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Organizing Competition for the Market*

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Abstract

The paper studies competition for the market in a setting where incumbents (and, to a lesser extent, neighboring incumbents) benefit from a cost advantage. The paper first compares the outcome of staggered and synchronous tenders, before drawing the implications for market design.

We find that the timing of tenders should depend on the likelihood of monopolization. When monopolization is expected, synchronous tendering is preferable, as it strengthens the pressure that entrants exercise on the monopolist. When instead other firms remain active, staggered tendering is preferable, as it maximizes the competitive pressure that comes from the other firms.

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Keywords: Dynamic procurement, incumbency advantage, local monopoly, competition, asymmetric auctions, synchronous contracts, staggered contracts.

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"The transactions that I wish to emphasize here, however, are exchanges of the recurring kind. Although large numbers competition is frequently feasible at the initial award stage for recurring contracts of all kinds, idiosyncratic transactions are ones for which the relationship between buyer and supplier is quickly thereafter transformed into one of bilateral monopoly- on account of the transaction-specific costs referred to above." (Williamson, 1979, p.241).

1 Introduction

The citizens of Rome have requested a referendum to open up to competitive tendering the provision of local transport services. This is, in microcosm, part of a movement which has seen numerous countries and municipalities worldwide progressively introducing competitive tendering for public services, such as rail and bus transport, refuse collection, waste management, school meals.[1] Yet, competition for the market is not always leading to market contestability (European Commission, 2016). Incumbents' positions remain dominant, with a few large players often winning contracts repeatedly within and across sectors. With about 12% of GDP spent by OECD countries on public procurement (OECD, 2017), and recurrent tendering characterizing the award of many public contracts, maintaining effective competition in the procurement of public services is becoming a key issue.

We address two questions in relation to organizing the market for competition. The first concerns the initial condition. As historical operators typically benefit from sunk cost and information advantages vis-à-vis potential competitors, market design should take measures to ensure a level playing field. Breaking up the historical operator may contribute to achieving this.

The second question concerns the evolution of competition over time, given that the service will be required for the foreseeable future. Having sunk the entry cost, the winner(s) of the initial competition may obtain an advantage in subsequent tenders. The timing of these tenders thus needs to be carefully planned. Previous work suggests that, in the presence of scale economies, lots should be awarded synchronously (see below). As we shall see, incumbency advantages may alter this finding.

In fact, these two questions should not be treated in isolation. Our key insight is that industry structure and tendering timing interplay significantly as instruments to ensure a competitive environment. Whether synchronous

[1] European Regulation 1370/2007 requires that, by 2019, public passenger transport services (rail and road transport) are awarded to third parties solely by competitive tendering.

or staggered contracts should be used both affects and depends on whether a competitive market structure can result from an appropriate market design.

We consider an infinitely repeated setting with two-period contracts for two adjacent markets; they can therefore be tendered synchronously, in which case both markets are tendered in the same period, or in a staggered manner, in which case tenders alternate across the two markets. All firms face the same cost of providing the service but, in order to operate in a market, must sink a fixed cost, which is lower if the firm is already operating in the other market and zero if the firm is the incumbent. This is the source of incumbency advantages. Any firm that loses a market must again sink the fixed cost in order to re-enter. There is a large number of potential entrants and cost information is public knowledge. We focus on Markov equilibria and compare per-period prices.

We show that one of two market structures may arise in equilibrium: either one firm serves both markets (monopoly), or distinct firms operate in the two markets (duopoly). Which market structure arises depends on the initial market structure, the tendering regime, the discount factor and the relative level of sunk costs. A duopoly always yields lower prices than a monopoly, but it can be maintained only when the discount factor and/or the incumbency advantage is low; monopolization prevails otherwise.

We derive the implications for the organization of competitive tendering, by considering an extended setting in which a public authority, liberalizing a number of markets, must choose whether to break up the incumbent, as well as whether to auction-off the markets on a city-by-city basis (so as to have synchronous tenders within each city) or on a market-by-market basis (so as to have staggered tenders within each city). Abstracting from transaction costs, we find that it is always optimal to break up the historical operator, so as to start the tendering process with a duopoly rather than a monopoly, and then use staggered or synchronous tendering, depending on whether a duopoly can be sustained. The optimal timing depends on the equilibrium outcome: staggered tendering is preferable when it maintains a duopoly whilst synchronous tendering is preferable when monopolization prevails. The key insight is that synchronous contracts facilitate competition from potential entrants, and therefore should be used in case of a monopoly, whilst staggered contracts facilitate competition among firms already active in the markets, and therefore should be used in case of a duopoly.

These issues are very much alive. For example, French local buses are normally tendered on a decentralized, and so staggered, basis. Amaral *et al.* (2009) document the lack of competition in the sector. Over 60% of local bus tenders in France between 2002 and 2005 received only one bid and the sector as a whole is dominated by three companies. When privatizing British Rail, there was extensive (and acrimonious) discussion on how to organize the horizontal split in passenger franchises in order to maximize competition. There was also significant discussion on the length of franchises, with the Treasury arguing for three-year franchise awards in each case, all issued nearly simultaneously; eventually the franchises offered were for longer periods, varying between 5 and 15 years, with the most common being approximately 7 years, so there was a natural staggering (Gourvish, 2002; Shaw, 2000). At the end of the paper, we engage in a brief investigation of the London bus market, considered an example of good practice in maintaining competition (Amaral et al., 2009), and relate the policy trade-offs to the tendering procedures followed there.

Private operators face similar issues. For example, National Express coaches (NX), Britain's largest inter-city and regional express coach operator with around 150 timetabled routes and hundreds of daily destinations, contracts out almost all its routes to a large number of coach companies (around 20).[2] They need to buy coaches to NX specifications and paint them in NX livery. Hence, a new operator may need to spend money that an incumbent does not. An operator on similar routes (e.g. in geographical proximity) may have benefits that an entrant does not. NX runs the website, plans the routes, and sells tickets through it and through a variety of agents. Prices are set on revenue management principles, but all money goes to NX directly. Coach drivers, who must conform to particular standards, are able to action spot sales, subject to conditions, but for the significant majority of passengers, they simply check tickets against a manifest when boarding them.

More generally, firms face similar problems when they outsource services such as maintenance, logistics or IT, and tender contracts recurrently. Incumbency advantage can there arise from the acquisition of knowledge on the firm's products and resource management system.

Related literature. This paper relates to a vast body of research on how to increase competition in procurement when asymmetries among bidders are present. Asymmetries are commonplace in procurement and may arise from technology choices, locations of firms, capacity constraints, switching costs, better information and familiarity with local rules and regulations, or from ownership of important assets. To maintain competition in such a context, a number of papers have pointed out potential benefits from using discriminatory procurement rules (in a static setting, see Myerson, 1981 and

[2] Flixbus manages a similar network of bus routes in continental Europe.

Maskin and Riley, 2000; in a dynamic setting see Laffont and Tirole, 1988, Lewis and Yildirim, 2002 and 2005; and Barbosa and Boyer, 2017), discounting switching costs in the evaluation of bids (Cabral and Greenstein, 1990), splitting supply (Anton and Yao, 1987 and 1992), using shorter and more frequent contracts (Saini 2012), or enhancing the information on the common value components of potential entrants (De Silva *et al.* 2009).[3] We are more specifically looking at the choice of the initial market structure and the timing of tenders when the asymmetry arises from incumbency advantage.[4]

In the context of repeated interaction, the relative merits of staggered and synchronous contracts have been left almost unexplored. One exception is Cabral (2017), who compares staggered and synchronous contracts in an industry with an infinite sequence of short-lived buyers.[5] The main point of departure is that Cabral focuses on economies of scale, whereas we focus on incumbency advantages arising from sunk costs. A first implication of economies of scale is that, with homogenous products, monopolization always arises; as a result, synchronous tenders always yield lower prices. By contrast, in our setting a duopoly can survive when incumbency advantages are not too large, and staggered tenders are socially desirable in that case. A second implication is that, in Cabral's setting, the initial market structure does not matter, as incumbency plays no role; by contrast, in our setting it is desirable to break up historical incumbents, so as to benefit from a level playing field.

The rest of the paper proceeds as follows. In Section 2 we describe the set-up. In Sections 3 and 4 we characterize the equilibria under staggered and synchronous contracts. In Section 5 we derive the implications for market design. In Section 6, we use our framework to discuss the case of London Bus Tendering. In Section 7 we provide some concluding remarks and policy implications.

[3] Empirical procurement studies present evidence in support of these predictions. See e.g. De Silva *et al.* (2003, 2009) for evidence on the bidding behaviour of entrants; Athey et al. (2013) on the impact of discriminatory procurement rules; De Silva (2005) and De Silva *et al.* (2005) on the role of synergies across projects auctioned; Jofre-Bonet and Pesendorfer (2000) on the effect of capacity constraints; and Weiergraeber and Wolf (2018) on incumbency advantage due to lower cost or better information in a common value setting.

[4] This links our paper also to the literature on the endogenous determination of market structure when property rights are auctioned (see, e.g., Dana and Spier 1994).

[5] The impact of the timing of contracts on competition has been studied also by Dana and Fong (2011) and Iacobucci and Winter (2012), but their focus is on collusion or exclusion.

2 Setup

We consider two markets A and B that are repeatedly up for tender over an infinite horizon, discrete time setting indexed by $t = 0, 1, ...$ Specifically, we suppose that each market is tendered every other period, so that all contracts cover two consecutive periods of operation, and compare two scenarios:

- synchronous tenders: both markets are tendered in even periods;
- staggered tenders: market A is tendered in even periods, whereas market B is tendered in odd periods.

All firms face the same (total discounted) cost of providing the service for two periods, which we normalize to zero.[6] In addition, to service a market a firm must sink a fixed cost, which is however lower if the firm is already operating in the other market. In each tender, there are therefore potentially three types of firms:

- the firm currently operating in the market that is up for tender has already sunk this cost;
- the firm operating in the other market (if it is not the same as the first one) needs to sink a fixed cost $s > 0$;
- potential entrants need to sink a higher fixed cost $S > s$.

We further assume that there is a large number of potential entrants, and that any firm that loses a market will have to sink again the fixed cost (s or S, depending on whether the firm is operating in the other market).

In each tendering date, there are thus two states:

- State $\mathcal{M}$ (monopoly): one firm, which we denote by M, currently services both markets, and faces competition for the tender(s) only from potential entrants, which we denote by E.
- State $\mathcal{D}$ (duopoly): two distinct firms currently service the two markets, and compete against each other as well as against potential entrants for the tender(s). We will refer to the "incumbent" firm currently operating in the market that is up for tender as I, and to the "challenger" currently operating in the other market as C.

[6] In what follows, firms' prices can be interpreted as firms' margins, net of operating costs.

In order to avoid coordination issues, we assume that the tender takes the form of a combinatorial first-price auction. With staggered tenders, each firm simply submits a price for the market that is up for tender; the lowest bidder then wins and services the market for the offered price p. The resulting profit for the winner is p if it already services the market (firm M in state $\mathcal{M}$, or firm I in state $\mathcal{D}$), $p - s$ if it does not but currently services the other market (firm C in state $\mathcal{D}$), and $p - S$ if it is not currently operating in any market (firm E).

With synchronous tenders, each firm instead submits a price for every combination of markets, that is:

- a price P for both markets;
- and prices p_A and p_B for markets A and B.

The winning allocation minimizes the total price of servicing the two markets, and each winner receives the offered price for each market it obtains. The profits are then computed as above.

Firms maximize the sum of their discounted profits, using the same discount factor $\delta \in (0, 1)$. We study the subgame-perfect equilibria and, to eliminate any scope for tacit collusion, focus on Markov equilibria, in which firms' equilibrium strategies in a given period can only depend on the current state, $\mathcal{M}$ or $\mathcal{D}$. In state $\mathcal{D}$, under synchronous tenders, we further focus on symmetric equilibria, in which both incumbents adopt the same strategy. Finally, to discard dominated equilibria, we restrict attention to Coalition-Proof Nash equilibria.[7] In our setting, this amounts to a focus on equilibria such that, in each period, the equilibrium strategies form a Pareto-efficient Nash equilibrium given the equilibrium continuation values associated with states $\mathcal{M}$ and $\mathcal{D}$. In case of staggered tenders, this rules out losing bids that are lower than firms' values; in case of synchronous tenders, this amounts to focus on the most profitable equilibrium. In what follows, "equilibrium" thus stands for "(symmetric) coalition-proof Markow subgame-perfect equilibrium".

We first characterize below the equilibria for both staggered and synchronous tenders. We then derive the implications for market design.[8]

[7] See Bernheim, Peleg and Whinston (1987).

[8] For the sake of exposition, we assume that the two markets are already serviced in period 0, so that the game already starts in state $\mathcal{M}$ or $\mathcal{D}$. This is consistent with our market design analysis, which considers the transition from in-house to competitive tendering.

3 Staggered tenders

We first consider the case of staggered tenders. Obviously, competition among entrants implies that they obtain zero equilibrium profit. By contrast, incumbent firms may obtain positive profits. Furthermore, intuitively, an incumbent firm is better off when it monopolizes the market than when a different firm is operating in the other market.

Hence, letting V_i denote the equilibrium continuation value of firm $i = M, I, C$ at the beginning of each period, we expect:

$$V_M > V_I + V_C \,(> 0)\,.$$

Building on this insight, in state $\mathcal{M}$, M prevails over E: it has lower costs (it does not have to incur the entry cost S) and greater long-term benefits from winning, as M's gain from remaining a monopolist, $\delta\,(V_M - V_I)$,[9] exceeds E's gain from becoming a duopolist, δV_C. M thus wins by matching the best price that entrants are willing to offer, namely:

$$p_E = S - \delta V_C,$$

which corresponds to their cost of entering the market, minus the discounted value of becoming a challenger in the next tender. We thus have:

$$V_M = p_E + \delta V_M = S + \delta\,(V_M - V_C)\,. \tag{1}$$

Likewise, in state $\mathcal{D}$ we expect I to prevail over E: the long-term benefit from winning is the same for both firms (it is equal to δV_C), but I does not have to incur the entry cost S. By contrast, the comparison between I and C is less clear-cut: firm C must sink cost s, but derives greater long-term benefits from winning, as this enables it to monopolize the market – C's expected gain from monopolization is again given by $\delta\,(V_M - V_I)$, and thus exceeds I's gain from winning and maintaining a duopoly, δV_C.

It follows that, depending on which firm wins in state $\mathcal{D}$, two types of equilibrium can arise:

- *Single-state equilibrium:* if $s < \delta\,(V_M - V_I - V_C)$, then C wins and monopolizes the market; the equilibrium then remains in state $\mathcal{M}$ forever.

[9] If M wins, it remains a monopolist and obtains V_M in the next tender; if instead it loses, the entrant becomes a challenger, and M obtains V_I in the next tender.

- *Dual-state equilibrium:* if instead $s > \delta(V_M - V_I - V_C)$, then I wins and two firms thus remain active. The equilibrium path remains forever on the initial state: starting from state $\mathcal{M}$, M keeps servicing both markets forever; starting instead from state $\mathcal{D}$, two firms remain active, each one servicing the same market forever.

Consider first the case where C wins:

$$\delta(V_M - V_I - V_C) > s. \tag{2}$$

I thus exits the market and obtains $V_I = 0$, whereas C pays the best price that I is willing to offer, namely:

$$p_I = -\delta V_C,$$

reflecting the discounted value of being a challenger in the next tender. We thus have:

$$V_C = p_I - s + \delta V_M = -s + \delta(V_M - V_C). \tag{3}$$

Combining (1) and (3) yields $V_M - V_C = S + s$; using $V_I = 0$, (2) thus amounts to $\delta(S + s) > s$. That is, for a single-state equilibrium to arise, the gains from monopolization should be large enough, which is the case when entrants face greater cost disadvantage (S high) and firms pay sufficient attention to future profits (δ high). In addition, the cost handicap of the challenger, s, should not exceed the gain from monopolization; although this gain also increases with s, this indirect effect is discounted by δ, and so a single-state equilibrium is more likely to arise when s is small.

If instead

$$\delta(V_M - V_I - V_C) < s, \tag{4}$$

then I wins against C in state $\mathcal{D}$ (the roles of I and C are then swapped in the next tender); hence, C obtains

$$V_C = \delta V_I, \tag{5}$$

whereas I pays the best price that C is willing to offer, namely:

$$p_C = s - \delta(V_M - V_I),$$

reflecting the cost of entering the neighboring market and the discounted value of becoming a monopolist. I thus obtains:

$$V_I = p_C + \delta V_C = s - \delta(V_M - V_I - V_C). \tag{6}$$

Combining (1) with (5) and (6), it can be checked that (4) amounts to $\delta(S+s) < s$. The equilibrium price then depends on the initial state: starting from state $\mathcal{M}$, the incumbent monopolizes the market forever and the price is equal to $p_E = S - \delta V_C$; starting instead from state $\mathcal{D}$, the incumbent prevails in each tender and the equilibrium is equal to $p_C = s - \delta(V_M - V_I)$. Building on this leads to:

Proposition 1 (staggered tenders) *Under staggered tendering, generically there exists a unique Markov equilibrium, which can be of two types:*

- *Single-state equilibrium. If*

$$\frac{s}{S} < \sigma^{Stag}(\delta) \equiv \frac{\delta}{1-\delta},$$

  then, regardless of the state in period 0*, from period* 1 *onwards the equilibrium path stays in the monopoly state; one firm then keeps servicing both markets, and the equilibrium price is*

$$p_{\mathcal{M}}^{Stag} \equiv (1-\delta)\left[(1+\delta)S + \delta s\right].$$

- *Dual-state equilibrium. If instead*

$$\frac{s}{S} > \sigma^{Stag}(\delta),$$

  then the equilibrium path remains in the initial state:

  - *starting from the monopoly state in period* 0*, the same firm services both markets forever and the equilibrium price is*

$$p_{\mathcal{M}}^{Stag} \equiv \frac{1-\delta}{1-2\delta}\left[\left(1-\delta-\delta^2\right)S - \delta^2 s\right];$$

  - *starting instead from the duopoly state in period* 0*, the same firms service their respective markets forever and the equilibrium price is*

$$p_{\mathcal{D}}^{Stag} \equiv \frac{1-\delta^2}{1-2\delta}\left[(1-\delta)s - \delta S\right].$$

- *In the limit case where* $s/S = \sigma^{Stag}(\delta)$*, there are infinitely many equilibria, which yield the same prices and profits and differ only in the probability of moving from state* $\mathcal{D}$ *to state* $\mathcal{M}$*.*

Proof. See Appendix A. ■

Note that the monopoly price $p_{\mathcal{M}}^{Stag}$ varies continuously with s, S and δ, as the expressions given by the two previous propositions coincide in the limit case even across the two regions:

$$\left.(1-\delta)\left[(1+\delta)S+\delta s\right]\right|_{\delta=\frac{s/S}{1+s/S}}=\left.\frac{1-\delta}{1-2\delta}\left[\left(1-\delta-\delta^2\right)S-\delta^2 s\right]\right|_{\delta=\frac{s/S}{1+s/S}}=S.$$

4 Synchronous tenders

We now turn to the case of synchronous tenders, and focus on symmetric equilibria in which, along the equilibrium path: in state $\mathcal{M}$, each firm offers a bundled price and a symmetric unbundled price for each market (obviously, the incumbent and the entrants will offer different prices); in state $\mathcal{D}$, both incumbent firms adopt the same strategy, which stipulates a price for the market that it currently services, a (possibly different) price for the other market, and a bundled price for both markets.

As before, competition among entrants implies that they obtain zero profit, whereas incumbent firms may obtain positive profits, all the more so when the same firm operates in both markets. Hence, letting V_M and V_D denote the equilibrium continuation values of an incumbent firm in states $\mathcal{M}$ and $\mathcal{D}$, we have:

$$V_M > 2V_D \geq 0.$$

Building on this insight, in state $\mathcal{M}$, M prevails over the entrants. Furthermore, the total price that two entrants are willing to offer for becoming a duopolist, $2p_E = 2S - \delta^2(2V_D)$, exceeds the bundle price that an entrant is willing to offer for securing a monopoly position, $P_E = 2S - \delta^2 V_M$.[10] Hence, in order to win M must match the entrants' bundle price:

$$P_E = 2S - \delta^2 V_M.$$

M thus obtains:

$$V_M = P_E + \delta^2 V_M = 2S. \tag{7}$$

[10] We stick here to the assumption that entrants must incur a sunk cost S for each market. If entry benefits from scale economies, the cost for entering both markets may be lower than $2S$ (anywhere between $S+s$ and $2S$, say). In the Online Appendix we show that, while this may slightly tilt the balance in favor of synchronous tenders, it does not qualitatively affect the insights.

In state $\mathcal{D}$, the two incumbents again constitute the relevant source of competition. Hence, in equilibrium, either one incumbent wins both markets, or each incumbent wins one market. We consider in turn these two types of equilibrium.

Consider first an equilibrium in which one incumbent wins both markets; competition among the two incumbents then drives their profits down to zero ($V_D = 0$) and the equilibrium price is the best bundled price that they are willing to offer, namely:

$$P_D = s - \delta^2 V_M = s - 2\delta^2 S.$$

We show in Appendix B that this equilibrium indeed always exists – in particular, it is not profitable for an incumbent firm to deviate so as to win a single market.

Consider now an equilibrium in which each incumbent wins a market, at some price p; obviously, they must then win the markets that they already service.[11] Furthermore, without loss of generality, we can assume $P = 2p$: the bundle price cannot be lower than $2p$ (otherwise, one incumbent – either one – would then win both markets), and any bundle price exceeding $2p$ is irrelevant.[12] But then, to ensure that incumbents do not find it profitable to win both markets, the price p must satisfy:

$$p + \delta^2 V_D \geq 2p - s + \delta^2 V_M.$$

It follows that the price p cannot exceed $s - \delta^2 (V_M - V_D)$, and thus:

$$V_D = p + \delta^2 V_D \leq s - \delta^2 (V_M - 2V_D). \tag{8}$$

Obviously, this equilibrium can exist only if $V_D \geq 0$, as firms would exit if their total discounted values were negative; using (7) and (8), this amounts to:[13]

$$\frac{s}{S} \geq 2\delta^2. \tag{9}$$

[11] Starting from a candidate equilibrium in which the incumbents would win each other's markets, deviating and targeting its own market would allow any incumbent to save the entry cost s, and would therefore constitute a profitable deviation.

[12] We assume here that the procurer can choose to "unblundle" and pay $2p$ when assigning both markets to the same firm. In practice, some procurers actually require bundled prices to be at most equal to the sum of the stand-alone prices (this is the case, for instance, of *Transport for London*, the authority in charge of tendering London buses). However, we show in Appendix B that the argument still applies if the firms can insist on higher prices for the bundle.

[13] We have:

$$0 \leq V_D \leq \frac{s - \delta^2 V_M}{1 - 2\delta^2} = \frac{s - 2\delta^2 S}{1 - 2\delta^2},$$

where the second inequality follows from (8) and the equality stems from (7).

Intuitively, for each incumbent to win a market, the future gains from monopolization must not be too high: firms should therefore discount the future substantially (δ low) and monopolization should not be too profitable (the cost S of the entrants should not be too high); in addition, the cost of serving the additional market, s, should be high enough.

Conversely, we show in Appendix B that this equilibrium indeed exists under (9). Furthermore, $V_D > 0$ whenever $s/S > 2\delta^2$, in which case this equilibrium is the unique coalition-proof equilibrium in state $\mathcal{D}$, as the other equilibrium (in which one incumbent wins both markets) yields zero continuation value. This leads to:

Proposition 2 (synchronous tenders) *Under synchronous tendering, there exists a unique symmetric Coalition-Proof Markov equilibrium, characterized as follows:*

- *Single-state equilibrium. If*
$$\frac{s}{S} < \sigma^{Sync}(\delta) \equiv 2\delta^2,$$
then, regardless of the state in period 0, from period 1 onwards the equilibrium path stays in the monopoly state: one firm keeps servicing both markets, and the equilibrium price is
$$p_{\mathcal{M}}^{Sync} \equiv \left(1-\delta^2\right) S.$$

- *Dual-state equilibrium. If instead*
$$\frac{s}{S} \geq \sigma^{Sync}(\delta),$$
then the equilibrium path remains in the initial state:
  - *Starting from the monopoly state in period 0, the same firm services both markets forever; the firm again obtains $V_M = 2S$ and the equilibrium price remains equal to*
$$p_{\mathcal{M}}^{Sync} \equiv \left(1-\delta^2\right) S.$$
  - *Starting instead from the duopoly state in period 0, the same firms service their respective markets forever; they each obtain*
$$V_D = \frac{s - 2\delta^2 S}{1-2\delta^2} < \frac{V_M}{2},$$
and the equilibrium price is
$$p_{\mathcal{D}}^{Sync} \equiv \left(1-\delta^2\right) \frac{s-2\delta^2 S}{1-2\delta^2}.$$

Proof. See Appendix B. ■

5 Market design

We first compare equilibrium prices across tendering regimes and states of competition. We then note that competition is more likely to obtain under synchronous tendering, and draw the implications for market liberalization.

5.1 Price comparisons

The following proposition shows that equilibrium prices can be ranked:

Proposition 3 (price comparisons) *We have:*

$$p_{\mathcal{M}}^{Stag} > p_{\mathcal{M}}^{Sync} > p_{\mathcal{D}}^{Sync} > p_{\mathcal{D}}^{Stag}.$$

Proof. See Appendix C. ■

The intuition relies on three observations:

- *Monopoly prices are lower under synchronous tendering:* $p_{\mathcal{M}}^{Stag} > p_{\mathcal{M}}^{Sync}$.

Synchronous tendering decreases monopoly power by allowing the entrants to exert a greater competitive pressure. Winning both tenders enables any entrant to replace immediately the incumbent monopolist, whereas under staggered tendering, an entrant needs to win two subsequent tenders in order to become a monopolist.

- *Duopoly prices are lower under staggered tendering:* $p_{\mathcal{D}}^{Sync} > p_{\mathcal{D}}^{Stag}$.

Staggered tendering increases the competitive pressure that the other incumbent exerts on the firm currently servicing the market. In both tendering regimes, winning the other market enables an incumbent to become a monopolist: this is the case for C under staggered tendering, and for both incumbents under synchronous tendering. However, from the previous observation, the benefit from monopolization is greater under staggered tendering. Hence, C bids more aggressively under staggered tendering than the incumbents do under synchronous tendering.

- *Prices are lower under duopoly:* $p_{\mathcal{M}}^{Stag} > p_{\mathcal{D}}^{Stag}$ and $p_{\mathcal{M}}^{Sync} > p_{\mathcal{D}}^{Sync}$.

In the monopoly state, entrants need to incur a large fixed cost, S, in order to challenge the incumbent. By contrast, in the duopoly state, the other incumbent only needs to incur $s < S$, and thus exerts a greater competitive competitive pressure.

5.2 On the sustainability of competition

The above analysis shows that, under both tendering regimes, competition may be sustainable, in which case it yields lower prices. Furthermore, any competitive price – under either tendering regime – is lower than any monopoly price – in any regime. The following proposition shows further that competition is easier to sustain under synchronous tendering:

Proposition 4 (sustainability of competition) *The threshold for the existence of a dual-state equilibrium is lower under synchronous tendering:* $\sigma^{Sync}(\delta) > \sigma^{Stag}(\delta)$.

Proof. We have:

$$\sigma^{Stag}(\delta) - \sigma^{Sync}(\delta) = \frac{\delta}{1-\delta} - 2\delta^2 = \frac{\delta}{1-\delta}\left[\delta^2 + (1-\delta)^2\right] > 0.$$

■

This is illustrated by Figure 1.

Under both tendering regimes, competition cannot be sustained when s/S is too low and/or δ is too high: when $s/S > \sigma^{Stag}(\delta)$, a single-state equilibrium always arises, in which (at least from period 1 onwards) a firm monopolizes the market forever. Conversely, competition can be sustained when s/S is high enough and/or δ is low enough: when $s/S < \sigma^{Sync}(\delta)$, a dual-state always arises in which, starting from the duopoly state, different firms service the two markets. However, there exists a middle range (namely, when $\sigma^{Stag}(\delta) > s/S > \sigma^{Sync}(\delta)$), where competition can be sustained only under synchronous tendering. The intuition follows from the first two observations above, which imply that the price increase stemming from monopolization is lower under synchronous tendering (that is, $p_{\mathcal{M}}^{Stag} - p_{\mathcal{D}}^{Stag} > p_{\mathcal{M}}^{Sync} - p_{\mathcal{D}}^{Sync}$); this, in turn, makes it easier to sustain a duopoly outcome, by reducing the benefit of switching to monopoly.[14]

[14] Recall that competition is sustainable when $s \geq \delta(V_M - V_I - V_C)$ under staggered tendering (from (4)), and when $s \geq \delta^2(V_M - 2V_D)$ under synchronous tendering (using $V_D \geq 0$ and (8)). In the former case, we have $V_M = p_{\mathcal{M}}^{Stag}/(1-\delta)$ and $V_C = \delta V_I =$

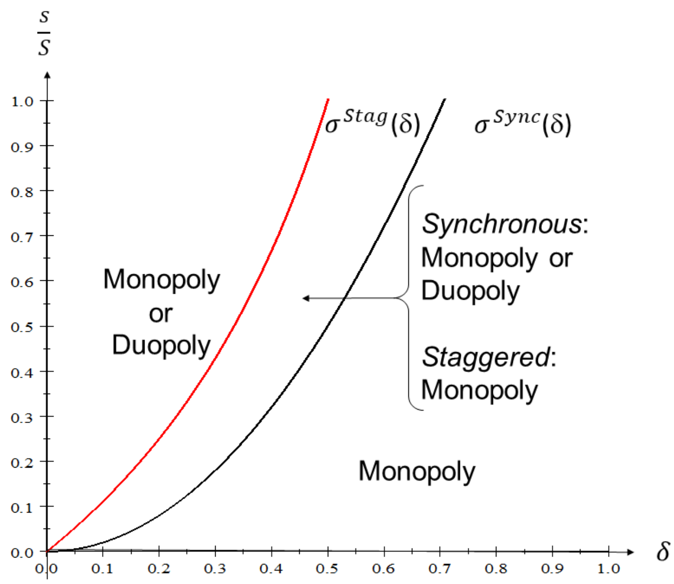

Figure 1: Equilibrium Outcome

Propositions 3 and 4 compare stationary equilibrium prices and do not study the convergence towards these equilibrium paths. In the next subsection, we study how market design can affect this convergence and determine the equilibrium outcome.

5.3 Market liberalization

In practice, many services with natural monopoly features, such as urban transportation or the local distribution of water, electricity and gas, have traditionally been provided by regulated monopolies, before being opened to competition – in the form of "competition for the market", rather than "competition in the market". Our analysis can shed some light on the design

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$\delta p_{\mathcal{D}}^{Stag} / \left(1-\delta^2\right)$, and so

$$\delta \left(V_M - V_I - V_C\right) = \frac{\delta}{1-\delta}\left(p_{\mathcal{M}}^{Stag} - p_{\mathcal{D}}^{Stag}\right).$$

Under synchronous tendering, we have instead $V_M = 2p_{\mathcal{M}}^{Sync} / \left(1-\delta^2\right)$ and $V_D = p_{\mathcal{D}}^{Sync} / \left(1-\delta^2\right)$, and so

$$\delta^2 \left(V_M - 2V_D\right) = \frac{2\delta}{1+\delta}\frac{\delta}{1-\delta}\left(p_{\mathcal{M}}^{Sync} - p_{\mathcal{D}}^{Sync}\right).$$

It follows that $p_{\mathcal{M}}^{Stag} - p_{\mathcal{D}}^{Stag} > p_{\mathcal{M}}^{Sync} - p_{\mathcal{D}}^{Sync}$ implies $\delta \left(V_M - V_I - V_C\right) > \delta^2 \left(V_M - 2V_D\right)$.

of the liberalization process.

For the sake of exposition, we consider a setting in which two "pairs" of local markets, $\{A_i - B_i\}_{i=1,2}$, are initially serviced by regulated monopolies and to be liberalized; a "pair" of markets can, for example, be interpreted as cities, and a market as a bus route.[15] The liberalization may involve privatizing the historical operator, and possibly breaking it up. To ensure that the same number of markets are opened to competition in each period under both synchronous and staggered tenders, we assume that liberalization must take place progressively; specifically, we assume that the regulator can initially (in period 0, say) open only two markets to competition, and must wait for the next period (period 1) before opening the other two markets to competition. This can be justified, for example, by limited capacity within the regulator.[16]

In this setting, the regulator faces two choices; it can:

- select which markets to open in period 0; the two relevant options are:
  - opening one city to competition in period 0, and the other city in period 1; in each city, both markets are then tendered synchronously.
  - in each city, opening one market to competition in period 0 and the other market in period 1; tenders are then staggered in both cities.
- decide whether to break up the historical operator:
  - if it breaks up the historical operator into two independent firms (assigning to each of them the necessary human and capital needed to service a market), the first tenders take place in a duopoly state, in which two incumbents compete against each other as well as against potential entrants (these may, for instance, comprise historical operators from other cities);
  - otherwise, the first tenders take place in a monopoly state, in which the historical operator only faces competition from potential entrants.

[15] The reasoning readily extends to any number of cities and any number of market pairs for each city, provided that there exists overall an even number of market pairs.

[16] An alternate approach would consist in initially tendering some of the markets for a single period.

The above analysis yields the following implications:

- When $s/S < \sigma^{Sync}(\delta)$, there is no dual-state equilibrium in either tendering regime; synchronous tenders then deliver the lowest (monopoly) price.
- When instead $\sigma^{Sync}(\delta) \leq s/S < \sigma^{Stag}(\delta)$, a dual-state equilibrium arises only under synchronous tenders; synchronous tenders then again deliver the lowest prices (regardless of which state they lead to).
- Finally, when $s/S \geq \sigma^{Stag}(\delta)$, a dual-state equilibrium arises under both tendering regimes; in this case, staggered tenders deliver the lowest price if they lead to the duopoly state, otherwise synchronous tenders still deliver lower prices (regardless of which state they lead to).

Hence, we have:

Corollary 1 (market design: long-term prices) *When focussing on stationary equilibrium prices, breaking up the historical operators is strictly optimal if $s/S \geq \sigma^{Sync}(\delta)$; in addition:*[17]

- *if $s/S > \sigma^{Stag}(\delta)$, then prices are lower when, in period 0, one market is opened to competition in each city (staggered tenders);*
- *if instead $s/S < \sigma^{Stag}(\delta)$, then stationary prices are lower when, in period 0, both markets are opened to competition in one city (synchronous tenders).*

Organizing the market prior to tendering by breaking up the incumbents is weakly optimal, as it helps to ensure that a duopoly outcome will emerge whenever it is feasible. By contrast, the optimal tendering regime depends on market conditions. For high discount factors (δ high), or when the incumbency advantage is particularly strong (s/S small), monopolization always occurs; as in Cabral (2017), it is then preferable to opt for synchronous tendering, so as to strengthen the pressure that entrants exert on the monopolist. When instead the discount factor is low or the incumbency advantage is small (δ low and/or s/S high), then – in contrast to Cabral (2017) – competition between two firms operating in the market can be sustained over time.

[17] In the limit case where $s/S = \sigma^{Stag}(\delta)$, the optimal tendering regime depends on which equilibrium arises under staggered tenders: synchronous tenders are optimal when they lead to monopolization, whereas staggered tenders are optimal when the state remains in duopoly forever.

In this case, opting for staggered tendering is optimal, as it maximizes the competitive pressure that incumbent firms exert on each other.

Corollary 1 is limited to the comparison of stationary prices, which arise from $t = 1$ onwards. They are also the prices that emerge at $t = 0$ when the initial state is a monopoly, or in case of a dual-state equilibrium. By contrast, when starting from a duopoly in a single-state equilibrium, the prices that emerge in the first period are not the stationary prices: firms instead compete aggressively for securing a monopoly position forever; as a result, prices are very low, and even negative. Indeed, we show in Appendix D that the first-period prices are then given by:

$$\begin{aligned} p_{\mathcal{D}}^{Stag}(SSE) &= \delta\left[(1-\delta)s - \delta S\right] \leq 0, \\ p_{\mathcal{D}}^{Sync}(SSE) &= \frac{s}{2} - \delta^2 S \leq 0. \end{aligned}$$

Therefore, it is important to consider how market design is affected when first-period prices are explicitly taken into account.

We first note that breaking up the incumbents is always strictly optimal. In a dual-state equilibrium, this leads to lower stationary prices (from the first period onwards). In a single-state equilibrium (SSE), this generates a tougher competition in the first period: prices are then "negative" (meaning that they are below cost, here normalized to zero), and thus lower than the stationary monopoly prices that would otherwise emerge from the beginning. In what follows, we thus suppose that the initial state is in a duopoly.

When the equilibrium remains in the same state forever under both tendering regimes $\left(s/S > \sigma^{Stag}(\delta)\right)$, then we know from the previous comparison of stationary prices that staggered tenders yield lower prices. When instead monopolization arises under both tendering regimes $\left(s/S < \sigma^{Sync}(\delta)\right)$, it can be checked that the first-period price is lower under staggered tenders – that is, $p_{\mathcal{D}}^{Stag}(SSE) < p_{\mathcal{D}}^{Sync}(SSE)$. Yet, synchronous tenders deliver lower total discounted prices, as they generate more intense competition that leads firms to give up all profit.[18]

Consider now the intermediate range where monopolization occurs only under staggered tenders, that is, $\sigma^{Sync}(\delta) \leq s/S < \sigma^{Stag}(\delta)$. First-period prices are again lower under staggered tenders (DSE refers to dual-state equilibrium):

$$p_{\mathcal{D}}^{Stag}(SSE) - p_{\mathcal{D}}^{Sync}(DSE) = -\frac{s(1-\delta)\left(2\delta^3+1\right) + S\delta^2}{1-2\delta^2} < 0,$$

[18] That is, $V_D = 0$. In addition, opting for synchronous tenders reduces total costs, by postponing the occurence of the setup cost s for one of the cities.

where the inequality holds due to condition (9). It follows that the desirability of staggered tenders increases, relative to the previous comparison based solely on stationary prices. Building on these insights, the following Proposition characterizes the market design that minimizes total prices:

Proposition 5 (market design: overall prices) *In the above setting, breaking up the historical operator minimizes the total discounted price. In addition, there exists a threshold $\hat{\sigma}(\delta) \in (\sigma^{Sync}(\delta), \sigma^{Stag}(\delta)]$, which coincides with $\sigma^{Stag}(\delta)$ for delta small and lies strictly below $\sigma^{Stag}(\delta)$ for delta large enough, such that:*

- *if $s/S > \hat{\sigma}(\delta)$ (which, by construction, includes the entire region where $s/S > \sigma^{Stag}(\delta)$), then total discounted prices are lower when, in period 0, one market is open to competition in each city (staggered tenders);*
- *if $s/S < \hat{\sigma}(\delta)$ (which, by construction, includes the entire region where $s/S < \sigma^{Sync}(\delta)$), then total discounted prices are lower when, in period 0, both markets are opened to competition in one city (synchronous tenders).*

Proof. See Appendix D. ■

These insights are illustrated in Figure 2, where the solid line represents the threshold $\hat{\sigma}(\delta)$.

The future rents that accrue to the monopolist under staggered tenders induce more aggressive bidding in the first period, which raises the benefit of staggered tendering. The effect is greater when future profits are not discounted heavily, which explains why $\hat{\sigma}(\delta)$ may lie below $\sigma^{Stag}(\delta)$ for δ sufficiently high.[19]

Whenever monopolization is the ultimate outcome, intense competition generates a "windfall gain" in the first period. This may create an illusion about the gain from liberalization, as well as distribution concerns across generations of users. In principle, this windfall gain could be invested or partly saved to be redistributed over time; however, politicians and regulators may be tempted to spend it at once, which raises issues about commitment and

[19] In principle, under staggered tendering the public authority could also choose to auction off which market should be tendered first. Whilst the public authority is indifferent between starting with market A or market B, the firms are not indifferent: in the duopoly state, if the equilibrium is a single-state one, then each incumbent firm would rather see the other market being auctioned first, so as to get an opportunity to monopolize both markets. Hence, by auctioning-off the choice of the initial market, the public authority could extract all the rents, as the two broken-up incumbents are symmetric at that stage.

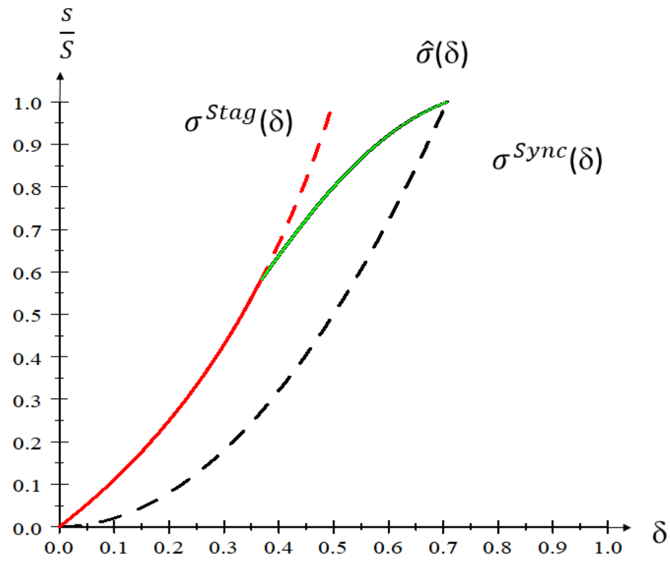

Figure 2: Market Design

intertemporal fairness. Indeed, short-termism in politics provides incentives to opt for a low price in the initial period, followed by price increases in later periods, for example, through greater public contributions, or increased fares.

We conclude this section by briefly discussing the case where the market structure cannot be adjusted at the time when liberalization is introduced. In practice, closing down or restructuring the in-house provider may generate substantial transaction costs, and redundancies may also have significant social costs. Because of these transaction and social costs, breaking up the incumbent may be politically infeasible or even socially undesirable. In such a case, it follows from the above analysis that monopoly remains the only possible equilibrium state; synchronous tenders then always lead to lower prices:

Remark 1 *Absent the break up of the historical operators, prices are lower when, in period* 0*, both markets are opened to competition in one city.*

6 Tendering for London buses

The case of competitive tendering for bus services in London offers interesting stylized facts that appear consistent with our theoretical predictions. With over 600 routes, and over two billion passenger journeys annually, this is a very large market. Aiming to facilitate competition for the market, the UK Government chose in 1992 to break up and privatize the London historical operator, creating 13 firms, each related to particular garaging facilities (see Amaral *et al.*, 2013, and Iossa and Waterson, 2017a). It then allowed the firms to compete through a tendering process on a route-by-route basis. Since 2001, tender competition has been on a gross cost basis, fares going directly to the organizer, *Transport for London* (*TfL*), with tenders being on the basis of supplying buses, drivers, maintenance and garaging to match the timetabling requirements of *TfL* for a period of five (commonly extendable to seven) years.[20] Thus, we are able to examine outcomes where the same route has been tendered twice.

Despite a number of acquisitions, entry and exit, to date the London market appears to remain competitive. There are around 10 companies active in the market, with five having a share greater than 10%. This oligopolistic framework relates to our duopolistic model. Over the years, on average around three firms have bid for each route (see Table 1 below, and Amaral *et al.*, 2013), but in about half the cases, the contract is awarded the second time around to the Incumbent operator and in a further quarter of cases it is awarded to the same company with a different name, or a successor company (see Table 2). This leaves around a quarter of cases where the contract clearly changes hands, almost always to a Challenger in our terminology. This is consistent with the incumbency advantage present in our setting.

To provide the service, firms must have depots or garages for stabling, cleaning and maintenance purposes and these are rarely rented – most are owned by existing bus service operators. Our data reveals that in 47% of cases, the contract is won by the company with a garage nearest to the route and in a further 22% of cases, the winner is the second closest firm (see Table 3). This suggests that the incumbency advantage is linked to garage ownership.

It appears from Table 4 that the oligopolistic structure itself is stable, although there is churn amongst operators and there have been entries and exits from the London market. Interestingly though, the entrants of any significance have all purchased existing facilities from departing firms – for example when *First group* left the market in 2013, largely for exogenous reasons, *Transit Systems* entered by buying up some of its garages and buses. Ascertaining whether the market is moving towards monopolization is not easy, as most of the contracts we observe (over the 2003 to 2015 period) have

[20]See Transport for London (2017); there is also a quality monitoring element, with payments to or from the operator.

been re-tendered only once on the same contracting terms, but the market share data suggest any such movement is slow at most.

In addition to examining market structure, Iossa and Waterson (2017b) have investigated how prices (per mile) are evolving over time and in particular whether prices the second time around are significantly greater than the previous tender for the same route, after allowing for input price inflation. Regressions show that, if prices are uprated only by the uprating formula used by TfL, which allows 85% of labour and fuel costs to be passed through, then there is some evidence of rising prices; however, on the basis of uprating fully for inflation in these items, there is no evidence that prices are higher.

One possible explanation, consistent with our theory, is that garage remains dispersed both in ownership and geography. The number of garages sufficiently proximal to a route is such that several nearby active firms exert competitive pressure on incumbents. As Table 5 shows, in 75% of tenders, there are at least three operators who own a garage within 20 minutes driving distance of the relevant route and rough estimates indicate that the resulting cost penalty would be around 1%. This suggests a small difference between S and s in our setting, interpreting s as the handicap of the closest competitor and S as the handicap of the next closest one; this, in turn, makes it more likely for competition to survive.

Regarding tender timing, the evidence suggests a mix of synchronous and staggered tenders. Each tranche of route tenders, issued every two to three weeks on a rotating basis throughout the year, includes some nearby routes, but the tranches are quite small, perhaps 6 routes, so that each covers only a very small fraction of the total market. Bids for the whole tranche are extremely rare, although package bids are quite common (sometimes, across tranches).[21] For the most part, we would argue that contracts are awarded in a staggered manner.

Tender round	Average numbers of bidders	Percent of contracts with more bidders
First	3.03	37.3
Second	2.85	29.9

Table 1: Number of Bidders

[21] Cantillon and Pesendorfer (2007) examine the issue of package bids in a structural econometric model, focussing on cost synergies.

Second tender winner	Contracts awarded	Percentage
Same company	194	48.3
Different division/ name	106	26.4
Different company	102	25.4
Total	402	

Table 2: Winning Company

Winner's rank	Count	Percentage
1	262	47
2	123	22.1
3	77	13.8
4	49	8.8
5 or greater	46	8.3

Table 3: Is the winner the firm whose garage is nearest?

Operator	Percent market share	
	2009	2015
Go-Ahead	20.1	24.7
Arriva	20.3	17.8
Stagecoach	15.8	14.0
Metroline	12.9	18.0
First	12.9	0
Transdev	9.4	0
RATPDev	0	11.5
National Express	4.3	0
Abellio	0	7.6
Transit systems	0	5.1
Others	4.3	1.4

Table 4: Market shares
Sources: Amaral *et al.*(2013) and
London bus routes.net/garages.htm(10/2015)

Time from garage to route	Winner's time %	Minimum time %	Second min. %	Third min. %
< 10 minutes	53.1	84.2	31.4	6.8
< 15 minutes	77.6	99.3	83.3	46.5
< 20 minutes	89.0	99.8	96.8	75.6

Table 5: Are other firms able to compete?

7 Concluding remarks

We have studied the design of competition for the market in a setting where incumbents (and, to a lesser extent, neighboring incumbents) benefit from a cost advantage. We have focused on two main instruments: market structure and the timing of tenders, and shown that these are inherently interlinked. Our findings suggest that it is always optimal to break up the historical operator, so as to start the tender process in a more competitive state. When the discount factor is low and/or the incumbency advantage is small, this suffices to ensure that a competitive market structure will be maintained over time, yielding lower stationary prices than monopolization.

The choice of the tendering timing should depend on the likelihood of monopolization. When monopolization is expected, it is preferable to have synchronous tendering so as to strengthen the pressure that entrants exercise on the monopolist. When instead other firms remain active, staggered tendering is preferable, as it maximizes the competitive pressure that comes from the other firms.

Our framework can be further developed along several dimensions. One important issue that we have left out of the analysis is the endogenous determination of the number of contracts put up for tender – the so called "tranches" or "lots". The existing literature has typically considered contracts that are tendered synchronously and highlighted the link between the size and number of contracts, and the sustainability of competition over time.[22] It would be interesting to investigate how the number and size of contracts affects the trade-off between cost synergies and competition when tenders are staggered.

Another important issue worth investigating further relates to the effect of contract duration. Our analysis shows that the discount factor affects both the level of equilibrium prices and the threshold values characterizing the equilibrium configurations. Further investigation could aim at disentangling these two effects. A further consideration is whether alternative time gaps between tenders would be desirable, by creating asymmetries in the duration of contracts put up for tenders over time.

We have used a stylized model with no uncertainty about cost conditions or reliability, to better highlight the role that tendering timing and market structure play in the presence of incumbency advantage. Recent episodes in Europe, with large service operators going into liquidation whilst holding hundreds of public sector contracts, suggest that having existing operators ready to replace a failing contractor could yield significant benefits to con-

[22] See Grimm et al. (2006) for an informed discussion of this trade-off.

sumers, making it even more desirable to maintain competition over time. Future research should consider introducing cost and reliability uncertainty to explore how to best manage this type of termination risk.

Appendix

A Staggered tenders: proof of Proposition 1

We characterize here the equilibrium of the game in which, in each period, one market is up for tender. We first characterize firms' best offers, and then derive the implications for the equilibrium outcome.

A.1 Best offers

A.1.1 Entrants

In both states $\mathcal{M}$ and $\mathcal{D}$, any potential entrant obtains:

$$v_E = \begin{cases} p - S + \delta V_C & \text{if it wins at price } p, \\ 0 & \text{if it loses.} \end{cases}$$

Potential entrants are thus willing to lower their prices down to:

$$p_E = S - \delta V_C. \tag{10}$$

A.1.2 Incumbent monopolist

In state $\mathcal{M}$, the incumbent monopolist, M, obtains:

$$v_M = \begin{cases} p + \delta V_M & \text{if it wins at price } p, \\ \delta V_I & \text{if it loses.} \end{cases}$$

It is thus willing to lower its price down to:

$$p_M = -\delta \left(V_M - V_I \right). \tag{11}$$

A.1.3 Incumbent duopolists

In state $\mathcal{D}$, the firm currently operating in the market that up for tender, I, obtains:

$$v_I = \begin{cases} p + \delta V_C & \text{if it wins at price } p, \\ 0 & \text{if it loses.} \end{cases}$$

It is thus willing to lower its price down to:

$$p_I = -\delta V_C.$$

The firm currently operating in the other market, C, obtains

$$v_C = \begin{cases} p - s + \delta V_M & \text{if it wins at price } p, \\ \delta V_I & \text{if it loses.} \end{cases}$$

It is thus willing to lower its price down to:

$$p_C = s - \delta (V_M - V_I). \tag{12}$$

It is useful to note that:

$$p_I < p_E, \tag{13}$$

and:

$$p_M < p_C. \tag{14}$$

A.2 Equilibrium configurations

We first note that M always prevails in state $\mathcal{M}$:

Lemma 1 (M wins in state $\mathcal{M}$) *In state $\mathcal{M}$, M wins at price $p_E = S - \delta V_C$ and obtains:*

$$V_M = \frac{S - \delta V_C}{1 - \delta}. \tag{15}$$

Proof. In state $\mathcal{M}$, E can win only when $p_E \leq p_M$, which, using (13) and (14), yields:

$$p_I < p_E \leq p_M < p_C.$$

Therefore, in state $\mathcal{D}$, I wins (as its best offer is the lowest, and thus it can profitably undercut any rival) at a price not exceeding p_E (otherwise, any entrant could profitably undercut I); I thus obtains

$$V_I \leq p_E + \delta V_C \leq S,$$

whereas C obtains

$$V_C = \delta V_I.$$

Furthermore, as M loses in state $\mathcal{M}$, $V_M = \delta V_I = V_C$; but then, using (10) and (11), the condition $p_E \leq p_M$ amounts to:

$$S \leq \delta V_I \leq \delta S,$$

a contradiction.

Therefore, M wins in state $\mathcal{M}$. It cannot do so at a price exceeding p_E, otherwise any entrant could win and make a positive profit. Hence, M wins at price p_E.[23] ■

Next, we show that the incumbents constitute the relevant source of competition in state $\mathcal{M}$:

Lemma 2 (incumbents are most effective competitors in state $\mathcal{D}$) *In state $\mathcal{D}$, either I wins at price p_C, or C wins at price p_I.*

Proof. As $p_I < p_E$, E can be a relevant source of competition in state $\mathcal{D}$ only if $p_E \leq p_C$, which, using (10) and (12), amounts to:

$$\delta \left(V_M - V_I - V_C\right) \leq -\left(S - s\right). \tag{16}$$

I then wins at price p_E and thus obtains

$$V_I = p_E + \delta V_C = S,$$

whereas C obtains

$$V_C = \delta V_I = \delta S.$$

In state $\mathcal{M}$, (15) yields:

$$V_M = \frac{S - \delta V_C}{1 - \delta} = \frac{S - \delta^2 S}{1 - \delta} = \left(1 + \delta\right) S.$$

But then,

$$\delta \left(V_M - V_I - V_C\right) = 0 > -\left(S - s\right),$$

contradicting (16). Therefore, in equilibrium, either I wins at price p_C (if $p_I \leq p_C < p_E$), or C wins at price p_I (if $p_C \leq p_I < p_E$). ■

The only equilibrium configurations are thus the single-state and dual-state equilibria described in the text, which we now consider in turn.

[23] As mentioned, we discard equilibria where losing firms offer prices lower than their values (implying that they would make a loss if they were to win); for example, entrants could offer less than p_E, forcing M to offer a lower price as well. These equilibria are neither trembling-hand perfect nor coalition-proof.

A.3 Single-state equilibrium

In a single-state equilibrium, in state $\mathcal{D}$, I loses the tender and thus obtains

$$V_I = 0,$$

whereas C wins at p_I and obtains

$$V_C = p_I - s + \delta V_M = \delta\left(V_M - V_C\right) - s = \frac{\delta V_M - s}{1+\delta}.$$

Combining this condition with (15) yields the equilibrium values:

$$V_C = \delta S - (1-\delta)\, s = 0 \text{ and } V_M = (1+\delta)\, S + \delta s.$$

For this to be an equilibrium, we must have $p_C \leq p_I$,[24] which amounts to[25] $V_C \geq \delta V_I = 0$ and thus boils down to:

$$\frac{s}{S} \geq \sigma^{Stag}\left(\delta\right) \equiv \frac{\delta}{1-\delta}.$$

From period 1 onwards, state $\mathcal{M}$ prevails; from Lemma 1, the equilibrium price is then:

$$p_{\mathcal{M}} = S - \delta V_C = (1-\delta)\left[(1+\delta)\, S + \delta s\right].$$

A.4 Dual-state equilibrium

Consider now a dual-state equilibrium. In state $\mathcal{D}$, I wins at p_C and thus obtains

$$V_I = s - \delta\left(V_M - V_I - V_C\right),$$

whereas C obtains

$$V_C = \delta V_I.$$

Combining these conditions with (15) yields:

$$\begin{aligned} V_I &= \frac{(1-\delta)\, s - \delta S}{1-2\delta}, \\ V_C &= \delta \frac{(1-\delta)\, s - \delta S}{1-2\delta}, \\ V_M &= \frac{\left(1-\delta-\delta^2\right) S - \delta^2 s}{1-2\delta}. \end{aligned}$$

[24] Using (13) and (14), this implies that M indeed wins in state $\mathcal{M}$, as $p_M < p_C \leq p_I < p_E$.

[25] By construction, C is indifferent between servicing the market at price p_C or not servicing it, in which case it obtains δV_I; hence, winning at price p_I gives C a continuation value equal to $V_C = \delta V_I + p_I - p_C$.

For this to be an equilibrium, we must have $p_I \leq p_C \leq p_E$, which, using (10) and (12),[26] The last condition amounts to:

$$\delta\left(V_M - V_I - V_C\right) \geq -\left(S - s\right) \Leftrightarrow \frac{\delta}{1 - 2\delta} \geq -1,$$

which, together with $\delta < 1$, is equivalent to $\delta < 1/2$.[27] The first condition amounts to $V_I \geq 0$,[28] or:

$$\frac{\left(1 - \delta\right) s - \delta S}{1 - 2\delta} \geq 0,$$

which, together with $\delta < 1/2$, is equivalent to:

$$\frac{s}{S} \leq \frac{\delta}{1 - \delta} = \sigma^{Stag}\left(\delta\right).$$

The equilibrium path depends on the initial state:

- If the game starts in state $\mathcal{M}$ in period 0, then it remains in the monopoly state forever; from Lemma 1, the price is then

$$p_{\mathcal{M}} = p_E = S - \delta V_C = \left(1 - \delta\right) \frac{\left(1 - \delta - \delta^2\right) S - \delta^2 s}{1 - 2\delta}.$$

- If instead the game starts in state $\mathcal{D}$ in period 0, then it remains in the duopoly state; from Lemma 2, in each period the incumbent wins and (using (12)) the price is :

$$p_{\mathcal{D}} = p_C = s - \delta\left(V_M - V_I\right) = \frac{1 - \delta^2}{1 - 2\delta}\left[\left(1 - \delta\right) s - \delta S\right].$$

Furthermore:

$$\begin{aligned} V_I &= \frac{\left(1 - \delta\right) s - \delta S}{1 - 2\delta}, \\ V_C &= \delta \frac{\left(1 - \delta\right) s - \delta S}{1 - 2\delta}, \\ V_M &= \frac{\left(1 - \delta - \delta^2\right) S - \delta^2 s}{1 - 2\delta}. \end{aligned}$$

[26] Using (14), the last inequality implies that M indeed wins in state $\mathcal{M}$, as $p_M < p_C \leq p_E$.

[27] If $\delta > 1/2$, the condition implies $\delta \leq 2\delta - 1 \Leftrightarrow \delta \geq 1$.

[28] By construction, I is indifferent between servicing the market at price p_I or leaving, in which case it obtains 0; hence, winning at price p_C gives I a continuation value equal to $V_I = p_C - p_I$.

$$V_M - V_I - V_C = \frac{p_{\mathcal{M}} - p_{\mathcal{D}}}{1-\delta} = \frac{S-s}{1-2\delta} > 0,$$

where the inequality stems from $\delta < 1/2$. Therefore, the monopoly outcome features higher prices and industry profits.

A.5 Equilibrium multiplicity

When

$$\frac{s}{S} = \sigma^{Stag}(\delta) = \frac{\delta}{1-\delta},$$

in state $\mathcal{D}$ the incumbents are indifferent between winning both markets, none of them, or keeping only their own market: they obtain zero profit anyway; in particular, in particular, $V_I = V_C$ in the single-state equilibrium, and $V_D = 0$ in the dual-state equilibrium. As a result, both types of equilibria coexist and, more generally, for any $\rho \in [0,1]$, there exists an equilibrium in which state $\mathcal{D}$ switches to state $\mathcal{M}$ with probability ρ. However, all these equilibria yield the same prices and profits. This is obvious for the monopoly state, as prices then remain forever equal to the monopoly price, equal in both equilibria to $p_{\mathcal{M}} = S - \delta V_C = S$. For the duopoly state, as just noted all firms obtain zero profit anyway and, in both equilibria, the prices are also zero: in the dual-state equilibrium, we have:

$$p_{\mathcal{D}}|_{\frac{s}{S}=\sigma^{Stag}(\delta)} = \frac{1-\delta^2}{1-2\delta}\left[(1-\delta)s - \delta S\right]|_{\frac{s}{S}=\frac{\delta}{1-\delta}} = 0,$$

and, in the single-state equilibrium, where C wins by matching I's best price, the equilibrium price is therefore $p_{\mathcal{D}} = p_I = -\delta V_C = 0$.

A.6 Staggered tenders: recap

We can therefore distinguish two situations:

- If $s/S < \sigma^{Stag}(\delta)$, then there exists a unique equilibrium, which is a single-state equilibrium: regardless of the initial state in period 0, from period 1 onwards a monopolist services both markets, and the equilibrium price is:

$$p^s_{\mathcal{M}} \equiv (1-\delta)\left[(1+\delta)S + \delta s\right].$$

- If instead $s/S > \sigma^{Stag}(\delta)$, then there exists a unique equilibrium, which is a dual-state equilibrium: the equilibrium path remains in the initial state forever:

– starting from state $\mathcal{M}$ in period 0, a monopolist services both markets, and the equilibrium price is

$$p_{\mathcal{M}}^{d} \equiv (1-\delta) \frac{\left(1-\delta-\delta^{2}\right) S-\delta^{2} s}{1-2 \delta}.$$

– starting instead from state $\mathcal{D}$ in period 0, a duopoly services the two markets, and the equilibrium price is:

$$p_{\mathcal{D}}^{d} \equiv \frac{1-\delta^{2}}{1-2 \delta}[(1-\delta) s-\delta S]<p_{\mathcal{M}}.$$

- For the limit case $s/S=\sigma^{Stag}(\delta)$, both types of equilibrium exist and we have:

$$p_{\mathcal{M}}^{s}=p_{\mathcal{M}}^{d}=S, p_{\mathcal{D}}^{s}=p_{\mathcal{D}}^{d}=0.$$

Therefore, the monopoly price (which is also the higher price, when both states can arise in equilibrium) is a continuous function of s/S and δ.

B Synchronous tenders: proof of Proposition 2

We now study the equilibria of the game in which, in every even period, both markets are up for tender. We start again by characterizing best offers, and derive the implications for the equilibrium outcomes.

B.1 Best offers

B.1.1 Entrants

In both states $\mathcal{M}$ and $\mathcal{D}$, any potential entrant obtains:

$$v_{E}=\begin{cases}P-2S+\delta^{2} V_{M} & \text{if it wins both markets at total price } P, \\ p-S+\delta^{2} V_{D} & \text{if it wins one (and only one) market at price } p, \\ 0 & \text{if it loses both markets.}\end{cases}$$

Potential entrants are thus willing to offer:

- servicing both markets for a bundled price

$$P_{E}=2S-\delta^{2} V_{M}, \tag{17}$$

- or servicing a single market for a stand-alone price

$$p_{E}=S-\delta^{2} V_{D}.$$

B.1.2 Incumbent monopolist

In state $\mathcal{M}$, the incumbent monopolist, M, obtains:

$$v_M = \begin{cases} P + \delta^2 V_M & \text{if it wins both markets at total price } P, \\ p + \delta^2 V_D & \text{if it wins only one market at price } p, \\ 0 & \text{if it loses both markets.} \end{cases}$$

It follows that M would be willing to service both markets for a bundle price $P_M = P_E - 2S < P_E$ and to service a single market for a stand-alone price $p_M = p_E - S < p_E$.

It follows that M always find it profitable to win at least one market. Furthermore, we have:

Lemma 3 (state $\mathcal{M}$ for synchronous tenders) *Under synchronous tendering, in state $\mathcal{M}$:*

- if
$$\delta^2 (V_M - 2V_D) > -S,$$
then in equilibrium M wins both markets at price $\hat{P}_E \equiv \min\{P_E, 2p_E\}$; the game then remains in state $\mathcal{M}$, and M obtains
$$V_M = 2S + \delta^2 \min\{0, V_M - 2V_D\} \in [S, 2S].$$

- If instead
$$\delta^2 (V_M - 2V_D) < -S,$$
then in equilibrium M wins a single market at price $\hat{p} = p_E$; the game then switches to state $\mathcal{D}$ and M obtains
$$V_M = S.$$

- Finally, if $\delta^2 (V_M - 2V_D) = -s$, both options can arise in equilibrium, and $V_M = S$.

Proof. If $V_M \geq 2V_D$, then $P_E \leq 2p_E$; it follows that:

- in order to win both markets, M must match P_E, which yields
$$V_b = P_E + \delta^2 V_M = 2S;$$

- in order to win a single market, M must offer a price p such that $p + p_E \leq P_E$, which yields

$$V_s = P_E - p_E + \delta^2 V_D = S - \delta^2 (V_M - 2V_D).$$

If instead $V_M < 2V_D$, then $P_E > 2p_E$; it follows that:

- in order to win both markets, M must match $2p_E$, which yields $V_b = 2p_E + \delta^2 V_M = 2S + \delta^2 (V_M - 2V_D)$;
- in order to win a single market, M must match p_E, which yields

$$V_s = p_E + \delta^2 V_D = S.$$

In the former case ($V_M \geq 2V_D$), $V_b - V_s = S + \delta^2 (V_M - 2V_D) > 0$; in the latter case ($V_M < 2V_D$), $V_b - V_s = S + \delta^2 (V_M - 2V_D)$. Therefore:

- If

$$\delta^2 (V_M - 2V_D) > -S,$$

then in equilibrium M wins both markets at price $\hat{P}_E$; the game then remains in state $\mathcal{M}$, and M obtains

$$\begin{aligned} V_M &= \hat{P}_E + \delta^2 V_M \\ &= 2S - \delta^2 \max\{0, 2V_D - V_M\} \\ &= 2S + \delta^2 \min\{0, V_M - 2V_D\} \, (\leq 2S). \end{aligned}$$

It follows from $\delta^2 (V_M - 2V_D) > -S$ that $\delta^2 \min\{0, V_M - 2V_D\} \in [-S, 0]$, and thus $V_M \in [S, 2S]$.

- If instead

$$\delta^2 (V_M - 2V_D) < -S,$$

which implies $V_M < 2V_D$ and thus $\hat{P}_E = 2p_E$, then in equilibrium M wins a single market at price $\hat{p} = p_E$; the game then switches to state $\mathcal{D}$ and M obtains

$$V_M = p_E + \delta^2 V_D = S.$$

- Finally, if $\delta^2 (V_M - 2V_D) = -S$, both options can arise in equilibrium, and $V_M = V_b = V_s = S$.

■

Lemma 3 implies in particular that it is strictly profitable to be a monopolist servicing both markets.

B.1.3 Incumbent duopolists

In state $\mathcal{D}$, each incumbent firm obtains:

$$v_D = \begin{cases} P - s + \delta^2 V_M & \text{if it wins both markets at total price } P, \\ \underline{p} + \delta^2 V_D & \text{if it wins only its own market at price } \underline{p}, \\ \bar{p} - s + \delta^2 V_D & \text{if it wins only the other market at price } \bar{p}, \\ 0 & \text{if it loses both markets.} \end{cases}$$

Each incumbent is thus willing to lower its prices down to:

$$\begin{aligned} P_D &= s - \delta^2 V_M, \\ \underline{p}_D &= -\delta^2 V_D, \\ \bar{p}_D &= s - \delta^2 V_D. \end{aligned} \tag{18}$$

Noting that $P_D < P_E$ and $\underline{p}_D < \bar{p}_D < p_E$ leads to:

Lemma 4 (state $\mathcal{D}$ for synchronous tenders) *In equilibrium, either one incumbent wins both markets, or each incumbent wins the market that it is currently servicing.*

Proof. We have: $P_E = P_D + 2S - s > P_D$, $p_E = \bar{p}_D + S - s > \bar{p}_D$ and $\bar{p}_D = \underline{p}_D + s > \underline{p}_D$.

We first check that potential entrants cannot win any market. Suppose first that a potential entrant wins a single market, implying that at least one incumbent must exit. The entrant must charge at least p_E (otherwise, it would make a loss, and thus profitably opt out); but then, the exiting incumbent could profitably outbid the entrant, as $p_E > \max\left\{\bar{p}_D, \underline{p}_D\right\}$. Likewise, if a potential entrant wins both markets, then any incumbent could profitably outbid it.

It follows that either one incumbent wins both markets, or each incumbent wins a single market. Furthermore, in the latter case, the incumbents must win the markets that already service. Indeed, if the incumbents were to win each other's markets, then any of them could profitably deviate by targeting its own market instead, so as to save the entry cost s. ■

This lemma establishes that there are only two types of equilibrium outcomes in state $\mathcal{D}$. We show in the next two sections that, in both cases, M wins both markets in state $\mathcal{M}$, implying that, again, the equilibrium is either a single-state or a dual-state equilibrium.

B.2 Single-state equilibrium

Consider a candidate equilibrium in which, in state $\mathcal{D}$, one incumbent firm wins both markets. If the total price is strictly lower than P_D, then the winner could profitably deviate by opting out. If instead the total price P is strictly higher than P_D, then the losing incumbent could profitably deviate by offering to service both markets at a price lying between P_D and P (together with prohibitively high stand-alone prices). Hence, the equilibrium total price must be equal to P_D, implying that both incumbents obtain $V_D = 0$.

It follows from Lemma 3 that $V_M \geq S > 0 = 2V_D$ and thus, in state $\mathcal{M}$, M wins both markets at total price P_E and obtains:

$$V_M = 2S.$$

This establishes that the candidate equilibrium is a single-state equilibrium, in which the equilibrium path stays in the monopoly state from period 1 onwards, and that the outcome of these equilibria is unique, and (using (17) and (18)) such that:

- in state $\mathcal{M}$, M wins both markets at per market price:

$$\frac{P_E}{2} = S - \delta^2 \frac{V_M}{2} = \left(1 - \delta^2\right) S;$$

- in state $\mathcal{D}$, one incumbent firm wins both markets at per market price:

$$\frac{P_D}{2} = \frac{s - \delta^2 V_M}{2} = \frac{s}{2} - \delta^2 S.$$

To establish existence, consider the following equilibrium strategies:

- in state $\mathcal{M}$, M offers a bundle price equal to $P_E = 2\left(1 - \delta^2\right) S$, together with stand-alone prices $p_E = S$.
- in state $\mathcal{D}$, both incumbents offer a bundle price equal to $P_D = s - 2\delta^2 S$, together with stand-alone prices $p_E = S$.

In state $\mathcal{M}$, M then wins both markets and obtains $V_M = 2S$: the auctioneer is indeed indifferent between allocating both markets to M or to an entrant (and M could break that indifference by offering slightly less than P_E), and it prefers this to allocating the markets to different firms, as $P_D = s - 2\delta^2 S < P_E = 2S - 2\delta^2 S < 2p_E = 2S$. Furthermore, Lemma 3 and $V_M > 2V_D$ together ensure that M has no incentive to deviate.

In state $\mathcal{D}$, one incumbent then wins both markets, as $p_E = S < s/2 - \delta^2 S = P_D/2$, and both incumbents obtain $V_D = 0$. Furthermore, incumbents cannot profitably deviate: exiting yields the same zero value, and focusing on a single market requires offering a price $\tilde{p}$ such that $\tilde{p} + p_E \leq P_D$; hence the profit from such a deviation does not exceed (using $\tilde{p} \leq P_D - p_E$ and assuming that the incumbent targets its own market – targeting the other market would be even less profitable):

$$\tilde{V} = P_D - p_E + \delta^2 V_D = \left(s - 2\delta^2 S\right) - S + 0 = -\left(S - s\right) - 2S\delta^2 < 0.$$

Therefore, there always exists a Markov perfect equilibrium that is a single-state equilibrium, and the outcome of such equilibria is unique; in particular, from period 1 onwards, the per market equilibrium price is equal to

$$\frac{P_E}{2} = \left(1 - \delta^2\right) S.$$

To determine whether this equilibrium is coalition-proof, we first need to study the possibility of alternative equilibria in which, in state $\mathcal{D}$, the two incumbents win their respective markets.

B.3 Dual-state equilibrium

Consider now a candidate equilibrium in which, in state $\mathcal{D}$, each incumbent firm wins the market that it already services. Letting p denote the equilibrium price, each incumbent obtains:

$$p + \delta^2 V_D = p - \underline{p}_D.$$

The equilibrium prices p and P must satisfy the following conditions:

- Winning the market must be profitable:

$$p \geq \underline{p}_D.$$

- The auctioneer must prefer splitting the market between the incumbents:

$$2p \leq \min\left\{P, P_E, 2p_E\right\}. \tag{19}$$

- No incumbent should find it profitable to deviate by outbidding the other so as to win both markets:

$$p - \underline{p}_D \geq P - P_D. \tag{20}$$

Condition (19) implies $P \geq 2p$, which, combined with (20), implies

$$p \leq \tilde{p} \equiv P_D - \underline{p}_D = s + \delta^2 (V_D - V_M).$$

It follows that the equilibrium price p must satisfy

$$\underline{p}_D \leq p \leq \min\left\{\tilde{p}, \frac{P_E}{2}, p_E\right\}.$$

Conversely, any price p satisfying this condition, together with $P = 2p$, satisfies all the above conditions and thus constitutes an equilibrium.

Such an equilibrium therefore exists if and only $\underline{p}_D \leq \min\{\tilde{p}, P_E/2, p_E\}$. As $p_E > \underline{p}_D$ and $\tilde{p} \geq \underline{p}_D$ implies $P_E/2 > \underline{p}_D$,[29] the relevant equilibrium condition is

$$\tilde{p} = P_D - \underline{p}_D \geq \underline{p}_D \Longleftrightarrow P_D \geq 2\underline{p}_D \Longleftrightarrow \delta^2 (V_M - 2V_D) \leq s.$$

Conversely, whenever such an equilibrium exists, the most profitable of these equilibria, which is thus a coalition-proof equilibrium,[30] is such that the incumbents charge $\min\{\tilde{p}, P_E, 2p_E\}$.

To study the existence of such an equilibrium, we note that:

$$\begin{aligned}
\tilde{p} > \frac{P_E}{2} &\iff \delta^2 (V_M - 2V_D) < -2(S - s), \\
\tilde{p} > p_E &\iff \delta^2 (V_M - 2V_D) < -(S - s), \\
\frac{P_E}{2} > p_E &\iff V_M < 2V_D.
\end{aligned}$$

Therefore:

- If $\delta^2 (V_M - 2V_D) \leq -(S - s)$, then $p_E \leq \min\{\tilde{p}, P_E/2\}$; incumbents thus win their markets at price p_E and obtain $V_D = S$.
- If $-(S - s) < \delta^2 (V_M - 2V_D) \leq s$, then $\tilde{p} < \min\{p_E, P_E/2\}$; incumbents thus win their markets at price $\tilde{p}$ and obtain $V_D = s - \delta^2 (V_M - 2V_D)$.

As the outcome of state $\mathcal{M}$ depends on the comparison between $\delta^2 (2V_D - V_M)$ and $-S$, we can therefore distinguish three configurations, depending on where $\delta^2 (2V_D - V_M)$ lies, compared with the thresholds $-(S - s)$ and $-S$. We consider each case in turn.

[29] $\tilde{p} = P_D - \underline{p}_D \geq \underline{p}_D$ amounts to $P_D \geq 2\underline{p}_D$; as $P_E > P_D$, this implies $P_E > 2\underline{p}_D$.

[30] Recall that the alternative equilibrium, in which an incumbent wins both markets, bring zero continuation values.

B.3.1 Equilibrium configuration 1: $\delta^2 (V_M - 2V_D) \leq -S$

From Lemma 3, in state $\mathcal{M}$ the monopolist obtains $V_M = S$ and, from the above analysis, in state $\mathcal{D}$ each incumbent obtains $V_D = S$. Hence, $\delta^2 (V_M - 2V_D) = -\delta^2 S > -S$, a contradiction.

B.3.2 Equilibrium configuration 2: $-S < \delta^2 (V_M - 2V_D) \leq -(S - s)$

As noted above, in state $\mathcal{D}$, the two incumbents win their respective markets at price p_E and obtain $V_D = S$. Furthermore:

- If in addition $\delta^2 (V_M - 2V_D) \leq -S$, then, from Lemma 3, M obtains $V_M = S$ in state $\mathcal{M}$, and thus $\delta^2 (V_M - 2V_D) = -\delta^2 S > -S$, a contradiction.

- If instead $-S < \delta^2 (V_M - 2V_D) \leq -(S - s)$, then, in state $\mathcal{M}$, M obtains

$$V_M = 2S + \delta^2 (V_M - 2V_D) = \left(1 - \delta^2\right) 2S + \delta^2 V_M = 2S.$$

  We thus have:

$$\delta^2 (V_M - 2V_D) = 0 > -(S - s),$$

  a contradiction.

B.3.3 Equilibrium configuration 3: $-(S - s) < \delta^2 (V_M - 2V_D) \leq s$

In state $\mathcal{D}$, each incumbent keeps its market at price $\tilde{p}$ and obtains

$$V_D = s - \delta^2 (V_M - 2V_D). \tag{21}$$

In state $\mathcal{M}$, M obtains both markets at price $\hat{P}_E = \min\{2p_E, P_E\}$. It will be useful to distinguish two cases, depending on the relevant option, P_E or $2p_E$.

Case a: $-(S - s) < \delta^2 (V_M - 2V_D) < 0$ In that case, in state $\mathcal{M}$, M obtains both markets at price $2p_E$ and obtains

$$V_M = 2S + \delta^2 (V_M - 2V_D).$$

Combining this condition with (21) yields:

$$V_M = 2\frac{\left(1 - 2\delta^2\right) S - \delta^2 s}{1 - 3\delta^2} \text{ and } V_D = \frac{\left(1 - \delta^2\right) s - 2\delta^2 S}{1 - 3\delta^2}.$$

The required conditions thus amount to:

$$-(S-s)<\delta^2\left(2V_D-V_M\right)<0$$

$$\begin{aligned}-(S-s)<\delta^2\left(V_M-2V_D\right) &= \delta^2\left(2\frac{\left(1-2\delta^2\right)S-\delta^2 s}{1-3\delta^2}-2\frac{\left(1-\delta^2\right)s-2\delta^2 S}{1-3\delta^2}\right)\\ &= -\frac{2\delta^2}{3\delta^2-1}(S-s)<0.\end{aligned}$$

The last inequality requires $\delta^2>1/3$; but then, the first inequality amounts to:

$$-\left(3\delta^2-1\right)<-2\delta^2\Longleftrightarrow\delta^2>1,$$

a contradiction.

Case b: $0\leq\delta^2\left(V_M-2V_D\right)\leq s$ In that case, in state $\mathcal{M}$, M obtains both markets at price P_E and obtains

$$V_M=2S.$$

Condition (21) then yields:

$$V_D=s-\delta^2\left(2S-2V_D\right)=\frac{s-2\delta^2 S}{1-2\delta^2}.$$

The required conditions thus amount to:

$$0\leq\delta^2\left(V_M-2V_D\right)=\delta^2\left(2S-2\frac{s-2\delta^2 S}{1-2\delta^2}\right)=\frac{2\delta^2}{1-2\delta^2}(S-s)\leq s.$$

The first condition requires $\delta^2<1/2$, and the second condition then amounts to:

$$\left(1-2\delta^2\right)s\geq 2\delta^2(S-s)\Leftrightarrow\frac{s}{S}\geq\sigma^{Sync}(\delta)=2\delta^2.$$

Given that $s<S$, this condition implies $\delta^2<1/2$. Therefore, if $s/S\geq\sigma^{Sync}(\delta)$, there exists a (symmetric) Markov perfect equilibrium in which: (i) in state $\mathcal{M}$, M wins both markets at price P_E; and (ii) in state $\mathcal{D}$, the two incumbents keep their respective markets at price $\tilde{p}$ and obtain

$$V_D=\frac{s-2\delta^2 S}{1-2\delta^2}\geq 0,$$

where the inequality is strict when $s/S>\sigma^{Sync}(\delta)$.

B.4 Equilibrium multiplicity

When

$$\frac{s}{S} = \sigma^{Sync}(\delta) = 2\delta^2,$$

both types of equilibria coexist, but they yield again the same prices and profits in both states. This is obvious in the monopoly state, as prices remain forever equal to the monopoly price, which is always the same in both equilibria. In the duopoly state, both equilibria yield zero value: this is always the case in the single-state equilibrium, and in the dual-state equilibrium we have:

$$V_D|_{\frac{s}{S}=\sigma^{Sync}(\delta)} = \left.\frac{s - 2\delta^2 S}{1 - 2\delta^2}\right|_{\frac{s}{S}=2\delta^2} = 0.$$

It follows that both equilibrium prices are also zero: in the dual-state equilibrium, the price is equal to:

$$p_{\mathcal{D}}|_{\frac{s}{S}=\sigma^{Sync}(\delta)} = \left(1 - \delta^2\right) V_D|_{\frac{s}{S}=\sigma^{Sync}(\delta)} = 0,$$

and in the single-state equilibrium, the equilibrium price is given by:

$$p_{\mathcal{D}} = \left.\frac{P_D}{2}\right|_{\frac{s}{S}=\sigma^{Sync}(\delta)} = \left.\frac{s}{2} - \delta^2 S\right|_{\frac{s}{S}=2\delta^2} = 0.$$

B.5 Synchronous tenders: recap

Summing-up, we have:

- If $s/S > \sigma^{Sync}(\delta)$, there exists a unique coalition-proof, symmetric Markov perfect equilibrium which is a dual-state equilibrium:
  - in state $\mathcal{M}$, M wins both markets at price P_E and obtains $V_M = 2S$;
  - in state $\mathcal{D}$, the two incumbents keep their respective markets at price $\tilde{p}$ and obtain

    $$V_D = \frac{s - 2\delta^2 S}{1 - 2\delta^2} > 0.$$

  The equilibrium path depends on the initial state:

  - starting from state $\mathcal{M}$ in period 0, the equilibrium path remains in the monopoly state and the *per* market equilibrium price is:

    $$p_{\mathcal{M}} \equiv \frac{P_E}{2} = \left(1 - \delta^2\right) S;$$

– starting instead from state $\mathcal{D}$ in period 0, the equilibrium path remains in the duopoly state and the equilibrium market price is lower (as $V_M > 2V_D$) and equal to:

$$p_{\mathcal{D}} \equiv \tilde{p} = \left(1-\delta^2\right) \frac{s-2\delta^2 S}{1-2\delta^2}.$$

- If instead $s/S < \sigma^{Sync}(\delta)$, there exists a unique Markov perfect equilibrium which is a single-state equilibrium: regardless of the initial state, from period 1 onwards the equilibrium path stays in the monopoly state, and yields the same outcome as above, namely, M wins both markets at price P_E and obtains $V_M = 2S$; the equilibrium per market price is thus again equal to:

$$p_{\mathcal{M}} = \left(1-\delta^2\right) S.$$

- Finally, in the limit case $s/S = \sigma^{Sync}(\delta)$, both of the above equilibria coexist, and yield the same prices and profits:

$$\begin{aligned} V_M &= 2S \text{ and } V_D = 0, \\ p_{\mathcal{M}} &= \left(1-\delta^2\right) S \text{ and } p_{\mathcal{D}} = 0. \end{aligned}$$

C Proof of Proposition 3

As already noted, $p_{\mathcal{M}}^{Sync} > p_{\mathcal{D}}^{Sync}$ whenever a dual-state equilibrium exists under synchronous tenders. We now check that the monopoly price is higher under staggered tendering; noting that monopoly prices are continuous functions of the parameters across the entire range, we have:

- If $s/S \leq \sigma^{Sync}(\delta)$, then:

$$p_{\mathcal{M}}^{Stag} - p_{\mathcal{M}}^{Sync} = (1-\delta)\left[(1+\delta) S + \delta s\right] - \left(1-\delta^2\right) S = (1-\delta)\,\delta s > 0.$$

- If instead $s/S \geq \sigma^{Sync}(\delta)$, then:

$$p_{\mathcal{M}}^{Stag} - p_{\mathcal{M}}^{Sync} = \frac{1-\delta}{1-2\delta}\left[\left(1-\delta-\delta^2\right) S - \delta^2 s\right] - \left(1-\delta^2\right) S = (1-\delta)\,\delta^2 \frac{S-s}{1-2\delta} > 0.$$

- By contrast, duopoly prices are higher under synchronous tendering whenever a dual-state equilibrium exists under both tendering regimes:

$$\begin{aligned} p_{\mathcal{D}}^{Sync} - p_{\mathcal{D}}^{Stag} &= \left(1-\delta^2\right) \frac{s-2S\delta^2}{1-2\delta^2} - \frac{1-\delta^2}{1-2\delta}\left[(1-\delta) s - \delta S\right] \\ &= \frac{1+(1-2\delta)^2}{2} \frac{\left(1-\delta^2\right)\delta\,(S-s)}{(1-2\delta)\left(1-2\delta^2\right)} > 0, \end{aligned}$$

where the conclusion follows from the fact that, under staggered tenders, a dual-state equilibrium exists only when $\sigma^{Stag}(\delta) = \delta/(1-\delta) < s/S < 1$, which thus requires $\left(\delta^2 <\right) \delta < 1/2$.

D Market liberalization

We compare here the various liberalization scenarios:

- starting with a duopoly (break-up) versus a monopoly (no break-up)
- staggered versus synchronous tendering

In the process, it is moreover shown that the equilibrium prices are uniquely defined, even in the limit case where both single-state and dual-state equilibria exist. Furthermore, in that limit case, both equilibria are equally profitable, and thus are both coalition-proof.

D.1 Equilibrium prices

D.1.1 Staggered tenders

Dual-state equilibrium From Proposition 1, this is the unique equilibrium whenever

$$\frac{s}{S} > \sigma^{Stag}(\delta) = \frac{\delta}{1-\delta}.$$

As this equilibrium remains in the initial state forever, the equilibrium price remains constant over time; from Proposition 1, depending on the equilibrium state it is given by (where the argument DSE refers to "dual-state equilibrium", and the subscript $\mathcal{M}$ or $\mathcal{D}$ to the state):

$$\begin{aligned} p_{\mathcal{M}}^{Stag}(DSE) &\equiv \frac{1-\delta}{1-2\delta}\left[\left(1-\delta-\delta^2\right)S-\delta^2 s\right], \\ p_{\mathcal{D}}^{Stag}(DSE) &\equiv \frac{1-\delta^2}{1-2\delta}\left[(1-\delta)s-\delta S\right]. \end{aligned}$$

Single-state equilibrium From Proposition 1, this is the unique equilibrium whenever

$$\frac{s}{S} < \sigma^{Stag}(\delta).$$

• *Initial monopoly.* If the equilibrium starts in the monopoly state, it remains forever in that state and the price is thus constant; from Proposition 1, it is equal to (where the argument SSE refers to "single-state equilibrium"):

$$p_{\mathcal{M}}^{Stag}(SSE) \equiv (1-\delta)\left[(1+\delta)S+\delta s\right].$$

- *Initial duopoly*

  If the equilibrium starts in the duopoly state, it switches forever to the monopoly state from the second tender onwards. Hence:

  - From the second tender onwards, the price is, as above, equal to $p_{\mathcal{M}}^{Stag}(SSE)$.
  - In the first tender, the price is lower, as I is a more effective competitor for C (remember that C is going to prevail, so as to switch to monopoly) than the entrants are for the incumbent later on, in the monopoly state. Specifically, C wins by matching I's best price offered, given by $p_I = -\delta V_C$, where V_C is characterized by condition (3), that is:

    $$V_C = p_I - s + \delta V_M = -s + \delta (V_M - V_C).$$

    Combining this condition with condition (1) yields:

    $$V_M - V_C = S + s,$$

    and plugging this in the above expression of p_I and V_C leads to:

    $$p_{\mathcal{D}}^{Stag}(SSE) = p_I = \delta [(1-\delta)s - \delta S].$$

As a single-state equilibrium exists only when $s/S \leq \sigma^{Stag}(\delta) = \delta/(1-\delta)$, it follows that the duopoly price is non-positive:

$$p_{\mathcal{D}}^{Stag}(SSE) \leq 0.$$

It is therefore a fortiori lower than the monopoly price; indeed, we have:

$$p_{\mathcal{M}}^{Stag}(SSE) - p_{\mathcal{D}}^{Stag}(SSE) = (1-\delta)[(1+\delta)S + \delta s] - \delta[s - \delta(S+s)] = S > 0.$$

Equilibrium coexistence In the boundary case where s/S, both types of equilibrium coexist, as well as many other equilibria, which however differ only in the probability of switching from state $\mathcal{D}$ to $\mathcal{M}$; from Proposition 1, all these equilibria yield the same prices and profits in both states.

D.1.2 Synchronous tenders

Dual-state equilibrium From Proposition (2), this is the unique equilibrium whenever

$$\frac{s}{S} > \sigma^{Sync}(\delta) = 2\delta^2.$$

This equilibrium remains again in the initial state forever, and thus the equilibrium price remains constant over time; from Proposition (2), depending on the equilibrium state it is given by:

$$\begin{aligned} p_{\mathcal{M}}^{Sync}(DSE) &= \left(1-\delta^2\right)S, \\ p_{\mathcal{D}}^{Sync}(DSE) &= \left(1-\delta^2\right)\frac{s-2\delta^2 S}{1-2\delta^2}. \end{aligned}$$

Single-state equilibrium From Proposition (2), this is the unique equilibrium whenever

$$\frac{s}{S} < \sigma^{Sync}(\delta).$$

• *Initial monopoly*

If the equilibrium starts in the monopoly state, it remains forever in that state and the price is thus constant; from Proposition (2), it has the same value as in the dual-state equilibrium:

$$p_{\mathcal{M}}^{Sync}(SSE) = \left(1-\delta^2\right)S = p_{\mathcal{M}}^{Sync}(DSE).$$

• *Initial duopoly*

If the equilibrium starts in the duopoly state, it switches forever to the monopoly state from the second tender onwards. Hence:

- From the second tender onwards, as above the price is equal to $p_{\mathcal{M}}^{Sync}(SSE) = p_{\mathcal{M}}^{Sync}(DSE)$.
- In the first tender, the price is again lower thanks from tougher competition among I and C:
    - From the first condition on page 10, the bundle price is equal to:

      $$P_D = s - 2\delta^2 S.$$

      It follows that the per-market price is given by:

      $$p_{\mathcal{D}}^{Sync}(SSE) = \frac{P_D}{2} = \frac{s}{2} - \delta^2 S.$$

As this single-state equilibrium exists only when $s/S \leq \sigma^{Sync}(\delta) = 2\delta^2$, it follows that the duopoly price is again non-positive:

$$p_{\mathcal{D}}^{Stag}(SSE) \leq 0,$$

and thus lower than the monopoly price:

$$p_{\mathcal{M}}^{Sync}(SSE) - p_{\mathcal{D}}^{Sync}(SSE) = \left(1-\delta^2\right)S - \left(\frac{s}{2} - \delta^2 S\right) = S - \frac{s}{2} > 0.$$

Equilibrium coexistence As already noted, (coalition-proof) equilibrium prices and payoffs are uniquely defined. This is obvious when the (coalition-proof) equilibrium itself is unique, which is generically the case, but it holds as well in the particular cases where both equilibria (single-state and dual-state) coexist, as they then yield the same prices and the same payoffs to all firms in all states.

D.2 Break-up decision

Taking as given the nature of the tendering process (staggered or synchronous), it is always optimal to break up the incumbent, so as to start in the duopoly state.

To see this, consider first the generic case where the (coalition-proof) equilibrium is unique. As duopoly prices are lower than monopoly ones (that is, $p^t_{\mathcal{D}}(DSE) < p^t_{\mathcal{M}}(DSE)$ for any $t \in \{Stag, Sync\}$), starting in the duopoly state rather than the monopoly state always lowers the price that emerges in the first tender; furthermore, in the following tenders, this either has no impact (in single-state equilibria) or it also lowers the prices forever (in dual-state equilibria). It follows that breaking up the incumbent is optimal.

Consider now the limit case where both types of equilibrium coexist. If the first tender takes place in the monopoly state, the price remains forever equal to the monopoly price – regardless of which equilibrium is selected. If instead the first tender takes place in the duopoly state, which yields a lower price than under monopoly. In the subsequent tenders, the price is the monopoly price (as in the previous scenario) if the single-state equilibrium is selected, and the lower, duopoly price otherwise. Hence, regardless of which equilibrium is selected, breaking up the incumbent yields a lower price in the first tender, and a weakly lower price afterwards.

D.3 Total bills

We now derive the total bill for the two cities when the incumbent has been broken up. For each tendering regime, we consider both types of equilibria in turn.

D.3.1 Staggered tenders

Under staggered tenders, each city runs one tender in every period. The total bill per city is therefore of the form $\Sigma_{t=1}^{+\infty}\delta^{t-1}p_t^{Stag}$.

Dual-state equilibrium

In a dual-state equilibrium, tenders take place in the duopoly state forever. Hence, in each city the total bill is:

$$\begin{aligned}\frac{\mathcal{P}^{Stag}(DSE)}{2} &= \frac{1}{1-\delta}p_{\mathcal{D}}^{Stag}(DSE) \\ &= \frac{1}{1-\delta}\frac{1-\delta^2}{1-2\delta}\left[(1-\delta)s-\delta S\right] \\ &= \frac{1+\delta}{1-2\delta}\left[(1-\delta)s-\delta S\right].\end{aligned}$$

Single-state equilibrium

In a single-state equilibrium, tenders take place in the duopoly state in the first period, and in the monopoly state forever afterwards. Hence, in each city the total bill is:

$$\begin{aligned}\frac{\mathcal{P}^{Stag}(SSE)}{2} &= p_{\mathcal{D}}^{Stag}(SSE)+\frac{\delta}{1-\delta}p_{\mathcal{M}}^{Stag}(SSE) \\ &= \delta\left[(1-\delta)s-\delta S\right]+\frac{\delta}{1-\delta}(1-\delta)\left[(1+\delta)S+\delta s\right] \\ &= \delta(S+s).\end{aligned}$$

D.3.2 Synchronous tenders

Under synchronous tenders, each city runs two tenders every other period, and one city starts in the first period whereas the other starts one period later. The total bill for the two cities is therefore of the form $2p_1^{Sync}+\delta 2p_2^{Sync}+\Sigma_{t=3}^{+\infty}\delta^{t-1}2p_t^{Sync}$.

Dual-state equilibrium

In a dual-state equilibrium, all tenders take place in the duopoly state forever. Hence, the total bill is such that:

$$\begin{aligned}\frac{\mathcal{P}^{Sync}(DSE)}{2} &= \frac{1}{1-\delta}p_{\mathcal{D}}^{Sync}(DSE) \\ &= \frac{1}{1-\delta}\left(1-\delta^2\right)\frac{s-2\delta^2 S}{1-2\delta^2} \\ &= (1+\delta)\frac{s-2\delta^2 S}{1-2\delta^2}.\end{aligned}$$

D.3.3 Single-state equilibrium

In a single-state equilibrium, in each city the first tender takes place in the duopoly state, and all subsequent tenders take place in the monopoly state. Hence, the total bill is such that:

$$\begin{aligned}\frac{\mathcal{P}^{Sync}(SSE)}{2} &= (1+\delta)\,p_{\mathcal{D}}^{Sync}(SSE)+\frac{\delta^2}{1-\delta}p_{\mathcal{M}}^{Sync}(SSE)\\ &= (1+\delta)\left(\frac{s}{2}-\delta^2 S\right)+\frac{\delta^2}{1-\delta}\left(1-\delta^2\right)S\\ &= (1+\delta)\,\frac{s}{2}.\end{aligned}$$

D.4 Tendering decision

D.4.1 Case 1: $s/S > \sigma^{Stag}(\delta)$

In this region, we have a dual-state equilibrium under both tendering regimes. It follows that all tenders take place forever in the duopoly state. As duopoly prices are lower under staggered tenders, it follows that staggered tenders are preferable.

Indeed, we have:

$$\begin{aligned}\frac{\mathcal{P}^{Sync}(DSE)}{2}-\frac{\mathcal{P}^{Stag}(DSE)}{2} &= (1+\delta)\,\frac{s-2\delta^2 S}{1-2\delta^2}-\frac{1+\delta}{1-2\delta}\left[(1-\delta)\,s-\delta S\right]\\ &= \frac{\delta\,(1+\delta)\left(1-2\delta+2\delta^2\right)}{(1-2\delta)\left(1-2\delta^2\right)}(S-s)\\ &> 0,\end{aligned}$$

where the inequality follows from the condition $s/S > \sigma^{Stag}(\delta) = \delta/(1-\delta)$, which implies $\left(\delta^2 <\right)\delta < 1/2$.

D.4.2 Case 2: $s/S < \sigma^{Sync}(\delta)$

In this region, we have a single-state equilibrium under both tendering regimes. The comparison of the total bills shows that synchronous tenders are preferable:

$$\begin{aligned}\frac{\mathcal{P}^{Stag}(SSE)}{2}-\frac{\mathcal{P}^{Sync}(SSE)}{2} &= \delta\,(S+s)-(1+\delta)\,\frac{s}{2}\\ &= \delta S-(1-\delta)\,\frac{s}{2}\\ &> 0,\end{aligned}$$

where the inequality follows from the condition $s/S < \sigma^{Sync}(\delta)$:

$$\frac{s}{S} < \sigma^{Sync}(\delta) = 2\delta^2 < 2\frac{\delta}{1-\delta}.$$

D.4.3 Case 3: $\sigma^{Sync}(\delta) < s/S < \sigma^{Stag}(\delta)$

In this region, we have a single-state equilibrium under staggered contracts and a dual-state equilibrium under synchronous tenders. The comparison of the total bills yields:

$$\begin{aligned}\frac{\mathcal{P}^{Sync}(DSE)}{2} - \frac{\mathcal{P}^{Stag}(SSE)}{2} &= (1+\delta)\frac{s-2\delta^2 S}{1-2\delta^2} - \delta(S+s) \\ &= \frac{\left(1+2\delta^3\right)s - (1+2\delta)\delta S}{1-2\delta^2}.\end{aligned}$$

This expression is positive when s/S is large enough, namely, when

$$\frac{s}{S} > \hat{\sigma}(\delta) \equiv \frac{1+2\delta}{1+2\delta^3}\delta,$$

and negative otherwise. The threshold $\hat{\sigma}(\delta)$ lies above We have:

$$\begin{aligned}\sigma^{Sync}(\delta) &< \hat{\sigma}(\delta) \Leftrightarrow 2\delta^2 < \frac{1+2\delta}{1+2\delta^3}\delta \\ &\Leftrightarrow 2\delta\left(1+2\delta^3\right) < 1+2\delta \\ &\Leftrightarrow 4\delta^4 < 1,\end{aligned}$$

where the last inequality follows from $2\delta^2 = \sigma^{Sync}(\delta) < s/S \leq 1$. Furthermore, $\hat{\sigma}(\delta)$ lies below σ^{Stag} for delta large enough:

$$\begin{aligned}\hat{\sigma}(\delta) &< \sigma^{Stag}(\delta) \Leftrightarrow \frac{1+2\delta}{1+2\delta^3}\delta < \frac{\delta}{1-\delta} \\ &\Leftrightarrow 0 < (1+2\delta)(1-\delta) - \left(1+2\delta^3\right) = \delta\left(1-2\delta-2\delta^2\right) \\ &\Leftrightarrow \delta < \frac{\sqrt{3}-1}{2} \simeq 0.37.\end{aligned}$$

D.4.4 Recap

It follows that staggered contracts are preferred if $s/S > \min\left\{\sigma^{Sync}(\delta), \hat{\sigma}(\delta)\right\}$ (which, by construction, includes the entire region where $s/S > \sigma^{Sync}(\delta)$), whereas synchronous tenders are preferred if $s/S < \min\left\{\sigma^{Sync}(\delta), \hat{\sigma}(\delta)\right\}$ (which includes the entire region where $s/S < \sigma^{Stag}(\delta)$, as $\sigma^{Sync}(\delta)$ lies below $\hat{\sigma}(\delta)$ and $\sigma^{Stag}(\delta)$), as illustrated in Figure 2.

E References

- Amaral, Miguel, Stéphane Saussier and Anne Yvrande–Billon (2009) "Auction procedures and competition in public services: The case of urban public transport in France and London," *Utilities Policy*, 17(2): 166-175.

- Amaral, Miguel, Stéphane Saussier and Anne Yvrande–Billon (2013), "Expected Number of Bidders and Winning Bids: Evidence from the London Bus Tendering," *Journal of Transport Economics and Policy*, 47(1): 17-34

- Anton, James J., and Dennis A. Yao (1987), "Second Sourcing and the Experience Curve: Price Competition in Defense Procurement," *RAND Journal of Economics*, 18(1): 57-76.

- Anton, James J., and Dennis A. Yao (1992), "Coordination in Split Awards Auctions," *Quarterly Journal of Economics*, 107(2): 681-707.

- Athey, Susan, Dominic Coey and Jonathan Levin (2013), "Set-Asides and Subsidies in Auctions," *American Economic Journal: Microeconomics*, 5(1): 1-27.

- Barbosa, Klenio, and Pierre C. Boyer (2017), "Discrimination in Dynamic Procurement Design with Learning-by-doing," *Mimeo,* Sao Paulo School of Economics.

- Bernheim, B. Douglas, Bezalel Peleg and Michael D. Whinston (1987), "Coalition-Proof Nash Equilibria I. Concepts," *Journal of Economic Theory*, 42(1): 1-12.

- Cabral, Luis (2017), "Staggered Contracts, Market Power, and Welfare," *Mimeo*, Columbia University.

- Cabral, Luis, and Shane Greenstein (1990), "Switching Costs and Bidding Parity in Government Procurement of Computer Systems," *Journal of Law, Economics, and Organization*, 6(2): 453-469.

- Cantillon, Estelle, and Martin Pesendorfer (2007), "Combination bidding in multi-unit auctions," CEPR Discussion Paper n° 6083.

- Dana, James D., and Kathryn Spier (1994), "Designing a Private Industry: Government Competition with Endogenous Market Structure," *Journal of Public Economics*, 53(1): 127-147.

- Dana, James D., and Yuk-Fai Fong (2011), "Long-lived Consumers, Intertemporal Bundling and Tacit Collusion," *Journal of Industrial Economics*, 59(4): 609-629.

- De Silva, Dakshina G. (2005), "Synergies in Recurring Procurement Auctions: An Empirical Investigation," *Economic Inquiry*, 43(1): 55-66.

- De Silva, Dakshina G., Timothy Dunne and Georgia Kosmopoulou (2003), "An Empirical Analysis of Entrant and Incumbent Bidding in Road Construction Auctions," *Journal of Industrial Economics*, 51(3): 295-316.

- De Silva, Dakshina G., Thomas D. Jeitschko and Georgia Kosmopoulou (2005), "Stochastic Synergies in Sequential Auctions," *International Journal of Industrial Organization*, 23(3-4): 183-201.

- De Silva, Dakshina G., Georgia Kosmopoulou and Carlos Lamarche (2009), "The Effect of Information on the Bidding and Survival of Entrants in Procurement Auctions," *Journal of Public Economics*, 93(1-2): 56-72.

- European Commission (2016), *Study on Economic and Financial Effects of the Implementation of Regulation 1370/2007 on Public Passenger Transport Services*, European Commission.

- Gourvish, Terence R. (2002), *British Rail 1974-1997: From Integration to Privatisation*, Oxford: Oxford University Press.

- Grimm, Veronika, Riccardo Pacini, Giancarlo Spagnolo and Matteo Zanza (2006), "Division in lots and Competition in Procurement," in *Handbook of Procurement*, N. Dimitri, G. Piga and G. Spagnolo eds., Cambridge: Cambridge University Press, 168-192.

- Iacobucci, Edward, and Ralph A. Winter (2012), "Collusion on Exclusion," Mimeo.

- Iossa, Elisabetta and Michael Waterson (2017a), "Maintaining Competition in Recurrent Procurement Contracts: A case study on the London bus market," Forthcoming in *Transport Policy.*

- Iossa, Elisabetta, and Michael Waterson (2017b), "Competition in London local bus tendering," *Mimeo*, University of Warwick.

- Jofre-Bonet, Mireia, and Martin Pesendorfer (2000), "Bidding behavior in a repeated procurement auction: A summary," *European Economic Review*, 44 (4-6): 1006-1020

- Laffont, Jean-Jacques, and Jean Tirole (1988), "Repeated Auctions of Incentive Contracts, Investment, and Bidding Parity with an Application to Takeovers," *RAND Journal of Economics*, 19(4): 516-537.

- Lewis, Tracy, and Huseyin Yildirim (2002), "Managing Dynamic Competition," *American Economic Review*, 92(4): 779-797.

- Lewis, Tracy, and Huseyin Yildirim (2005), "Managing Switching Costs in Multiperiod Procurements With Strategic Buyers," *International Economic Review*, 43: 1233-1269.

- Maskin, Eric, and John Riley (2000), "Asymmetric Auctions," *Review of Economic Studies*, 67(3): 413-438.

- Myerson, Roger (1981), "Optimal Auction Design," *Mathematics of Operations Research*, 6(1): 58–73.

- OECD (2017), *Government at a Glance 2017*, Paris: OECD.

- Saini, Viplav (2012), "Endogenous Asymmetry in a Dynamic Procurement Auction," *RAND Journal of Economics* 43(4): 726-760.

- Shaw, Jon (2000), *Competition, Regulation and the Privatisation of British Rail*, Aldershot: Ashgate.

- Transport for London (2017), *London's Bus Contracting and Tendering Process,* London.

- Weiergraeber, Stefan and Christoph Wolf (2018), "Bidder Asymmetries in Procurement Auctions: Efficiency vs. Information," *Mimeo*, Bocconi University.

- Williamson, Oliver E. (1979), "Transaction-Cost Economics: The Governance of Contractual Relations," *Journal of Law and Economics* 22(2): 233-261.

Online Appendix
(Not for Publication)

We revisit here the case of synchronous tenders under the assumption that entrants benefit from scale economies: entering both markets requires to sink $S+s$ rather than $2S$. We have:

Proposition 6 (synchronous tenders under scale economies for entry) *Under synchronous tendering, there exists a unique Coalition-Proof Nash equilibrium, characterized as follows:*

- *Single-state equilibrium. If*

$$\frac{s}{S} < \hat{\sigma}^{Sync}(\delta) \equiv \frac{\delta^2}{1-\delta^2},$$

then, regardless of the state in period 0*, from period* 1 *onwards the equilibrium path stays in the monopoly state; one firm then keeps servicing both markets, and the equilibrium price is*

$$\hat{p}^{Sync}_{\mathcal{M}} \equiv \left(1-\delta^2\right)\frac{S+s}{2}.$$

- *Dual-state equilibrium. If instead*

$$\frac{s}{S} \geq \hat{\sigma}^{Sync}(\delta),$$

then the equilibrium path remains in the initial state:

  - *Starting from the monopoly state in period* 0*, the same firm services both markets forever; the firm obtains again* $V_M = 2S$ *and the equilibrium price remains equal to*

$$\hat{p}^{Sync}_{\mathcal{M}} \equiv \left(1-\delta^2\right)\frac{S+s}{2}.$$

  - *Starting instead from the duopoly state in period* 0*, the same firms service their respective markets forever; they each obtain*

$$\hat{V}_D = \frac{s-\delta^2\left(S+s\right)}{1-2\delta^2} < \frac{\hat{V}_M}{2},$$

and the equilibrium price is

$$\hat{p}^{Sync}_{\mathcal{D}} \equiv \left(1-\delta^2\right)\frac{s-\delta^2\left(S+s\right)}{1-2\delta^2}.$$

Proof. See Section A of this Online appendix. ■

Comparing these findings with that of Proposition 2 shows that entry scale economies make a dual-state equilibrium more likely to arise:

$$\begin{aligned}
\sigma^{Sync}(\delta) = 2\delta^2 < \frac{s}{S} \,(< 1) \quad &\Longrightarrow \quad \delta^2 < \frac{1}{2} \\
&\Longrightarrow \quad \frac{\delta^2}{1-\delta^2} < 2\delta^2 \\
&\Longrightarrow \quad \hat{\sigma}^{Sync}(\delta) = \frac{\delta^2}{1-\delta^2} < \frac{s}{S}.
\end{aligned}$$

This comparison also shows that, under synchronous tenders, entry scale economies tend to lower equilibrium prices in the monopoly state, and increase them instead in the duopoly state:

$$\begin{aligned}
p_{\mathcal{M}}^{Sync} - \hat{p}_{\mathcal{M}}^{Sync} &= \left(1-\delta^2\right) S - \left(1-\delta^2\right) \frac{S+s}{2} = \left(1-\delta^2\right) \frac{S-s}{2} > 0, \\
\hat{p}_{\mathcal{D}}^{Sync} - p_{\mathcal{D}}^{Sync} &= \left(1-\delta^2\right) \frac{s-\delta^2(S+s)}{1-2\delta^2} - \left(1-\delta^2\right) \frac{s-2\delta^2 S}{1-2\delta^2} = \left(1-\delta^2\right) \frac{\delta^2(S-s)}{1-2\delta^2} > 0.
\end{aligned}$$

The following proposition shows that equilibrium prices are nevertheless ranked in the same order:

Proposition 7 (price comparison under scale economies for entry) *We have:*

$$p_{\mathcal{M}}^{Stag} > \hat{p}_{\mathcal{M}}^{Sync} > \hat{p}_{\mathcal{D}}^{Sync} > p_{\mathcal{D}}^{Stag}.$$

Proof. See Section B of this Online appendix. ■

With entry scale economies ($S+s$ rather than $2S$) under synchronous tenders, the entrants exert more pressure on the incumbent in the monopoly state, which tends to lower the monopoly price; indirectly, this reduces the intensity of competition among the two incumbents in the duopoly state, which tends to increase duopoly prices. Still, the four equilibrium prices are still ranked as in the baseline model. Intuitively, entry scale economies under synchronous tenders reinforce the result that $p_{\mathcal{M}}^{sync} < p_{\mathcal{M}}^{stag}$. As we have discussed in Section 5, this, in turn, explains why $p_{\mathcal{D}}^{sync} < p_{\mathcal{D}}^{stag}$, and these two inequalities again imply that the profit increase resulting from switching to monopoly is reduced, making dual state more likely

A Proof of Proposition 6

We now study the equilibria of the game in which, in every even period, both markets are up for tender. We start again by characterizing best offers, and derive the implications for the equilibrium outcomes.

A.1 Best offers

A.1.1 Entrants

In both states $\mathcal{M}$ and $\mathcal{D}$, any potential entrant obtains:

$$v_E = \begin{cases} P - S - s + \delta^2 V_M & \text{if it wins both markets at total price } P, \\ p - S + \delta^2 V_D & \text{if it wins one (and only one) market at price } p, \\ 0 & \text{if it loses both markets.} \end{cases}$$

Potential entrants are thus willing to offer:

- servicing both markets for a bundled price

$$P_E = S + s - \delta^2 V_M, \tag{22}$$

- or servicing a single market for a stand-alone price

$$p_E = S - \delta^2 V_D.$$

A.1.2 Incumbent monopolist

In state $\mathcal{M}$, the incumbent monopolist, M, obtains:

$$v_M = \begin{cases} P + \delta^2 V_M & \text{if it wins both markets at total price } P, \\ p + \delta^2 V_D & \text{if it wins one market at price } p, \\ 0 & \text{if it loses both markets.} \end{cases}$$

It follows that M would be willing to service both markets for a bundle price $P_M = P_E - S - s < P_E$ and to service a single market for a stand-alone price $p_M = p_E - S < p_E$.

It follows that M always find it profitable to win at least one market. Furthermore, we have:

Lemma 5 (state $\mathcal{M}$ for synchronous tenders under scale economies for entry) *Under synchronous tendering, in state $\mathcal{M}$:*

- if

$$\delta^2 (V_M - 2V_D) > -S,$$

then in equilibrium M wins both markets at price

$$\hat{P}_E \equiv \min \{P_E, 2p_E\};$$

the game then remains in state $\mathcal{M}$, and M obtains

$$V_M = S + s + \min \left\{0, S - s + \delta^2 (V_M - 2V_D)\right\} \in [S, S + s].$$

- If instead
$$\delta^2 (V_M - 2V_D) < -S,$$
then in equilibrium M wins a single market at price $\hat{p} = p_E$; the game then switches to state $\mathcal{D}$ and M obtains
$$V_M = S.$$

- Finally, if $\delta^2 (V_M - 2V_D) = -s$, both options can arise in equilibrium, and $V_M = S$.

Proof. If $V_M \geq 2V_D - (S - s)$, then $P_E \leq 2p_E$; it follows that:

- in order to win both markets, M must match P_E, which yields
$$V_b = P_E + \delta^2 V_M = S + s;$$

- in order to win a single market, M must offer a price p such that $p + p_E \leq P_E$, which yields
$$V_s = P_E - p_E + \delta^2 V_D = s - \delta^2 (V_M - 2V_D).$$

If instead $V_M < 2V_D - (S - s)$, then $P_E > 2p_E$; it follows that:

- in order to win both markets, M must match $2p_E$, which yields$V_b = 2p_E + \delta^2 V_M = 2S + \delta^2 (V_M - 2V_D)$;

- in order to win a single market, M must match p_E, which yields
$$V_s = p_E + \delta^2 V_D = S.$$

In the former case ($V_M \geq 2V_D - (S - s)$), $V_b - V_s = S + \delta^2 (V_M - 2V_D) \geq s > 0$; in the latter case ($V_M < 2V_D$), $V_b - V_s = S + \delta^2 (V_M - 2V_D)$. Therefore:

- If
$$\delta^2 (V_M - 2V_D) > -S,$$
then in equilibrium M wins both markets at price $\hat{P}_E$; the game then remains in state $\mathcal{M}$, and M obtains
$$\begin{aligned} V_M &= \hat{P}_E + \delta^2 V_M \\ &= \min\left\{S + s - \delta^2 V_M, 2\left(S - \delta^2 V_D\right)\right\} + \delta^2 V_M \\ &= S + s + \min\left\{0, S - s + \delta^2 (V_M - 2V_D)\right\} (\leq S + s). \end{aligned}$$
It follows from $\delta^2 (V_M - 2V_D) > -S$ that $\min\left\{0, \delta^2 (V_M - 2V_D) + S - s\right\} \in [-s, 0]$, and thus $V_M \in [S, S + s]$.

- If instead
$$\delta^2 (V_M - 2V_D) < -S,$$
which implies $V_M < 2V_D - (S - s)$ and thus $\hat{P}_E = 2p_E$, then in equilibrium M wins a single market at price $\hat{p} = p_E$; the game then switches to state $\mathcal{D}$ and M obtains
$$V_M = p_E + \delta^2 V_D = S.$$
- Finally, if $\delta^2 (V_M - 2V_D) = -S$, both options can arise in equilibrium, and $V_M = V_b = V_s = S$.

■

Lemma 5 implies in particular that it is strictly profitable to be a monopolist servicing both markets.

A.1.3 Incumbent duopolists

In state $\mathcal{D}$, each incumbent firm obtains:

$$v_D = \begin{cases} P - s + \delta^2 V_M & \text{if it wins both markets at total price } P, \\ \underline{p} + \delta^2 V_D & \text{if it wins only its own market at price } \underline{p}, \\ \bar{p} - s + \delta^2 V_D & \text{if it wins only the other market at price } \bar{p}, \\ 0 & \text{if it loses both markets.} \end{cases}$$

Each incumbent is thus willing to lower its prices down to:

$$\begin{aligned} P_D &= s - \delta^2 V_M, \\ \underline{p}_D &= -\delta^2 V_D, \\ \bar{p}_D &= s - \delta^2 V_D. \end{aligned} \tag{23}$$

Noting that $P_D < P_E$ and $\underline{p}_D < \bar{p}_D < p_E$ leads to:

Lemma 6 (state $\mathcal{D}$ for synchronous tenders under scale economies for entry) *In equilibrium, either one incumbent wins both markets, or each incumbent wins the market that it is currently servicing.*

Proof. We have: $P_E = P_D + S > P_D$, $p_E = \bar{p}_D + S - s > \bar{p}_D$ and $\bar{p}_D = \underline{p}_D + s > \underline{p}_D$.

We first check that potential entrants cannot win any market. Suppose first that a potential entrant wins a single market, implying that at least one incumbent must exit. The entrant must charge at least p_E (otherwise, it would make a loss, and thus profitably opt out); but then, the exiting incumbent could profitably outbid the entrant, as $p_E > \max\left\{\bar{p}_D, \underline{p}_D\right\}$. Likewise, if a potential entrant wins both markets, then any incumbent could profitably outbid it.

It follows that either one incumbent wins both markets, or each incumbent wins a single market. Furthermore, in the latter case, the incumbents must win the markets that already service. Indeed, if the incumbents were to win each other's markets, then any of them could profitably deviate by targeting its own market instead, so as to save the entry cost s. ■

This lemma establishes that there are only two types of equilibrium outcomes in state $\mathcal{D}$. We show in the next two sections that, in both cases, M wins both markets in state $\mathcal{M}$, implying that, again, the equilibrium is either a single-state or a dual-state equilibrium.

A.2 Single-state equilibrium

Consider a candidate equilibrium in which, in state $\mathcal{D}$, one incumbent firm wins both markets. If the total price is strictly lower than P_D, then the winner could profitably deviate by opting out. If instead the total price P is strictly higher than P_D, then the losing incumbent could profitably deviate by offering to service both markets at a price lying between P_D and P (together with prohibitively high stand-alone prices). Hence, the equilibrium total price must be equal to P_D, implying that both incumbents obtain $V_D = 0$.

It follows from Lemma 5 that $V_M \geq S > 0 = 2V_D$ and thus, in state $\mathcal{M}$, M wins both markets at total price P_E and obtains:

$$V_M = S + s.$$

This establishes that the candidate equilibrium is a single-state equilibrium, in which the equilibrium path stays in the monopoly state from period 1 onwards, and that the outcome of these equilibria is unique, and (using (22) and (23)) such that:

- in state $\mathcal{M}$, M wins both markets at per market price:

$$\frac{P_E}{2} = \frac{S + s - \delta^2 V_M}{2} = \left(1 - \delta^2\right) \frac{S + s}{2};$$

- in state $\mathcal{D}$, one incumbent firm wins both markets at per market price:

$$\frac{P_D}{2} = \frac{s - \delta^2 V_M}{2} = \frac{s - \delta^2 (S + s)}{2}.$$

To establish existence, consider the following equilibrium strategies:

- in state $\mathcal{M}$, M offers a bundle price equal to $P_E = \left(1-\delta^2\right)(S+s)$, together with stand-alone prices $p_E = S$.
- in state $\mathcal{D}$, both incumbents offer a bundle price equal to $P_D = s - \delta^2 (S+s)$, together with stand-alone prices $p_E = S$.

In state $\mathcal{M}$, M then wins both markets and obtains $V_M = S + s$: the auctioneer is indeed indifferent between allocating both markets to M or to an entrant (and M could break that indifference by offering slightly less than P_E), and it prefers this to allocating the markets to different firms, as $2p_E = 2S > \left(1-\delta^2\right)(S+s) = P_E$. Furthermore, Lemma 5 and $V_M > 2V_D$ together ensure that M has no incentive to deviate.

In state $\mathcal{D}$, one incumbent then wins both markets, as $P_D = s - \delta^2 (S+s) < P_E = \left(1-\delta^2\right)(S+s) < 2p_E = 2S$, and both incumbents obtain $V_D = 0$. Furthermore, incumbents cannot profitably deviate: exiting yields the same zero value, and focusing on a single market requires offering a price p such that $p + p_E \leq P_D$; hence the profit from such a deviation does not exceed (using $p \leq P_D - p_E$ and assuming that the incumbent targets its own market – targeting the other market would be even less profitable):

$$V = P_D - p_E + \delta^2 V_D = s - \delta^2 (S+s) - S = -(S-s) - \delta^2 (S+s) < 0.$$

Therefore, there always exists a Markov perfect equilibrium that is a single-state equilibrium, and the outcome of such equilibria is unique; in particular, from period 1 onwards, the per market equilibrium price is equal to

$$\frac{P_E}{2} = \left(1-\delta^2\right)\frac{S+s}{2}.$$

To determine whether this equilibrium is coalition-proof, we first need to study the possibility of alternative equilibria in which, in state $\mathcal{D}$, the two incumbents win their respective markets.

A.3 Dual-state equilibrium

Consider now a candidate equilibrium in which, in state $\mathcal{D}$, each incumbent firm wins the market that it already services. Letting p denote the equilibrium price, each incumbent obtains:

$$p + \delta^2 V_D = p - \underline{p}_D.$$

The equilibrium prices p and P must satisfy the following conditions:

- Winning the market must be profitable:

$$p \geq \underline{p}_D.$$

- The auctioneer must prefer splitting the market between the incumbents:

$$2p \leq \min\{P, P_E, 2p_E\}. \tag{24}$$

- No incumbent should find it profitable to deviate by outbidding the other so as to win both markets:

$$p - \underline{p}_D \geq P - P_D. \tag{25}$$

Condition (24) implies $P \geq 2p$, which, combined with (25), implies

$$p \leq \tilde{p} \equiv P_D - \underline{p}_D = s + \delta^2 (V_D - V_M).$$

It follows that the equilibrium price p must satisfy

$$\underline{p}_D \leq p \leq \min\left\{\tilde{p}, \frac{P_E}{2}, p_E\right\}.$$

Conversely, any price p satisfying this condition, together with $P = 2p$, satisfies all the above conditions and thus constitutes an equilibrium.

Such an equilibrium therefore exists if and only $\underline{p}_D \leq \min\{\tilde{p}, P_E/2, p_E\}$. As $p_E > \underline{p}_D$ and $\tilde{p} \geq \underline{p}_D$ implies $P_E/2 > \underline{p}_D$,[31] the relevant equilibrium condition is

$$\tilde{p} = P_D - \underline{p}_D \geq \underline{p}_D \Longleftrightarrow P_D \geq 2\underline{p}_D \Longleftrightarrow \delta^2 (V_M - 2V_D) \leq s.$$

Conversely, whenever such an equilibrium exists, the most profitable of these equilibria, which is thus a coalition-proof equilibrium,[32] is such that the incumbents charge $\min\{\tilde{p}, P_E, 2p_E\}$.

To study the existence of such an equilibrium, we note that:

$$\tilde{p} > \frac{P_E}{2} \Longleftrightarrow \delta^2 (V_M - 2V_D) < -(S - s) \Longleftrightarrow \tilde{p} > p_E \Longleftrightarrow \frac{P_E}{2} > p_E.$$

Therefore:

[31] $\tilde{p} = P_D - \underline{p}_D \geq \underline{p}_D$ amounts to $P_D \geq 2\underline{p}_D$; as $P_E > P_D$, this implies $P_E > 2\underline{p}_D$.

[32] Recall that the alternative equilibrium, in which an incumbent wins both markets, bring zero continuation values.

- If $\delta^2 (V_M - 2V_D) \leq -(S-s)$, then $p_E \leq \min\{\tilde{p}, P_E/2\}$; incumbents thus win their markets at price p_E and obtain $V_D = S$.
- If $\delta^2 (V_M - 2V_D) > -(S-s)$, then $\tilde{p} < \min\{p_E, P_E/2\}$; incumbents thus win their markets at price $\tilde{p}$ and obtain $V_D = s - \delta^2 (V_M - 2V_D)$.

As the outcome of state $\mathcal{M}$ depends on the comparison between $\delta^2 (2V_D - V_M)$ and $-S$, we can therefore distinguish three configurations, depending on where $\delta^2 (2V_D - V_M)$ lies, compared with the thresholds $-(S-s)$ and $-S$. We consider each case in turn.

A.3.1 Equilibrium configuration 1: $\delta^2 (V_M - 2V_D) \leq -S$

From the above analysis, we then have $V_M = V_D = S$, and thus $\delta^2 (V_M - 2V_D) = -\delta^2 S > -S$, a contradiction.

A.3.2 Equilibrium configuration 2: $-S < \delta^2 (V_M - 2V_D) \leq -(S-s)$

From the above analysis, we then have

$$V_M = S + s + S - s + \delta^2 (V_M - 2V_D) = 2S + \delta^2 (V_M - 2V_D)$$

and $V_D = S$, leading to

$$V_M - 2V_D = \delta^2 (V_M - 2V_D).$$

We thus have:

$$\delta^2 (V_M - 2V_D) = 0 > -(S-s),$$

a contradiction.

A.3.3 Equilibrium configuration 3: $-(S-s) < \delta^2 (V_M - 2V_D) \leq s$

In state $\mathcal{D}$, each incumbent keeps its market at price $\tilde{p}$ and obtains

$$V_D = s - \delta^2 (V_M - 2V_D).$$

In state $\mathcal{M}$, M obtains both markets at price P_E and obtains

$$V_M = S + s.$$

We thus have:

$$V_M - 2V_D = S + s - 2\left(s - \delta^2 (V_M - 2V_D)\right) = S - s + 2\delta^2 (V_M - 2V_D),$$

leading to:

$$V_M - 2V_D = \frac{S-s}{1-2\delta^2}.$$

The required conditions thus amount to:

$$-\left(S-s\right) \leq \delta^2 \left(V_M - 2V_D\right) = \frac{\delta^2}{1-2\delta^2} \left(S-s\right) \leq s.$$

The first condition requires $\delta^2 < 1/2$,[33] and the second condition then amounts to:

$$\left(1-2\delta^2\right) s \geq \delta^2 \left(S-s\right) \Leftrightarrow \frac{s}{S} \geq \sigma^{Sync}\left(\delta\right) = \frac{\delta^2}{1-\delta^2}.$$

Given that $s < S$, this condition implies $\delta^2 < 1/2$. Therefore, if $s/S \geq \sigma^{Sync}\left(\delta\right)$, there exists a (symmetric) Markov perfect equilibrium in which: (i) in state $\mathcal{M}$, M wins both markets at price P_E; and (ii) in state $\mathcal{D}$, the two incumbents keep their respective markets at price $\tilde{p}$ and obtain

$$V_D = \frac{s - \delta^2 \left(S+s\right)}{1-2\delta^2} \geq 0,$$

where the inequality is strict when $s/S > \sigma^{Sync}\left(\delta\right)$.

A.4 Synchronous tenders: recap

Summing-up, we have:

- If $s/S > \sigma^{Sync}\left(\delta\right)$, there exists a unique coalition-proof, symmetric Markov perfect equilibrium which is a dual-state equilibrium:
  - in state $\mathcal{M}$, M wins both markets at price P_E and obtains $V_M = 2S$;
  - in state $\mathcal{D}$, the two incumbents keep their respective markets at price $\tilde{p}$ and obtain

$$V_D = \frac{s - \delta^2 \left(S+s\right)}{1-2\delta^2} > 0.$$

  The equilibrium path depends on the initial state:

[33] If $\delta^2 > 1/2$, then $\delta^2 < 1$ implies $\delta^2 / \left(1-2\delta^2\right) < -1$.

– starting from state $\mathcal{M}$ in period 0, the equilibrium path remains in the monopoly state and the *per* market equilibrium price is:

$$p_{\mathcal{M}} \equiv \frac{P_E}{2} = \left(1-\delta^2\right)\frac{S+s}{2};$$

– starting instead from state $\mathcal{D}$ in period 0, the equilibrium path remains in the duopoly state and the equilibrium market price is lower (as $V_M > 2V_D$) and equal to:

$$p_{\mathcal{D}} \equiv \tilde{p} = \left(1-\delta^2\right)\frac{s-\delta^2\left(S+s\right)}{1-2\delta^2}.$$

- If instead $s/S < \sigma^{Sync}(\delta)$, there exists a unique Markov perfect equilibrium which is a single-state equilibrium: regardless of the initial state, from period 1 onwards the equilibrium path stays in the monopoly state, and yields the same outcome as above, namely, M wins both markets at price P_E and obtains $V_M = 2S$; the equilibrium per market price is thus again equal to:

$$p_{\mathcal{M}} = \left(1-\delta^2\right)\frac{S+s}{2}.$$

- Finally, in the limit case $s/S = \sigma^{Sync}(\delta)$, both of the above equilibria constitute coalition-proof, symmetric Markov perfect equilibrium; they moreover yield the same equilibrium prices and profits: this is obvious in the monopoly state, as both equilibria yield $p_{\mathcal{M}} = \left(1-\delta^2\right)S$ and $V_M = S$, but it also holds in the duopoly state, where it is straightforward to check that both equilibria yield zero price and continuation values when $s/S = \sigma^{Sync}(\delta)$.

B Proof of Proposition 7

We first check that the monopoly price is higher under staggered tendering:

- If $\delta \geq \delta^{Stag}(s/S)$, then:

$$p_{\mathcal{M}}^{Stag} - p_{\mathcal{M}}^{Sync} = (1-\delta)\left[(1+\delta)S+\delta s\right] - \left(1-\delta^2\right)\frac{S+s}{2} = (1-\delta)\frac{S-s+\delta\left(S+s\right)}{2} > 0.$$

- If instead $\delta < \delta^{Stag}(s/S)$, then:

$$p_{\mathcal{M}}^{Stag} - p_{\mathcal{M}}^{Sync} = \frac{1-\delta}{1-2\delta}\left[\left(1-\delta-\delta^2\right)S-\delta^2 s\right] - \left(1-\delta^2\right)\frac{S+s}{2} = \frac{(1-\delta)^2}{2}\frac{S-s}{1-2\delta} > 0.$$

- By contrast, the duopoly prices are higher under synchronous tendering:

$$\begin{aligned} p_{\mathcal{D}}^{Sync} - p_{\mathcal{D}}^{Stag} &= \left(1-\delta^2\right)\frac{s-\delta^2\left(S+s\right)}{1-2\delta^2} - \frac{1-\delta^2}{1-2\delta}\left[\left(1-\delta\right)s-\delta S\right] \\ &= \delta\left(1-\delta\right)\left(1-\delta^2\right)\frac{S-s}{\left(1-2\delta\right)\left(1-2\delta^2\right)} \\ &> 0, \end{aligned}$$

The conclusion then follows from the fact that, as already noted, $p_{\mathcal{M}}^{Sync} > p_{\mathcal{D}}^{Sync}$.