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ORIGINAL ARTICLE

An alternative to natural monopoly

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Abstract
We consider a shared ownership arrangement among consumers/owners as a means to organize production with an underlying decreasing average cost function typical of natural monopolies. The resulting output allocation yields a lower deadweight loss than the monopoly allocation, and is, in some cases, efficient.

Keywords Natural monopoly · Deadweight loss from monopoly · Decreasing average costs · Shared ownership

JEL classification L12 · L13

1 Introduction

According to a standard argument within the neoclassical economics tradition, an exclusive franchise to serve a market should be granted to a single firm in the presence of decreasing average costs of production (or, more generally, subadditive costs)—a situation commonly known as the case of a *natural monopoly*.[1] This argument has undoubtedly contributed to the growing concentration of market power observed in the U.S. over the last forty years.[2] Traditionally, the case for natural monopolies has focused on the potential welfare gains derived from low production costs at large-scale output levels from a sole vendor.[3] Using a different approach, this paper makes a case against natural monopolies, based on the observation that decentralized choices under a joint ownership rule are welfare improving.

[1] For the definition of subadditive costs, see, *e.g.*, Braeutigam (1989).
[2] See, *e.g.*, Khan (2016).
[3] This cost efficiency argument must account for the deadweight loss from monopoly, which acts as a countervailing force.

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While we abstract from institutional details on the implementation of shared ownership—and focus instead on its effects—some authors have suggested similar arrangements of local public ownership. For example, Ostrom (2010) advocates so-called "polycentric governance" as a way to escape the market-state dichotomy, emphasizing community-governed common-pool resources. Comparing private, community, and state governed common-pool resources, Grafton (2000) finds that "a common factor in ensuring successful governance of common-pool resources is the active participation of resource users in the management of the flow of benefits from the resource." Some authors have argued that privatization of public utilities transfers public value to private interests, whose profit motive is not necessarily aligned with the needs of a broad base of customers.[4] These and other considerations have led some to propose alternative structures for utility companies aimed at strengthening local public ownership, giving power back to communities (see, *e.g.*, Milburn and Russell 2019). But perhaps the best example of joint ownership is that of a cooperative. The unique organizational structure of cooperatives ensures a more equitable distribution of resources and, at the same time, prioritizes social value over pure profit maximization and growth (see, *e.g.*, Cato 2012; Cumbers 2012).[5] Some authors (*e.g.*, Lamoreaux et al. 2004; Brown 2004) have also described cooperatives as catalyzers of productivity and innovation.

In our setting, when consumers share ownership of the monopoly, they recognize the effect of their consumption choices on the value of the ownership shares. We first consider a sharing rule for which the "effective" price paid by each consumer/owner for each unit of output (*i.e.*, the unit price net of the consumer's ownership share of profits) is precisely the average production cost. In the presence of decreasing average costs, this generates an externality whereby each agent benefits from her own consumption—both in terms of a direct utility effect and an indirect effect acting on the price—as well as from the other agents' consumption, via the price effect. Because consumers internalize the effect of their consumption on the price, the joint ownership rule improves welfare relative to the standard monopoly allocation. However, since, in the neoclassical framework, consumers care only about their own utility, they do not take account of the benefits other consumers derive from a lower price. Consequently, the shared ownership arrangement does not generally achieve the first best. Nevertheless, alternative joint ownership rules for which the "effective" price (net of profit ownership shares) lies below the average cost of production mitigate the externality problem and lead to a welfare improvement. In some cases, the "effective" price schedule coincides with the marginal cost function, and the resulting output allocation is efficient.

The property rights approach to the problem of natural monopoly consists in conducting an ex-ante bidding competition to award an exclusive franchise to serve the market (see, *e.g.*, Demsetz 1968). We comment on the (tangential) relationship between this approach and the analysis in this paper at the end of Sect. 2.

[4] Consider the case of Pacific Gas and Electric Company, the investor-owned utility headquartered in San Francisco, and its handling of recent fire threats in California by employing sweeping power outages.

[5] Consider planned obsolescence in market economies, a phenomenon that is hard to sustain under shared ownership by consumers/users.

2 The model

There are N consumers with preferences over $K+1$ commodities, x and $y_1, \ldots, y_K$. Each consumer i's utility function is denoted by $u_i(x_i, \boldsymbol{y}_i) = u_i(x_i, y_{i1}, \ldots, y_{iK})$. Here, x_i (resp. y_{ik}) denotes the quantity of good x (resp. the quantity of good y_k) consumed by agent i.

Let $\boldsymbol{p} = (p, p_1, \ldots, p_K) \gg 0$ be the price vector for the $K+1$ commodities, where p and p_k denote the price of good x and y_k, respectively. Given a wealth level for consumer i, $w_i > 0$, consumer i's Walrasian demand function for good x is denoted by $x_i(\boldsymbol{p}, w_i)$.

The production technology for good x gives rise to a cost function $C(x) := F + c(x)$, where F represents the fixed production cost.

We are interested in cost structures that have been used in the literature to justify the existence of "natural monopolies;" namely, cost functions that exhibit decreasing average costs over the relevant range of output levels.

An (interior) efficient allocation for the market of good x is a vector of consumption levels, $x^* = (x_1^*, \ldots, x_N^*)$, one for each consumer, such that

$$x_i^* = x_i(\boldsymbol{p}, w_i), \quad i \in \{1, \ldots, N\}$$

and (under the usual differentiability assumptions)

$$p_k \left[\frac{\partial u_i(x_i^*, \boldsymbol{y}_i^*)}{\partial x_i} \bigg/ \frac{\partial u_i(x_i^*, \boldsymbol{y}_i^*)}{\partial y_{ik}} \right] = c' \left(\sum_j x_j^* \right), \quad \text{for each } i \text{ and } k, \tag{1}$$

where $\boldsymbol{y}_i^*$ denotes consumer i's associated optimal consumption basket for the rest of the goods. The last equation says that each consumer's willingness to pay for an extra unit of good x equals the marginal cost of production for good x.

Given $\boldsymbol{p} \gg 0$, the optimality conditions

$$\left[\frac{\partial u_i(x_i, \boldsymbol{y}_i)}{\partial x_i} \bigg/ \frac{\partial u_i(x_i, \boldsymbol{y}_i)}{\partial y_{ik}} \right] = \frac{p}{p_k}, \quad \text{for each } i \text{ and } k,$$

from the consumers' utility maximization problems, induce an implicit market inverse demand function, $p(x)$. A monopolist chooses x to maximize

$$p(x)x - c(x) - F,$$

and sets $x = x_M$, where $p'(x_M)x_M + p(x_M) = c'(x_M)$. Note that, if $p'(\cdot) < 0$, then, at a solution to the consumers' utility maximization problems at prices $(p(x_M), p_1, \ldots, p_K)$,

$$p_k \left[\frac{\partial u_i(x_i, \boldsymbol{y}_i)}{\partial x_i} \bigg/ \frac{\partial u_i(x_i, \boldsymbol{y}_i)}{\partial y_{ik}} \right] = p(x_M) > c'(x_M), \quad \text{for each } i \text{ and } k,$$

and so, in view of (1), we see that $x_M < \sum_j x_j^*$, so that a monopolist operates at an inefficiently low level of output.

Note that if the monopoly allocation is viable, *i.e.*, if $p(x_M)x_M - C(x_M) > 0$, then, at a solution to the consumers' utility maximization problems at prices $(p(x_M), p_1, \ldots, p_K)$,

$$p_k \left[\frac{\partial u_i(x_i, \mathbf{y}_i)}{\partial x_i} \Big/ \frac{\partial u_i(x_i, \mathbf{y}_i)}{\partial y_{ik}} \right] = p(x_M) > AC(x_M), \quad \text{for each } i \text{ and } k, \tag{2}$$

where $AC(x)$ denotes the average cost at x, *i.e.*, $AC(x) := \frac{C(x)}{x}$ for all $x > 0$.

The problem of organizing production in industries with declining average costs goes back to Hotelling (1938) and Coase (1946). See Frischmann and Hogendorn (2015) and references therein. Standard solutions to the monopoly problem, *i.e.*, the inefficiencies associated with monopoly power, typically involve some form of price regulation. The regulator can set the monopoly price equal to average cost, so that the monopoly is viable, forcing production at more efficient levels, above x_M (the monopoly output). In the case of a natural monopoly, *i.e.*, when average costs are decreasing over the relevant output range, a monopolist chooses not to operate at the efficient level, $\sum_j x_j^*$, which yields negative profits. However, a benevolent regulator may want to subsidize the monopolist to induce higher output levels, even when the associated profits are negative. Hotelling (1938) advocated marginal cost pricing with government subsidies. Coase (1946) cautioned on the impact of distortionary taxation as a means of raising revenue for monopoly subsidization. If subsidies rely on distortionary taxation, the regulator ought to weigh the welfare gains from output expansion beyond the break-even point against the welfare losses of tax distortions. This trade-off has been considered in Laffont and Tirole (1993) and is resolved by the so-called *Ramsey pricing rule*, but any applicable policy implication derived from the Ramsey rule requires a cost-benefit analysis of the actual net welfare gains/losses from monopoly subsidization. But, even if lump sum taxes were feasible, Hotelling's proposal would be subject to the Coase critique of marginal cost pricing (Coase 1946): ascertaining whether production is socially optimal or the firm should shut down requires a calculation—which governments, lacking information on consumer preferences, are unlikely to carry out adequately—of the actual net welfare gains/losses from production.

In this paper, the focus is on alternative ways of increasing the net social benefit brought about by a natural monopoly; the approach taken here does not rely on distortionary taxation, nor does it require that governments properly evaluate the net social gains/costs associated with production; the proposed solution outperforms the 'price-equals-average-cost' rule and, in some cases, it implements the efficient output allocation.

2.1 Monopoly with shared ownership

Suppose that the consumers share ownership of the firm producing and selling good x. If each consumer i receives a share θ_i of total profits, then each consumer i's optimal consumption of good x, x_i, solves

$$\max_{(x_i,\boldsymbol{y}_i)} u_i(x_i, \boldsymbol{y}_i)$$
$$\text{s.t. } px_i + \sum_{k=1}^{K} p_k y_{ik} = w_i + \theta_i \left[p \sum_j x_j - C\left(\sum_j x_j\right)\right]. \tag{3}$$

Assuming that each consumer i's share of profits is given by the proportion of i's consumption of good x, *i.e.*, $\theta_i = \frac{x_i}{\sum_j x_j}$, the budget constraint in (3) is expressible as

$$AC\left(\sum_j x_j\right) x_i + \sum_k p_k y_{ik} = w_i. \tag{4}$$

This 'reduced-form' budget constraint illustrates the consequences of the behavioral assumption that each consumer recognizes the effect of her actions on her ownership share: the average cost function acts as the 'effective price' of good x.[6]

Each consumer i's optimal basket at an interior solution satisfies

$$\frac{\partial u_i(x_i, \boldsymbol{y}_i)}{\partial x_i} = \lambda \left[(1-\theta_i)AC\left(\sum_j x_j\right) + \theta_i c'\left(\sum_j x_j\right)\right],$$
$$\frac{\partial u_i(x_i, \boldsymbol{y}_i)}{\partial y_{ik}} = \lambda p_k, \quad \text{for each } k,$$

where λ is the Lagrange multiplier. Consequently, an interior solution $(\hat{x}_i, \hat{\boldsymbol{y}}_i)$ to (3) satisfies

$$p_k \left[\frac{\partial u_i(\hat{x}_i, \hat{\boldsymbol{y}}_i)}{\partial x_i} \Big/ \frac{\partial u_i(\hat{x}_i, \hat{\boldsymbol{y}}_i)}{\partial y_{ik}}\right] = (1-\hat{\theta}_i)AC\left(\sum_j \hat{x}_j\right) + \hat{\theta}_i c'\left(\sum_j \hat{x}_j\right), \quad \text{for each } k, \tag{5}$$

where $\hat{\theta}_i := \frac{\hat{x}_i}{\sum_j \hat{x}_j}$.

Decreasing average costs lie above marginal costs, *i.e.*, $AC(x) > c'(x)$ for all x. Therefore, comparing (5) and (2), we see that the allocation in the market for good x resulting from shared ownership, with the particular weights $\theta_i = \frac{x_i}{\sum_j x_j}$, entails $x_M < \sum_j \hat{x}_j$. In addition, comparing (1) and (5), we see that $\sum_j \hat{x}_j < \sum_j x_j^*$. Thus, the 'shared-ownership' allocation is more efficient than the monopoly allocation, although it is not fully efficient.

6 The behavioral assumption matters even in the case when consumer decisions have a limited effect on ownership shares (as would be the case here if n were 'large,' *i.e.*, if consumers were 'small' relative to the size of the market), in the sense that, in our framework, equilibrium outcomes differ from those that would obtain in a 'Walrasian-like' setting where consumers ignore the ownership effect.

Observe that the allocation $(\hat{x}_1, \ldots, \hat{x}_N)$ not only is more efficient than the monopoly allocation (and also the allocation resulting from setting the price equal to average cost) but the consumers also prefer it over the monopoly allocation. Indeed, the budget line faced by each consumer i under shared ownership is given by (4), and so the average cost—a decreasing function of output—can be viewed as the 'price' of good x faced by each consumer; given that individual consumption levels at $\hat{\boldsymbol{x}} = (\hat{x}_1, \ldots, \hat{x}_N)$ exceed those at the monopoly allocation, x_M, each consumer i can always consume the same amount of good x that she would consume at x_M, in response to the other consumers choosing the levels in $\hat{\boldsymbol{x}}$, and in this case the consumer would be better off than at x_M, since she would be facing a lower 'price' (average cost) than $p(x_M)$, implying that consumer i's best response, $\hat{x}_i$, to the consumption profile $(\hat{x}_1, \ldots, \hat{x}_{i-1}, \hat{x}_{i+1}, \ldots, \hat{x}_N)$ must give consumer i a higher utility than the monopoly allocation.

Finally, the existence of a positive demand for good x, given the cost structure and the shared ownership arrangement, ensures that production is socially beneficial, provided that each consumer i's surplus for the first unit consumed exceeds $AC(\sum_{j \neq i} \hat{x}_j)$ (*i.e.*, the average cost when i consumes zero units of good x while each $j \neq i$ consumes $\hat{x}_j$). This can be understood, in intuitive terms, as follows. First, note that, in light of (4), (5) is expressible as

$$p_k \left[\frac{\partial u_i(\hat{x}_i, \hat{\boldsymbol{y}}_i)}{\partial x_i} \Big/ \frac{\partial u_i(\hat{x}_i, \hat{\boldsymbol{y}}_i)}{\partial y_{ik}} \right] = AC' \left(\sum_j \hat{x}_j \right) \hat{x}_i + AC \left(\sum_j \hat{x}_j \right), \quad \text{for each } k. \quad (6)$$

We claim that i's consumer surplus from her consumption $\hat{x}_i$ of good x exceeds the cost of production $\hat{x}_i AC\left(\sum_j \hat{x}_j\right)$. Indeed, as per (6), i consumes good x up to the point where her willingness to pay for an extra unit (the left hand side of (6)) equals the average production cost minus the average cost savings on i's inframarginal units from the last unit of output (the right hand side of (6)).[7] Thus, even though i's consumer surplus from the last unit is less than the average production cost, the "excess" average cost is compensated by the average cost savings (and hence the net consumer surplus) on the inframarginal units. A similar argument can be used for the inframarginal units whose valuations lie below the average production cost. Overall, i's total consumer surplus for her equilibrium consumption of good x, $\hat{x}_i$, must exceed the production cost $\hat{x}_i AC\left(\sum_j \hat{x}_j\right)$.[8]

Next, consider the following alternative ownership rule. Initially, each consumer i pays a *fixed* fraction α_i of the fixed cost, $\alpha_i F$, and then receives a fraction $\frac{x_i}{\sum_j x_j}$ of total net profits (*i.e.*, net of the fixed cost). Then consumer i's optimization problem becomes

7 Recall that the average cost curve is decreasing.

8 If the assumption that each consumer i's surplus for the first unit consumed exceeds $AC(\sum_{j \neq i} \hat{x}_j)$ is not fulfilled, then the consumers will not demand good x. More precisely, only consumers for which the said assumption holds will consume good x. If no one values the good enough to pay its average cost, production will not take place, solving Coase's problem.

$$\max_{(x_i, \boldsymbol{y}_i)} u_i(x_i, \boldsymbol{y}_i)$$
$$\text{s.t. } px_i + \sum_{k=1}^{K} p_k y_{ik} = w_i - \alpha_i F + \frac{x_i}{\sum_j x_j}\left[p \sum_j x_j - c\left(\sum_j x_j\right)\right].$$

The analogue of (5) is now

$$p_k \left[\frac{\partial u_i(\bar{x}_i, \bar{\boldsymbol{y}}_i)}{\partial x_i} \Big/ \frac{\partial u_i(\bar{x}_i, \bar{\boldsymbol{y}}_i)}{\partial y_{ik}}\right] = (1 - \bar{\theta}_i) AVC\left(\sum_j \bar{x}_j\right) + \bar{\theta}_i c'\left(\sum_j \bar{x}_j\right), \quad \text{for each } k, \tag{7}$$

where $AVC(x) := \frac{c(x)}{x}$ is the average variable cost (net of the average fixed cost) and $\bar{\theta}_i := \frac{\bar{x}_i}{\sum_j \bar{x}_j}$, and the budget constraint is expressible as

$$AVC\left(\sum_j x_j\right) x_i + \sum_k p_k y_{ik} = w_i - \alpha_i F.$$

Note that, because the 'effective price' (net of profit ownership shares) does not contain the (average) fixed cost, the positive external effect of an agent's consumption bundle on the price faced by the other consumers is diminished in magnitude here (relative to the mechanism considered earlier), which results in a more efficient allocation, at least if the average variable cost lies (weakly) above the marginal cost.

If the underlying technology exhibits constant returns to scale *relative* to the variable inputs (while the average cost is decreasing), then $AVC(x) = c'(x)$ for all $x > 0$, and the externality vanishes completely.[9] In this case, the fixed cost is the only source of diminishing average cost and is fully paid for via lump-sum contributions, and we have $(\bar{x}_1, \ldots, \bar{x}_N) = (x_1^*, \ldots, x_N^*)$ [recall (1)], *i.e.*, the shared ownership arrangement yields the efficient allocation.

Under increasing returns to scale (relative to the variable inputs), we have

$$AC(x) = \frac{C(x)}{x} > AVC(x) = \frac{c(x)}{x} > c'(x), \tag{8}$$

implying that $\sum_i \hat{x}_i < \sum_i \bar{x}_i < \sum_i x_i^*$, and so the allocation $\bar{\boldsymbol{x}} = (\bar{x}_1, \ldots, \bar{x}_N)$ results in increased efficiency.

Next, we briefly comment on the property rights approach to the problem of natural monopoly. Demsetz (1968), Stigler (1968), and Posner (1972) advocate competition among firms entering noncollusive bids to become the supplier of the decreasing cost activity as a mechanism to reduce the deadweight loss from monopoly. Their key point is that the franchise award criterion of lowest per-unit price should be adopted. In this case, Demsetz argues (in the context of production of license plates), "the winning price will differ insignificantly from the per-unit cost of producing license plates" (Demsetz

9 As an example, consider the production function $f(l, k) = lk^2$, which exhibits increasing returns to scale (resp. constant returns to scale) with respect to labor and capital (resp. labor).

1968, p. 58). Setting aside the objections to the property rights approach raised in Williamson (1976), we note that the shared ownership arrangements considered here outperform the "per-unit cost" rule predicted by Demsetz. Indeed, under the first joint ownership rule, the price of good x is given by the expression in Eq. (5), which lies below the Demsetz breakeven price (*i.e.*, the average cost of production) whenever the average cost curve is decreasing. A similar argument can be made about the second joint ownership rule, via Eqs. (7) and (8).

We conclude with a discussion on the role of information. Note that, under the shared ownership mechanism, it is in the collective interest of consumers to arrange matters so that the cost function and the total quantity produced are a matter of public record among consumers. The role of private information about costs as an obstacle in the design of monopoly regulation has been emphasized by Baron and Myerson (1982), *inter alia*. But, in the neoclassical monopoly framework, a monopolist benefits from hiding private information, whereas, in the present setting, asymmetric information is detrimental to the collective interests of the consumers/owners, who will favor the implementation of a reliable mechanism for cost and output information disclosure among consumers.

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