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Gian Luigi Albano[*], Walter Ferrarese[†], Roberto Pezzuto[‡]

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Abstract

We show that in a single-lot low-price auction, a merger can be simultaneously profitable and increase the buyer's surplus, even in the absence of cost synergies. Thus the buyer's purchasing price may go down even when a lower number of bids is submitted. In determining our main result we highlight the role of firms' cost exhibiting a discontinuity due to short-term capacity constraints or non-linear contractual agreements. The paper contributes to a new strand of literature showing that in bidding markets the lack of merger-induced synergies does not necessarily imply worse outcomes for the buyer. Hence the Authorities need not worry about resorting to possibly convoluted assessment of the attainability of this kind of efficiencies.

Keywords: Horizontal Mergers, Buyer Surplus, Cost Discontinuity.
JEL codes: L11; L23; L51.

[*]CONSIP and Luiss Guido Carli, University of Rome, e-mail: galbano@luiss.it.

[†]Universitat de Les Illes Balears, Departamento de Economía Aplicada. Edificio Gaspar Melchor de Jovellanos Ctra. Valldemossa km. 7.5, 07122 Palma de Mallorca Baleares - Spain. tel. +34 971259734, e-mail: walter.ferrarese@uib.es.

[‡]Università degli Studi di Roma "Tor Vergata", e-mail: roberto.pezzuto@uniroma2.it.

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1 Introduction

Competition is a fundamental force that delivers economic efficiency and innovation, leading to a higher level of consumer welfare. In public procurement, competitive procedures lead in most cases to the highest possible level of value for money. While a competitive public procurement market is a desirable goal, it is less clear how to recognise when there is effective competition in these markets. Effective competition is often thought to be simply measured by the number of participants in a given bidding procedure. However, while more participants would in many circumstances increase the level of competition, the number of participants is at best only a proxy for the intensity of competition. First, participants may have quite different characteristics, among which the size plays a major role (say, large vs. small-and-medium enterprises — SMEs). Second, they differ with regard to whether they bid as an "incumbent" rather than a "potential entrant". Third, the number of participating firms does not necessarily coincide with the number of bids submitted, mainly because smaller firms may decide to participate as a (temporary) consortium: this is the scenario that we discuss in this paper. We show that a merger reducing the number of independent bidders may yield lower prices for buyers, even absent any merger-related cost synergies, while also being profitable for the merging firms.

Joint bidding in procurement usually falls under the close scrutiny of policy makers and antitrust authorities since, while providing an opportunity for SMEs to bid for large and/or complex projects, it may be used as a mechanism for coordinating tenders, especially when it comprises only large firms that may be in principle in a position to participate as solo bidders. As joint bidding may have both pro-competitive and anticompetitive effects, it is not necessarily the case that a procurement procedure with three solo bidders will trigger a higher level of competition than another procedure with one solo bidder and one consortium comprising two firms. Said differently, one cannot take for granted that the former case leads to a better outcome for the buyer than the latter.

The traditional view in Industrial Organization is that mergers can favour consumers only if sufficiently strong efficiencies more than compensate for the upward pressure on price due to the reduction in market competition (Williamson, [1968]). Different kinds of efficiencies are possible. One possibility is that the new entity becomes more efficient simply by having access to multiple plants rather than just one. In this regard, in a quite general Cournot oligopoly, Farrell and Shapiro [1990] show that cost savings from rationalization - shifting production from high-marginal-cost to low-marginal-cost plants - are insufficient for market prices to decline. Beyond rationalization, the merged entity must be able to produce any output at lower cost than that resulting from simply becoming a multi-plant firm. In other words, the merger must generate "synergies," that is, a new and cheaper technology.[1] There is a crucial difference between these two kinds of efficiencies. Even assuming rationalization to be a natural and virtually frictionless process, a technological improvement is nonetheless an inherently uncertain event. Hence, if synergies are desirable for both public authorities and merging parties, the acceptance of a merger necessarily involves a valid persuasion effort regarding their actual attainability.

Indeed, a typical problem faced by public authorities is that although the firms under scrutiny often claim that synergies will be generated by the merger, in practice it is difficult to fulfil such promises. As stated in the U.S. Merger Guidelines: "*Pro-competitive efficiencies are often speculative and difficult to verify and quantify, and the efficiencies projected by the merging firms are often not realized*".[2]

But even in those cases where a sufficiently reliable methodology is available, it is hard to imagine that antitrust

[1] Other key works confirming this result are Salant *et al.* [1983], Perry and Porter [1985], McAfee and Williams [1992]) (in Cournot oligopoly); Deneckere and Davidson [1985], Werden and Froeb [1994], Chen and Li [2018], Motta and Tarantino [2021], Wang and Zhao [2022] (in Bertrand oligopoly).

[2] Both the US and Europe are aligned on this issue.

authorities are not prone to errors when asked to accept or reject a merger proposal. Furthermore, even when synergies are realized, there could be no pass-through to consumers via a lower market price. This is mainly due to the fact that such information is typically private for the merging parties, and could be strategically not transmitted by maintaining a high market price rather than a lower one, which would in turn induce a price cut by the non-merging rivals (Harrington [2021]; Leccese *et al.* [2024]). For this reason it is crucial to understand whether mergers should be accepted in their absence.[3]

Aware of these issues, several papers investigated whether consumer surplus-enhancing mergers are possible even in the absence of synergies.[4] Some evidence has been provided for oligopolistic markets. For instance, building on Dastidar [1995] (*i.e.* Bertrand competition with strictly convex costs, and firms serving an equal share of the market in case of a price tie), Bakaouka *et al.* [2024] show that, given certain pre-merger prices, mergers can be profitable for a range of lower post-merger prices. The revenue loss from lower prices is offset by cost savings due to reduced and more efficient (rationalization) combined production.[5] Stennek [2003] shows that when firms face cost uncertainty, a merger may reduce the market price if pre-merger cost variability is sufficiently large. In such cases, the expected marginal cost after the merger may decrease even if firms do not adopt an improved technology. Qiu and Zhou [2006] analyse an international economy with demand uncertainty and asymmetric information, and provide conditions for a consumer surplus enhancing merger: when a foreign firms merge with a more informed domestic one, the benefit to consumers outweighs the harm due to the reduction of competition.

On the other hand, despite a growing interest on the effect of mergers in bidding markets (Waehrer and Perry [2003], Thomas [2004] and [2019)], to the best of our knowledge Thomas [2021] is the only one who explicitly excludes the possibility of merger-induced synergies in this context. He considers a setting with multiple costly auctions and demonstrates that both the buyer's surplus and the firms' profits can increase following a merger. More specifically, the buyer's loss in overlapping auctions (*i.e.* auctions in which both merging parties were participating) can be offset by the gain in non-overlapping auctions (*i.e.* auctions in which only one merging party was participating). It follows that Thomas' result requires multiple, costly, and non-overlapping auctions. Clearly this is not always the case in practice as often buyers run a single tender. Thus, whether mergers in a single (and hence overlapping) procurement auction with free entry can be profitable and CS enhancing in the absence of synergies is the question that we tackle in the present paper. Specifically, we discuss horizontal mergers in a procurement model with a single awardee, and a non-convex cost structure.

The non-convexity is due to a finite upward jump at a given production level. This phenomenon is well-documented in the economic literature and is often associated with soft capacity constraints: a new plant has to be built or a new machinery has to be purchased to produce beyond the current maximum level. In this sense, the cost jump represents a reduced form of a long-term commitment by a firm to increase her capacity beyond such limit to meet the buyer's request. Traditional oligopoly theory has extensively analysed this setup (see among others, Boccard and Wauthy [2000, 2004], Chowdhury [2009], and Cabon-Dhersin and Drouhin [2014, 2020]), whereas less has been done when mergers are included in the picture. The influential work of Compte *et al.* [2002] assumes hard capacity constraints (Kreps and Scheinkman [1983]), as well as [Chen and Li, 2018].

Many real-world examples share our production cost feature. In the Electric Vehicle industry, Tesla's production is tied to its so called Gigafactories that require substantial investment in infrastructure, equipment, and

[3] It is also worth mentioning that the state of the art of the debate on merger efficiencies seems far from being conclusive. See, for instance, Kaplow [2021, 2024] for a recent discussion on the topic.

[4] Although the discussion on whether a consumer surplus-oriented regulator could be more appropriate than a social welfare-oriented regulator is still open, Lyons [2003], Pittman [2007], and Fridolfsson [2007] among others provide strong arguments in favour of the former. In the paper we will use consumer surplus (CS henceforth) and buyer's surplus interchangeably.

[5] The existence of an entire range of prices is due to the multiplicity of equilibria identified in Dastidar [1995].

technology. If demand exceeded the production capacity of existing factories, Tesla would need to build a new factory or expand an existing one, which would imply a discrete jump in fixed costs. Similarly, the discontinuity could model non-linear contractual agreements between the firms and their suppliers. For instance, Semiconductor Manufacturing, Airlines, or Energy Generation (specifically Renewables), are sectors where block contracts are common and are equivalent to capacity agreements: for example Wafer Supply Agreements (WFA) between AMD and NVIDIA with GlobalFoundries and TSMC [6]; Capacity Purchase Agreements (CPA) signed between major US airlines and regional carriers[7]; Power Purchase Agreements (PPA) that major tech companies commit to with Solar and Wind suppliers.[8]

In all of these cases, any modification of the terms prescribed by the block contracts result in discrete cost jumps, due, at minimum, to transaction costs. This distinctive element of our framework thus informs the broader discussion of how coalitions or mergers in bidding markets influence both firms' profitability and buyer welfare.

The rest of the paper is organized as follows: in Section 2 we discuss the pre-merger market, setting the benchmark scenario; in Section 3 we analyse the post-merger market and provide an equilibrium analysis and our main result; Section 4 concludes. In Appendix A we provide an example of our machinery under hyperbolic demand; all proofs are contained in Appendix B; in Appendix C we show that our main results are qualitatively identical under different specifications of the variable cost component.

2 The baseline model

A buyer wishes to procure $q(p) \in [0, +\infty)$ units of a good at price $p \in [0, +\infty)$. The procurement process is carried out through a one-shot low-price auction. The inverse demand $p(q)$ is downward sloping and twice continuously differentiable for $q \in [0, q^{\max})$, where $q^{\max}$, if finite, is such that $p(q) = 0\ \forall q \geq q^{\max}$, and we also allow for an infinite $q^{\max}$. This demand structure is meant to model, for instance, situations where a centralized procurement organization (CPO) allocates a fixed budget and awards contracts on behalf of a set of public bodies (be they at the central or local government level or both). If final demand is not certain, while keeping the estimated value of the contract fixed, the CPO may translate lower unit prices into a higher number of items that can be purchased by final users. Thus for a given estimated value (which results from an initial estimated number of item multiplied by the highest unit price the CPO is willing to pay) the actual number of items will depend on the awarding price, thus giving rise to a CPO's (implicit) demand function. A set of N potential bidders is willing to participate in the auction. Let $\mathcal{N} = \{1, 2, ..., N\}$ be the index set of the competing firms. The firm submitting $p_{\min} = \min_i(p_i), i \in \mathcal{N}$ is awarded the contract.[9] In case of ties, a single contractor is selected by a fair random device, thus ruling out the possibility that the buyer splits the contract among different awardees.[10]Each firm $i \in \mathcal{N}$ is a single-plant firm and produces q units according to the following cost function:[11]

[6]https://www.sec.gov/Archives/edgar/data/2488/000000248823000047/amd-20221231.htm; and https://investor.tsmc.com/chinese/encrypt/files/encrypt_file/reports/2025-01/84aeb15bbe33894365d33f52e027c5268ba95dcf/TSMC%204Q24%20Transcript.pdf

[7]https://www.sec.gov/Archives/edgar/data/793733/000155837024014135/skyw-20240930x10q.htm

[8]https://sustainability.google/operating-sustainably/stories/ppa/

[9]A special case of our analysis is the one where a CPO wishes to allocate a fixed budget B to procure at least $q(p^{\max}) = \frac{B}{p^{\max}}$ units of a good, where $p^{\max}$ is the highest amount she is willing to pay for each unit, that is, the unit *reserve price*. Consequently, for any $p \leq p^{\max}$ the auction game defines the hyperbolic buyer's demand function $q(p) = \frac{B}{p}$. Since B in practice can be fixed but not binding, we let $q(p)$ be any demand function satisfying the aforementioned properties.

[10]We assume, following what is often the case in practice, that equally splitting the contract among tied lowest bidders would incur in contract management costs that offsets potential benefits.

[11]Given the symmetry across firms, we suppress the index i whenever possible.

$$C(q(p)) = \begin{cases} c(q(p)) & \text{if } 0 \leq q \leq \bar{q}; \\ c(q(p)) + F & \text{otherwise} \end{cases} \tag{1}$$

where $c(q(p) = 0) = 0$, $c' > 0$, and for some $\bar{q} > 0$ and $F > 0$. In what follows we present our results for a strictly convex variable cost component (*i.e.* for $c'' > 0$). However, our main results are qualitatively identical for constant variable marginal costs, which highlights the importance of the cost discontinuity rather than the shape of $c(q(p))$ as, for instance, in Bakaouka *et al.*[2024].

When costs are continuous, constant returns to scale imply that a firm bears the same cost irrespective of the way in which total output is redistributed across the plants. Thus, without loss of generality, production post-merger can be assumed to be concentrated in a single plant. However, this simplification cannot capture the empirical observation that mergers often aim to exploit the complementary resources of multiple production facilities, resulting in structurally more complex entities (Huck *et al.* [2004]). Under cost continuity this feature can be captured only by a strictly convex variable cost since production costs are minimized when an output is shared across plants in such a way the marginal costs are equalized. This is the rationale highlighted by Perry and Porter [1985] in their critique to the constant marginal cost setup of Salant *et al.*[1983], which is considered a lock-up model rather than a proper merger model. In this paper, in contrast, the discontinuity in total costs provides scope for profitable exploitation of multiple plants irrespective of the shape of the variable cost component.
At this point, let:

$$\pi(p) = \begin{cases} pq(p) - c(q(p)) - F & \text{if } 0 \leq p < p(\bar{q}); \\ pq(p) - c(q(p)) & \text{otherwise} \end{cases} \tag{2}$$

be firm i's payoff when completely satisfying the buyer's demand. Notice also that given our assumptions on $q(p)$ and $c(q(p))$, we have that $pq(p) - c(q(p))$ is concave and bounded from above. We define:

$$p^m \equiv \underset{p}{\operatorname{argmax}}\, pq(p) - c(q(p)), \tag{3}$$

that is p^m is the monopolist's payoff maximizing price without the cost jump. Firm i's payoff is:

$$\Pi(\boldsymbol{p}) = \begin{cases} \pi(p_i) & \text{if } p_i < p_j \, \forall \, j \neq i; j \in \mathcal{N}; \\ \frac{1}{S}\pi(p_i) & \text{if } S \text{ firms set the lowest price;} \\ 0 & \text{if } p_i > p_j \text{ for some } j \neq i; j \in \mathcal{N} \end{cases} \tag{4}$$

where $\boldsymbol{p} = (p_1, p_2, ..., p_i, ...p_N) \in \mathbb{R}^N_+$ and $\mathcal{S}$ is the set of firms charging the lowest price in the market, with cardinality $S \leq N$. The above payoff function entails a winner-take-all structure since, in case of a price tie, each firm bidding the lowest price has an equal chance of getting the entire contract. Notice that this formulation is, in general, different from the case of an equal split contract as in Dastidar[1995], and the two interpretations coincide with a constant marginal cost technology.[12]

[12] One could argue that a buyer running a unique tender under decreasing returns to scale is questionable. Indeed, diseconomies of scale imply that procurement cost minimization is achieved when all firms are active, namely when the buyer splits demand into multiple lots, each awarded via an independent procedure (Bru *et al.* [2023]). However, transaction costs arguments are mostly overlooked in multi-lot procedures, often leading buyers to prefer awarding the contract as a whole rather than chopping it off in smaller pieces. This is often the same reasoning for not adopting competitive auctions altogether, and instead using discretionary procedures. As an example, take the Public Procurement Act accepted in 2011 by the Hungarian Parliament which foresees simplified procedures for the awarding of projects whose value is no larger than 90000 USD. More specifically, as reported in Szucs [2024], direct negotiation with sellers has been the main mechanism from 2011 to 2013, whereas after 2013, supposedly to avoid or reduce corruption concerns coupled with pure discretion, a simple auction mechanism was implemented. Another example of the use of simple contracts in procurement is the US construction industry (Bajari and Tadelis [2001]).

Firms are assumed to have complete and symmetric information about the technology and cost structure. The buyer, though, is not informed about the firms' costs and only knows the number of competing firms bidding for the contract. We focus on firms adopting pure strategies, and a Nash equilibrium of our game is a vector of prices $\boldsymbol{p}^* = (p_1^*, p_2^*, ..., p_i^*, ..., p_N^*) \in \mathbb{R}_+^N$ such that:

$$\Pi_i\left(p_1^*, p_2^*, ..., p_i^*, ..., p_N^*\right) \geq \Pi_i\left(p_1^*, p_2^*, ..., p_i', ..., p_N^*\right), \ \forall p_i' \neq p_i^* \text{ and } \forall i \in \mathcal{N}.$$

2.1 The pre-merger scenario

First note that had $\pi(p)$ been continuous (in addition to having an initial break-even price and being bounded from above), any equilibrium outcome would involve zero profits (see Theorem 2 in Baye and Morgan, [2002]): if N firms bidding the same price get a positive payoff $\frac{\pi(p)}{N} > 0$, then there would always exist a sufficiently small ϵ such that the deviation to $p - \epsilon$ would result in $\pi(p-\epsilon) > \frac{\pi(p)}{N}$. Only at $\pi(p) = 0$ there would be no profitable deviation.

In our case, instead, the profit function is not left lower semicontinuous, thus potentially opening the door to equilibria in which the winning firm makes positive profits. In what follows, we present the necessary and sufficient conditions for these equilibria to arise. In this regard, let $\bar{p}$ be the price at which firm i's monopolist cost function exhibits a jump. Then, either $\bar{p} \leq p^m$ or $\bar{p} > p^m$. We have the following result:

Proposition 1. *Consider the strategy profile* $\bar{\boldsymbol{p}} \equiv (\bar{p}, \bar{p}, ..., \bar{p}) \in \mathbb{R}_+^N$.

- *If* $\bar{p} > p^m$, *then* $\bar{\boldsymbol{p}}$ *is the unique pure strategy Nash Equilibrium with positive payoffs iff:*

  i) $\bar{p}q(\bar{p}) - c(q(\bar{p})) > N\left(p^m q(p^m) - c(q(p^m)) - F\right);$

- *If* $0 < \bar{p} \leq p^m$, *then* $\bar{\boldsymbol{p}}$ *is the unique pure strategy Nash Equilibrium with positive payoffs iff:*

  ii) $\bar{p}q(\bar{p}) - c(q(\bar{p})) > 0$ *when* $\bar{p}q(\bar{p}) - c(q(\bar{p})) \leq F$, *or*

  iii) $\bar{p}q(\bar{p}) - c(q(\bar{p})) < F\left(\frac{N}{N-1}\right)$ *when* $\bar{p}q(\bar{p}) - c(q(\bar{p})) > F$.

Proposition 1 illustrates that positive payoff equilibria are possible iff all firm bid $\bar{p}$. When the jump occurs after p^m, then the expected payoff when all firms bid $\bar{p}$ has to exceed the one obtained in the best possible deviation, p^m, which is assumed to be strictly positive; this is case *i*). When the jump occurs at a p no larger than p^m, the best deviation payoff is at a price "just below" the jump, $\bar{p}q(\bar{p}) - c(q(\bar{p})) - F$. If such payoff is null or negative, then $\bar{p}q(\bar{p}) - c(q(\bar{p})) > 0$ is clearly necessary and sufficient to ensure the existence of the desired equilibrium; this is case *ii)*). When instead $\bar{p}q(\bar{p}) - c(q(\bar{p})) - F > 0$, then $\bar{p}q(\bar{p}) - c(q(\bar{p}))$ must be large enough to ensure that obtaining the contract with probability $\frac{1}{N}$ is better than being the solo winner with certainty at a slightly lower price; this is case *iii)*).

Throughout the paper, we will assume that Proposition 1 holds, and consider the positive payoff equilibrium as the outcome of the pre-merger market. In case a zero payoff equilibrium existed as well, a trivial payoff dominance argument would imply that the positive payoff equilibrium is the most preferred outcome for all firms. This also allows us to show that merger profitability can be achieved under harsher conditions with respect to a pre-merger scenario involving zero profits.

3 The model with a merger

We now consider the possibility that two firms, say, firms $\{i, j\} \in \mathcal{N}$ merge into a new entity that we label as M. A first effect is that the number of bids diminishes from N to $N-1$. All else being equal, and if one excludes the limit case of a merger to monopoly, this change is not harmful as far as CS is concerned; all firms (including M) keep bidding $\bar{p}$ and obtain a larger expected payoff of $\frac{\pi(\bar{p})}{N-1}$.[13]

However, the two merging firms would not have an incentive to form the coalition in the first place, as their post-merger individual expected payoff would be lower at $\bar{p}$ than before the merger.[14] The typical criterion adopted to justify the formation of a coalition is its profitability. Given a post-merger bidding profile $(p_M, \boldsymbol{p}_{-M})$, we say that a merger is profitable if M's payoff is larger than the aggregate payoff that the members would make as independent firms.[15] Formally, we need that the gain function, $g(p_M, \boldsymbol{p}_{-M}, \bar{p}, N)$, is positive:

$$g(p_M, \boldsymbol{p}_{-M}, \bar{p}, N) = \Pi^M(p_M, \boldsymbol{p}_{-M}) - 2\left(\frac{\bar{p}q(\bar{p}) - c(q(\bar{p}))}{N}\right) > 0, \tag{5}$$

where $\Pi^M(p_M, \boldsymbol{p}_{-M})$ is the equivalent of (4) for the merged entity. If the only effect induced by the coalition was a reduction in the number of firms, then $g(\cdot)$ would boil down to $\pi(\bar{p})\left(\frac{1}{N-1} - \frac{2}{N}\right)$, which is negative when $N \geq 3$.

Nevertheless, when variable costs are strictly convex, the formation of the coalition does not just reduce the number of bids. The new entity may now utilize both production plants and share the production across them in order to minimize costs. In absence of an upward jump in the cost function, the optimal sharing is such that marginal costs are equalized across plants. This formally means that the optimal post-merger per-plant production is $\frac{q}{2}$ and that M's cost function is $2c\left(\frac{q}{2}\right)$. It is worth noting that the ability of the merged entity to access both plants does not provide any cost advantage *per se*: if M's production was equal to the cumulated pre-merger production of the merging parties, then M's cost would be the same.

The presence of a cost discontinuity makes things more involving. When $0 \leq q < 2\bar{q}$, the equal output sharing still applies. However, when $q > 2\bar{q}$, by continuity of the variable cost component, it must exist a $\hat{q}$ such that the efficient way of producing any $q \in (2\bar{q}, \hat{q}]$ is to assign exactly $\bar{q}$ units to a plant and $q - \bar{q}$ units to the other plant, and avoid paying twice a too large F.[16] Eventually, this way of redistributing the output becomes inefficient as the variable cost of the plant receiving $q - \bar{q}$ units is too large compared to paying an extra F and evenly share production. Formally, M's cost function from controlling two plants rather than one is:

$$C^M(q(p)) = \begin{cases} 2c\left(\frac{q(p)}{2}\right) & \text{if } 0 \leq q \leq 2\bar{q}; \\ c(q(\bar{p})) + c(q(p) - q(\bar{p})) + F & \text{if } 2\bar{q} < q \leq \hat{q}; \\ 2c\left(\frac{q(p)}{2}\right) + 2F & \text{if } q > \hat{q}, \end{cases} \tag{6}$$

whereas the cost function of non participating firms is unaffected.[17] Notice that the merged entity experiences the

[13] A merger to monopoly is the only case in which a mere reduction in the number of firms could alter the awarding price. This would happen were π^M's (the monopolist's payoff of the new entity) maximizing price or the buyer's reservation price on the right of the jump.

[14] We assume an egalitarian split inside the coalition.

[15] We label $\boldsymbol{p}_{-M}$ a vector of bids of those firms not participating to the merger.

[16] Clearly any sharing in which a plant receives less than $\bar{q}$ is inefficient. The entity could redistribute some output from the plant receiving $q > \bar{q}$ to the one producing less and reduce the overall cost.

[17] As said the model is perfectly valid under non-decreasing returns to scale as well. The difference is that (6) does not exhibit the $2c\left(\frac{q(p)}{2}\right) + 2F$ component, since for any q, variable costs are minimized when production is concentrated in one plant. Hence, cost minimization cannot imply paying F twice. However, as far as the equilibrium outcome is concerned, it is important to notice that the post-merger cost discontinuity occurs at $2\bar{q}$ in any case.

cost jump at twice the production level of an outside firm. It follows that the profit of the merged entity acting as a monopolist, $\pi^M(p)$, writes:

$$\pi^M(p) = \begin{cases} pq(p) - 2c\left(\frac{q(p)}{2}\right) - 2F & \text{if } 0 \leq p < p(\hat{q}); \\ pq(p) - (c(q(\overline{p})) + c(q(p) - q(\overline{p})) + F) & \text{if } p(\hat{q}) \leq p < p(2\overline{q}); \\ pq(p) - 2c\left(\frac{q(p)}{2}\right) & \text{if } p(2\overline{q}) \leq p \leq p^{\max}. \end{cases} \tag{7}$$

We define:

$$p' \equiv \operatorname*{argmax}_p \pi^M(p). \tag{8}$$

At this point, we are ready to provide the equilibrium analysis of our post-merger scenario. A clear difference with respect to the pre-merger case is that now players are asymmetric with respect to costs. This opens the door to the possibility of equilibria in which firms do not bid the same price. We now proceed to present two classes of equilibria of our post-merger market.

3.1 Partially and fully symmetric equilibria

The first class of equilibria are those in which the merged entity probabilistically shares the market with any non-empty subset of non participating firms. A symmetric equilibrium is the limit case in which all firms bids the same price and thus obtain the contract with the same probability. Before stating a more general result, let us provide an illustrative example.

Consider a pre-merger market with three firms $i = \{1, 2, 3\}$. The buyer has the linear demand $q(p) = 3 - p$. Firms have quadratic variable costs $c(q(p)) = q(p)^2$, and the fixed component is $F = 1$. We assume the following cost function:

$$C(q(p)) = \begin{cases} q(p)^2 & \text{if } 0 \leq q \leq \frac{1}{2}; \\ q(p)^2 + 1 & \text{otherwise,} \end{cases} \tag{9}$$

namely firms experience an upward jump if the desired production exceeds $\frac{1}{2}$. This leads to:

$$\pi(p) = \begin{cases} (3-p)(2p-3) - 1 & \text{if } 0 \leq p < \frac{5}{2}; \\ (3-p)(2p-3) & \text{otherwise.} \end{cases} \tag{10}$$

Now we let firms 1 and 2 merge. In this case we have that:

$$\underbrace{\frac{q^2}{2} + 2}_{\text{cost in case of equal split}} \geq \underbrace{\frac{1}{4} + \left(q - \frac{1}{2}\right)^2 + 1}_{\text{cost in case of unequal split}}, \text{ for } q \in \left(1, 1 + \sqrt{2}\right], \tag{11}$$

with equality for $q = 1 + \sqrt{2}$, and the inequality is reversed otherwise. Hence, we have that M's cost and monopolist's profit functions are:

$$C^M(q(p)) = \begin{cases} \frac{q(p)^2}{2} & \text{if } 0 \leq q \leq 1; \\ \frac{5}{4} + \left(q(p) - \frac{1}{2}\right)^2 & \text{if } 1 < q \leq 1 + \sqrt{2}; \\ \frac{q(p)^2}{2} + 2 & \text{if } 1 + \sqrt{2} < q \leq 3 \end{cases} \tag{12}$$

and

$$\pi^M(p) = \begin{cases} (3-p)\left(\frac{3(p-1)}{2}\right) - 2 & \text{if } 0 \le p < 2-\sqrt{2}; \\ p(8-2p) - \frac{15}{2} & \text{if } 2-\sqrt{2} \le p < 2; \\ (3-p)\left(\frac{3(p-1)}{2}\right) & \text{if } 2 \le p \le 3, \end{cases} \tag{13}$$

respectively. First, note that the vector $(p_1, p_2, p_3) = \left(\frac{5}{2}, \frac{5}{2}, \frac{5}{2}\right)$ is a pre-merger equilibrium, and firms get the positive payoff $\frac{\pi(\frac{5}{2})}{3} = \frac{1}{3}$.nIn fact, $p^m = \frac{9}{4} > \bar{p}$, so that the best deviating payoff is $\pi\left(\frac{9}{4}\right) = \frac{1}{8}$.

Regarding the post-merger scenario, we argue that the vector $(p_M, p_3) = (2, 2)$ is a symmetric post-merger equilibrium. Indeed, neither M nor the outside firm 3 have a profitable deviation from such a strategy profile. First, since $\pi(2) = 0$, firm 3 can neither profitably undercut M, nor set a larger price and still get zero profits. Furthermore, it is possible to check that M prefers to probabilistically share the market with firm 3 rather than setting a slightly lower price and get the contract with certainty. Formally, we have that:

$$\frac{3}{4} = \frac{\pi^M(2)}{2} > \lim_{p \to 2^-} \pi^M(p) = \frac{1}{2}. \tag{14}$$

Finally, we can see that the merger is also profitable, since $\frac{3}{4} = \frac{\pi^M(2)}{2} > 2\left(\frac{\pi(\frac{5}{2})}{3}\right) = \frac{2}{3}$ (and obviously CS enhancing). Figure 1 provides a graphical illustration.

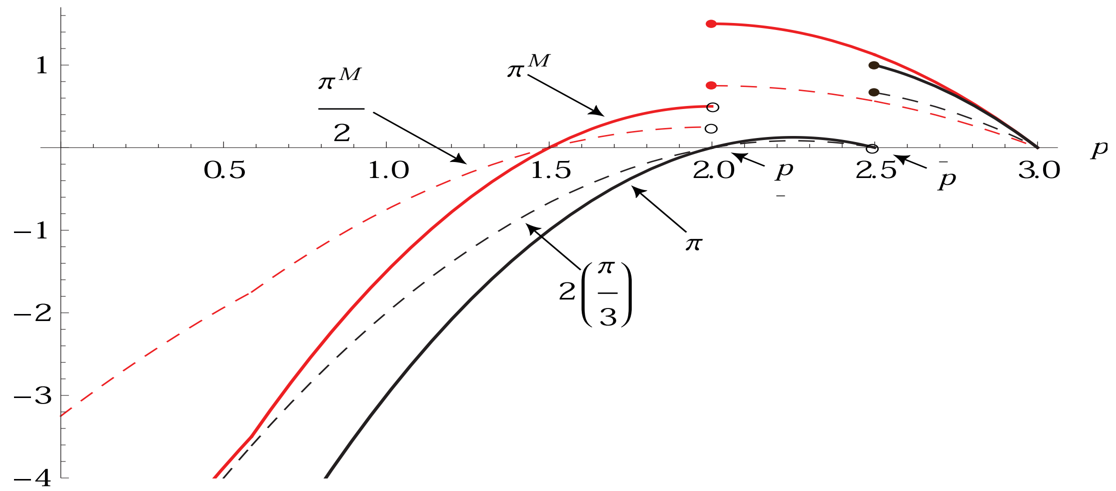

Figure 1: *The pre and post-merger symmetric equilibria in the winner-take-all low-price auction with quadratic costs, linear demand $q(p) = 3 - p$, fixed component $F = 1$, a pre-merger upward cost jump at $q = \frac{1}{2}$ and where* $\underline{p} \equiv p(2\bar{q})$.

This first example illustrates one of the possible mechanisms leading to a profitable merger, despite a lower post-merger awarding price. Notice that the pre-merger discontinuity is located in the decreasing portion of the monopolist's profit function and thus, absent the jump, $p = 2.5$ would be a point of underproduction. After the merger the awarding price decreases, which in turns increases the number of units demanded by the buyer. It turns out that such increase is sufficiently strong to make M's expected production rise to $\frac{1}{2}$, causing its expected costs to increase to $\frac{1}{4}$, compared to the cumulated pre-merger cost of $\frac{1}{6}$. Hence, merger profitability is ensured by M's increase in expected revenue - denoted as $\Delta \mathbb{E} R^M = \frac{7}{12}$ - which more than compensates the increase in costs, denoted as $\Delta \mathbb{E} C^M = \frac{1}{12}$.[18]

We can now state the following result, which generalizes the post-merger equilibrium of the above example to situations where M does not necessarily shares the market with all the outside firms. We describe an equilibrium by means of a vector of bids whose first entry is M's bid.

Proposition 2. *Let $\underline{p} \equiv p(2\overline{q})$ be such that $\pi(\underline{p}) = 0$. Then the vector $(p_M, \boldsymbol{p}_{S-1}, \boldsymbol{p}_{N-S-1}) = (\underline{p}, \underline{\boldsymbol{p}}, \boldsymbol{p})$ where $\boldsymbol{p}$ is such that $p_i > \underline{p}$, $\forall i = \{1, 2, ..., N-S-1\}$, is an equilibrium bidding profile of the post-merger WTA market if and only if π^M is not left lower semicontinuous at $\underline{p}$ and $c(q(\underline{p})) - 2c\left(\frac{q(p)}{2}\right) < \frac{F}{S-1}$.*

Proposition 2 illustrates that, despite the asymmetric nature of the firms, a symmetric equilibrium is still possible in the post-merger scenario. To sustain such awarding price: *i)* M's monopolist payoff function cannot be left lower semicontinuos at that price, (*i.e.* it must have an upward jump); *ii)* the jump must be sufficiently large; *iii)* the non-participating firms obtain zero profits at the awarding price. Hence a symmetric equilibrium is possible only under stronger conditions with respect to the pre-merger scenario, in which the presence of a sufficiently high upward jump in the monopolist's payoff function was necessary and sufficient.

If $\pi(\underline{p}) = 0$, then the indifference condition for a non-participating firm between the payoff at $\underline{p}$ and the one at any other $p > \underline{p}$ makes it also possible to find equilibria in which a strict subset of non participating firms charges the same price as the merged entity. Furthermore, since $\frac{1}{S-1}$ is decreasing in S, if an equilibrium in which $\bar{S}$ firms charge $\underline{p}$ exists, then an equilibrium in which $S < \bar{S}$ firms charge $\underline{p}$ also exists. We now move to the second class of equilibria.

3.2 The merged entity as the unique winner

The fact that the two-plant merged entity can now produce q units at a lower cost with respect to her single-plant competitors opens the door to equilibria in which the new entity emerges as the unique winner in the auction. As before, let us present an example, in which we maintain most of the assumptions of the previous one: pre-merger there are three firms $i = \{1, 2, 3\}$, each producing according to the quadratic variable costs technology $c(q(p)) = q(p)^2$, and the fixed component is $F = \frac{1}{2}$. We assume an upward jump if the desired production exceeds $\frac{1}{2}$:

$$C(q(p)) = \begin{cases} q(p)^2 & \text{if } 0 \leq q \leq \frac{1}{2}, \\ q(p)^2 + 1 & \text{otherwise.} \end{cases} \tag{15}$$

Here the buyer has the linear demand $q(p) = 2 - p$, so that:

$$\pi(p) = \begin{cases} (2-p)(2p-2) - 1 & \text{if } 0 \leq p < \frac{3}{2}; \\ (2-p)(2p-2) & \text{otherwise.} \end{cases} \tag{16}$$

Now we let firms 1 and 2 merge. According to (11), the merged entity prefers to share production unevenly across the two plants for $q \in [1, 2]$.[19] Hence M's cost and monopolist's profit functions are:

$$C^M(q(p)) = \begin{cases} \frac{q(p)^2}{2} & \text{if } 0 \leq q \leq 1, \\ \frac{5}{4} + \left(q(p) - \frac{1}{2}\right)^2 & \text{otherwise} \end{cases} \tag{17}$$

[18] Clearly, the entity still takes advantage of her sharing capabilities, since concentrating the post-merger production in one plant would actually result in a loss of $\frac{5}{4}$.

[19] We will maintain an upward jump if production exceeds $\frac{1}{2}$ in the third example in Appendix A.

and:

$$\pi^M(p) = \begin{cases} p(2-p) - \left(\frac{3}{2} - p\right)^2 - \frac{5}{4} & \text{if } 0 \leq p < 1, \\ (2-p)\left(\frac{3p-2}{2}\right) & \text{otherwise,} \end{cases} \tag{18}$$

respectively. First, notice that the vector $(p_1, p_2, p_3) = \left(\frac{3}{2}, \frac{3}{2}, \frac{3}{2}\right)$ is the unique pre-merger equilibrium and firms get the positive payoff $\frac{\pi(\frac{3}{2})}{3} = \frac{1}{6}$. Regarding the post-merger scenario, it is easy to see that the strategy profile in which the merged entity sets her profit maximizing price as a monopolist, $\frac{4}{3}$, and the outside firm 3 sets any price above $\frac{4}{3}$ is a post-merger equilibrium. Clearly, M cannot improve her situation, and since $\pi(\frac{4}{3}) = -\frac{5}{4}$, firm 3 strictly prefers to bid any price above $\frac{4}{3}$, from which there is no profitable deviation as all of them imply zero profits. Finally, we can show that the merger is profitable, since $\pi^M\left(\frac{4}{3}\right) = \frac{2}{3} > 2\left(\frac{\pi(\frac{3}{2})}{3}\right) = \frac{1}{3}$ (and obviously CS enhancing).

Figure 2 provides a graphical illustration.

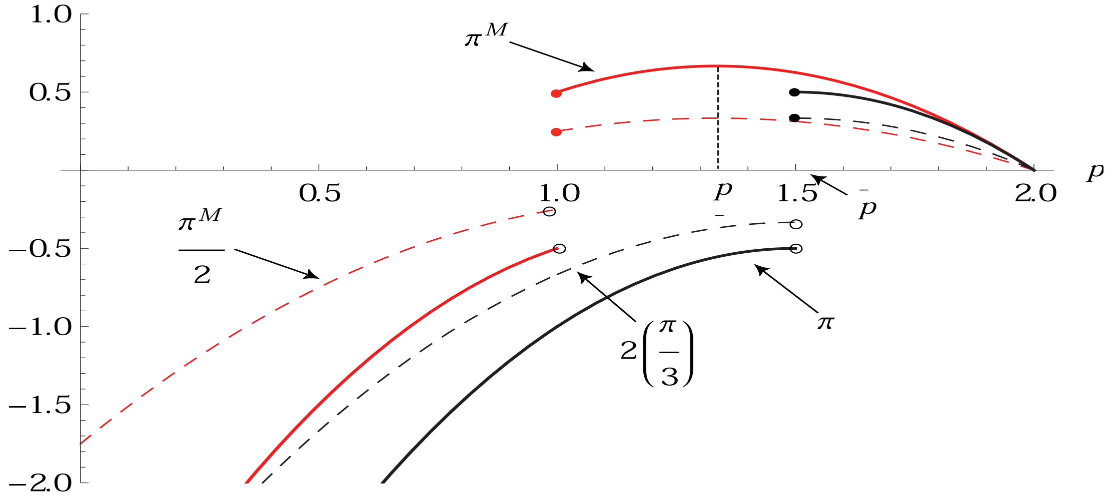

Figure 2: *The pre and post-merger equilibria with M as the unique awardee in the winner-take-all low-price auction with quadratic costs, linear demand $q(p) = 2 - p$, fixed component $F = 1$, and a pre-merger upward cost jump at $q = \frac{1}{2}$.*

We can now state the following general result regarding our post-merger scenario.

Proposition 3. *Let $\pi(p') < 0$. Then, the vector $(p_M, \mathbf{p}_{-M}) = (p', \mathbf{p})$, where $\mathbf{p}$ is such that $p_i > p'$ $\forall i = \{1, 2, ..., N-2\}$ is an equilibrium bidding profile of the post-merger WTA market.*

Proposition 3 implies that an uninformed buyer on the firms' identity (or technology) can rely on the vector of submitted bids as a screening device to identify the most efficient one; furthermore, in this type of equilibria the highest value for money is achieved (*i.e.* the most efficient firm is also the unique awardee of the contract).

We are now in a position to present our two main results which summarize the conditions for the existence of a pre and post-merger equilibrium involving a profitable and CS enhancing merger. Let us first focus on the equilibria described in Proposition 2:

Theorem 1. *If:*

i) $2\frac{S}{N}\pi(\overline{p}) - F < c(q(\underline{p})) - 2c\left(\frac{q(\underline{p})}{2}\right) < \frac{F}{S-1}$;

ii) $N\left(\pi(p^m) - F\right) < \pi(\overline{p}) < F\left(\frac{N}{2(S-1)}\right)$;

iii) $\pi(p^m) < F\left(\frac{2S-1}{2(S-1)}\right)$,

then there exists $(\underline{p}, \overline{p}) \in [0, p^{\max}] \times [0, p^{\max}]$, *such that: i) the pre-merger equilibrium is* $\overline{\boldsymbol{p}} \in \mathbb{R}_+^N$*; ii) the post-merger equilibrium is a vector* $(p_M, \boldsymbol{p}_{S-1}, \boldsymbol{p}_{N-S-1})$ *as defined in Proposition 2; iii) the merger is profitable; iv)* $\underline{p} < \overline{p}$ *(i.e. the merger is CS enhancing).*

With a similar reasoning we get the existence conditions for the equilibria described in Proposition 3:

Theorem 2. *If:*

i) $\frac{2}{N}\pi(\overline{p}) < \pi^M(p') < F + c(q') - 2c\left(\frac{q'}{2}\right)$;

ii) $\pi(\overline{p}) < F\left(\frac{N + c(q') - 2c\left(\frac{q'}{2}\right)}{2}\right)$,

then there exists $(\underline{p}, \overline{p}) \in [0, p^{\max}] \times [0, p^{\max}]$, *such that: i) the pre-merger equilibrium is* $\overline{\boldsymbol{p}} \in \mathbb{R}_+^N$*; ii) the post-merger equilibrium is a vector* $(p_M, \boldsymbol{p}_{-M})$ *as defined in Proposition 3; iii) the merger is profitable; iv)* $p' < \overline{p}$ *(i.e. the merger is CS enhancing).*

The main message of Theorems 1 and 2 is that the common wisdom that a lower number of bids cannot translate into a better performance for the buyer unless synergy gains are generated by the coalition must be carefully reconsidered, at least in winner-take-all scenarios. The results here demonstrate that a merger can be simultaneously profitable and yield a lower procurement price. If on the one hand, Thomas [2021] has been the first to explore this possibility in bidding markets, his results stem from introducing exogenous entry costs in the analysis, and require multiple procurement auctions. In turn, in this paper, we have been able to keep our focus on the conventional setting of a single market with free entry.

We can now go back to our illustrative examples and directly check that Theorems 1 and 2 do actually hold. Regarding our first example, since M's payoff has an upward jump at $p = 2$, we can verify that condition i) in Theorem 1:

$$-\frac{1}{3} < c(q(\underline{p})) - 2c\left(\frac{q(\underline{p})}{2}\right) < 1, \tag{19}$$

holds. This is because $q(2) = 1$ and $c(q(\underline{p})) - 2c\left(\frac{q(\underline{p})}{2}\right) = \frac{q^2}{2}$. Condition ii) holds as well since $\pi(p^M) - F = \frac{1}{8}$ and $F\left(\frac{N}{2(S-1)}\right) = \frac{3}{2}$. Finally, condition iii) holds as $F\left(\frac{2S-1}{2(S-1)}\right) = \frac{3}{2}$.

Regarding our second example, since M's payoff has an upward jump at $p = 1$, whereas $(2-p)\left(\frac{3p-2}{2}\right)$ is maximized at $p = \frac{4}{3}$, we have that condition i) in Theorem 2 is:

$$\frac{1}{9} < \frac{2}{3} < 1 + c\left(\frac{4}{3}\right) - 2c\left(\frac{2}{3}\right), \tag{20}$$

which is clearly satisfied due to cost convexity. For condition ii) we have that $c\left(\frac{4}{3}\right) - 2c\left(\frac{2}{3}\right) = \frac{8}{9}$ and the RHS equals to $\frac{35}{36}$, while for the LHS $\pi(\overline{p}) = \frac{1}{2}$.

The discussion carried out so far may leave the reader wonder whether our main result could emerge without the jump in the cost function. Indeed, in the post-merger scenario M could produce any output more efficiently than a single-plant firm, which would clearly favour profitability. Furthermore, since $\pi^M(p) > \pi(p)$ for all $p < p^{\max}$, it is possible to show that $p' < p^m$. Hence if $\pi(p') < 0$, and given that before the merger the equilibrium entails all firms bidding the initial break-even price, a post-merger equilibrium as in Proposition 3 would exist, and the merger would be CS enhancing. However, $\pi(p') > 0$, which implies the existence, at that price, of a profitable deviation for both M and each non-merging firm. In fact, the profit-maximizing price of $pq(p) - \frac{q(p)^2}{2}$ is $p' = q - \frac{q}{dq/dp}$, which once replaced into $pq(p) - q(p)^2$ yields $-\frac{q(p)^2}{dq/dp}\Big|_{p=p'} > 0$. Finally, by the usual argument of the continuity of $\pi(p)$, any other strategy profile cannot constitute a Nash equilibrium.

4 Conclusions

Can a procurement market become more competitive when the number of bids go down? In this paper we have tackled this question and shown that in a single-lot (and single-award) procurement auction a merger can simultaneously enhance consumer surplus and be profitable, even in the absence of synergies. Hence competition does not go necessarily hand in hand with the number of bids.

Our findings challenge the commonly held view that the consumer benefits from mergers are contingent upon the realization of cost efficiencies stemming from post-merger synergies. By focusing on the distinctive features of firms' cost structure — such as the strict convexity of the variable costs and the presence of a discontinuity — we have shown that these elements can fundamentally alter the post-merger competitive dynamics, making it possible for a merger to generate consumer welfare improvements.

Our results contribute to a rather new strand of literature which aims to reconsider the welfare effects of mergers in imperfectly competitive settings with no synergies. Moving away from earlier works, such as Thomas [2021], this study analyses single procurement scenarios, shedding novel light on situations that can be desirable for both consumers and firms. The implications are significant for antitrust authorities, further underscoring the necessity to adopt a nuanced perspective when assessing mergers, taking into account industry-specific cost structures.

Several avenues for further investigation could be considered. First, empirical studies that analyse procurement markets with soft capacity constraints would be valuable in validating the theoretical framework presented here. Secondly, relaxing the assumption of complete information to explore how informational asymmetries between bidders might influence post-merger outcomes could provide richer insights. Finally, extending the analysis to dynamic environments — where firms' bidding strategies include investments aimed at reducing their capacity constraints (that is, in our framework, reducing the size of the cost-jump), could provide deeper insights into the strategic considerations influencing merger outcomes.

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Appendix A: A symmetric equilibrium under hyperbolic demand

In this example we assume a pre-merger market with 5 firms $i = \{1,2,3,4,5\}$ and a buyer with the hyperbolic demand function $q(p) = \frac{B}{p}$, $B > 0$. As pointed out in footnote 9, this specification allows to model a scenario in which a buyer entirely allocates the fixed budget B to acquire at least $\frac{B}{p^r}$ units, where p^r is the buyer's reserve price. We retain the assumption of quadratic variable costs $c(q(p)) = q(p)^2$ and let $F = 4$. Before the merger we assume that:

$$C(q(p)) = \begin{cases} q(p)^2 & \text{if } 0 \le q \le \frac{1}{2}, \\ q(p)^2 + 4 & \text{otherwise.} \end{cases} \tag{21}$$

We also assume that the buyer allocates a budget $B = 5$. Hence:

$$\pi(p) = \begin{cases} 5\left(1 - \frac{5}{p^2}\right) - 4 & \text{if } 0 \le p < 10; \\ 5\left(1 - \frac{5}{p^2}\right) & \text{otherwise.} \end{cases} \tag{22}$$

Now, let say firms 1 and 2 merge. We have that:

$$\underbrace{\frac{q^2}{2} + 8}_{\text{cost in case of equal split}} \ge \underbrace{\frac{1}{4} + \left(q - \frac{1}{2}\right)^2 + 4}_{\text{cost in case of unequal split}}, \text{ for } q \in \left(1, 1 + 2\sqrt{2}\right], \tag{23}$$

with equality for $q = 1 + 2\sqrt{2}$, and the inequality is reversed otherwise. Hence, M's post-merger cost and monopolist's payoff functions are:

$$C^M(q(p)) = \begin{cases} \frac{q(p)^2}{2} & \text{if } 0 \le q \le 1; \\ \frac{17}{4} + \left(q(p) - \frac{1}{2}\right)^2 & \text{if } 1 < q \le 1 + 2\sqrt{2}; \\ \frac{q(p)^2}{2} + 8 & \text{if } q > 1 + 2\sqrt{2} \end{cases} \tag{24}$$

and

$$\pi^M(p) = \begin{cases} 5\left(1 - \frac{5}{2p^2}\right) - 8 & \text{if } 0 \le p < \frac{5}{1+2\sqrt{2}}; \\ \frac{1}{2} + \frac{5}{p}\left(1 - \frac{5}{p}\right) & \text{if } \frac{5}{1+2\sqrt{2}} \le p < 5; \\ 5\left(1 - \frac{5}{2p^2}\right) & \text{if } 5 \le p \le p^r, \end{cases} \tag{25}$$

respectively. First, note that all firms bidding $p = 10$ is the unique pre-merger equilibrium and firms get the positive payoff $\frac{\pi(10)}{5} = \frac{95}{100}$. In fact, if a firm slightly undercuts the rivals, she gets $\frac{3}{4}$. Regarding the post-merger scenario, both M and the outside firm bidding $p = 5$ is a post-merger equilibrium. First, we have that $\pi(5) = 0$, so that the non-merging firm does not have a profitable deviation. Also, according to Proposition 2, we have that $c(q(5)) - 2c\left(\frac{q(5)}{2}\right) = \frac{1}{2} < \frac{4}{3}$. Finally, the merger is profitable, since M obtains $\frac{\Pi^M(5)}{2} = 2,25 > 1,9 = 2\pi(10)$.[20]

[20] Is is of course possible to present a more general result in line with Theorems 1 and 2 taking into account the pre-merger equilibrium condition *iii)* in Proposition 1. All the details are available from the authors upon request.

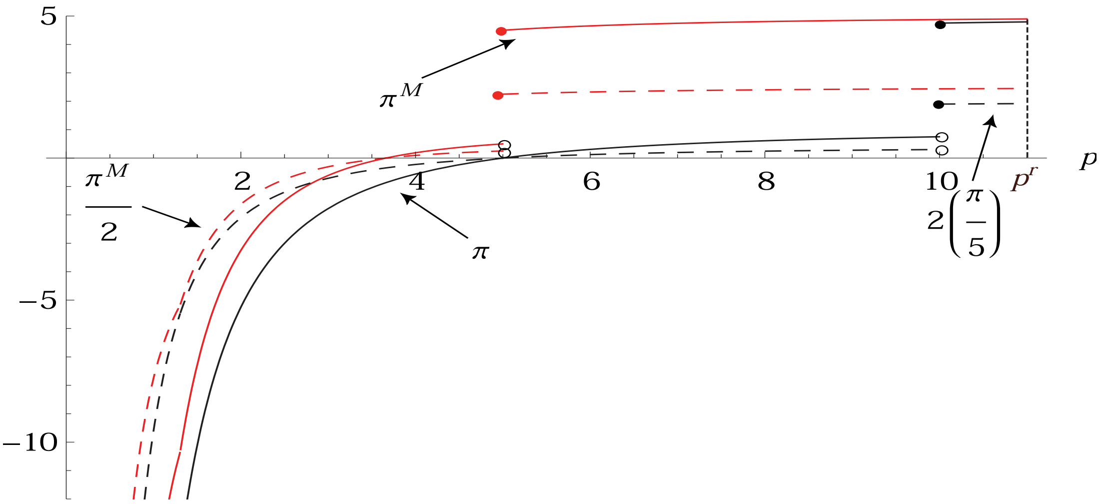

Figure 3: *The pre and post-merger equilibria in the winner-take-all low-price auction with quadratic costs, hyperbolic demand $q(p) = \frac{5}{p}$, fixed component $F = 4$, and a pre-merger upward cost jump at $q = \frac{1}{2}$.*

Appendix B

Proof of Proposition 1.

Let the strategy profile where all firms bid $\bar{\bar{p}} \in \mathbb{R}_+$ be another symmetric equilibrium with positive profits, apart from the one where all firms bid $\bar{p}$. Since $\bar{p}$ is the unique point of discontinuity of $\pi(p)$, it must be that $\pi(\bar{\bar{p}} - \epsilon) > \frac{\pi(\bar{\bar{p}})}{N}$ for $\epsilon > 0$ sufficiently small, a contradiction. Next we show that the conditions in Proposition 1 are necessary and sufficient, starting from the latter.

($\Leftarrow$ sufficiency)

Let us first tackle the $0 < \bar{p} \leq p^m$ case. In this case $\pi(p)$ is increasing if $p < \bar{p}$, and therefore a slight undercut is also the best deviation. Formally, such deviation is unprofitable if, for each $i = \{1, 2, ..., N\}$:

$$\Pi_i(\bar{\boldsymbol{p}}) > \lim_{p_i \to \bar{p}^-} \Pi_i(p_i, \bar{\boldsymbol{p}}_{\boldsymbol{-i}}); \tag{A-1}$$

$$\Pi_i(\bar{\boldsymbol{p}}) > 0. \tag{A-2}$$

The previous conditions can be rewritten as:

$$\frac{\bar{p}q(\bar{p}) - c(q(\bar{p}))}{N} > \max\{0, \bar{p}q(\bar{p}) - c(q(\bar{p})) - F\}, \tag{A-3}$$

which coincides with i) and ii). When instead $\bar{p} > p^m$, then firm i's best deviation is to set exactly p^m. Hence, it must be that:

$$\frac{\bar{p}q(\bar{p}) - c(q(p))}{N} > p^m q(p^m) - c(q(p^m)) - F. \tag{A-4}$$

($\Rightarrow$ Necessity) Obvious.

■

Proof of Proposition 2.

We start the proof with the following lemma.

Lemma 1. *In any post-merger equilibrium, outside firms get zero profits.*

Proof Consider any vector of bid $(p_M, \boldsymbol{p_{-M}})$ and let $\underline{p}$ be the smallest (and hence winning) bid. First, if for any firm $i = \{M, 2, \ldots, N-1\}$, $\pi_i\left(\underline{p}\right) < 0$, then any $p > \underline{p}$ represents a profitable deviation. Hence, any bidding profile at equilibrium must involve non-negative payoffs for all firms. Consider then a bidding profile in which $\pi\left(\underline{p}\right) > 0$ for at least one outside firm. This also cannot be an equilibrium: if the merged entity is bidding a $p^M > \underline{p}$, since $\pi^M(p) > \pi(p) \, \forall p$, M always has a profitable deviation by charging $\underline{p}$; and if M is charging $\underline{p}$, since $\pi^M(p) > \pi(p)$, $\forall p$ and the fact that the jumps in $\pi\left(p\right)$ and $\pi^M(p)$ occur at different prices, then either $\pi\left(p\right)$ or $\pi^M(p)$ (or both) is (are) continuous in a neighbourhood of $\underline{p}$ and undercutting is profitable for some firm. Thus, if an equilibrium exists, then outside firms must get a zero payoff. ■

($\Rightarrow$ Necessity) Suppose π^M is not left-lower semicontinuous at $\underline{p}$. Then, assume first it is continuous. In this case, the merged entity can profitably set $\underline{p} - \epsilon$ and act as the monopolist. A fortiori, this is true in case π^M has a downward jump at $\underline{p}$.

($\Leftarrow$ Sufficiency) If at $\underline{p}$, $\pi^M\left(p\right)$ has an upward jump and $S \leq N-1$ firms charge $\underline{p}$, then the merged entity does not deviate iff:

$$\frac{1}{S}\left(\underline{p}q(\underline{p}) - 2c\left(\frac{q(\underline{p})}{2}\right)\right) > \lim_{p \to \underline{p}^-} \pi^M(p) =$$
$$= \underline{p}q(\underline{p}) - c(q(\overline{p})) - c(q(\underline{p}) - q(\overline{p})) - F \tag{A-5}$$
$$= \underline{p}q(\underline{p}) - 2c\left(\frac{q(\underline{p})}{2}\right) - F,$$

where the first equality in (A-5) follows from (6) and (7), and the second equality follows from:

$$c\left(q(\underline{p}) - q(\overline{p})\right) = c(q(\overline{p})) = c\left(\frac{q(\underline{p})}{2}\right), \tag{A-6}$$

given that $q(\underline{p}) = 2q(\overline{p})$. Rearranging terms in (A-5) yields:

$$\underline{p}q(\underline{p}) - 2c\left(\frac{q(\underline{p})}{2}\right) < F\left(\frac{S}{S-1}\right). \tag{A-7}$$

Now, because of Lemma 1, $S \leq N-1$ firms can charge $\underline{p}$ iff $\pi(\underline{p}) = 0$ in equilibrium. But it is clear that none of these firms has a profitable deviation by undercutting M (and getting a negative payoff) nor by bidding a larger price than M (and still getting a zero payoff). Since $\pi(\underline{p}) = 0$ is equivalent to $\underline{p}q(\underline{p}) = c(q(\underline{p})) + F$, we have that (A-7) can be rewritten as:

$$0 < c(q(\underline{p})) - 2c\left(\frac{q(\underline{p})}{2}\right) < \frac{F}{S-1}. \tag{A-8}$$

where $0 < c(q(\underline{p})) - 2c\left(\frac{q(\underline{p})}{2}\right)$ is due to strict convexity. Finally, and still due to Lemma 1, the remaining $N-1-S$ firms can charge any vector of prices with entries above $\underline{p}$ without having a profitable deviation. This completes the proof.

■

Proof of Proposition 3. In each strategy profile as in Proposition 3, a non-merging firm cannot profitably deviate by i) bidding any larger price (and still get zero); ii) bidding any price no larger than p' and get a negative payoff; while M is already maximizing her payoff.

■

Proof of Theorem 1.

From the proof of Proposition 2 we have that a post-merger equilibrium where the merged entity and at least one non-merging firm set the same price exists iff (A-8) holds. Now, from the profitability condition (5) and $\underline{p}q(\underline{p}) = c(q(\underline{p})) + F$, we get:

$$c(q(\underline{p})) - 2c\left(\frac{q(\underline{p})}{2}\right) > 2\frac{S}{N}\pi(\bar{p}) - F \tag{A-9}$$

In order for both (A-8) and (A-9) to hold we need that $2\frac{S}{N}\pi(\bar{p}) - F < \frac{F}{S-1}$, which after some algebra, boils down to:

$$\pi(\overline{p}) < F\left(\frac{N}{2(S-1)}\right). \tag{A-10}$$

From the pre-merger equilibrium condition, we have that:

$$\pi(\overline{p}) > N\left(\pi(p^m) - F\right) \tag{A-11}$$

which implies that:

$$N\left(\pi(p^m) - F\right) < \pi(\overline{p}) < F\left(\frac{N}{2(S-1)}\right). \tag{A-12}$$

In order for (A-12) to hold we need that $N\left(\pi(p^m)-F\right)<F\left(\frac{N}{2(S-1)}\right)$, which after some algebra boils down to:

$$\pi(p^m)<F\left(\frac{2S-1}{2(S-1)}\right). \tag{A-13}$$

■

Proof of Theorem 2.
From Proposition 3, it must be that $p'q(p')-c(q(p'))-F<0$, namely:

$$p'q(p')<F+c(q(p')). \tag{A-14}$$

This implies that:

$$\pi^M(p')\equiv p'q(p')-2c\left(\frac{q(p')}{2}\right)<F+c(q(p'))-2c\left(\frac{q(p')}{2}\right). \tag{A-15}$$

From the profitability condition (5), we have that $\pi^M(p')>\frac{2}{N}\pi(\bar{p})$. Hence:

$$\frac{2}{N}\pi(\bar{p})<\pi^M(p')<F+c(q(p'))-2c\left(\frac{q(p')}{2}\right). \tag{A-16}$$

In order for this condition to hold it must be that $F+c(q(p'))-2c\left(\frac{q(p')}{2}\right)>\frac{2}{N}\pi(\bar{p})$, which boils down to:

$$\pi(\bar{p})<F\left(\frac{N+c(q(p'))-2c\left(\frac{q(p')}{2}\right)}{2}\right). \tag{A-17}$$

where $\left(\frac{N+c(q(p'))-2c\left(\frac{q(p')}{2}\right)}{2}\right)>0$ since $c(q(p'))-2c\left(\frac{q(p')}{2}\right)>0$ by strict convexity. Finally, notice that since, in equilibrium, $\pi(p')<0$, then $p'<\bar{p}$.

■

Proof of Corollary 1.
Omitted.

Appendix C: Main results under linear variable costs

In this section we show that our main result holds under a linear variable cost as well, once again highlighting the relevance of the cost discontinuity rather than the shape of $c(q(p))$. In this case, the variable cost for a given production q is the same regardless of how it is distributed between the two plants. It follows that the merged entity bears one fixed component F if $q>2\overline{q}$. Hence, M's cost and profit functions write:

$$C^M(q(p))=\begin{cases}c(q(p)) & \text{if } 0\leq q\leq 2\overline{q};\\ c(q(p))+F & \text{if } q>2\overline{q},\end{cases} \tag{A-18}$$

and

$$\pi^M(p)=\begin{cases}pq(p)-c\left(q(p)\right)-F & \text{if } 0\leq p<p(2\overline{q});\\ pq(p)-c\left(q(p)\right) & \text{if } p(2\overline{q})\leq p\leq p^{\max},\end{cases} \tag{A-19}$$

respectively. As in the main body of the paper, let us first present an example. Pre-merger there are three firms $i=\{1,2,3\}$ producing according to the variable cost component $c(q(p))=\frac{q(p)}{2}$. The fixed component $F=\frac{3}{50}$.

We assume an upward jump if the desired production exceeds $\frac{1}{10}$:

$$C(q(p)) = \begin{cases} \frac{q(p)}{2} & \text{if } 0 \le q \le \frac{1}{10}, \\ \frac{q(p)}{2} + \frac{3}{50} & \text{otherwise.} \end{cases} \tag{A-20}$$

Here the buyer has the linear demand $p(q) = 1 - q$, so that:

$$\pi(p) = \begin{cases} (1-p)\left(p - \frac{1}{2}\right) - \frac{3}{50} & \text{if } 0 \le p < \frac{13}{4}; \\ (1-p)\left(p - \frac{1}{2}\right) & \text{otherwise.} \end{cases} \tag{A-21}$$

Now we let firms 1 and 2 merge. According to (A-18):

$$C^M(q(p)) = \begin{cases} \frac{q(p)}{2} & \text{if } 0 \le q \le \frac{4}{5}, \\ \frac{q(p)}{2} + \frac{3}{50} & \text{otherwise} \end{cases} \tag{A-22}$$

so that:

$$\pi^M(p) = \begin{cases} (1-p)\left(p - \frac{1}{2}\right) - \frac{3}{50} & \text{if } 0 \le p < 3; \\ (1-p)\left(p - \frac{1}{2}\right) & \text{otherwise.} \end{cases} \tag{A-23}$$

First, note that the vector $(p_1, p_2, p_3) = \left(\frac{9}{10}, \frac{9}{10}, \frac{9}{10}\right)$ is the unique pre-merger equilibrium and firms get the positive payoff $\frac{\pi(\frac{9}{10})}{3} = \frac{1}{75}$. Since $p^m = \frac{3}{4}$, the best deviation payoff is $\pi\left(\frac{3}{4}\right) = \frac{1}{16} - \frac{30}{5} = \frac{1}{400}$. Regarding the post-merger scenario, the vector $(p_M, p_3) = \left(\frac{4}{5}, \frac{4}{5}\right)$ is a symmetric post-merger equilibrium. Since $\pi(\frac{4}{5}) = 0$, firm 3 can neither profitably undercut M, nor set a larger price and still get zero profits. Furthermore, since:

$$\frac{3}{100} = \frac{\pi^M(3)}{2} > \lim_{p \to 3^-} \pi^M(p) = 0. \tag{A-24}$$

M does not deviate either. Finally, we can see that the merger is also profitable, since $\frac{3}{100} = \frac{\pi^M(3)}{2} > 2\left(\frac{\pi(\frac{9}{10})}{3}\right) = \frac{2}{75}$ (and obviously CS enhancing). Figure 4 provides a graphical illustration.

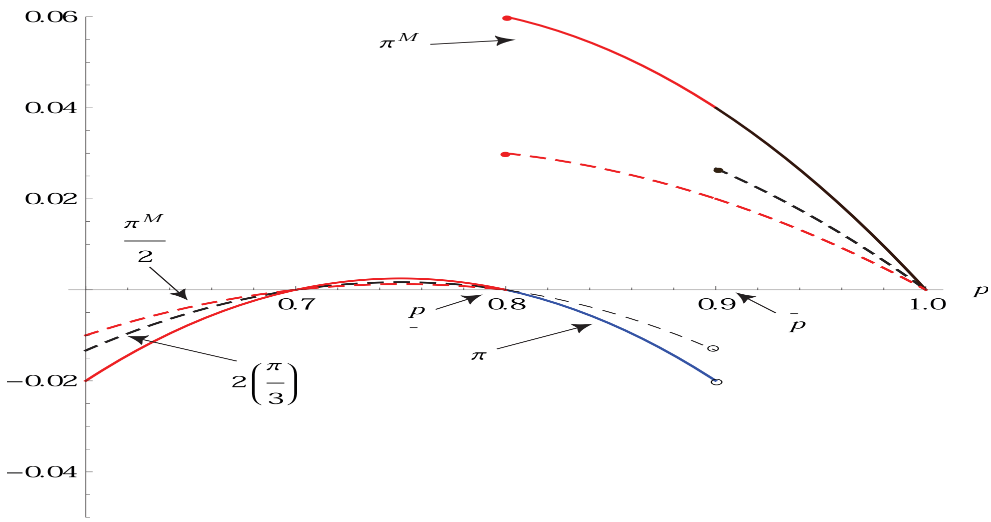

Figure 4: *The pre and post-merger symmetric equilibria in the winner-take-all low-price auction with linear variable costs, linear demand $q(p) = 1 - p$, fixed component $F = \frac{3}{50}$, and a pre-merger upward cost jump at $q = \frac{1}{10}$. The black solid curve shows that under constant marginal costs $\pi(p)$ and $\pi^M(p)$ coincide for $p < \underline{p}$ and $p > \bar{p}$.*

We can now present the equivalent of Theorem 1:

Theorem 3. *Assume $c'' = 0$. If:*

i) $N\left(\pi(p^m) - F\right) < \pi\left(\overline{p}\right) < F\left(\frac{N}{2S}\right)$*;*

ii) $\pi(p^m) < F\left(\frac{2S+1}{2S}\right)$*,*

there exists $(\overline{p}, \underline{p}) \in [0, p^{\max}] \times [0, p^{\max}]$, such that: i) the pre-merger equilibrium is $\overline{\boldsymbol{p}} \in \mathbb{R}^N_+$; ii) the post-merger equilibrium is a vector $(p_M, \boldsymbol{p}_{S-1}, \boldsymbol{p}_{N-S-1})$ as defined in Proposition 2; iii) the merger is profitable; iv) $\underline{p} < \overline{p}$ (i.e. the merger is CS enhancing).

Proof of Theorem 3. First notice that the right hand side of (A-5) is zero. When deviating from $\underline{p}$, both the merged entity and any outside firm minimize costs by concentrating the output in one plant and paying F once. Hence, by Lemma 1, $\lim_{p \to \underline{p}^-} \pi^M(p) = 0$, and (A-5) is satisfied. For $c'' = 0$, and from (A-19), profitability implies that:

$$\frac{\underline{p}q(\underline{p}) - c(q(\underline{p}))}{S} > 2\frac{\pi(\overline{p})}{N}. \tag{A-25}$$

By Lemma 1, $\underline{p}q(\underline{p}) - c(q(\underline{p})) = F$, so that (A-25) becomes:

$$\pi\left(\overline{p}\right) < F\left(\frac{N}{2S}\right). \tag{A-26}$$

Regarding the pre-merger equilibrium we need that (A-11) is satisfied, which implies that:

$$N\left(\pi(p^m) - F\right) < \pi\left(\overline{p}\right) < F\left(\frac{N}{2S}\right). \tag{A-27}$$

In order for (A-27) to hold, we need that $N\left(\pi(p^m) - F\right) < F\left(\frac{N}{2S}\right)$, which after some algebra boils down to:

$$\pi(p^m) < F\left(\frac{2S+1}{2S}\right). \tag{A-28}$$

■

We can directly check that the conditions in Theorem 3 are satisfied. Regarding condition i), $\pi(p^m) - F = \frac{1}{400} < \frac{\pi(\overline{p})}{3} = \frac{1}{75} < \frac{3}{200} = F\left(\frac{N}{2S}\right)$. Condition ii) holds as well since $\pi(p^m) = \frac{1}{16} < \frac{3}{40} = F\left(\frac{2S+1}{2S}\right)$.

We can now move to the case where the merged entity emerges as the unique winner of the auction. Pre-merger there are three firms $i = \{1, 2, 3\}$ producing according to the variable cost component $c(q(p)) = q(p)$. The fixed component $F = 1$. We assume an upward jump if the desired production exceeds $\frac{1}{2}$:

$$C(q(p)) = \begin{cases} q(p) & \text{if } 0 \leq q \leq \frac{1}{2}, \\ q(p) + 1 & \text{otherwise.} \end{cases} \tag{A-29}$$

Here the buyer has the linear demand $q(p) = \frac{5}{2} - p$, so that:

$$\pi(p) = \begin{cases} \left(\frac{5}{2} - p\right)(p-1) - 1 & \text{if } 0 \leq p < 2; \\ \left(\frac{5}{2} - p\right)(p-1) & \text{otherwise.} \end{cases} \tag{A-30}$$

Now we let firms 1 and 2 merge. The merged entity's cost and monopolist profit functions are:

$$C^M(q(p)) = \begin{cases} q(p) & \text{if } 0 \leq q \leq 1, \\ q(p) + 1 & \text{otherwise} \end{cases} \tag{A-31}$$

and:

$$\pi^M(p) = \begin{cases} \left(\frac{5}{2} - p\right)(p-1) - 1 & \text{if } 0 \le p < \frac{3}{2}; \\ \left(\frac{5}{2} - p\right)(p-1) & \text{otherwise,} \end{cases} \tag{A-32}$$

respectively. First, note that the vector $(p_1, p_2, p_3) = \left(\frac{1}{2}, \frac{1}{2}, \frac{1}{2}\right)$ is the unique pre-merger equilibrium and firms get the positive payoff $\frac{\pi\left(\frac{3}{2}\right)}{3} = \frac{1}{6}$. Regarding the post-merger scenario, it is easy to see that the strategy profile in which the merged entity sets her profit maximizing price as a monopolist, $\frac{7}{4}$, and the outside firm 3 sets any price above $\frac{7}{4}$ is a post-merger equilibrium. Clearly, M cannot improve her situation, and since $\pi\left(\frac{7}{4}\right) = -0.4375$, firm 3 strictly prefers to bid any price above $\frac{7}{4}$, from which there is no profitable deviation as all of them imply zero profits. Finally, we can show that the merger is profitable, since $\pi^M\left(\frac{7}{4}\right) = \frac{9}{16} > 2\left(\frac{\pi(2)}{3}\right) = \frac{1}{3}$ (and obviously CS enhancing).

Figure (5) provides a graphical illustration.

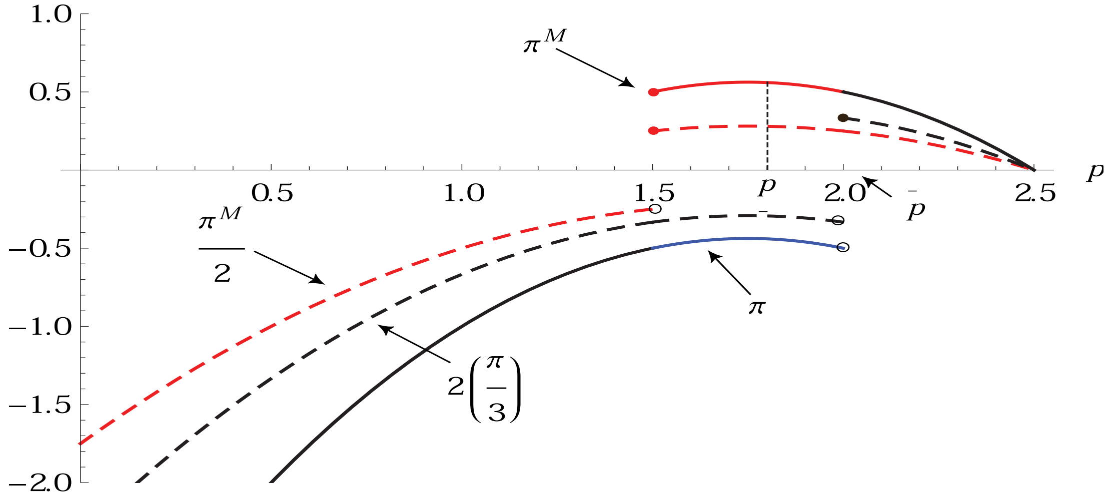

Figure 5: *The pre, and post-merger equilibria with M as the unique awardee, in the winner-take-all low-price auction with linear variable costs, linear demand $q(p) = \frac{5}{2} - p$, fixed component $F = 1$, and a pre-merger upward cost jump at $q = \frac{1}{2}$. The black solid curve shows that under constant marginal costs $\pi(p)$ and $\pi^M(p)$ coincide for $p < \underline{p}$ and $p > \bar{p}$.*

The equivalent of Theorem 2 is the following:

Theorem 4. *Assume $c'' = 0$. If:*

i) $\frac{2}{N}\pi(\bar{p}) < \pi^M(p') < F$;

ii) $\pi(\bar{p}) < F\left(\frac{2}{N}\right)$,

there exists $(\bar{p}, \underline{p}) \in [0, p^{\max}] \times [0, p^{\max}]$, such that: i) the pre-merger equilibrium is $\bar{\boldsymbol{p}} \in \mathbb{R}^N_+$; ii) the post-merger equilibrium is a vector $(p_M, \boldsymbol{p}_{-M})$ as defined in Proposition 3; iii) the merger is profitable; iv) $p' < \bar{p}$ (i.e. the merger is CS enhancing).

Proof of Theorem 4 From Proposition 3, it must be that $\pi(p') \equiv p'q(p') - c(q(p')) - F < 0$. Under constant marginal costs $\pi^M(p') \equiv p'q(p') - c(q(p'))$, and hence:

$$0 < \pi^M(p') < F. \tag{A-33}$$

From the profitability condition (5), we have that $\pi^M(p') > \frac{2}{N}\pi(\bar{p})$. This, joint with (A-33), yields:

$$\frac{2}{N}\pi(\bar{p}) < \pi^M(p') < F. \tag{A-34}$$

In order for (A-34) to hold it must be that $\pi(\bar{p}) < F\left(\frac{N}{2}\right)$. Finally, notice that since, in equilibrium, $\pi(p') < 0$, then $p' < \overline{p}$. ■

We can finally check that the conditions in Theorem 4 are satisfied. Regarding condition i), $\frac{2}{N}\pi(\overline{p}) = \frac{1}{3} < \pi^M(p') = \frac{9}{16} < 1 = F$. Condition ii) holds as well since $\pi(\overline{p}) = \frac{1}{2} < \frac{2}{3} = F\left(\frac{2}{N}\right)$.

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