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**COMPETITIVE PROCUREMENT AND
ASSET SPECIFICITY**

By V. Sorana

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Competitive procurement and asset specificity

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Abstract

This paper studies the effects of asset specificity on the performance of procurement auctions with subcontracting and asset sales. The analysis highlights the role of several asset features like transfer costs, type of alternative uses and maintenance requirements. It is argued that, if bargaining over subcontracting or asset sales is efficient enough, then the presence of durable specific assets *per se* does not have decisive effects on the competitive pressure from potential entrants.

Keywords: Fundamental Transformation, Transaction Cost Economics, franchise bidding, natural monopoly, regulation, procurement, auctions, hold-up, subcontracting, resale, unbundling, bargaining, Markov-Perfect equilibrium.

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1 Introduction

The central notion of Transaction Cost Economics is the *Fundamental Transformation* from ex-ante competition to ex-post (bilateral) monopoly for transactions involving *specific* durable assets.¹ Its logic can be explained in four steps.

First, long-term complete contingent contracts are generally not feasible because of *bounded rationality* or other costs of writing and enforcing contractual clauses.²

Second, short-term or otherwise incomplete contracts have to be adapted (i.e., renegotiated) to keep track of unfolding events after a relatively short term – hence before the end of the useful life of the specific assets involved.

Third, even if competitive conditions prevailed at the time the transaction was first agreed upon, contracts are renewed in an essentially non-competitive environment: only one party owns some assets that are necessary for the transaction and practically useless for anything else. This asymmetry, it is argued, would make other potential producers virtually irrelevant: all the action is about the distribution of quasi-rents arising from the sunk asset.

Finally, the anticipation of this ex-post *hold-up* over quasi-rents may be the source of ex-ante inefficiencies. Appropriate choices of ownership patterns or more complex governance structures may thus be required to mitigate such inefficiencies.

This paper focuses on the third step of the argument and studies how different types of asset specificity affect the degree of ex-post competition. A first key observation is that the asset may be specific to the provision of a given good to a given buyer, but not specific to any given seller: The incumbent seller could sell the asset to a new entrant. This is not, of course, an original observation. Surprisingly, however, the corresponding bargaining game has not been formally investigated in the existing literature. A second key observation is that, even if the asset is also specific

¹Williamson (1985) is the classic reference. A shorter and more recent survey is in Williamson (2002).

²The enforcement problems comes from Williamson's other behavioral assumption: agents are seeking *self-interest with guile*. Reputational concerns may be insufficient to induce respect for the spirit, as well as the letter of contracts.

to the seller, a new entrant could win the contract to supply the buyer and then subcontract production (or part of it) to the former incumbent. To the best of my knowledge, the possibility of subcontracting has not been considered in discussions of the *Fundamental Transformation*. In this paper, it is shown that subcontracting could be enough to fix prices at competitive levels also at the contract renewal stage.

Formally, this paper studies a class of infinite sequences of procurement auctions in which winning entrants can freely bargain with current asset owners over asset transfers or subcontracting. Bargaining after each auction is assumed to follow a generalized Nash rule, although some forms of bargaining inefficiencies will also be considered.

The effectiveness of ex-post competition is shown to depend on the efficiency of bargaining, the parties's bargaining power, the duration of contracts (here taken as an exogenous parameter), the discount factor (which can also proxy for the degree of uncertainty over future transactions) and, of course, the durability and specificity of the assets.

The bargaining component of the analysis is decisive. For almost all values of the other parameters, ex-post competition can be totally irrelevant or completely effective at eliminating incumbency advantages depending on (the product of) the probability of reaching an agreement and entrants' share of surplus in the agreement.³ However, if one assumes that bargaining is efficient enough and that entrants would not buy assets from incumbents at prices above market levels, then ex-post competition can be shown to be quite effective *in these models*. The potential failures of ex-post competition would then have to be searched among aspects not considered here – and probably not related to the presence of durable assets.

In the next section, we provide further motivations for this paper by referring to the related literature. Section 3 presents the simplest version of the model, which is then extended to include different operating costs in Section 4, alternative forms of asset specificity in Section 5, resale obligations in Section 6, investment requirements in Section 7. Concluding remarks are in Section 8.

³Williamson's own work is always very careful to point out that his analysis shows the importance of potential contractual problems, not their inevitability.

2 Related literature

2.1 Franchise bidding for natural monopoly

The possibility of transferring transaction-specific assets to a new supplier was first made by Posner (1972) in his proposal to use franchise bidding for the cable television industry.⁴

The idea of franchise bidding, i.e., using competitive bidding for the exclusive right to provide some public utility services, has a long history.⁵ More than one hundred and fifty years ago, Sir Edwin Chadwick began his advocacy of “competition for the field” as an alternative to (unregulated) “competition within the field”. Chadwick (1859) advocates franchise bidding not only for what we now call “public utilities” (water distribution and railways), but also for a variety of other industries, including funerals, cabs, bread and beer. His arguments are based partly on the exploitation of (alleged) economies of scale, but mainly on the need to remedy other kinds of market failures. Demsetz’s (1968) case for franchise bidding comes from a different direction. He pointed out that technological economies of scale do not imply *per se* the necessity of price regulation to prevent monopoly pricing. The regulator (a government agency or a buyers’ cooperative) could “simply” have to run a procurement auction and the “competitive” price will prevail.⁶ According to Demsetz (1968), whether franchise bidding or regulation are to be preferred must be decided on the basis of a case-by-case analysis of the relevant contracts and transaction costs.

In his analysis of the cable television industry, Posner (1972) advocates the use of franchise bidding as opposed to traditional price regulation. In particular, he proposes the use of franchise contracts with relatively short-term duration in order to

⁴The paper by Posner(1972) actually predates the use of the term *Fundamental Transformation* and is more or less contemporaneous with Williamson’s earliest work on the topic.

⁵See Crocker and Masten (1996) for an extensive survey.

⁶This “competitive price” may be a first-best non-linear price or a second-best (minimum average cost) linear price, but this is a side issue. See the 1972 exchange between Telser and Demsetz in the *Journal of Political Economy*. For formal analysis of second-best mechanism design solutions see the monographs by Spulber (1989) and Laffont and Tirole (1993).

maintain flexibility in dealing with a (then) young industry. Williamson (1976) and Goldberg (1976) argue instead that the transaction costs involved in the production of public utility services are quite considerable. Franchise bidding arrangements would likely be fraught with controversies and renegotiations that may be better dealt with in a more hands-on regulatory environment. Most of Williamson's and Goldberg's arguments seem to be concerned with uncertainty and risk-sharing in the presence of long-term investments and contracts.⁷ Williamson, in particular, worries about the hold-up problems related to the Fundamental Transformation.⁸ Posner himself had considered this issue and argued that it did not pose a serious problem for a couple of reasons: first, because a winning entrant and a losing incumbent would always negotiate an efficient transfer of the specific assets; second, because regulators could always mandate the transfer of the assets "at its original cost, as depreciated." Williamson convincingly argues that the latter claim is unwarranted, as finding an appropriate valuation is much harder and open to manipulation than Posner seemed to believe. Williamson's criticism of Posner's first claim (which is the focus of this paper) is less cogent. Williamson mentions the possibility that transaction-specific human capital may be acquired in the course of operating the franchise and that human capital can be hard to transfer to another firm.⁹ However, Williamson does not consider the possibility of subcontracting as an alternative to asset transfers. Moreover, the quantitative significance of such firm-specific capital (human or otherwise) is unclear and, at least in the models of this paper, small cost differences have only small (or even zero) effects on equilibrium prices.

Williamson's criticism seems to have been taken as conclusive by most undergraduate textbooks on regulation – even more than by Williamson himself.¹⁰ Fur-

⁷Demsetz (1968) instead focused on the more traditional rationale for regulation, namely economies of scale. Indeed, his paper can be interpreted as doing for economies of scale what Coase (1960) had done earlier for externalities.

⁸Peacock and Rowley (1972) also criticized

Demsetz's proposal on this ground.

⁹See Lewis and Yildirim (2002) for a model of optimal buyer's policy in the presence of learning-by-doing.

¹⁰For example, see Schmalensee (1979) and Sherman (1989). Train (1991) makes an interesting

ther research has focused exclusively on the design of auction procedures that jointly determined the winner's prize and the terms for the transfer (when technically possible) of production assets to winning entrants. For example, Laffont and Tirole (1988) studies how regulators should commit to bias the renewal auction in order to compensate for the incumbency asymmetry while providing incentives for the incumbent to make efficient unobservable investments in the asset.¹¹

The paper closest to this one is Harstad and Crew (1999). They also consider an infinite sequence of second-price auctions (as opposed to two period models), but in their model bids determine the price of the asset that would be transferred according to a (more or less arbitrary) function.¹² In order to preserve incentive compatibility, the losing incumbent receives a higher payment than the price paid by the winning entrant. Coming up with the difference (and committing to do so in future auctions by using the same transfer function) may be a problem for regulators.¹³

These papers assume that the asset is fully relationship specific and that the incumbent cannot threaten to walk away with it. It is as if they assumed that the assets are owned by the regulator/buyer and merely operated by the incumbents. In practice, that is what often happens: Many public services are procured using "Build, Operate and Transfer" (BOT) contracts.¹⁴ The problem is essentially reduced to a possibly difficult, but conceptually standard moral hazard issue. The principal (regulator or buyer) "only" needs to provide incentives for the contractor

connection with the contestability literature, implicitly equating the feasibility of franchise bidding with that of moving assets to other uses. For a counterexample, see the textbook by Viscusi, Vernon and Harrington (2000).

¹¹See also Stole (1994). The mechanism design literature on auctioning franchise contracts, supplier switching and dual sourcing is surveyed in Laffont and Tirole (1993).

¹²Their paper also differs from this one in that they allow for period-by-period private cost information, but consider only costlessly transferable assets.

¹³The authors discuss informally some ways in which the balanced-budget problem could be tackled. This would not be a problem in a procurement context, but there the commitment problem would be more serious.

¹⁴See Klein et. al. (1998) for more details and a rather positive assessment of the effectiveness of these contracts. Engel, Fischer and Galetovic (2001) propose an original method to determine endogenously the duration of such contracts.

to make enough efforts to maintain the asset.

The point of Williamson's analysis, however, is that it is often inefficient to assign *de facto* ownership of the assets to the buyer. For example, the buyer may be unable to assess the conditions, technical needs and market value of an asset. The point of this paper is that the incumbent's competitors may instead have the ability to evaluate such assets (or to negotiate subcontracting agreements) at reasonable cost.

In support of his thesis, Williamson (1976) cites the city of Oakland's unhappy experience with cable television franchising, where the auction winner successfully renegotiated the contract, supplying lower quality service at higher prices. However, later empirical investigations by Mark Zupan (1989a,b,c) and Robin Prager (1989, 1990), however, showed that Williamson's example was not really representative of the U.S. CATV franchising experience.¹⁵ Franchise bidding has also been employed in other industries and infrastructure projects such as roads and seaports in Chile (Engel, Fischer and Galetovic, 2001), railways (Affuso and Newbery, 2002), bus services (Cantillon and Pesendorfer, 2003), local electricity distribution (Littlechild, 2002) in the United Kingdom, telecommunications services in Peru, Chile and Colombia (Raja, 2003). In sum, the empirical evidence suggests that franchise bidding can work well, at least if enough care is taken in designing the auctions.

2.2 Subcontracting

Technically, this paper extends the analysis in Sorana (2000) to take durable assets into account. Kamien, Li and Samet (1989) and Spiegel (1993) are some of the earliest models of subcontracting.¹⁶ They consider one-shot procurement situations

¹⁵In their survey, Crocker and Masten (1996) point out that a proper evaluation ought to consider a comparison with cases where alternative regulatory methods had been employed. Such relative comparisons would be quite difficult due to selection bias: franchise bidding may seem to work well precisely because regulators are smart enough to choose it only when it would work well.

¹⁶The case of seller's auctions with resale is somewhat more complex since there is no natural deadline for post-auction bargaining. The seminal analysis, also in a complete information setting, is in Milgrom (1987). Extensions to imperfect information are in Ausubel and Cramton (1999a,b), Haile (2003) and Zheng (2003).

where asset sales are indistinguishable from post-auction subcontracting and the latter is motivated by the assumption of decreasing returns to scale technologies. Krishnan and Röller (1993) and Antelo and Bru (2002) focus on how subcontracting affects the degree of competition *in the market*. Krishnan and Röller (1993) study the case in which entrants can buy capacity from the incumbent *before* competing (once) *à la* Cournot. Antelo and Bru (2002) show the equivalence of subcontracting (via forward contracts) and sales of capacity *before* one stage of a model of Cournot competition with a competitive fringe. Gale, Hausch and Stegeman (2000) study a (finite) sequence of procurement auctions with post-auction subcontracting. In their model, the auctions are run independently (and asynchronously) by several buyers and the dynamic links are due to the sellers' capacity constraints. They do not consider the possibility of altering capacity by selling the corresponding assets.

2.3 Contract duration

Williamson's (1976) criticism of Posner (1972) focuses on the privileged position of incumbents when the franchise duration is shorter than the life of specific assets. Goldberg (1976) worries about the opposite problem: in the ex-post bilateral monopoly situation caused by the Fundamental Transformation, regulators may have the upper hand and *de facto* expropriate the incumbent's assets, e.g., by setting rates that ignore the (sunk) cost of the assets. Firms' fears of expropriation could lead to lack of investment incentives and higher procurement prices incorporating that risk. The problem is caused by the alleged lack of commitment power by the regulator, who would switch from franchise bidding to negotiated rate-setting.¹⁷ This could happen also within the duration of the franchise contract, possibly in response to unforeseen contingencies affecting the firm's costs or consumers' valuations.

The effect of unforeseen contingencies on contract structure is still theoretically

¹⁷In the U.S. and elsewhere there are constitutional provisions against such "takings." Goldberg essentially assumes that unscrupulous regulators (or, rather, regulators that are overzealous in defending consumers' interests) might be able to evade judicial enforcement. These tactics would probably be easier for private buyers in procurement contexts.

unsettled and it will not be discussed further in this paper. In fact, there is no explicit consideration of uncertainty in this paper, except in the last section on asset maintenance.¹⁸ Moreover, only the most passive of regulatory behavior is considered here: the regulator/buyer is committed to run a sequence of second-price procurement auctions without reserve prices. Even with full commitment and no uncertainty, Goldberg's concern with short franchise duration is justified: procurement costs are higher with shorter franchises.¹⁹

Longer contract durations tend to increase incentives for (non-verifiable) investments.²⁰ This is generally considered to be beneficial, because of under-investment results in standard property rights models.

Affuso and Newbery (2002) show that, in the case of UK railway operation franchises, incumbents have generally invested sufficiently, though they seemed to concentrate their investments near the end of the franchise term. They conjecture that this is done to induce the regulator to extend their franchise.²¹

As shown in Section 7, it is also possible that investment incentives are excessive from the social welfare point of view. The intuition comes directly from Williamson's Fundamental Transformation: if being the incumbent confers ex-post market power, it may pay to own productive assets already at the ex-ante competitive stage. The role of durable capital as a pre-emption device to create or develop incumbency advantages has also been studied in the industrial organization literature, starting

¹⁸The discount factor may be interpreted as incorporating a probability of termination of the relationship. This would not be enough to allow a meaningful discussion of the costs of long contract duration, because the discount factor applies also to periods within a contract. Introducing a separate probability of termination at the end of the contract would be a straightforward extension and it is left for further research.

¹⁹However, contrary to Goldberg's case, incumbents benefit from shorter franchises.

²⁰See Bandiera (2002) for some empirical evidence on contract duration and further references. Fudenberg, Levine and Milgrom (1990) show that, in the absence of non-verifiable investments, anything that can be implemented by long-term contracts can also be implemented by short-term ones.

²¹At the time of this writing, only a few franchise have expired, so it is too early to judge this issue. Neeman and Orosel (1999) develop a formal model along these lines.

with Eaton and Lipsey (1980).²²

3 The basic model

Consider an industry with two firms, referred to as the incumbent I and the entrant E , competing for the provision of “service” to a (representative) consumer with rigid unit demand for the service. The quality and features of the service are assumed to be well-defined and verifiable. Its production requires an infinitely lived asset which can be produced at cost K and that has no alternative use.²³ I will abuse notation by using K for both the asset itself and for its cost. Both firms require the same kind of asset in order to provide service and the structure and quality of the asset cannot be modified. The asset can be transferred freely between the two firms.²⁴ There are no other production costs.²⁵

The time-line of the model is as follows:

1. Firms bid in a second-price procurement auction without reserve price. The object of the auction is the obligation to provide service for D periods ($D \geq 1$); the lowest bidder is paid the other firm’s bid, with ties resolved by uniform randomization.²⁶
2. The winner has one period to procure the asset – either externally (at cost K) or via bargaining with the other firm if the latter owns one. Bargaining is efficient and the auction winner gets share $\alpha \in [0, 1]$ of the gains from trade.²⁷
3. The winner must provide (directly or via subcontracting) service for D periods.

²²See Gilbert (1989) for a survey and Ponsard (2000) for a more recent contribution.

²³Alternative uses are considered in section 5. The possibility of asset failures and the role of maintenance costs are considered in section 7.

²⁴Section 5 considers transfer costs.

²⁵Operating costs are considered in section 4.

²⁶The assumption that the winner receives the whole price as an initial lump sum payment does not affect the analysis in this paper. Some of its effects on the incentives for service quality and collusion are studied in Sorana (2001, Ch. 4).

²⁷These are determined endogenously as continuation values of the game.

4. The game goes back to step one.²⁸

Both buyer and firms discount the future at the same (commonly known) discount factor $(1+r)^{-1} \in [0, 1)$ per period. It will be convenient to let $\delta \equiv (1+r)^{-D}$.

Firms are not allowed to sign contracts that extend beyond the current franchise duration, nor can they own more than one instance of the asset.

The state of this dynamic game is defined by the firms' asset ownership profiles $x = \{x^f \in \{0, K\}\}_{f \in \{I, E\}}$.

Only Markov perfect equilibria with constant α will be considered.

Proposition 1 *In the only symmetric Markov-perfect equilibrium of the game, the net present values NPV of procurement costs (s_{npv}) and of the firms' profits (π^f) are*

State:	$(K, 0)$	(K, K)	$(0, 0)$
s_{npv}	$\frac{1-\alpha}{1-\delta(1-\alpha)}K$	0	K
π^I	$\frac{1-\alpha}{1-\delta(1-\alpha)}K$	0	0
π^E	0	0	0

The values in state $(0, K)$ are then determined by symmetry.

Proof: In state (K, K) both firms can provide service at zero cost and the usual Bertrand logic (together with the observation that (K, K) is an absorbing state) gives the desired result.

Assume now that the initial state is $(K, 0)$. If I wins the auction at price p' , then it provides the service and the state is unchanged. We have:

$$\begin{aligned}\pi_{wins}^I &= p' + \delta\pi^I(K, 0) \\ \pi_{loses}^E &= 0 + \delta\pi^E(K, 0)\end{aligned}$$

If E wins the auction at price p , then it must buy the asset.²⁹

²⁸One may think of the auction as being run one period before the end of the franchise in order to allow time for asset procurement without service interruption.

²⁹Borrowing the asset or subcontracting service provision to I would lead to the same equilibrium payoffs.

The efficient outcome is to buy it from the incumbent, say at price p_K , in which case

$$\begin{aligned}\pi^I &= p_K + \delta\pi^I(0, K) \\ \pi^E &= p - p_K + \delta\pi^E(0, K)\end{aligned}$$

If bargaining fails, E procures K externally and

$$\begin{aligned}\pi^I &= 0 + \delta\pi^I(K, K) = 0 \\ \pi^E &= p - K + \delta\pi^E(K, K) = p - K\end{aligned}$$

The gains from trade are

$$G = \delta(\pi^I(0, K) + \pi^E(0, K)) + K > 0$$

These are positive since profits must always be non-negative.³⁰ By assumption, the efficient payoffs are realized and I gets a fraction $(1 - \alpha)$ of G over the disagreement payoff: $\pi^I = (1 - \alpha)G + 0$. From this we get $p_K = (1 - \alpha)G - \delta\pi^I(0, K)$.

Therefore

$$\begin{aligned}\pi_{loses}^I &= (1 - \alpha)\{\delta[\pi^I(0, K) + \pi^I(K, 0)] + K\} \\ \pi_{wins}^E &= p - \alpha\delta[\pi^I(0, K) + \pi^I(K, 0)] + (1 - \alpha)K\end{aligned}$$

Bids in the second-price (procurement) auction are the difference between the profit in case of loss and those in case of victory (apart from the auction payment):

$$\begin{aligned}b^I &= \pi_{loses}^I - (\pi_{wins}^I - p') \\ b^E &= \pi_{loses}^E - (\pi_{wins}^E - p)\end{aligned}$$

We get

$$b^I = (1 - \alpha)\{\delta[\pi^I(0, K) + \pi^I(K, 0)] + K\} - \delta\pi^I(K, 0) = b^E = p = p'$$

³⁰This proves that the efficient outcome is indeed efficient from the point of view of the firms.

It follows that $\pi_{wins}^f = \pi_{loses}^f = \pi^f(K, 0)$, hence we can find the firms' payoffs by looking at π_{loses}^f . For the entrant, we get $\pi^E(K, 0) = 0 + \delta\pi^E(K, 0)$, hence $\pi^E(K, 0) = 0$. For the incumbent, we get

$$\begin{aligned}\pi^I(K, 0) &= (1 - \alpha)\{\delta[0 + \pi^I(K, 0)] + K\} \\ &= \frac{1 - \alpha}{1 - \delta(1 - \alpha)}K\end{aligned}$$

Finally, we get $s = \frac{(1-\delta)(1-\alpha)}{1-\delta(1-\alpha)}K$. This concludes the proof for $x_0 = (K, 0)$.

Assume now that the initial state is $(0, 0)$. The winner of the auction will have to “build” the asset at cost K and will then enter the next auction as the incumbent in state $(K, 0)$. So both firms will bid $K - \delta\pi^I(K, 0) = K - \delta\frac{1-\alpha}{1-\delta(1-\alpha)}K$ and this will be the procurement cost in the first auction. The net present values are then

$$\begin{aligned}s_{npv}(0, 0) &= K - \delta\frac{1 - \alpha}{1 - \delta(1 - \alpha)}K + \delta s_{npv}(K, 0) = K \\ \pi^{Win}(0, 0) &= [K - \delta\frac{1 - \alpha}{1 - \delta(1 - \alpha)}K] - K + \delta\pi^I(K, 0) = 0 \\ \pi^{Win}(0, 0) &= 0\end{aligned}$$

Q. E. D.

Recalling that $\delta = (1 + r)^{-D}$, it follows immediately that

Corollary 1 *If the initial state is $(K, 0)$, procurement costs are strictly decreasing in the auction winner's bargaining power (α) and in the franchise duration (D) .*

Proof: By direct computation: $\frac{\partial s_{npv}(K, 0)}{\partial \alpha} = -[1 - \delta(1 - \alpha)]^{-2} < 0$ and $\frac{\partial s_{npv}(K, 0)}{\partial D} = \frac{\partial s_{npv}(K, 0)}{\partial \delta} \frac{\partial \delta}{\partial D} < 0$ since the first term is positive and the second negative.

Q. E. D.

Goldberg's conjecture that procurement costs would be higher with shorter franchise terms is thus confirmed even in a model without uncertainty. The intuition for this result is that the NPV of profits from future auctions without duplicate assets decreases with D , hence so do the gains from trade G , the asset price $p_K = (1 - \alpha)G$ and thus the firms' bids.

It is important to notice that procurement costs are highly dependant on the model's “free” parameter α . For example:

- if $\alpha = 0$, then $s_{npv}(K, 0) = \frac{K}{1-\delta}$, i.e., in every auction other than the first one, procurement costs are equal to the entire value of the infinitely lived asset. In this case, payoffs are as if neither asset sales, nor subcontracting were possible and Williamson's hold-up theory is fully confirmed.
- if $\alpha = 0.5$, then $s_{npv}(K, 0) = \frac{K}{2-\delta} < K$.
- if $\alpha = 1$, then $s_{npv}(K, 0) = 0 = \pi^I(K, 0)$. Goldberg's concern about expropriation can thus be justified also in this model, but for different reasons and with a very different outcome: consumers benefit from it.

This wide range of possible outcomes may be a serious cause of concern for risk-averse regulators who have little information or control over the structure of post-auction bargaining. If the model presented here were to be taken literally, this problem would have an easy solution: the regulator could simply require that the winning bidder make a single take-it-or-leave-it offer to buy the asset. Obviously, however, this would be a dangerous restriction in the more realistic case in which the firms do not know each other's costs and asset conditions exactly.³¹

In the MPE of the basic model, the resale price of the asset is larger than its production cost if $\delta > \frac{1-\alpha}{\alpha}$ or, equivalently, $\alpha < \delta/(1+\delta)$.

So believing that p_K must be smaller than K is equivalent to believing a restriction on $\alpha \geq \delta/(1-\delta)$.

The result does not depend on the fact that there is only one potential entrant in the model. If the potential entrants differ in their bargaining power (i.e., in the price for which they can get the asset from its owner), then the one with the best bargaining power (highest α) will have a higher value from winning. It will bid less than the other entrants and its bid (equal to the incumbent's) will determine the outcome of the game.

³¹A natural direction of further research would be to move towards mechanism design approaches in which the regulator controls at least some aspects of the asset transfer procedure. The motivation for this paper, however, was to study what happens when the regulator does *not* bother with this problem at all.

3.1 Bargaining failures

The analysis in this paper is based on the assumption that when the deadline for service provision (or for the time-to-build constraint to become binding) approaches, the parties reach an efficient agreement. Yet there is experimental evidence that bargaining parties may fail to reach an agreement before the deadline even in complete information games that are simpler than those studied in this paper.³² In this section we account for bargaining failures, albeit in a rather ad hoc fashion.

We assume that there is an exogenous probability β of break-down in bargaining negotiations. However, if there is no breakdown, then the bargaining outcome is as before (i.e., as if $\beta = 0$).³³

The expressions for the firms' payoffs when the incumbent wins, for the efficient and disagreement payoffs when the entrant wins are unchanged and so is that for the asset resale price when bargaining succeeds.

However, the expected payoffs when the entrant wins must now reflect the possibility of bargaining failure:

$$\begin{aligned}\pi_{loses}^I &= \beta \cdot 0 + (1 - \beta)\pi_{eff}^I \\ &= (1 - \beta)(1 - \alpha)(K + \delta\pi^I(K, 0)) \\ \pi_{wins}^E &= \beta[p^E - K] + (1 - \beta)\pi_{eff}^E \\ &= p^E - [\beta + (1 - \beta)(1 - \alpha)]K + (1 - \beta)\alpha\delta\pi^I(K, 0)\end{aligned}$$

By the usual calculations, the firms' equilibrium bids satisfy

$$\begin{aligned}b^I &= (1 - \beta)(1 - \alpha)K - [1 - (1 - \beta)(1 - \alpha)]\delta\pi^I(K, 0) \\ b^E &= [\beta + (1 - \beta)(1 - \alpha)]K - (1 - \beta)\alpha\delta\pi^I(K, 0)\end{aligned}$$

Since $b^E - b^I = \beta(K + \delta\pi^I(K, 0)) > 0$, the (current) incumbent always wins and the equilibrium price in the auction is equal to entrant's bid: $s = p^I = b^E$.

³²See Roth et al. (1988) for the experimental evidence. Ma and Manove (1993) build a theoretical model based on random delays in the communication of offers in which the (unique) MPE involves strategic delay and positive probability of bargaining failure.

³³In the model by Ma and Manove (1993) the levels of α and β are determined as part of the equilibrium and α is shown to be close to one half.

The incumbent's payoff then satisfies

$$\begin{aligned}\pi^I(K, 0) &= s + \delta\pi^I(K, 0) \\ &= [\beta + (1 - \beta)(1 - \alpha)]K + [1 - (1 - \beta)\alpha]\delta\pi^I(K, 0) \\ &= \frac{1 - \alpha(1 - \beta)}{1 - \delta[1 - \alpha(1 - \beta)]}K\end{aligned}$$

Finally we get

$$s = \frac{(1 - \delta)[1 - \alpha(1 - \beta)]}{1 - \delta[1 - \alpha(1 - \beta)]}K$$

Summing up,

Proposition 2 *If post-auction bargaining breaks down with (exogenous) probability $\beta > 0$, then the incumbent will always win the auction. The firms' payoff and the procurement costs will change as if the bargaining power of the auction winner had been lowered from α to $\hat{\alpha} \equiv \alpha(1 - \beta)$.*

Remark: Since the incumbent always wins, there is no bargaining, hence the possibility of bargaining failure at the subcontracting stage remains off the equilibrium path of the whole game. This need not be the case if bidders had private information about their valuations.

Remark: Although the formulas remain the same, one should be careful in the interpretation. The “intuitive” reason for restricting α to the interval $[\delta/(1 + \delta), 1]$ (i.e., keeping $p_K \leq K$) does not extend to $\bar{\alpha}$.

4 Operating costs

In the basic model, both firms are assumed to have the same (zero) costs to operate the durable assets. In this section, the model is extended to allow different operating costs which do not depend on asset ownership. For notational simplicity, only the case of constant costs will be considered.

Let service provision in any given period require costs equal to c^f for firm $f \in \{I, E\}$. These operating costs are independent of whether a firm buys or leases a new durable asset or one previously used by the other firm.

The description of post-auction bargaining now needs some assumptions about timing. It seems natural to assume that, if bargaining initially ends in disagreement and an entrant builds duplicate facilities, there is still time to bargain over the transfer of service production (subcontracting).³⁴ The idea is that procurement of the asset cannot be instantaneous and simultaneous with the provision of service, so there is always time for further negotiations.

Somewhat informally, the structure of bargaining can be described as follows:

1. if the winner owns the asset and has lower variable costs than the loser, then there is nothing to bargain about.
2. if the winner does not own the asset and has lower variable costs than the loser, then it will try to buy the asset from the loser. As in the basic model, the (privately) efficient outcome is reached (i.e., the asset is sold) and the buyer gets a fraction $\alpha \in [0, 1]$ of the gains from trade.
3. if the winner does not own the asset and has higher variable costs than the loser, then it will try to delegate production to the loser. Since the winner has to provide service by a fixed deadline, if no agreement is reached “early enough,” the winner will have to procure the asset externally.³⁵ After that, it will bargain again over the provision of service. In all cases, reached agreements give the winner a fraction α of the gains from trade.
4. if the winner owns the asset and has higher variable costs, then it will want to buy subcontracting services and either lease or sell the asset to the loser. In the context of this model, leasing and selling are equivalent and I will present the calculations for the case of sale only. Once again, agreements are reached which give the winner a fraction α of the gains from trade.

Following steps similar to those used in the solution of the basic model, we get

³⁴No hard feelings after previous break-ups!

³⁵“Early enough” here means that there is enough time to build duplicate assets. If the auction winner does not have enough time to do so, it would be at the mercy of the incumbent and end up with an infinitely negative payoff.

Proposition 3 *Let $c^{(1)} \equiv \min\{c^I, c^E\}$ and $c^{(2)} \equiv \max\{c^I, c^E\}$. In the only symmetric Markov-Perfect equilibrium of the game defined above, the net present value of total procurement costs is*

$$s_{npv} = \begin{cases} \frac{1}{1-\delta}[\alpha c^{(1)} + (1-\alpha)c^{(2)}] + K & \text{if } x = (0,0) \\ \frac{1}{1-\delta}[\alpha c^{(1)} + (1-\alpha)c^{(2)}] + \frac{1-\alpha}{1-\delta(1-\alpha)}K & \text{if } x \neq (0,0) \end{cases}$$

and the firms' net present value of profits are

$$\pi^f = \frac{1-\alpha}{1-\delta}(c^{(2)} - c^f)^+ + \frac{1-\alpha}{1-\delta(1-\alpha)}(x^f - x^{(2)})^+$$

Proof: See Appendix.

Given the assumptions of risk-neutrality and efficient bargaining, it is straightforward to generalize the above proposition to the case in which operating costs may change from period to period, following some Markov process independent of asset ownership: The same formulas would hold in expectations. In particular, the randomness of variable costs would not make shorter franchise terms more desirable. However, this could be an important issue if subcontracting is not fully efficient: if the firms are asymmetrically informed, auctions may achieve efficiency when private bargaining cannot, so running auctions more frequently may increase efficiency.

It is also easy to allow for the presence of several independent assets and corresponding operating costs. Let H be the set of asset types, K_h the cost of asset $h \in H$, c_h^f is the corresponding operating cost for firm f and $x_h^{(2)}$ be equal to K_h if there is more than one firms that owns a type h asset and equal to zero otherwise. Then the linearity of the Nash bargaining solution guarantees that the different cost components can be simply added. The MPE values are then

$$\begin{aligned} s_{npv} = & \sum_{h \in H} \frac{1}{1-\delta}[\alpha c_h^{(1)} + (1-\alpha)c_h^{(2)}] + \\ & + \sum_{\{h \in H | \forall f, x_h^f = 0\}} K_h + \sum_{\{h \in H | \exists f, x_h^f = K_h\}} \frac{1-\alpha}{1-\delta(1-\alpha)}(K_h - x_h^{(2)}) \end{aligned}$$

and

$$\pi^f = \frac{1-\alpha}{1-\delta} \sum_{h \in H} (c_h^{(2)} - c_h^f)^+ + \frac{1-\alpha}{1-\delta(1-\alpha)} \sum_{h \in H} (x_h^f - x_h^{(2)})^+$$

It is just a bit more difficult (but much more tedious) to show that exactly the same formulas hold if there are more than two firms – at least if auction winners have enough time to run subcontracting auctions as well as direct negotiations.³⁶

5 Alternative forms of asset specificity

The previous sections dealt with the case of assets that are perfectly transferable across firms. This may be a reasonable assumption if all firms share the same technology and can thus easily incorporate other firms' assets into their network.

In the case of transferable assets, it is possible to provide service not only by building or buying the asset, but also by leasing the asset for one or more periods at the time. As mentioned above, allowing for the possibility of leasing does not change the result of the analysis. In practice, however, leasing the incumbent's assets for one period may not be an efficient contractual arrangement because of moral hazard considerations (e.g., with regard to care and maintenance of the assets). But even sales may be problematic if the quality of the asset is not easily observable by the potential buyer. And sales could be out of the question if entrants are going to adopt a technology that is incompatible with the incumbent's. In sum, the asset may be firm-specific as well as specific to the service under auction. Conversely, the asset may be (at least partially) generic with respect to both firms and services.

5.1 Transfer costs

In practice, the transfer of assets always entails some adaptation costs. For example, the new owner's employees must learn the inevitable idiosyncracies of the assets.³⁷

³⁶For more details, see Sorana (2000, 2001).

³⁷This includes the case of a winning entrant which buys out the incumbent firm as a whole or simply hires its key employees: the buyer must then learn about the idiosyncracies of his or her new employees.

This is one Williamson's (1976) major arguments for concern. However, *if subcontracting is efficient, and there are no operating costs, then transfer costs have no effect on the equilibrium payoffs of the basic model.* Their only consequence is that a winning entrant will subcontract service provision instead of buying the asset and providing the service itself. The incumbent will maintain the property of the asset, but the future gains from incumbency will be reflected in a lower subcontracting price.

Transfer costs do matter, even with efficient subcontracting, if we consider operating costs. The equilibrium outcome may then be socially inefficient, but the impact on procurement costs need not be too severe.

5.1.1 Firm-specific sunk assets with subcontracting

Assume that the asset K is not transferable, but fully sunk. For simplicity, I only consider the model with one service component, one incumbent that already owns the asset and one entrant that does not.³⁸ Thus the system can be in only two states: $x = (K, 0)$ or $x = (K, K)$. To save on notation, I will drop the first component of the state and write $x \in \{0, K\}$.

Even if the asset is not transferable, it may still be possible to subcontract the provision of service. The presence of sunk costs, however, introduces a new possibility: production by the entrant may be unprofitable for bidders even when it is efficient. If the incumbent has relatively high variable costs, delegating production to an entrant may be efficient even considering the necessity to build duplicate assets, but the presence of duplicate assets could reduce the equilibrium level of subsidies in future auctions by more than the cost savings.³⁹ This makes calculations

³⁸Obviously, except for stranded costs consideration, it does not matter how much the incumbent paid for the asset originally. Therefore this section does not assume that the two firms need the same kind of asset or assets of equal prices. Formally, the analysis also applies to the case in which one firm (here called "the incumbent") does not need any specialized fixed assets, while the other (called "the entrant") does.

³⁹With transferable assets subcontracting can always occur without building duplicate assets and thus leaving future subsidies unaffected.

of disagreement payoffs much more complicated and, for simplicity, this section considers the case $D = 1$ only and defers the proof to Appendix B.

Proposition 4 *Consider a sequence of procurement auctions without reserve price with one incumbent having operating costs equal to c^I and a potential entrant having operating costs equal to c^E . Assume that the entrant would also have to incur a one-time sunk cost K before it can provide any service.*

Then, in the Markov-perfect equilibrium of the game, service is provided by the incumbent if

$$c^I - c^E < \frac{1 - \delta}{1 - \alpha\delta} K$$

Otherwise, service will be provided by the entrant.

As a consequence, entry is efficient when it occurs, but it fails to occur even if it would be efficient when

$$(1 - \delta)K < c^I - c^E < \frac{1 - \delta}{1 - \alpha\delta} K$$

The firms' profits, the level of subsidies in the initial period and the net present value of total subsidies are reported in the tables below.

$c^I - c^E$	$\pi^I(0)$	$\pi^E(0)$
$c^I - c^E < 0$	$\frac{1-\alpha}{1-\delta}(c^I - c^E) + \frac{1-\alpha}{1-\delta(1-\alpha)}K$	0
$0 < c^I - c^E < \frac{1-\delta}{1-\alpha\delta}K$	$\frac{1-\alpha}{1-\delta} \frac{1-\alpha\delta}{1-\delta(1-\alpha)} [\frac{1-\delta}{1-\alpha\delta}K - (c^I - c^E)]$	0
$\frac{1-\delta}{1-\alpha\delta}K < c^I - c^E$	0	$\frac{1-\alpha}{1-\delta}(c^I - c^E - \frac{1-\delta}{1-\alpha\delta}K)$

$c^I - c^E$	$s(0)$	s^{npv}
$c^I - c^E < 0$	$\alpha c^I + (1 - \alpha)c^E + \frac{(1-\delta)(1-\alpha)}{1-\delta(1-\alpha)}K$	$\frac{\alpha c^I + (1-\alpha)c^E}{1-\delta} + \frac{1-\alpha}{1-\delta(1-\alpha)}K$
$0 < c^I - c^E < \frac{1-\delta}{1-\alpha\delta}K$	$c^I + \frac{(1-\alpha)(1-\alpha\delta)}{1-\delta(1-\alpha)} [\frac{1-\delta}{1-\alpha\delta}K - (c^I - c^E)]$	$\frac{1}{1-\delta}s(0)$
$\frac{1-\delta}{1-\alpha\delta}K < c^I - c^E$	$\alpha c^E + (1 - \alpha)c^I + \alpha \frac{1-\delta}{1-\alpha\delta}K$	$\frac{\alpha c^E + (1-\alpha)c^I}{1-\delta} + \frac{\alpha(1-\delta)}{1-\alpha\delta}K$

Remark: As mentioned above, that the incumbent may have never paid the entry cost K . It may be simply a firm that uses a technology with low (zero) sunk costs. This result thus suggests that the procurement process is biased against technologies that have higher sunk costs.

5.1.2 Moderate transfer costs without subcontracting

For completeness, consider the possibility that the asset is transferable at some (non-prohibitive) cost $\chi > 0$, but subcontracting of service provision is not allowed. For simplicity, I disregard variable costs and assume $\chi < K$. In this case, the (efficient) payoffs for a winning entrant is equal to $s^E - p_K - \chi + \delta\pi$, the gains from trade are $K - \chi + \delta\pi > 0$ and the usual analysis gives

$$\begin{aligned} b^I &= (1 - \alpha)(K - \chi) - \alpha\delta\pi \\ b^E &= b^I + \chi \end{aligned}$$

Therefore the incumbent always wins and $s = b^E$. As in the case of potential bargaining failures, the incumbent has an efficiency advantage and this is reflected in the bids. We finally obtain

$$\begin{aligned} s &= b^E = \frac{1 - \delta}{1 - \delta(1 - \alpha)}[(1 - \alpha)K + \alpha\chi] \\ s_{npv} &= \pi = \frac{(1 - \alpha)K + \alpha\chi}{1 - \delta(1 - \alpha)} \\ p_K &= \frac{1 - \alpha}{1 - \delta(1 - \alpha)}[K - (1 - \delta)\chi] \end{aligned}$$

5.2 Partially specific assets

There are two different cases to be considered. First, a firm may be able to use the asset for other purposes that do not affect the other bidder. For example, the asset may have a positive scrap value. Second, the “other purposes” may affect the other firm’s profit. For example, it could be used to compete with the other firm in other markets or, if the regulator does not prevent it, in the market for the service under consideration. As shown below, the two cases have dramatically different implications for the equilibrium level of bids.

5.2.1 Assets with positive scrap value

Assume that the asset could be sold to third parties at price $S \leq K$. The disagreement outcome (in case the entrant wins the auction) is now for the incumbent to sell the asset to third parties at price S rather than keeping it for no use. Therefore the state of the game in the next auction will be $(0, K)$ instead of (K, K) and the firms' payoffs will be

$$\begin{aligned}\pi^I &= S + \delta\pi^I(0, K) = S \\ \pi^E &= p^E - K + \delta\pi^E(0, K)\end{aligned}$$

The corresponding gains from trade in post-auction bargaining will then be equal to $K - S$, so $\pi_{loses}^I = S + (1 - \alpha)(K - S) = \alpha S + (1 - \alpha)K$. The usual steps show that this will be equal to the NPV of the incumbent's profits and of the procurement costs. The price p_K at which the entrant will buy the asset from the incumbent, the firms' bids and the payment s are all equal to $(1 - \delta)[\alpha S + (1 - \alpha)K]$.

It then follows that

Proposition 5 *If the asset has a positive scrap value $S \leq K$, the NPV of procurement costs and incumbent's profits in the MPE of the game can never exceed the actual cost of "building" the asset:*

$$s_{npv} = \pi^I = \alpha S + (1 - \alpha)K \leq K$$

In particular, they are independent of the interest rate and of the franchise duration.

The presence of a positive scrap value (weakly) increases the procurement costs and the incumbent's profit if

$$\alpha S + (1 - \alpha)K \geq \frac{1 - \alpha}{1 - \delta(1 - \alpha)}K$$

and (weakly) decreases them if the reverse inequality holds.

5.2.2 Asset usable for additional services

Control of the asset may confer advantages in markets other than the one for which the auction is used. For example, the local loop used for basic telephone service can also be used for ADSL and access to long distance services. Arguably, these advantages would be less useful if other firms also owned similar assets.

To fix ideas, let us assume that the asset is the only input that can produce an additional service W , that no other input is useful for that purpose, that W is sold in an unregulated market characterized by Bertrand competition, and that the per-period monopoly profit is $w \equiv (1 - \delta)\pi_W^{mon}$. By the Bertrand assumption, the duopoly profit is zero for a firm that already owns the asset and negative otherwise.⁴⁰ It follows that $\pi^f(K, K) = 0$, the disagreement payoffs are as before and the efficient payoffs (should the entrant win) are

$$\begin{aligned}\pi_{eff}^I &= p_K + \delta\pi^I(0, K) = p_K \\ \pi_{eff}^E &= p^E - p_K + w + \delta\pi^E(0, K)\end{aligned}$$

The gains from trade are then $G = K + w + \delta\pi^E(0, K)$ and the usual analysis gives

$$\begin{aligned}\pi_{loses}^I = p_K &= (1 - \alpha)[K + w + \delta\pi^I(K, 0)] \\ &= \frac{1 - \alpha}{1 - \delta(1 - \alpha)}(K + w) \\ \pi_{wins}^E &= p^E - p_K + w + \delta\pi^E(0, K) \\ &= p^E + w - (1 - \delta)p_K\end{aligned}$$

⁴⁰This is not strictly necessary for the analysis below. It suffices that the duopoly profits do not justify investing in the asset. If so, one can simply reinterpret w as the difference between total industry profits in monopoly and duopoly.

If the incumbent wins, the payoffs are

$$\begin{aligned}\pi_{wins}^I &= p^I + w + \delta\pi^I(K, 0) \\ &= p^I + w + \delta p_K \\ \pi_{loses}^E &= 0\end{aligned}$$

So the bids (and the equilibrium price of the auction) are all equal to

$$\begin{aligned}s &= (1 - \delta)p_K - w \\ &= \frac{(1 - \delta)(1 - \alpha)}{1 - \delta(1 - \alpha)}K - \frac{\alpha}{1 - \delta(1 - \alpha)}w\end{aligned}$$

The key point to note is that firms compete away (part, all or more than) the monopoly rents in the market for additional services.⁴¹

5.2.3 Asset usable for “competition in the field”

In a regulatory context, the regulator-auctioneer may be unable to prevent a losing incumbent from competing for customers with the auction winner. For example, the U.S. Telecommunications Act of 1996 prevents federal and state regulators from granting any monopoly franchise for telecommunications services. After a Demsetz-type auction or an auction for universal service obligations, a losing incumbent that fails to sell its asset may still want to compete “in the field” with the winning entrant. This changes the disagreement payoffs in post-auction bargaining in a different way than in the case in which the asset is used for the provision of other services (i.e., other than those for which the auction is held).

Under the assumptions of zero operating costs and Bertrand competition, the usual analysis shows that

$$s_{npv} = \pi^I = \frac{1 - \alpha}{\alpha}K$$

and

$$s = p_K = (1 - \delta)\frac{1 - \alpha}{\alpha}K$$

⁴¹The equilibrium bids could even be negative. If that would be the case, but negative bids are not allowed, then we would have $\pi^E(K, 0) > 0$. I will not pursue the issue here.

Procurement costs are thus extremely sensitive to low levels of α : they tend to infinity as α tends to zero.⁴² The mixture of competition “for” and “in” the field can prove to be explosive.

6 Resale Obligations

In this paper it is assumed that an incumbent that loses its business is free to keep its assets if it so wishes. In many cases, however, incumbents do not have complete property rights over their assets. For example, Section 251 of the U.S. Telecommunications Act of 1996 mandates, *inter alia*, that incumbent Local Exchange Carrier (ILEC) provide access to their networks (wholesale or only selected “unbundled network elements”) at regulated prices to all other carriers. This may have a rather counterintuitive consequence: the imposition of resale (or unbundling) obligations may actually *benefit* the incumbent.

The intuition for this result is that the possibility for the entrant to lease the asset at (sufficiently low) regulated prices destroys the credibility of a winning entrant’s threat to build duplicate facilities. For some range of regulated resale prices, this would make the disagreement outcome in the subcontracting negotiations more favorable to the incumbent and lead to higher equilibrium rental prices (hence higher subsidies and profits) than in the absence of resale obligations.

Let $\bar{p}_K$ be the regulated asset resale price.⁴³ Assume $\bar{p}_K < K$ and consider what happens when $x = (K, 0)$ and the entrant wins the auction. The efficient outcome is, as before, for the entrant to buy the incumbent’s asset. In case of disagreement, the entrant will now buy the asset at price $\bar{p}_K$: the entrant would not accept a higher price and the incumbent can

refuse to bargain until the entrant runs out of time when, faced only with the alternative to procure the asset externally at cost K , it will buy the incumbent’s asset at price $\bar{p}_K$.

⁴²Of course, the usual caveat about cases with $p_K > K$ applies here, too.

⁴³Given the assumption of risk-neutrality, this could simply be the expected result of some mandated arbitration process in case of bargaining failure.

The usual calculations then show that, if $\bar{p}_K < K$, the Markov-perfect outcome with zero variable cost is

$$\begin{aligned} s &= (1 - \delta)\bar{p}_K \\ \pi^I(K, 0) &= \frac{1}{1 - \delta}\bar{p}_K = \bar{p}_K \\ \pi^E(K, 0) &= 0 \end{aligned}$$

If instead $\bar{p}_K > K$ and, in particular, if the obligation is not imposed (i.e., $\bar{p}_K = \infty$), the analysis in previous sections shows that the outcome would be

$$\begin{aligned} s &= b^I = b^E = \frac{(1 - \delta)(1 - \alpha)}{1 - \delta(1 - \alpha)}K \\ \pi^I(K, 0) &= \frac{1 - \alpha}{1 - \delta(1 - \alpha)}K \\ \pi^E(K, 0) &= 0 \end{aligned}$$

We thus get

Proposition 6 *The imposition of a resale obligation increases procurement costs and the incumbent's profits if and only if*

$$\frac{1 - \alpha}{1 - \delta(1 - \alpha)}K < \bar{p}_K < K$$

This result must be taken with more than the customary grain of salt. Even if the conditions of the above proposition apply, resale and unbundling obligations can still be defended on the basis of two other possible effects: eliminating the costs from bargaining failures and relaxing the time-to-build constraints for winning entrants. The latter may be a decisive element: if a winning entrant would not have the time necessary to build duplicate assets, its bargaining power would be nil. Temporary leasing obligations on incumbents would then be necessary conditions for the competitiveness of the procurement process.

7 Investment incentives and asset durability

So far, assets have been assumed to be eternally indestructible or, equivalently, to require only verifiable (and perfectly effective) maintenance. In this section, we consider the case of unverifiable maintenance. In particular, we assume that unless some unverifiable maintenance activity of cost m is undertaken at the beginning of a period, the asset is completely destroyed at the end of that period with probability $f \in (0, 1)$.⁴⁴ For simplicity, we assume that proper maintenance is perfectly effective (i.e., it guarantees that the asset will not fail),⁴⁵ that maintenance costs are paid at the end of the period, that the franchise ends immediately before the next auction;⁴⁶ and that negative bids are allowed in the auction.⁴⁷ To make the problem interesting, we assume that fines for asset failures are not feasible.

If only one asset exists, maintenance is technically efficient iff $m \leq fK$. If both firms have the asset, then maintenance is socially useful (ex post) only if both assets would have failed without it – a probability f^2 event. Hence it is never efficient for both of them to invest in maintenance and it is efficient for (only) one of them to do so iff $m \leq f^2K$.

An incumbent's incentive to invest in maintenance may be different in the last period of the franchise and in the other periods. If the entrant still has the asset at that time, the incentives depend also on whether the entrant invests in maintenance. Since $\pi^f(K, K) = 0$, it is never an equilibrium choice for both firms to invest in maintenance in the last period (or any other period). In fact, the entrant can never have a strictly higher incentive to invest than the incumbent. Therefore, whenever

⁴⁴The results in section 4 (additivity of procurement costs and firms' profit across service components) suggest that the analysis can be easily generalized to the case in which the asset is composed of several components, each subject to different failure probabilities.

⁴⁵The results below are also valid, *mutatis mutandis*, if even with proper maintenance, the probability of asset failure is strictly positive – and, of course, lower than without maintenance.

⁴⁶Thus post-auction bargaining should be thought of as happening in “virtual” time at the beginning of the auction period.

⁴⁷This guarantees that a firm's profit will be zero unless it is the only one with the asset. If bids were bound below by zero, then we could have $\pi^f(K, K) > 0$ as winning the auction could give a positive probability of entering the next auction as the only firm with the asset.

there is an equilibrium in which only the entrant invests, there is also an equilibrium in which only the incumbent invests. For simplicity, I will only consider the latter.

If both firms have the asset at the beginning of the last period, the incumbent will invest in maintenance in the last period iff

$$f\pi^I(K, 0) + (1 - f)\pi^I(K, K) - m = f\pi^I(K, 0) - m$$

is (weakly) larger than

$$f[f\pi^I(0, 0) + (1 - f)\pi^I(0, K)] + (1 - f)[f\pi^I(K, 0) + (1 - f)\pi^I(K, K)] = (1 - f)f\pi^I(K, 0)$$

This is equivalent to $m \leq f^2\pi^I(K, 0)$.

If the entrant does not have the asset in the last period of the franchise, then the incumbent will invest iff

$$\pi^I(K, 0) - m \geq f\pi^I(0, 0) + (1 - f)\pi^I(K, 0)$$

or, equivalently, iff $m \leq f\pi^I(K, 0)$.

In the periods before the expiration of the franchise, the incumbent who let its asset fail will surely have to buy a new one in the next period. Therefore, if the entrant does not have the asset, the incumbent will invest iff it is efficient to do so ($m \leq fK$). If the entrant has the asset, then it may still have it in the next period – and thus could sell it to the incumbent if needed. The value of the asset to the incumbent depends on whether the incumbent invests in maintenance in the last period. If it does, then the asset is not worth anything to the entrant (because $\pi^I(K, K) = 0$). Therefore, if the incumbent's asset fails in previous periods and the entrant still has a working asset, it will be exchanged at price $(1 - \alpha)K$.⁴⁸ The investment condition will thus be

$$m \leq f[fK + (1 - f)(1 - \alpha)K] = fK[1 - (1 - f)(1 - \alpha)]$$

Remark: Since the efficiency condition in this case is $m \leq f^2K$, it may seem that we have obtained an overinvestment result: the incumbent may invest in maintenance activities that are inefficient (when $f^2K < m < f^2K + f(1 - f)(1 - \alpha)K$).

⁴⁸I will not write the condition for the case in which the incumbent does not invest in the last period.

Actually, that is incorrect: in equilibrium only one firm has the asset, so the present case is off-the-equilibrium-path.

Let us now compute the equilibrium in which the (current) incumbent always invest in maintenance and firm I enters the auction as the only one that owns an asset.

If firm I wins the auction at price p_I (to be paid immediately as a lump sum), the firms' profits are

$$\begin{aligned}\pi_{wins}^I &= p_I - mA + \delta\pi^I(K, 0) \\ \pi_{loses}^E &= 0\end{aligned}$$

where $A \equiv \frac{1-(1+r)^{-D}}{r} = \sum_{i=1}^D (1+r)^{-i}$.

If firm E wins the auction at price p_E , it will be efficient to transfer the asset leading to payoffs

$$\begin{aligned}\pi_{eff}^I &= p_K \\ \pi_{eff}^E &= p_E - p_K - mA + \delta\pi^I(K, 0)\end{aligned}$$

The disagreement payoffs are instead

$$\begin{aligned}\pi_{dis}^I &= 0 \\ \pi_{dis}^E &= p_E - K - mA + \delta[1 - (1-f)^D]\pi^I(K, 0)\end{aligned}$$

The gains from trade are $\Delta = K + \delta(1-f)^D\pi^I(K, 0)$ and the asset price is

$$p_K = (1-\alpha)K + \delta(1-\alpha)(1-f)^D\pi^I(K, 0)$$

By the usual calculations we get

$$\begin{aligned}\pi^I(K, 0) &= \frac{1-\alpha}{1-\delta(1-\alpha)(1-f)^D}K = p_K \\ s &= mA + \frac{(1-\delta)(1-\alpha)}{1-\delta(1-\alpha)(1-f)^D}K \\ s_{npv} &= \frac{m}{r} + \frac{1-\alpha}{1-\delta(1-\alpha)(1-f)^D}K\end{aligned}$$

Proposition 7 *If maintenance is sufficiently cheap, procurement costs are decreasing in the perishability of the asset.*

The intuition for this result is quite simple. The possibility that the asset is destroyed increases the total profits from building duplicate facilities because the losing incumbent would probably be without the asset in the next auction and the entrant would then make some positive profit. This reduces the potential gains from trade in bargaining, hence the asset price and the equilibrium bids.

Finally, we can check the investment conditions – and we need doing it only for the case in which the incumbent is the only asset owner. In this case, the efficiency condition is $m \leq fK$. We have already found that in this case investment is efficient in all periods before the last one. In the last period, the condition is

$$m \leq f \frac{1 - \alpha}{1 - \delta(1 - \alpha)(1 - f)^D} K$$

We thus obtain

Proposition 8 *The incentives to invest in the last period of the franchise are insufficient, efficient or excessive according to whether $\frac{1 - \alpha}{1 - \delta(1 - \alpha)(1 - f)^D}$ is smaller, equal or larger than one or, equivalently, according to whether the transfer price of the asset is smaller, equal or larger than K .*

To the extent that parameter values for which $p_K > K$ are deemed unrealistic, this result confirms the conventional wisdom that firms tend to skimp on maintenance near the end of their contracts.

This result should not be surprising: the opposite concerns of keeping procurement costs low and investment incentives high are naturally hard to balance - for auctions as well as for other realistic mechanisms. In fact, the incentive to invest in maintenance is inefficiently low precisely when procurement costs reflect a value of the asset that is lower than its production cost: you get what you pay for.

8 Conclusion

This paper has shown that the presence of durable specific assets *per se* does not necessarily eliminate the competitive pressure exercised by potential entrants, even if no restriction is made over asset transfers and subcontracting agreements.⁴⁹ This optimistic conclusion relies crucially on aspects of the bargaining game played by the firms over which regulators and buyers are unlikely to have much information. However, the required assumption on such aspects, namely that a winning entrant would not pay the incumbent for its old assets more than what it would pay external providers for a new copy, does not seem unduly restrictive.⁵⁰

This does not mean that free subcontracting “solves” all the problems related to the *Fundamental Transformation*. First, Goldberg’s and Williamson’s intuitions about the need for long term franchises has been confirmed also within the context of the models presented in this paper. Even without invoking any sort of uncertainty, longer contract durations reduce procurement costs and may reduce distortions in maintenance incentives. Since longer-term contracts require more adjustments and renegotiations, the need for sophisticated governance structure will correspondingly increase. Second, and more important, a lot has been left outside of the context of this paper. In order to focus on asset specificity, we have excluded several issues of practical importance in the design of competitive procurement mechanism. Some of them have been excluded because unrelated to asset specificity. Among those, it is worth mentioning the uncertainty over the type of good to be transacted,⁵¹ the potential informational advantage of incumbents,⁵²

⁴⁹Indeed, forcing incumbents to make their durable assets available at (reasonable) regulated prices may actually increase procurement costs.

⁵⁰Even without much information, regulators and buyers could probably help satisfy it by committing to take up part of the cost to build duplicate assets when winning entrants fail to buy them from former incumbents. If bargaining is efficient, this will remain off the equilibrium path and have no adverse side-effects.

⁵¹See Bajari and Tadelis (2001) for a Transaction Cost Economics perspective. See also Ganuza and Huak (2002). Che (1993) and Branco (1997) study multidimensional bidding mechanisms and Spulber (1989, Ch. 9) proposes a more complex regulatory mechanism.

⁵²See Lewis and Yildirim (2002) for learning-by-doing. The work of Klemperer (1998) shows that

collusion and reputational interactions with other markets. The importance of other neglected issues, like the modelling of unforeseen contingencies, limited liability and risk-aversion, could be amplified by the presence of expensive specific assets and their analysis is simply left for future research. Such future research will probably provide foundations for the *Fundamental Transformation*. But those foundations will have to go deeper than the mere presence of bounded rationality, guile and asset specificity.

A Equilibrium with positive operating costs

Given variable costs c^I and c^E , there are four possible states: $x = (0, 0)$, in which nobody owns the asset, yet; $x = (K, 0)$, in which the incumbent is still the only firm which owns the asset; $x = (K, K)$, in which both firms own assets (i.e., the entrant procured the asset in some previous period); $x = (0, K)$, in which only the entrant owns the asset (i.e., the entrant bought the incumbent's asset in some previous period).⁵³ The net present value of total profit of firm f in state (x^I, x^E) is denoted by $\pi^f(x^I, x^E)$. By symmetry, there are only four cases to consider: duplicate facilities, one efficient incumbent, one inefficient incumbent and initial procurement.

Duplicate facilities: Given the no-disposal assumption, $x = (K, K)$ is an absorbing state. The analysis in Sorana (2000) and the Markovian restriction give us

$$\pi^f(K, K) = \frac{1}{1 - \delta}(1 - \alpha)(c^{(2)} - c^f)^+ \quad (1)$$

and

$$s(K, K) = \frac{1}{1 - \delta}[\alpha c^{(1)} + (1 - \alpha)c^{(2)}] \quad (2)$$

For the reader's convenience, I repeat the proof below.

Let L be the firm with the lowest cost and H the one with the highest cost. The firms' costs are c^L and c^H , their bids are b^L and b^H and the auction price is

even small informational advantages can have large effects on procurement costs.

⁵³I refer to firm I as the incumbent even in this third case, even though the term "original incumbent" would be more precise.

$p = \min\{b^L, b^H\}$.

If $b^L < b^H$, H loses the auction and gets a zero payoff, while L gets $\pi^L = p - c^L = b^H - c^L$.

If $b^L > b^H$, then H wins the auction and it will subcontract the provision of service to L . The gains from trade are $c^H - c^L$ and, by assumption, H gets a fraction α of them, so the subcontracting price is $p_s = c^H - \alpha(c^H - c^L) = \alpha c^L + (1 - \alpha)c^H$. The firms's payoffs are then $\pi^L = p_s - c^L = (1 - \alpha)(c^H - c^L)$ and $\pi^H = p - p_s = b^L - \alpha c^L - (1 - \alpha)c^H$.

In a second-price auction, it is a (weakly) dominant strategy to bid one's true value from winning the auction. Since this is a procurement auction, there is a sign reversal and the equilibrium bids are the difference between the payoff obtained in case of losing the auction and the payoff obtained in case of winning the auction (other than the auction price itself). Therefore $b^H = 0 - [p - \alpha c^L - (1 - \alpha)c^H - p]$ and $b^L = (1 - \alpha)(c^H - c^L) - (p - c^L - p)$. The solution of this system of equations is simply $b^L = b^H = p_s = \alpha c^L + (1 - \alpha)c^H$ and, regardless of how the tie is broken, $\pi^L = (1 - \alpha)(c^H - c^L)$ and $\pi^H = 0$.

Efficient incumbent: Consider now the case $x = (K, 0)$ when $c^I < c^E$. If the entrant has won the auction at price s , efficiency requires that the entrant subcontracts production to the incumbent. Letting p_s denote the subcontracting price, the firms' payoffs in the efficient outcome are

$$Eff = \{p_s - c^I + \delta\pi^I(K, 0); s - p_s + \delta\pi^E(K, 0)\}$$

In case of disagreement, the entrant would procure the asset at cost K and then bargain again to subcontract production. Since the state would then be $x = (K, K)$, the disagreement payoffs would be

$$Dis = \{(1 - \alpha)(c^E - c^I) + \delta\pi^I(K, K); \tag{3}$$

$$s - K - \alpha c^I - (1 - \alpha)c^E + \delta\pi^E(K, K)\} \tag{4}$$

The potential gains from trade are

$$GT = K + \delta[\pi^I(K, 0) + \pi^E(K, 0) - \pi^I(K, K) - \pi^E(K, K)]$$

Assume for the moment that

$$\Delta_1 \equiv \pi^I(K, 0) + \pi^E(K, 0) - \pi^I(K, K) - \pi^E(K, K) \geq 0$$

This will be shown to be true in equilibrium and guarantees that the gains from trade are positive. The subcontracting price that gives a share $(1 - \alpha)$ to the subcontractor (i.e., in this case, the incumbent) is

$$p_S = \alpha c^1 + (1 - \alpha)c^E + (1 - \alpha)K + \delta\pi^I(K, K) + (1 - \alpha)\delta\Delta_1 \quad (5)$$

The firms' profits are

$$\pi_L^I(s) = (1 - \alpha)(c^E - c^I) + (1 - \alpha)K + \delta\pi^I(K, K) + (1 - \alpha)\delta\Delta_1 \quad (6)$$

$$\pi_W^E(s) = s - \alpha c^1 - (1 - \alpha)c^E + \delta\pi^E(K, 0) - (1 - \alpha)\delta\Delta_1 \quad (7)$$

If the incumbent wins the auction there is no scope for subcontracting and profits are

$$\pi_W^I(s) = s - c^I + \delta\pi^I(K, 0) \quad (8)$$

$$\pi_L^E(s) = \delta\pi^E(K, 0) \quad (9)$$

In a second price auction, a firm's bid is the price level at which the firm is indifferent between winning and losing the auction:

$$b^I = \pi_L^I(s) - (\pi_W^I(s) - s) = \quad (10)$$

$$= p_S = \quad (11)$$

$$= \pi_L^E(s) - (\pi_W^E(s) - s) = \quad (12)$$

$$= b^E = s \quad (13)$$

The firms' total payoff must then solve the following equations

$$\pi^I(K, 0) = (1 - \alpha)(c^E - c^I) + (1 - \alpha)K + \delta\pi^I(K, K) + (1 - \alpha)\delta\Delta_1 \quad (14)$$

$$\pi^E(K, 0) = \delta\pi^E(K, 0) \quad (15)$$

Since $\delta \in [0, 1)$ by assumption, we have $\pi^E(K, 0) = 0$. Using the already known values for $x = (K, K)$ we can thus solve for $\pi^I(K, 0)$

$$\pi^I(K, 0) = \frac{1 - \alpha}{1 - \delta}(c^E - c^I) + \frac{1 - \alpha}{1 - \delta(1 - \alpha)}K \quad (16)$$

and for the price level s

$$s(K, 0) = \alpha c^I + (1 - \alpha)c^E + \frac{(1 - \alpha)(1 - \delta)}{1 - \delta(1 - \alpha)}K \quad (17)$$

Finally, we can check that $\Delta_1 = \frac{1 - \alpha}{1 - \delta(1 - \alpha)}K > 0$ as promised.

Inefficient incumbent: Consider now the case $x = (K, 0)$ and $c^E < c^I$. By switching the roles of the entrant and the incumbent, we already know from the analysis of the previous case that

$$\pi^I(0, K) = 0 \quad (18)$$

$$\pi^E(0, K) = \frac{1 - \alpha}{1 - \delta}(c^I - c^E) + \frac{1 - \alpha}{1 - \delta(1 - \alpha)}K \quad (19)$$

It only remains to find out what happens when the current incumbent (i.e., the firms that is currently the only owner of the asset) is the less efficient firm. In the present case, this means finding $\pi^I(K, 0)$ and $\pi^E(K, 0)$. By symmetry, we will then find $\pi^I(0, K)$ and $\pi^E(0, K)$ for the case $c^I < c^E$.

If the entrant wins, efficient subcontracting requires the sale of the asset and we have

$$\begin{aligned} Dis &= \{0 + \delta\pi^I(K, K); s - c^E - K + \delta\pi^E(K, K)\} \\ Eff &= \{p_K + \delta\pi^I(0, K); s - p_K - c^E + \delta\pi^E(0, K)\} \\ GT &= K + \delta[\pi^I(0, K) + \pi^E(0, K) - \pi^I(K, K) - \pi^E(K, K)] \\ &= K + \frac{\delta(1 - \alpha)}{1 - \delta(1 - \alpha)}K > 0 \end{aligned}$$

The gains from trade are positive, so the asset is sold. The asset price and the

firms' profits are

$$\begin{aligned} p_K &= \frac{1 - \alpha}{1 - \delta(1 - \alpha)} K \\ \pi_L^I(s) &= p_K \\ \pi_W^E(s) &= s - p_K - c^E + \delta\pi^E(0, K) \end{aligned}$$

If the incumbent wins, efficient subcontracting requires that the incumbent delegates production to the entrant to whom it transfers the asset. We obtain

$$\begin{aligned} Dis &= \{s - c^I + \delta\pi^I(K, 0); 0 + \delta\pi^E(K, 0)\} \\ Eff &= \{s - p_{KS} + \delta\pi^I(0, K); p_{KS} - c^E + \delta\pi^E(0, K)\} = \\ GT &= c^I - c^E + \delta[\pi^I(0, K) + \pi^E(0, K) - \pi^I(K, 0) - \pi^E(K, 0)] \end{aligned}$$

As in the previous case, assume for the moment (and prove later) that $\Delta_2 \equiv \pi^I(0, K) + \pi^E(0, K) - \pi^I(K, 0) - \pi^E(K, 0) \geq 0$. The gains from trade are thus positive and the transaction will occur at price

$$p_{KS} = \alpha c^E + (1 - \alpha)c^I - \delta[\pi^E(0, K) - \pi^E(K, 0)] + (1 - \alpha)\delta\Delta_2$$

leading to firms' profits of

$$\begin{aligned} \pi_W^I(s) &= s - p_{KS} \\ \pi_L^E(s) &= (1 - \alpha)(c^I - c^E) + \delta\pi^E(K, 0) + (1 - \alpha)\delta\Delta_2 \end{aligned}$$

The firms' bids will thus be

$$\begin{aligned} b^I &= \pi_L^I(s) - \pi_W^I(s) + s = \\ &= \alpha c^E + (1 - \alpha)c^I + \frac{1 - \alpha}{1 - \delta(1 - \alpha)} K + \\ &\quad - \delta[\pi^E(0, K) - \pi^E(K, 0)] + (1 - \alpha)\delta\Delta_2 \\ &= \pi_L^E(s) - \pi_W^E(s) + s = \\ &= b^E = s \end{aligned}$$

It follows that

$$\pi^I(K, 0) = \frac{1 - \alpha}{1 - \delta(1 - \alpha)} K$$

and that $\pi^E(K, 0)$ must solve the following equation

$$\pi^E(K, 0) = (1 - \alpha)(c^I - c^E) + \delta\pi^E(K, 0) + (1 - \alpha)\delta\Delta_2$$

Plugging in the expressions for the known $\pi^f(x^I, x^E)$ we get

$$\pi^E(K, 0) = \frac{1 - \alpha}{1 - \delta}(c^I - c^E)$$

Thus $\Delta_2 = 0 \geq 0$, as promised.

The equilibrium price is then

$$s(K, 0) = \alpha c^E + (1 - \alpha)c^I + \frac{(1 - \alpha)(1 - \delta)}{1 - \delta(1 - \alpha)}K$$

In sum, we have shown that, if at least one of the firms initially owns the asset

$$s(x^I, x^E) = \alpha c^{(1)} + (1 - \alpha)c^{(2)} + \frac{(1 - \alpha)(1 - \delta)}{1 - \delta(1 - \alpha)}(K - x^{(2)}) \quad (20)$$

$$\pi^f(x^I, x^E) = (1 - \alpha)(c^{(2)} - c^f)^+ + \frac{1 - \alpha}{1 - \delta(1 - \alpha)}(x^f - x^{(2)})^+ \quad (21)$$

where $c^{(i)}$ is the i^{th} lowest c^f , while $x^{(i)}$ is the i^{th} highest x^f .

Initial procurement: It remains to compute the equilibrium price $s(0, 0)$ and profits $\pi^f(0, 0)$ in the initial auction, when neither firm owns the asset. By going through the same kind of analysis, we obtain

$$s(0, 0) = \alpha c^{(1)} + (1 - \alpha)c^{(2)} + [1 - \frac{\delta(1 - \alpha)}{1 - \delta(1 - \alpha)}]K \quad (22)$$

$$\pi^f(0, 0) = \frac{1 - \alpha}{1 - \delta}(c^{(2)} - c^f)^+ \quad (23)$$

B Equilibrium with non-transferable asset

First note that, as in the case of transferable assets, $x = K$ is an absorbing state and the (stationary) equilibrium is the one computed in the previous chapter. We can thus focus on state $x = 0$.

If $c^I < c^E$, the fact that assets are not transferable is irrelevant. In this case, efficient subcontracting means delegating production to the incumbent and this does not require building duplicate assets that would lower future subsidies. Formally, the equilibrium computations of the previous section go through unchanged.

The trade-off between cost savings and lower future revenues occurs when $c^I > c^E$. In this case, efficiency requires that duplicate assets be built if and only if $c^I - c^E > (1 - \delta)K$, i.e., if and only if the net present value of cost savings from delegating production to the entrant in all periods are larger than the cost of duplicating the assets. Instead, as shown below, the equilibrium outcome implements a different (more stringent) test.

If the incumbent wins the auction and there is no subcontracting, payoffs are

$$Dis = \{s - c^I + \delta\pi^I(0); \delta\pi^E(0)\}$$

If production is delegated to the entrant (who will have to build duplicate assets for the purpose) and the subcontracting price is p_S , payoffs are

$$\begin{aligned} Sub &= \{s - p_S + \delta\pi^I(K); p_S - c^E - K + \delta\pi^E(K)\} \\ &= \{s - p_S; p_S - c^E - K + \delta\frac{1-\alpha}{1-\delta}(c^I - c^E)\} \end{aligned}$$

Subcontracting will occur only if it increases total payoffs, i.e., if

$$GT = c^I - c^E - K - \delta[\pi^I(0) + \pi^E(0) - \frac{1-\alpha}{1-\delta}(c^I - c^E)] \quad (24)$$

is positive. Let us assume so for the moment.

By the usual assumption, the subcontracting price will give the entrant a fraction $1 - \alpha$ of the gains from trade and will thus solve the following equation

$$p_S - c^E - K + \delta\frac{1-\alpha}{1-\delta}(c^I - c^E) = \delta\pi^E(0) + (1 - \alpha)GT$$

The solution is

$$p_S = \alpha(c^E + K) + (1 - \alpha)c^I - \alpha\delta\frac{1-\alpha}{1-\delta}(c^I - c^E) + \alpha\delta\pi^E(0) - (1 - \alpha)\delta\pi^I(0)$$

If the entrant wins, the gains from trade are negative⁵⁴ and there is no subcontracting. The entrant will build duplicate assets and provide the service, leading to payoffs equal to

$$\{0; s - c^E - K + \delta \frac{1-\alpha}{1-\delta} (c^I - c^E)\}$$

The usual calculations show that

$$b^E = p_S = b^I = s$$

and that firms' profits are thus equal to

$$\begin{aligned} \pi^I(0) &= 0 \\ \pi^E(0) &= \frac{1-\alpha}{1-\delta} [c^I - c^E - \frac{1-\delta}{1-\alpha\delta} K] \end{aligned}$$

Since firms can simply refuse to participate in the auction, the entrant's profit must be positive. The preceding calculations thus identify an equilibrium only if

$$c^I - c^E - \frac{1-\delta}{1-\alpha\delta} K \quad (25)$$

is positive.⁵⁵ If so, the gains from trade can be shown to be exactly equal to (25), hence they are positive and production will be delegated to the entrant - which is the efficient outcome since $c^E + \frac{1-\delta}{1-\alpha\delta} K < c^I$ implies $c^E + (1-\delta)K < c^I$.

The equilibrium price is then

$$s(0) = p_S = \alpha(c^E + \frac{1-\delta}{1-\alpha\delta} K) + (1-\alpha)c^I \quad (26)$$

in the first period and

$$s(K) = \alpha c^E + (1-\alpha)c^I \quad (27)$$

forever after.

We have seen that, if (25) is negative, there is no (Markov) equilibrium in which (24) is positive.

⁵⁴They are equal to minus GT in equation 24 and we are temporarily assuming $GT > 0$.

⁵⁵Note also that $\frac{1-\alpha}{1-\delta} [c^I - c^E - \frac{1-\delta}{1-\alpha\delta} K] > \frac{1-\alpha}{1-\delta} (c^I - c^E) - K = \pi^E(K) - K$ so the entrant has no incentive to build duplicate assets before the auction.

It only remains to consider the case in which (24) is negative, i.e., when the sum of the firms' payoffs would be lowered by duplicating the assets. As shown below, this will occur in equilibrium only if (25) is also negative, so the analysis is complete.

So let us assume that (24) is negative and go through the usual calculations. When the incumbent wins there is no subcontracting and payoffs are

$$\{s - c^I + \delta\pi^I(0); \delta\pi^E(0)\}$$

When the entrant wins, the gains from subcontracting are equal to minus GT , hence positive, and production is delegated to the incumbent at price

$$p_S = c^I - \delta\pi^I(0) - (1 - \alpha)GT$$

The corresponding payoffs are

$$\{p_S - c^I + \delta\pi^I(0); s - p_S + \delta\pi^E(0)\}$$

We would then get $b^I = b^E = s = p_S$ and profits would be

$$\begin{aligned}\pi^I(0) &= \frac{(1 - \alpha)(1 - \alpha\delta)}{(1 - \delta)[1 - (1 - \alpha)\delta]} \left[\frac{1 - \delta}{1 - \alpha\delta} K - (c^I - c^E) \right] \\ \pi^E(0) &= 0\end{aligned}$$

Note that $\pi^I(0) > 0$ requires that (25) be negative. Note also that the entrant cannot get positive payoffs from building duplicate assets and moving to $x = K$ because, as shown above, $\pi^E(K) - K = \frac{1 - \alpha}{1 - \delta}(c^I - c^E) - K < \frac{1 - \alpha}{1 - \delta}[c^I - c^E - \frac{1 - \delta}{1 - \alpha\delta}K]$ and this is negative whenever (25) is negative. Under this condition, we can verify that $GT < 0$, as assumed above:

$$GT = \frac{1 - \alpha\delta}{(1 - \delta)[1 - (1 - \alpha)\delta]} [c^I - c^E - \frac{1 - \delta}{1 - \alpha\delta}K]$$

The equilibrium price can be computed by plugging these values back into the formula for p_S and we get

$$s = c^I + \frac{(1 - \alpha)(1 - \alpha\delta)}{1 - (1 - \alpha)\delta} \left[\frac{1 - \delta}{1 - \alpha\delta} K - (c^I - c^E) \right] \quad (28)$$

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