (1+b)(1-c)^2/(3+2b)^2 - F^U$. This follows by noting that $(p^* - c)q_2^* - F^U$ is equal to π^c for $b = 0$ and is decreasing in b.

3.3. Step 3: equilibrium bids

The total payoffs as functions of the bids s^A and s^B (and assuming equilibrium behavior in the continuation of play) are

$$v^i(s^i, s^j) = \begin{cases} \pi_1^* & \text{if} \quad s^i > s^j \\ \pi_2^* + s^i & \text{if} \quad s^i < s^j, \end{cases} \quad i, j = \text{A, B},$$

where π_1^*, π_2^* are calculated as above. Note that the bids represent required subsidies and an 'aggressive' bid (one that increases the chance of winning the auction) is a low bid.

Now we can determine the equilibrium bids:[9]

Proposition 2. *In equilibrium, each firm requires a subsidy equal to*

$$s^* \equiv \pi_1^* - \pi_2^* = F^R - b\left[\frac{(1+b)(1-c)}{(3+2b)}\right]^2 \Big/ 25 \tag{9}$$

and wins the auction with probability 1/2. *The total after-subsidy profit for each firm is* π_1^* (*which exceeds* π^c). *Further, the joint profit in the U market exceeds the Cournot level.*

A firm that operates only in the U market strictly prefers that its U market opponent also operates in the R market, because this makes the U market opponent a softer competitor in the U market. Consequently, the required subsidy in equilibrium is $\pi_1^* - \pi_2^*$, which is higher than $\pi^c - \pi_2^*$. In other words, the point of reference for the firm that loses the auction is not π^c but π_1^*. When a firm loses the auction then its competitor wins, and this is a desirable outcome for the firm. Thus, each firm is more 'demanding' with respect to the subsidy it requires.

[9] The proof is immediate. If it bids $s < s^*$, the firm wins the auction and receives total profit $s + \pi_2^* < s^* + \pi_2^* = \pi_1^*$. On the other hand, with a bid $s > s^*$ the firm loses the auction and has the same profit, π_1^*. Proposition 2 describes the unique pure-strategy outcome. A symmetric mixed strategy bidding equilibrium also exists, but it requires unbounded support for the bid distribution and so does not survive if there is a finite upper bound on the requested subsidy. For a related construction see Baye and Morgan (1999).

The fact that equilibrium profit exceeds the Cournot level (if there were no link between the markets) represents a key effect in our analysis. The desire of the government to provide service to consumers in the rural market, in conjunction with the requirement that the rural price not exceed the urban price, can create a perverse incentive for each firm to lose the auction for the rural market in order to gain the more profitable position of serving only the urban market. Equilibrium bidding then leads to a subsidy that compensates for the strategic disadvantage associated with winning. As a result, both firms ultimately benefit and earn profit π_1^* which exceeds π^c (the profit level when no price constraint is imposed on the R market or, equivalently, the profit when U market firms are not allowed to enter the R market). Further, the urban market has higher prices and lower quantities relative to those of unconstrained oligopoly competition (Cournot) in the urban market.

The effects described above are valid for much more general settings than the simple model presented here. In particular, they hold for standard Cournot models with nonlinear demand and costs.[10] Further, the main effect is still present if there are more than two U market firms, as long as these have market power (of course, as the market power of each firm decreases, the incentive to manipulate the price becomes weaker). Finally, the effects of the price restriction are not dependent on the specifics of quantity-setting as the strategic mode. In a differentiated price-setting competitive interaction, the reaction function of the firm operating in both will also shift in the direction (up in the case of price-setting) associated with being a softer competitor.

4. Outsiders allowed to bid for the Rural market

Thus far we have focused on the interaction between the (two) firms that are active in the U market. We now introduce the possibility of entry into the R market by a firm that is not active in the U market, an 'outside' firm, for short. The critical difference is that an outside firm cannot directly affect or manipulate the price in the U market. In addition to being a useful benchmark for understanding the incentives of U market incumbent firms to relax the cross-market price constraint, the question of whether an insider or an outsider is expected to win the auction is an important strategic issue for firms in these markets as well as for policymakers. Our inquiry includes the question of whether an inside incumbent or an outsider is more likely to request a smaller subsidy and win the auction, as well as that of determining the strategic impact of an outsider on the bidding behavior of inside firms.

In order to focus on the implications of differences in strategic positions, we

[10] A sufficient condition is to have downward sloping reaction functions with a unique, stable equilibrium. We thank a referee for this suggestion.

begin by abstracting away from any other differences between U market incumbent firms and outside firms; later, we discuss the impact of differences in technology. Thus, all firms face the same marginal cost of c and fixed cost of F^{R}. The game is as before with the only change being that outside firms can also submit bids at the same time as U market incumbents for the R market subsidy. We begin with the case of one outside firm and then proceed to the case of many outsiders (this corresponds to 'free entry' into the R market auction).

4.1. Comparing the profit differences

Consider first the subgame given that an outsider has won the bidding. In this case, neither of the duopolists in the U market has any cross-market incentive to manipulate the U market price. Thus, the price in the U market will be the Cournot price p^c, and each of these two firms will earn the Cournot profit, π^c. The price constraint binds on the outside firm and so p^c will also be the price in the R market.[11] The profit for the firm operating in the R market (before the subsidy) is then

$$(p^c - c)b(1 - p^c) - F^{\mathrm{R}} = \frac{2b}{9}(1 - c)^2 - F^{\mathrm{R}} \equiv -\tilde{\pi} < 0. \tag{10}$$

Thus, $\tilde{\pi}$ is the *loss* for the firm operating (only) in the R market. It follows that in order for the outsider to be willing to enter the R market, a subsidy of at least $\tilde{\pi}$ is necessary (the outsider's profit when not operating in the R market is normalized to zero).

In the subsequent analysis, we need to compare $\tilde{\pi}$ to $\pi_1^* - \pi_2^*$ (the bid subsidy demanded in equilibrium when only the U market incumbents can bid for the R market) and $\pi^c - \pi_2^*$ (the decrease in an insider's profit after entering the R market). From the previous analysis, a direct comparison of $\tilde{\pi}$ from (10), $\pi_1^* - \pi_2^*$ from (9), and $\pi^c - \pi_2^*$ from (1) and (7) yields:

Lemma 2. (*i*) $b \leq b_L \Leftrightarrow \tilde{\pi} \leq \pi^c - \pi_2^* < \pi_1^* - \pi_2^*$,(*ii*) $b_L < b \leq b_H \Leftrightarrow \pi^c - \pi_2^* < \tilde{\pi} \leq \pi_1^* - \pi_2^*$, *and* (*iii*) $b_H < b \Leftrightarrow \pi^c - \pi_2^* < \pi_1^* - \pi_2^* < \tilde{\pi}$, *where* $b_L \equiv (1 + \sqrt{13})/2 \simeq 2.3$ *and* $b_H \equiv 3(1 + \sqrt{2}) \simeq 7.24$.

Observe that in most applications we expect demand in the rural market to be less than demand in the urban market. Taking $b < 1$, the above result implies that an outsider will incur a smaller loss from supplying service to the rural market than will an urban market insider. Thus, assuming that production technologies and all other aspects of the firms are identical, outsiders are in a better strategic position to submit a more aggressive bid in the auction for the R market.

[11] Since $p^c < p^*$ and from Remark 1 the price constraint binds at p^*, it also binds at p^c.

4.2. Equilibrium

We begin with the case of a single outsider who can bid for the R market. This allows us to isolate the effect of an outsider from that of competition among outsiders.[12]

Proposition 3. *Suppose that one outsider and the two firms active in the U market participate in the R market subsidy auction.*

(*i*) *If* $b \leq b_L$, *in equilibrium, all firms bid a subsidy of* $\pi^c - \pi_2^*$ *and the outsider wins. In equilibrium, the outsider has after subsidy profit* $\pi^c - \pi_2^* - \tilde{\pi} > 0$, *and each of the U market incumbents has profit* π^c.

(*ii*) *If* $b_L < b \leq b_H$, *in equilibrium, a U market incumbent wins with a bid of* $\tilde{\pi}$, *the outsider also bids* $\tilde{\pi}$, *and the other U market incumbent requires a subsidy higher than* $\tilde{\pi}$. *In equilibrium, the winning U market incumbent has after-subsidy profit* $\tilde{\pi} + \pi_2^*$, *the losing U market incumbent has profit* π_1^*, *and the outsider has zero profit.*[13]

(*iii*) *If* $b_H < b$, *in equilibrium, each of the U market incumbents bids* $\pi_1^* - \pi_2^*$ *and wins with probability* $1/2$ *while the outsider submits a higher bid.*

Proof. (i) In this case, Lemma 2 implies $\tilde{\pi} \leq \pi^c - \pi_2^* < \pi_1^* - \pi_2^*$. The outsider does not want to raise its bid because it would lose the auction and its profit would drop from $\pi^c - \pi_2^* - \tilde{\pi} > 0$ to zero. It also does not want to lower its bid since this would only decrease its subsidy. A U market insider does not want to lower its bid because it would then win the auction and its profit would decrease: a bid $s < \pi^c - \pi_2^*$ yields after-subsidy profit $\pi_2^* + s$, which is lower than π^c. Finally, raising the bid would not affect an insider's profit.

(ii) In this case, $\pi^c - \pi_2^* < \tilde{\pi} \leq \pi_1^* - \pi_2^*$. The outsider would still lose the auction if it asks for a higher subsidy and thus its profit would remain zero. Its profit would be negative if it bid less than $\tilde{\pi}$ and won the auction. By submitting a lower than $\tilde{\pi}$ bid, the losing insider wins and its after subsidy profit drops to below $\tilde{\pi} + \pi_2^*$ which is lower than the original profit of π_1^*, since for these parameter values $\tilde{\pi} \leq \pi_1^* - \pi_2^*$. Finally, if the winning insider asked for a lower subsidy, it would only decrease its profit by the amount of the subsidy reduction. If it asked for a higher subsidy, it would lose the auction and the outsider would win. This deviation leads to a profit of π^c which is lower than the original profit, $\tilde{\pi} + \pi_2^*$

[12] In practice, a large asymmetry could render other potential outsider firms irrelevant to the bidding competition, as when a prior R market incumbent has legal control of essential facilities (see Laffont and Tirole (1993, p. 260)).

[13] In this case, there is no pure-strategy equilibrium where the outsider wins or where an insider wins and both insiders have the same bid. There is, however, a symmetric mixed strategy equilibrium in which each insider mixes between $\tilde{\pi}$ and an arbitrary higher bid. Details are available from the authors upon request.

because we have $\pi^c - \pi_2^* < \tilde{\pi}$. Thus, the proposed strategy profile is an equilibrium, with the losing insider making higher profit than the winning insider and the outsider disciplining the winning bid.

(iii) In this case, $\pi^c - \pi_2^* < \pi_1^* - \pi_2^* < \tilde{\pi}$. The outsider would make a large enough loss ($\tilde{\pi}$) if it entered the R market that its presence is irrelevant for the auction. The U market firms behave exactly as in Proposition 2. The outsider loses the auction and submits a high bid. If the outsider were to submit a bid lower than $\pi_1^* - \pi_2^*$, it would win the auction and its loss in the R market would be larger than the subsidy. □

Recall that we consider the case of small rural market demand to be the most likely scenario for most applications. Proposition 3(i) then implies that the strategic advantage of an outsider translates directly into the ability to win the R market auction at a subsidy level that involves a positive profit. Insiders then operate only in the U market. Note that it is the willingness of insiders to bid (and operate) in the R market that disciplines the bid subsidy and that, in equilibrium, the insiders are pushed to indifference.[14] In addition, a comparison of the profits for insiders indicates clearly that the insiders would prefer that outside firms be excluded from the rural market auction.

Suppose now that there are two or more outsiders. The only difference is that the presence of other outsiders disciplines the bid of each outsider and, therefore, in case (i) of the above Proposition, the winning bid cannot be higher than $\tilde{\pi}$.

Proposition 4. *Suppose that $n \geq 2$ outsiders and the two firms active in the U market participate in the R market subsidy auction. Then, if $b \leq b_L$, in equilibrium, all outsiders bid $\tilde{\pi}$ and each of the outsiders wins with probability $1/n$. Insiders can bid any number higher than $\tilde{\pi}$. In equilibrium, each outsider has after subsidy zero profit and each of the U market incumbents has profit π^c. If $b > b_L$ the equilibrium is as in Proposition* 3.

Propositions 3 and 4 suggest that, when firms are otherwise identical, an outsider is expected to win the auction when demand in the R market is not too large, whereas a firm active in the U market is expected to win if demand in the R market is high.

The key point here is that an outsider cannot manipulate the U market price, whereas a U market insider can. Therefore, an insider has an additional instrument at its disposal. We know that the price in the R market will be higher and the loss smaller if a U market insider operates there as compared to when an outsider does.

[14] In case (i) there is also a continuum of equilibria that differ from the one above in that the winning bid belongs to $[\tilde{\pi}, \pi^c - \pi_2^*)$. Similarly, in case (ii) there is also a continuum of equilibria with the winning bid in $[\pi^c - \pi_2^*, \tilde{\pi})$. Such equilibria are usually viewed in the literature as 'unreasonable' because they require the firm that submits the 'disciplining' bid to employ a weakly dominated strategy.

Thus, if firms are otherwise identical, it appears that a U market insider always has an 'advantage' relative to an outsider. How can we then find that an outsider may win the auction? This is because, firstly, the intuition described above is not valid is a strategic framework. When an insider also operates in the R market, the U market price is not manipulated against a given choice of the other U market competitor in the U market. Rather, the equilibrium in the U market is shifted as both competitors alter their choices. The source of this shift is that the firm operating in both markets now behaves according to the reaction function r^2 rather than r^1. Thus, the value of being able to manipulate the U market price depends on the downstream incentives of the firm and the resulting interaction with the U market rival.[15] Secondly, an insider's point of reference in case it loses the auction is different from that of an outsider. An insider strictly prefers that its U market competitor also operates in the R market and therefore requires the larger subsidy of $\pi_1^* - \pi_2^*$ rather than $\pi^c - \pi_2^*$ in order to give up the opportunity to face a softer competitor. Thus, in the event that it loses the auction, an insider will still care about the identity of the winner. An outsider faces no such concerns.

4.3. Different costs

The above results imply that a firm can often submit a more aggressive bid purely because it has a more favorable strategic position than another firm (even if firms are otherwise identical). These results also imply that a less efficient firm may be able to win the auction:

Remark 2. *An outside firm may win the rural market auction simply because it has a stronger strategic position, despite having higher production costs than inside firms.*

For concreteness, suppose that b is not too high, so that an outsider has a strategic advantage ($b < b_L$). In addition, we now allow for different costs. Let $\bar{c}$ be the unit cost for an outsider (the analysis so far has assumed $\bar{c} = c$). Clearly, for $\bar{c} < c$ the previous analysis implies that an outsider will win the auction. Suppose now that $\bar{c} > c$, so that the insiders are more efficient.[16] Propositions 3(i) and 4 remain valid for a range of $\bar{c}$ above c and an outsider will still win the R market

[15] The loss for an outsider that enters the R market is $\tilde{\pi}$. The corresponding loss for a U market insider is $\pi^c - \pi_2^*$. As shown above, the loss in the U market for a firm operating in both markets may be greater than its gain in the R market and therefore we could have $\tilde{\pi} < \pi^c - \pi_2^*$. Note that if the incumbent could commit not to decrease its U market output, its total profit could never fall below $\pi^c - \tilde{\pi}$. But the fact that a firm's reaction curve shifts once it enters the R market makes it possible for π_2^* to be below $\pi^c - \tilde{\pi}$.

[16] Insiders may be more efficient due to economies of scope across multiple markets. Other factors, however, such as labor and capital structure inherited from prior regulatory policy, may disadvantage an insider.

auction.[17] Thus, a (single) less efficient outsider is able to win the R market auction at a positive profit subsidy level whenever the advantage of a strong strategic position dominates the high cost disadvantage. Of course, with multiple outsiders, the bidding competition dissipates the profit from the subsidy, although an outsider still wins auction. Similar points apply for differences in fixed costs.

5. Welfare

It is useful to summarize here some basic welfare implications of our analysis. The discussion is based on our analysis of price and profit implications earlier in the paper. A first benchmark to which we can compare the policy of the cross-market price constraint and auction for the R market (and when only U markets insiders can bid for the R market) is an auction without any price constraint in the R market (then the winner of the auction charges the monopoly price in the R market — see Section 2.1). Compared to this benchmark, price falls to p^* from the monopoly level in the R market and it rises to p^* from the Cournot level in the U market (p^c). It is easy to verify that the increase in consumers' surplus in the R market is larger than the loss in the U market. The auction bid subsidy falls from Π^M (see (2)) to $\pi_1^* - \pi_2^*$, and both U market firms earn a higher profit level of π_1^*. Further, the sum of consumers surplus (over both markets) and profits (over the two firms) less the subsidy increases as the price constraint is introduced. Thus, for the familiar welfare measure consisting of a weighted average of these terms, introducing the price constraint will increase welfare as long as the weights on consumers surplus in the U compared to R market are not too far apart, a presumption which appears consistent with the goals of universal service.

Opening the auction to outsider bidding has direct welfare implications. Focus on the case of a 'small' R market. Then, outsider bidding causes the price to fall from p^* to p^c in both markets, directly benefiting consumers. Further, insider profits fall to π^c from π_1^* as does the auction subsidy. Clearly, allowing an outsider to bid for the R market in this setting breaks the strategic link with the U market. The outcome then is equivalent to a second benchmark for our analysis, that of a policy that fixes the R market price to p^c. Moving from one to multiple outsiders then disciplines the bidding of outside firms (and the resulting profit) without changing prices and consumers surplus or insider profits. Therefore (and although advice to policy makers cannot be precise if based only on a simple model like ours) it appears that, when there is a cross-market price constraint,

[17] This is because $\pi^c - \pi_2^*$ is independent while $\tilde{\pi}$ is decreasing in the outsider's marginal cost. At $\bar{c} = c$ we have $\tilde{\pi}$ less than $\pi^c - \pi_2^*$ by a finite amount. Thus, we must have $\tilde{\pi} \leq \pi^c - \pi_2^*$ for a range of $\bar{c}$ above c.

opening the auction to outsiders may help neutralize the adverse effect of firms' strategic behavior on consumer surplus.[18]

6. Extensions and conclusion

Our analysis shows how, when a firm operates in both markets, the incentive to relax the cross-market restriction makes the firm a 'softer' competitor and places the firm at a strategic disadvantage relative to other urban market competitors. Entry incentives must account for this disadvantage and strategic bidding results in an equilibrium subsidy that contains a compensating premium. Consequently, the downstream strategic disadvantage becomes advantageous for insiders, leading to higher prices and profits. Further, the existence of a strategic disadvantage for a firm operating in both markets makes it important to distinguish between inside and outside firms. An entry auction in this setting involves external effects: a losing inside firm is affected by the identity of the winning firm since this determines whether the losing firm will face a weak or a strong competitor in the urban market. Importantly, we find that an inefficient outside firm may win the rural market auction.

An assumption of the model that can be easily relaxed is that firms have the same technology. For example, the analysis can be reproduced in a straightforward way when the incumbents have different marginal costs. In this case we find that, as expected, it is the more efficient of the two firms that requires a smaller subsidy and enters the R market.

Further, the number of firms in the U market can be endogenized. Suppose that two Cournot competitors make positive profit in the U market but three would have a loss. If one of these two firms entered the R market, it would decrease its U market output and, thus, increase the U market price and its R market profit. But with the higher price in the U market it is conceivable that further entry in the U market has become profitable. This further entry creates a force that would tend to decrease the price back towards its original level. The analysis can be modified to include this case, with the incumbent firms taking into consideration the possibility of further entry when they choose their output levels. While we do not explicitly model this possibility in the paper, it is important to keep in mind with respect to entry and policy issues that, if the price increase in the U market is very high, additional firms may find it profitable to enter.

[18] Concerning our discussion of cost differences above, note that it is not obvious that the government should necessarily award the R market to the lowest bidder versus employing some type of bidder handicap system. The reason is that, although the outsider may require a larger subsidy to operate in the R market (if its cost is sufficiently higher), the price (in both markets) is lower when the outsider operates in the R market than the price when one of the U market insiders operates in the R market. Another way to think about this is that when a U market insider operates in the R market, there are additional market distortions.

Universal service provisions often also require that the quality of services in rural markets be comparable to that provided in urban markets. The logic of our model also applies to the case where quality is endogenous. This case is of interest since imposing a cross-market price constraint is less important if the quality levels are allowed to differ substantially, and is particularly important in markets with rapid technical change. The model could be modified as follows. Suppose that firms compete in both quantity and quality, and that the cross-market constraint dictates that the product has to be provided in the R market at a price not higher and a quality not lower than the U market levels.[19] Then, a firm operating in both markets may have an incentive to supply lower quality to the U market to increase profit in the R market.

Finally, we have not considered how the government finances the subsidy. In principle, of course, if welfare maximization is the goal, the government should choose some tax that minimizes the resulting distortions. Often, this subsidy can be financed by some tax on the firms operating in this industry, essentially creating a cross-subsidy from the profitable (U) to the unprofitable (R) segments of the market. For example, there may be a tax on the revenues of firms. The main idea is that firms contribute part of their revenues to this fund, and the collected revenue is used to finance the subsidy to firms serving the unprofitable segments of the market. Thus, it is of interest to discuss briefly how such a scheme might affect competition from the point of view of our model. In a formal treatment of the issue, the tax rate should be treated as endogenous (because the tax must produce sufficient revenue to cover the subsidy, that is, revenue should equal the winning bid in the R market auction). This has implications not only for bidding strategies, but also for the way competition takes place. Since the main goal of the paper is to examine how the cross-market price constraint affects the strategic behavior of firms rather than provide a detailed evaluation of different ways to finance the subsidy, we merely summarize here the main ways in which taxation may affect the firms' strategies.

Suppose that there is a revenue tax in the U market. First, concentrate on competition between the two insiders. Since U market profit (through revenues) is subject to taxation, for the firm that operates in both markets, it becomes more profitable at the margin to decrease supply in the U market. In other words, a revenue tax makes it more attractive for the firm to sacrifice its U market profit in order to decrease its loss in the R market and thus tends to further increase prices. Second, when firms determine their bids they realize that, at the margin, a higher bid implies that a higher tax rate will need to be imposed on the U market to finance the subsidy. Thus, the U market insiders have an incentive to submit a lower bid than otherwise. Furthermore, an outsider may want to submit a higher bid since increasing the tax rate only affects firms active in the U market. Thus,

[19] For a discussion of the effect of price regulation on a firm's quality offerings in oligopolistic markets, see Vander Weide and Zalkind (1981).

the fact that the tax rate is determined so that it finances the required subsidy may make the insiders willing to bid for a lower subsidy than otherwise, and introduces an additional difference between the strategic positions of insiders and outsiders.

The ideas presented here and our analysis are relevant for a number of markets. Deregulation and privatization policies, which typically involve some form of bidding procedure for entry, have been enacted in a number of countries and allow firms to enter and compete in profitable segments of an increasing number of markets. These policies often coexist with a concern of governments that service and supply must also be provided to less profitable segments of these markets. In this paper we have identified how such an environment can alter the strategic positions of inside and outside firms and assessed the implications for market competition and entry.

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