Beating Coase at Monopoly[*]

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Abstract

We study how a buyer unable to price discriminate should satisfy his demand in the presence of diseconomies of scale in production. Defying the Coase Conjecture, we show that auctioning contracts for lots (*block sourcing*) followed by setting a price to realize (part of) the residual gains from trade always leads to higher buyer surplus than simply setting a price.

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1 Introduction

Monopsony (monopoly)[1] is one of the fundamental settings in economics. We all know that, as the monopsonist cares about his payments to the suppliers, not about the actual production costs, he offers an inefficiently low price, leading to unrealized gains from trade. This raises the question: why does he not open a residual market and try to capture some of the residual surplus? The answer is provided by the so called "Coase Conjecture" (Coase, 1972): since the price in the residual market would have to be higher than the original price – as all supply at the original price has been exhausted – the suppliers would prefer to wait for that price rather than selling for the original one, and thus the (frictionless) market would unravel. Consequently, a residual market would be of no use, thereby rationalizing the timeless nature of the institution of monopsony pricing, which includes a commitment to the price offered.

We revisit this classic problem and argue that the monopsonist can do better than committing to a price, even if price discrimination is not possible. To do so, we consider a buyer of a divisible homogeneous good facing a finite number of identical suppliers who have increasing marginal costs[2] of production. This set-up is compatible with the classic one – which only posits a supply function – but specifies the market structure in a realistic manner. The buyer's default option is classic monopsony: to purchase his requirements from the suppliers via setting a price per unit at which he is willing to buy from any seller. This will result in each seller supplying the quantity at which their marginal cost reaches the price.

In many practical situations the monopsonist does his purchases in two stages. For example, a residential gas supplier[3] will typically buy a large part of its requirements

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[1]The two models are technically equivalent. For concreteness, we tell our story in terms of a monopsony.

[2]This should not be seen as restrictive: constant marginal costs are just the knife-edge case between a natural monopoly and a market where multiple firms can operate. Note that in monopoly the corresponding assumption would be equally natural: that buyers have decreasing marginal willingness to pay.

[3]Alternatively, a tour operator looking for hotel rooms for its clients, or a produce wholesaler sourcing from many growers, etc.

forward, supplemented by later spot purchases. Of course, an important motivation there is risk management – absent in our analysis – but our point is that there are more fundamental reasons for going beyond the classical method.

As a first step, let us consider an alternative to setting a price: setting a quantity.[4] The monopsonist could decide on the quantity he wants to purchase in the market and let the suppliers compete for the right to supply. Short of an invisible hand, we need to posit a microstructure to predict how such a market would clear. For example, as shown by Burguet and Sákovics (2017), if quantity setting is implemented by the suppliers bidding for each infinitesimal unit of demand, the outcome for any quantity set will be a "competitive" equilibrium, where the suppliers are paid their marginal cost and the market clears. Given that, the buyer's optimal choice of quantity is the classical monopsony quantity and thus the auction leads to the same buyer surplus as setting the monopsony price. Out of the frying pan, into the fire: seemingly, switching to quantities is not the answer. Or is it?

From the buyer's point of view, the above auction has the unwanted feature that each supplier makes her (positive)[5] competitive profit. Consequently, he is interested in increasing the competition among the suppliers in order to capture some of this surplus. The buyer can achieve this by rationing some supplier(s): grouping together his requirements into sole-sourced lots (blocks) – at least one fewer than the number of suppliers – and auctioning them. We call this buying method *block sourcing*. Block sourcing trades off lower supplier profits against inefficient allocation of production, as with increasing marginal costs it is inefficient to leave a supplier out of production. Can it improve on monopsony profits? Let us work out an example.

Example 1 *Let the buyer's utility be given by $U(Q) = Q - \frac{Q^2}{2}$, leading to a demand function of $U'(Q) = 1-Q$; let there be two suppliers with identical cost functions $c(q) = \frac{q^a}{a}$. We will calculate at two values, $a = 3$ and $a = 1.5$, here.[6]*

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[4]Just as in the classic problem, the buyer cannot set *both* prices and quantities for any supplier.

[5]Recall that with increasing marginal costs, price equal marginal cost implies positive profits for the suppliers.

[6]In the rest of the examples, we will use $a = 2$ what simplifies calculations. In this example, when

The classical monopsony quantity, Q^m, is the solution to $\arg\max U(Q) - c'(Q/2)Q$, leading to the first-order condition

$$U'(Q) = c'(Q/2) + \frac{Qc''(Q/2)}{2}. \tag{1}$$

Substituting in, we obtain that $Q^m(a = 3) = 2/3$ or $Q^m(a = 1.5) \approx .3619$, the monopsony price is $p^m(a = 3) = 1/9$ or $p^m(a = 1.5) \approx .4253$, buyer surplus is $BS^m(a = 3) \approx .3704$ or $BS^m(a = 1.5) \approx .1425$. Supplier profits are $\pi^m(a = 3) = 2/81 \approx 0.02469$ or $\pi^m(a = 1.5) \approx .02564$, leading to utilitarian welfare $W^m(a = 3) \approx .4198$ or $W^m(a = 1.5) \approx .1938$.

With block sourcing, the optimal lot size, z, is the solution to

$$U'(z) = c'(z), \tag{2}$$

as the suppliers compete away all their profit, so the buyer only has to pay for the cost of production. Substituting in, we obtain that $z(a = 3) \approx .6180$ or $z(a = 1.5) \approx .3820$, and buyer surplus is $BS^{bs}(a = 3) = W^{bs}(a = 3) \approx .3484 < .3704 \approx BS^m(a = 3)$, while $BS^{bs}(a = 1.5) = W^{bs}(a = 1.5) \approx .1516 > .1425 \approx BS^m(a = 1.5)$.

Thus, block sourcing indeed may outperform monopsony, but need not do so.[7] The logic of the result is simple: the inefficiency caused by leaving out a supplier is increasing in the convexity of the cost function, a. Meanwhile, the supplier profits in classic monopsony are inverted U-shaped in a: they are small when a is either small (close to one) or large and sizable in between. Nonetheless, we do not pursue a full characterization, as block sourcing – on its own – turns out not to be the best the buyer can do.

Our key insight is that, unlike in the case of price setting, following block sourcing there is room for a residual market. Note that block sourcing separates the suppliers into two groups: winners and losers. Importantly, as they have already committed to produce the lot they have won, in the residual market the winners have higher marginal costs than the losers. As a result, the buyer can set a residual market price that is *lower* (recall that, in the Coasian set-up above, it had to be higher) than the per-unit price paid to the

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$a = 2$ both methods lead to the same buyer surplus: the inefficiency loss equals the gain from eliminating supplier profit.

[7]This fits with the emprical evidence that block sourcing is often but not universally used.

winners – so that they are not tempted to give up on the lot auction – and still be able to buy from the losers. Of course, the reopening of the market does reduce the intensity of competition in the auction, but – as we show in the remainder of the paper – the optimal policy of block sourcing followed by setting a price in the residual market always (that is, for any number of suppliers, and well-behaved utility and cost functions) leads to strictly higher buyer surplus than classic monopsony.

The competitive pressure facing the suppliers is largely determined by the lot policy chosen. How keen a supplier is to obtain a block contract depends on her outside option. This outside option is actually an inside option in our model: it is determined by what profit she can expect to make in the residual market. The size of the residual market is endogenous: the more demand is satisfied through lots, the less residual demand there is. By setting larger lots, the buyer can squeeze the losing supplier's production and, therefore, profit in the residual market. As this makes the bidders' inside option worse, they bid more aggressively for the block contracts, in the aggregate more than compensating the buyer for the concomitant inefficiency. Importantly – in the absence of fixed costs – this effect does not lead to the complete elimination of the residual market: all suppliers produce in equilibrium.

Our result holds whether or not the monopsonist is able to commit to the residual market price before the auction. A lack of commitment power implies that he is bound to set the monopsony price corresponding to the residual supply and demand, which is higher than the price he would prefer to set taking into account its effect on the bidding behavior in the auction. Nevertheless, he still improves his payoff over classic monopsony.

The welfare effects are in general indeterminate, as in most cases our method increases the traded quantity towards the efficient level but this is counteracted by the inefficient allocation of production: the lot winners produce too much and the loser too little.

Finally, we investigate the case when the suppliers' costs are not identical. We establish that asymmetry in costs reduces the effectiveness of block sourcing, but our results are robust to moderate asymmetry.

We carry out our analysis under complete information, in the spirit of the classic

monopsony. Not only is this a reasonable assumption for many applications – tour operators know the cost functions of the hotel chains they work with – but it simplifies and focuses the analysis. Moreover, we can afford to forgo the presence of informational rents, as they are not necessary in our model to give profits to the suppliers. Thus, we are not conducting a typical mechanism design exercise here (for that, see, for example, Maskin and Riley, 2000). Rather, we try to uncover robust insights while analyzing the usefulness of combining some standard practices. It is important to observe that with asymmetric information auctions would play a key additional role: to select the most efficient suppliers. We show that even without this function they are useful, especially when combined with a residual market.

2 The model

Consider $n > 1$ identical suppliers producing an infinitely divisible homogeneous good with a strictly increasing, strictly convex and thrice differentiable cost function $c(x)$, with $c(0) = 0$.[8] There is a single buyer, B, with a twice continuously differentiable, quasi-linear vNM utility function, $V(x, \$) = U(x) + \$$, with $U'(x) > 0$, $U''(x) < 0$ for $x \in [0, 1]$, with the normalization $U'(1) = 0$. The cost and utility functions are common knowledge. We study the following two-stage procurement game: First, B announces $m \in \{0, 1, ..., n-1\}$ contracts for (indivisible) lot sizes $z_1 \geq ... \geq z_m$, where $\sum_{i=1}^{m} z_i = Z \leq 1$. Next, these contracts are sequentially auctioned, in decreasing order of size.[9] To simplify the assignment of lots among suppliers (who make the same bids in equilibrium), we assume that – as standard in actual multi-sourcing arrangements – each supplier can win at most one block contract. Following the lot auctions, each supplier can make further sales in the residual market at (unit)price p^r chosen by B – we will analyze the cases where B commits to this price before (strong commitment) or after (weak commitment) the lot

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[8]To ensure that second-order conditions for optimality are globally satisfied in classical monopsony, we also assume that $c'''(x)x + 2c''(x) > 0$ for $x \in [0, 1]$.

[9]Given complete information, the exact format of the auctions does not matter, even sequentiality we only assume for simplicity.

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auction, separately. Note that not setting any lot corresponds to classical monopsony pricing.

3 Results

Our first observation is that – since all suppliers are identical – in equilibrium it must be the case that a seller who does not win a lot earns the same profit as any of the lot winners.[10] Basically, the auction and the residual market serve as inside options for the suppliers, enforcing indifference in equilibrium. Let $\mathbf{z} = (z_1, ..., z_m)$. Denote the profits of each supplier that only sells in the residual market by $\pi(\mathbf{z}) = p^r c'^{-1}(p^r) - c(c'^{-1}(p^r))$.

Lemma 1 *Given any feasible* $\mathbf{z}$*, the equilibrium profit of each supplier is equal to* $\pi(\mathbf{z})$*.*

Proof. Let the equilibrium profit of the winner of lot $m - k + 1$ be denoted by $\pi_w^{(k)}$. Induction hypothesis (IH): If there are k lots left then $\pi_w^{(k)} = \pi(\mathbf{z})$.

Step 1: The IH holds when $k = 1$. Since $m < n$ there are $n - m + 1 \geq 2$ remaining suppliers. It is immediate that in equilibrium neither $\pi_w^{(1)} > \pi(\mathbf{z})$ nor $\pi_w^{(1)} < \pi(\mathbf{z})$. In the first case any losing bidder could do better by bidding slightly below the winner's bid (which must have been the (weakly) lowest), whereas in the second case the winner could increase her profits by increasing her offer in order to lose. The latter argument presupposes that there is another valid bid for the lot in equilibrium – so that she indeed loses the auction and so that the number of suppliers in the residual market, and thus p^r, remain the same. But, if there were no other bid, the winner could increase her offer and still win, contradicting that we were in an equilibrium to start with.

Step 2: If the IH holds for k then it is also true for $k + 1$. By the IH, all the suppliers who do not win lot $m - k$ will earn $\pi(\mathbf{z})$. Thus, the argument used in Step 1 can be directly applied to show that $\pi_w^{(k+1)} = \pi(\mathbf{z})$. ∎

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[10]Of course, this observation does not hold for all symmetric games with identical players, but it holds in our game as shown in the proof of Lemma 1.

This result points to the important linkage between the lot auction and the residual market. The lemma implies that – conditional on the lot sizes – the market for the residual demand determines the bids in the lot auction and, therefore, all the payoffs. This interconnection is what the buyer exploits when setting his lot policy.

Our next observation is that the buyer's optimal policy does not have all suppliers participating in the residual market. He sets lots in a way that the lot winners are effectively priced out of the residual market – due to their high (interim) marginal costs:

Lemma 2 *Any lot z_j such that $c'(z_j) \leq p^r$ has no effect on the final outcome. Thus, it is without loss to assume that – if setting a lot is strictly better for the buyer then – all m lot winners are "priced out" of the residual market:*

$$c'(z_i) > p^r, \ i = 1, ..., m. \tag{3}$$

Proof. We start by showing that if, in equilibrium, the winner of the smallest lot is interested in participating in the residual market then the buyer's surplus is the same as if the smallest lot was not offered. Assume there is at least one lot winner, m, who also trades in the residual market. We have two cases to consider.

i) If the buyer can only set p^r after the auction, then the quantity traded in the residual market by a loser is q', where $U'\left(Z + (n-m)q' + \sum_{i=1}^{m-1}[q' - z_i]^+ + q' - z_m\right) = c'(q')$, as, of course, q' must be larger than z_m, for the winner of lot m to participate in the residual market. Without lot m, the quantity traded in the residual market by a loser would be q, where $U'\left(Z - z_m + (n-m+1)q + \sum_{i=1}^{m-1}[q - z_i]^+\right) = c'(q)$. By the monotonicity of supply and demand, it is immediate that $q = q'$ and, consequently, the two outcomes are the same. By step 1 of the proof of Lemma 1, the payoffs will also be unchanged.

ii) If the buyer can commit to p^r at the beginning, then we show that for each p^r the small lot makes no difference. If the small lot is offered, the market clearing condition is $p^r = c'(q')$ leading to total quantity bought $Q' = Z + (n-m)q' + \sum_{i=1}^{m-1}[q' - z_i]^+ +$

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$q' - z_m$, and $\pi' = p^r q' - c(q')$. If lot m were not offered, we would have $p^r = c'(q)$,

$$Q = Z - z_m + (n - m + 1)q + \sum_{i=1}^{m-1} [q - z_i]^+ \text{ and } \pi = p^r q - c(q). \text{ It is obvious that}$$

$q = q'$, $Q = Q'$ and $\pi = \pi'$.

Therefore, the only way the buyer can hope for a better outcome than the classical monopsony one is by setting the smallest – and, therefore, each – lot larger than the residual monopsony quantity for $n - m + 1$ suppliers: $c'(z_m) \geq p^r$. ∎

The logic of this result is simple: if a lot winner participated (selling an additional q' units) in the residual market – joining at least one loser (selling q units) – then, in equilibrium, marginal costs would equalize, $c'(z_i + q') = c'(q) \Rightarrow z_i + q' = q$, leading to the same outcome as if the lot won had not been offered.

We are now ready to turn to the derivation of the buyer's optimal lot+pricing policy. There are two cases to consider, based on whether the buyer can commit to the residual market price at the beginning of the game or he is bound to behave sequentially rationally – and therefore not factoring in the effect of p^r on the lot prices –, given the residual demand/supply following the lot auctions. As the next lemma shows, both cases lead to the same optimal number of lots: a single supplier will be left without.

Proposition 1 *The buyer strictly prefers to set $n - 1$ identical lots. Consequently, block sourcing followed by a residual market strictly improves buyer surplus over classic monopsony.*

Proof. First, since – given Lemma 2 – the lot size distribution does not affect the residual market (which by Lemma 1 determines the profits of all suppliers), the buyer can appropriate the efficiency gains from equalizing lots while keeping Z constant. Therefore, identical lots are optimal.

Suppose, by way of contradiction, that setting $m < n-1$ (identical) lots, z, is optimal.

i) First, let p denote the optimal unit price of the residual demand – committed to at the beginning of the game – leading to the losers producing $q_L(< z)$ that satisfies $c'(q_L) = p$. Now, set an additional lot of size q_L. It is straightforward to see that, if the

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buyer sets the same price p then there will be no change in the outcome. When $n > 2$, the buyer could strictly improve his payoff by equalizing the lot sizes as he is able to capture the efficiency gains. When $n = 2$, $m < n - 1$ implies no lot to start with and thus there is no scope for an efficiency gain. In this case, the buyer could strictly improve his payoff by marginally decreasing the residual market price from p (but leaving the new lot size at q_L). To see this, note that $q_L = \arg\max U(2q) - 2qc'(q)$, solving the first-order condition

$$U'(2q) - c'(q) - qc''(q) = 0. \tag{4}$$

In turn, buyer surplus with a lot of size q and residual market price $p' = c'(q')$ is $U(q + q') - c(q) + c(q') - 2q'c'(q')$. Then the first-order condition becomes

$$U'(q + q') - c'(q') - 2q'c''(q') = 0.$$

Evaluating its left-hand side at $q' = q$, we obtain

$$U'(2q) - c'(q) - 2qc''(q) < 0,$$

where the inequality follows from (4). Thus, setting p' slightly below p would strictly increase the buyer's payoff.

In conclusion, with full commitment, setting fewer than $n - 1$ lots is suboptimal.

ii) In case the buyer can fix the price only after the tendering process, he will choose the monopsony price at the residual demand, say $\widehat{p} = c'(\widehat{q})$, where

$$\widehat{q} = \arg\max_q U\left(Z + (n - m)q\right) - (n - m)c'(q)\, q.$$

He can again set an additional lot of size $\widehat{q}$, without changing the outcome. If $n > 2$, the buyer could strictly improve his payoff by equalizing the lot sizes and capture the efficiency gains. If $n = 2$, we will now show that setting a lot slightly higher than $\widehat{q}$ strictly increases consumer surplus. Buyer surplus given a lot q is $U(q + \widetilde{q}(q)) - c(q) + c(\widetilde{q}(q)) - 2c'(\widetilde{q}(q))\widetilde{q}(q)$, leading to the first-order condition

$$(1 + \widetilde{q}'(q))U'(q + \widetilde{q}(q)) - c'(q) - \widetilde{q}'(q)\left[c'(\widetilde{q}(q)) + 2c''(\widetilde{q}(q))\widetilde{q}(q)\right] = 0.$$

Evaluating its left-hand side at $q = \widehat{q}$ and substituting in the first-order condition for $\widetilde{q}(\widehat{q})$ $- U'(\widehat{q} + \widetilde{q}(\widehat{q})) = c'(\widetilde{q}(\widehat{q})) + 2c''(\widetilde{q}(\widehat{q}))\widetilde{q}(\widehat{q})$ $-$ and $\widetilde{q}(\widehat{q}) = \widehat{q}$, we obtain

$$U'(2\widehat{q}) - c'(\widehat{q}) = \widehat{q}c''(\widehat{q}) > 0.$$

Thus, increasing the lot size from $\widehat{q}$ would strictly benefit the buyer. ∎

The fact that the lots need to be equal follows from the fact that the supplier profits only depend on the aggregate size of the lots (Z) and therefore the buyer can afford to set lots sizes efficiently. The logic for setting $n-1$ lots harks back to Lemma 2: If the buyer sets an additional lot of the same size as the quantity sold by the losing suppliers in the residual market, the outcome will remain the same. However, the incentives to set the sizes of the lots and the residual market price do change with this reshuffling: In the case of strong commitment, the buyer will now prefer to further reduce the residual market price (as it now decreases his residual market purchases by less); while with weak commitment the buyer will prefer to increase the size of the new lot slightly (as decreasing his demand in the residual market is less costly than before). This argument works for any number of lots, including zero, what corresponds to classic monopsony.

The optimal lot size – and, of course, the residual market price – does depend on the timing of commitment:

Proposition 2 *If the buyer can commit to the price for the residual market before the lot auction, the optimal price is $p^s = c'(q^s)$, where the quantity bought from the loser, q^s, and the optimal size of the $n-1$ lots, z^s, uniquely solve*

$$U'\left((n-1)z + q\right) = c'(q) + nqc''(q),\tag{5}$$

$$U'\left((n-1)z + q\right) = c'(z).\tag{6}$$

Proof. By Proposition 1, we know that there will be $n-1$ identical lots. Thus, the buyer's objective function is

$$U\left((n-1)z + q\right) - (n-1)\left(c(z) - c(q)\right) - nqc'(q).$$

The two first-order conditions are the ones enunciated in the lemma. ∎

Let us return to our example to illustrate this result.

Example 2 *In our two-player linear example with strong commitment the set of equations becomes*

$$1 - z - q = 3q,$$

$$1 - z - q = z.$$

Solving, we obtain $q^s = \frac{1}{7}$ and $z^s = \frac{3}{7}$, leading to total quantity sold $Q^s = \frac{4}{7} > \frac{1}{2} = Q^m$, residual market price $p^s = \frac{1}{7} < \frac{1}{4} = p^m$, buyer surplus $BS^s = \frac{2}{7} > \frac{1}{4} = BS^m$.

When the buyer has weak commitment power, the lot size determines the price he will charge in the residual market, making the solution somewhat more involved.

Proposition 3 *If the buyer can set the price for the residual market only after the lot auction, then the optimal price is $p^w = c'(q^w)$, where the quantity bought from the loser, q^w, and the optimal size of the $n - 1$ lots, z^w, uniquely solve*

$$U'\left((n-1)z + q\right) = c'(q) + qc''(q), \tag{7}$$

$$U'\left((n-1)z + q\right) = \frac{(n-1)c'(z) + [c'(q) + nqc''(q)]\frac{\partial q}{\partial z}}{n - 1 + \frac{\partial q}{\partial z}}, \tag{8}$$

where

$$\frac{\partial q}{\partial z} = \frac{(n-1)U''\left((n-1)z + q\right)}{2c''(q) + qc'''(q) - U''\left((n-1)z + q\right)} < 0.$$

Proof. By Proposition 1, we know that there will be $n - 1$ identical lots. Thus, the buyer's problem is

$$\max_z U\left((n-1)z + q(z)\right) - (n-1)\left(c(z) - c(q(z))\right) - nq(z)c'\left(q(z)\right)$$

where $q(z) = \arg\max_q U\left((n-1)z + q\right) - c'(q)q$. The first-order condition for the latter is (7) and for the former is (8). Fully differentiating (7), we obtain the formula for $\frac{\partial q}{\partial z}$, which is negative by our assumptions. ∎

Our example illustrates once again.

Example 3 *In our two-player linear example with weak commitment the set of equations becomes*

$$1 - z - q = 2q,$$

$$1 - z - q = \frac{z - q}{1 - \frac{1}{3}}.$$

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Solving, we obtain $q^w = \frac{3}{16}$ and $z^w = \frac{7}{16}$, leading to total quantity sold $Q^w = \frac{10}{16} > \frac{4}{7} = Q^s > Q^m$, residual market price $p^w = \frac{3}{16}$, buyer surplus $BS^w = \frac{9}{32} > \frac{1}{4} = BS^m$. Obviously, $BS^w < BS^s$.

The above propositions have an important implication.

Corollary 1 *The buyer will always purchase in the residual market.*

Proof. Imagine otherwise. From (5) and (7), $q = 0$ would imply that the buyer sets the competitive price in the residual market: $U'(Z + q) = c'(q)$. However, by (6) $U'(Z + q) = c'(z)$ so, since $c(.)$ is strictly convex and $z > q$, we have a contradiction. In case of weak commitment we can also substitute $U'(Z + q) = c'(q)$ into (8) and reach a contradiction.

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This result is qualitatively important, as it implies that the buyer will purchase from every supplier – for example, he will never employ sole-sourcing (c.f. Anton and Yao, 1989) – and also that all suppliers make positive profits in equilibrium. Moreover, block sourcing on its own – running an auction, if you will – is never optimal.

The logic of this result is based on two observations. First, the profits of suppliers have zero derivative at zero: $\pi'(q) = \frac{d[qc'(q)-c(q)]}{dq} = qc''(q)$. That is, purchasing a small amount in the residual market increases the suppliers profits by very little. Second, the marginal value of the last unit to the buyer – having bought $(n - 1)z$ units – is $c'(z)$, which is always larger than $c'(0)$. So it is efficient to increase production (via the loser).

We can rank the quantities bought. Welfare, however, cannot be ranked as – despite starting from an inefficiently low quantity – higher production need not imply higher efficiency, since allocative inefficiency increases as well (c.f. Example 1).

Corollary 2 $\max\{Q^m, Q^s\} < Q^w$.

Proof. Suppose that $Q^w \leq Q^s$; then by Propositions 2 and 3:

(i) $c'(z^s) = U'(Q^s) \leq U'(Q^w) < c'(z^w)$, which implies $z^s < z^w$; and

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(ii) $c'(q^s) + c''(q^s)q^s < c'(q^s) + nc''(q^s)q^s = U'(Q^s) \leq U'(Q^w) = c'(q^w) + c''(q^w)q^w$, which implies (given that we have assumed that $c'''(q)q + 2c''(q) > 0$) that $q^s < q^w$.

But then $Q^s = (n-1)z^s + q^s < Q^w = (n-1)z^w + q^w$ contradicting the initial assumption.

Next, suppose that $Q^w \leq Q^m$; then, by the equivalent of (1) and Proposition 3, $c'\left(\frac{Q^m}{n}\right) + c''\left(\frac{Q^m}{n}\right)\frac{Q^m}{n} = U'(Q^m) \leq U'(Q^w) = c'(q^w) + c''(q^w)q^w$, which implies (given that we have assumed that $c'''(q)q + 2c''(q) > 0$) that $\frac{Q^m}{n} \leq q^w < z^w$. But then $Q^m < Q^w = (n-1)z^w + q^w$, contradicting the initial assumption. ∎

That the weak buyer will buy more than the strong one follows from the fact the he cannot commit to a low price, so he uses his alternative tool to reduce supplier profits: to reduce the residual demand. The intuition why the weak buyer will buy more than the classical monopsonist is that otherwise the residual market quantity would have to be (at least) as much lower as the decrease in the residual demand but such a drastic decrease is not optimal at that point.

The quantities bought by the classical and the strong monopsonist cannot be ranked in general, though the ranking $Q^m < Q^s$ is "more likely". To show this, we first show that this ranking is guaranteed for a reasonable family of cost functions: the homogeneous ones. Afterwards we will display an example where the ranking is the opposite.

Lemma 3 *If the cost function $c(q)$ is homogeneous of degree $k > 1$,[11] then $Q^m < Q^s$.*

Proof. We start by showing that total procurement cost inherits the homogeneity of the cost function. Assume the cost function $c(q)$ is homogeneous of degree $k > 1$, $c(\alpha q) = \alpha^k c(q)$. This leads to a marginal cost homogeneous of degree $k-1$, $c'(\alpha q) = \alpha^{k-1}c'(q)$ and to a second derivative homogeneous of degree $k - 2$, $c''(\alpha q) = \alpha^{k-2}c''(q)$. Procurement cost under classical monopsony is

$$T^m(Q^m) = c'\left(\frac{Q^m}{n}\right)Q^m.$$

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[11]Note that strict convexity of the cost function implies that the degree of homogeneity must exceed 1.

This function inherits the homogeneity of the cost function: $T^m(\alpha X) = c'\left(\frac{\alpha X}{n}\right)\alpha X = \alpha^k c'\left(\frac{X}{n}\right)X = \alpha^k T^m(X)$. Procurement cost under strong commitment is

$$T^s(Q^s) = (n-1)c\left(\frac{Q^s - q(Q^s)}{n-1}\right) + c(q(Q^s)) + n\left[c'(q(Q^s))q(Q^s) - c(q(Q^s))\right], \qquad (9)$$

where $q(X) = \arg\min_q \left\{(n-1)c\left(\frac{X-q}{n-1}\right) + c(q) + n\left[c'(q)q - c(q)\right]\right\}$.

Note that $q(X)$ is the solution to $nc''(q)q + c'(q) - c'\left(\frac{X-q}{n-1}\right) = 0$, while $q(\alpha X)$ solves $nc''(q)q + c'(q) - c'\left(\frac{\alpha X - q}{n-1}\right) = 0$. Thus, using the homogeneity property of the cost function, we obtain

$$nc''(\alpha q(X))\alpha q(X) + c'(\alpha q(X)) - c'\left(\frac{\alpha X - \alpha q(X)}{n-1}\right)$$
$$= \alpha^{k-1}\left\{nc''(q)q + c'(q) - c'\left(\frac{X-q}{n-1}\right)\right\} = 0.$$

That is, $\alpha q(X) = q(\alpha X)$.

Then,

$$T^s(\alpha X) = (n-1)c\left(\frac{\alpha X - q(\alpha X)}{n-1}\right) + c(q(\alpha X)) + n\left[c'(q(\alpha X))q(\alpha X) - c(q(\alpha X))\right] =$$
$$= (n-1)c\left(\frac{\alpha X - \alpha q(X)}{n-1}\right) + c(\alpha q(X)) + n\left[c'(\alpha q(X))\alpha q(X) - c(\alpha q(X))\right] =$$
$$= \alpha^k\left\{(n-1)c\left(\frac{X - q(X)}{n-1}\right) + c(q(X)) + n\left[c'(q(X))q(X) - c(q(X))\right]\right\} = \alpha^k T^s(X).$$

Next, observe that, by revealed preference, $U(Q^m) - T^m(Q^m) > U(Q^s) - T^m(Q^s)$ and $U(Q^s) - T^s(Q^s) > U(Q^m) - T^s(Q^m)$. The sum of these inequalities implies

$$[T^m(Q^s) - T^m(Q^m)] - [T^s(Q^s) - T^s(Q^m)] > 0.$$

Write Q^s in terms of Q^m as $Q^s = \alpha Q^m$. Using the fact that both procurement cost functions are homogeneous of degree k, we obtain $[T^m(\alpha Q^m) - T^m(Q^m)] - [T^s(\alpha Q^m) - T^s(Q^m)] = (\alpha^k - 1)[T^m(Q^m) - T^s(Q^m)] > 0$. Now, recall that, by Proposition 1, for any level of procurement X, $T^m(X) > T^s(X)$ (the buyer has strictly lower procurement costs when he sets $n-1$ lots). Thus, $\alpha^k - 1 > 0$, which – given $k > 1$ – requires $\alpha > 1$. Consequently, $Q^s = \alpha Q^m > Q^m$. ∎

Finally, we exhibit an example in which, for some parameter values, $Q^s < Q^m$.

Example 4 *Assume there are two suppliers and consider the following utility and cost functions*

$$U(Q) = \left(1 - \frac{Q}{2}\right) Q$$

and

$$c(q) = \begin{cases} \frac{q^2}{2}, & \text{if } 0 < q \le \bar{q} \\ \frac{q^2}{2} + \frac{m(q-\bar{q})^2}{2}, & \text{if } \bar{q} < q. \end{cases}$$

The classical monopsonist chooses

$$Q^m = \begin{cases} \frac{1+m\bar{q}}{2+m} & , \text{ if } \ 0 < \bar{q} < \frac{1}{4+m} \\ 2\bar{q} & , \text{ if } \ \frac{1}{4+m} \le \bar{q} \le \frac{1}{4} \\ \frac{1}{2} & , \text{ if } \ \frac{1}{4} < \bar{q} \end{cases} \tag{10}$$

whereas a buyer that can set a lot chooses

$$Q^s = \begin{cases} 2\frac{2+3m\bar{q}}{7+3m} & , \text{ if } \ 0 < \bar{q} < \frac{1+m}{7+5m} \\ \frac{4+m+3m\bar{q}}{7+4m} & , \text{ if } \ \frac{1+m}{7+5m} \le \bar{q} \le \frac{3}{7} \\ \frac{4}{7} & , \text{ if } \ \frac{3}{7} < \bar{q} \end{cases} \tag{11}$$

We obtain the following conclusion: If $\frac{1}{4} < \bar{q} < \frac{1}{3}$ and $m > \frac{1}{2(1-3\bar{q})}$, then $Q^s < Q^m$. Otherwise, $Q^m \le Q^s$.

4 Heterogeneous suppliers

In the above analysis we have abstracted away from asymmetry across cost functions. In this section, we argue that our results are robust to a moderate level of heterogeneity but large asymmetries render block sourcing ineffective.

Let us consider two sellers, with cost functions $c_1(x)$ and $c_2(x) = bc_1(x)$, with $b > 1$. We will restrict attention to the case of the strong buyer, who can commit to the residual market price before the auction. He can choose three qualitatively different combinations of the size of the lot z and the residual market price p:

I. $c_2'(z) < p$. Both firms participate in the residual market.

II. $c_1'(z) < p < c_2'(z)$. Firm 1 participates for sure in the residual market, firm 2 only if it does not win the lot.

III. $p < c_1'(z)$. Only the loser of the auction participates in the residual market.

Define $q_1(p)$ and $q_2(p)$ as the supply function of firm i, derived from $p = c_i'(q_i)$. For transparency, we drop the argument of q_i when there is no room for confusion.

In (I), both firms bid $B_i(z) = pz$: In case of winning the auction, their profits are $B_i(z) + p(q_i - z) - c_i(q_i)$; when they lose, their profits are $pq_i - c_i(q_i)$. Taking the difference, we see that both firms value winning at pz. Here, lot z is too small to have any real effect on total quantities and payments: At the end of the day, the buyer obtains quantity $X = q_1 + q_2$ and pays pX, irrespective of which firm wins the auction. Thus, just as in the homogeneous case, for too small lots our method reproduces the outcome of classic monopsony.

In (II), the efficient seller must receive at least pz for lot z as above, whereas the inefficient supplier compares $B_2(z) - c_2(z)$ and $pq_2 - c_2(q_2)$; therefore $B_2(z) \geq c_2(z) + pq_2 - c_2(q_2)$. Note that $pz < c_2(z) + pq_2 - c_2(q_2)$ since

$$pq_2 - c_2(q_2) = \max_q\{pq - c_2(q)\} > pz - c_2(z), \tag{12}$$

since $p < c_2'(z)$. The efficient firm wins the auction with the bid $B_1(z) = c_2(z) + pq_2 - c_2(q_2)$. Note that the buyer obtains quantity $X = q_1 + q_2$ but pays more than in classic monopsony:

$$B_1(z) + p(q_1 + q_2 - z) = c_2(z) + pq_2 - c_2(q_2) + p(q_1 + q_2 - z) =$$
$$= p(q_1 + q_2) + \{[pq_2 - c_2(q_2)] - [pz - c_2(z)]\} > p(q_1 + q_2),$$

where the inequality follows by (12). Therefore, setting a lot and a price in this manner is counter-productive. The reason is that the lot is too big for the inefficient firm, dampening its valuation of winning the lot and it is the efficient firm who gains the difference.

Finally, in (III), seller i must receive at least $c_i(z) + pq_i - c_i(q_i)$ to be willing to supply the lot. Note that the efficient firm will value more winning the auction as

$$c_1(z) + pq_1 - c_1(q_1) < bc_1(z) + pq_1 - bc_1(q_1)$$
$$= c_2(z) + pq_1 - c_2(q_1) \leq c_2(z) + pq_2 - c_2(q_2),$$

where the first inequality follows from $b > 1$ and $c_1(z) - c_1(q_1) > 0$ when $q_1 < z$ (what follows from $p < c_1'(z)$); the equality by the definition of $c_2(.)$; and the last inequality from the fact that $q_2 \in \arg\max_q\{pq - c_2(q)\}$. Therefore, the efficient seller wins the auction (and does not participate in the residual market) with the bid $B_1(z) = c_2(z) + pq_2 - c_2(q_2)$. As we have just seen, this lot price is above its cost of production, $c_1(z)$, plus its opportunity cost $pq_1 - c_1(q_1)$. In particular, if the buyer set the lot size at $z = q_1$, the efficient firm would make a profit $B_1(q_1) - c_1(q_1) > pq_1 - c_1(q_1)$, making the buyer worse off than under classical monopsony (similarly to (II) above). Of course, $z = q_1$ is not optimal, but we do have a countervailing effect when setting a lot if sellers are asymmetric: the efficient seller's extra rents, are to be evaluated against the savings from setting p below the monopsony price p^m.

The following example illustrates this trade-off.

Example 5 $c_1(q) = q^2/2$, $c_2(q) = bq^2/2$, $U(Q) = (1 - Q/2)Q$.

Since only the inefficient firm participates in the residual market, we write $q_2 = q$ and use $p = c_2'(q) = bq$. The buyer chooses p and z to maximize

$$U(z + q) - \{B_1(z) + pq\} = \left(1 - \frac{z + q}{2}\right)(z + q) - \frac{b}{2}\left(z^2 + 3q^2\right).$$

We obtain that the optimal lot, residual market price, total consumption are $z^L = \frac{3}{4+3b}$, $p^L = \frac{b}{4+3b}$ $\left(\text{and } q^L = \frac{1}{4+3b}\right)$, $Q^L = z^L + q^L = \frac{4}{4+3b}$, respectively. (We are in case (III), $p^L < c_1'(z^L)$, whenever $b < 3$). Buyer surplus is $BS^L = \frac{2}{4+3b}$.

Let us compare this with the classic monopsony solution: If the buyer sets a price p, firm 1 produces $q_1 = p$ whereas firm 2 produces $q_2 = p/b$; thus the buyer must set price $p = \frac{b}{1+b}Q$ to obtain total quantity Q. The buyer chooses Q to maximize

$$U(Q) - pQ = \left(1 - \frac{Q}{2}\right)Q - \frac{b}{1+b}Q^2 = \left(1 - \frac{1+3b}{2(1+b)}Q\right)Q.$$

We obtain $Q^m = \frac{1+b}{1+3b}$ and $BS^m = \frac{1+b}{2(1+3b)}$. Comparing the buyer surpluses, $BS^L > BS^m \iff b < 5/3$.

When sellers have not too dissimilar productivities, it makes sense to set a lot, followed by a residual market. When they are very asymmetric, the inefficient firm is a poor

competitor in the auction for a lot, and the efficient firm can bid much higher than its costs (production plus opportunity costs) and still win, rendering block sourcing ineffective.

5   Conclusions

We have revisited the classic problem of a monopsonist, where the aggregate supply is constructed from a finite number of producers with diseconomies of scale in production. We have proposed a (theoretically) novel procurement procedure: to group together part of the requirements into block contracts and auction them off, followed by a residual market. The buyer optimally will set just one lot less than the number of suppliers. Importantly, he does not want to reduce the quantity bought from the last supplier to zero – that is, he always wants to buy in the residual market – despite this having a negative effect on the competitiveness of the auction. We have shown that this procurement method always leads to higher buyer surplus (unless there is excessive cost heterogeneity among suppliers).

Finally, it is important to note that our two-stage process is qualitatively different from other mechanisms where there is also a first-stage auction followed by additional interaction (see, for example, Tunca and Wu, 2009). In our case, the second stage involves the loser, while in the preselection models it is the winners who earn the right to participate in the final round.

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