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Product differentiation, economies of scale and entry☆

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ABSTRACT

This paper extends the standard circular city model of spatial competition to incorporate economies of scale. We demonstrate that new market entry generates a negative externality by fragmenting demand and forcing existing firms to operate at a less efficient scale. This scale-fragmentation channel widens the wedge between private and social entry incentives, leading to an amplified excess-entry result. When firms can endogenously invest to lower their unit costs, market entry remains socially excessive.

1. Introduction

Many industries exhibit significant economies of scale alongside substantial product differentiation. In sectors ranging from manufacturing to food retail, firms benefit from lower unit costs as they expand production, yet simultaneously compete for consumers with heterogeneous preferences over product characteristics.

A central question in industrial organization is whether free entry leads to a socially efficient market structure. The classic excess-entry result implies that free entry tends to be excessive because entrants capture business from incumbents without fully internalizing the resulting profit destruction (Mankiw and Whinston, 1986). In spatial models, this excess-entry finding has also been confirmed (Salop, 1979). However, the existing literature has largely maintained the assumption of constant marginal costs, thereby neglecting a potentially important channel: economies of scale that make entry not only a source of business stealing but also affect productive inefficiency via lowering firm size.

This paper extends the circular city model of Salop (1979) to incorporate economies of scale, modelled as a unit cost that declines in a firm's output. We show that entry generates a novel negative externality not present in the standard model: by fragmenting demand across more firms, new entrants force existing firms to operate at a smaller, less efficient scale, driving up average production costs. This scale-fragmentation channel widens the wedge between private and social entry incentives and amplifies the excess-entry result.[1]

The model also delivers two further implications. First, market size has a non-monotonic effect on the equilibrium number of firms: although a larger market initially supports more entry, beyond a threshold it intensifies scale-driven price competition and can reduce the number of active firms.[2] Second, when firms can invest to improve their scale economies, free entry remains socially excessive. In that case, excessive entry also leads to insufficient cost-reducing investment because firms operate at too small a scale.

Our paper contributes to the spatial-competition literature on excess entry (Matsumura and Okamura, 2006; Gu and Wenzel, 2009) by identifying scale fragmentation as a new externality that amplifies the standard result. It complements (González-Maestre and Granero, 2020) who show that entry can be excessive or insufficient depending on product design. More broadly, our analysis is related to work in which market structure interacts with endogenous cost reduction (e.g., Vives, 2008) or scale effects, but our focus is on isolating this mechanism in the standard Salop framework. Our analysis also connects to Arve et al. (2026) and Schwierzy and Wenzel (2025), who study settings where

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[1] Related findings may also arise in other model specifications (such as Mankiw and Whinston, 1986). The contribution of this paper is to show how this mechanism operates in the canonical Salop framework with horizontal product differentiation.

[2] We note that similar non-monotonic effects of market size on the number of firms may also arise through different mechanisms. For example, the literature on endogenous sunk costs discusses how market expansion can induce increases in investment, potentially leading to fewer firms (see the discussion in Sutton, 1991), while Vives, 2008, for instance, shows how related patterns can emerge in models where firms invest in innovation.

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firm size and cost structure interact, but who do not analyse entry or the inefficient exploitation and generation of scale economies that we identify.

2. Model

A mass L of consumers is uniformly distributed on the unit circle. Each consumer buys one unit and has gross valuation v large enough to ensure purchase in equilibrium. If consumer $x \in [0,1)$ buys from firm i located at s_i and charging price p_i, their utility is

$$u(x,i) = v - p_i - t\,d(x,s_i),$$

where $t > 0$ is the transportation (mismatch) cost parameter and $d(\cdot,\cdot)$ is the shortest arc distance between the consumer (x) and the firm (s_i).

Let there be $N \geq 2$ symmetric firms located equidistantly on the circle. For a given N, firms compete in prices, and then consumers choose where to buy. A firm i serving quantity q_i has a *unit cost* of

$$\bar{c}(q_i) = c - gq_i,$$

where $c \geq 0$, and $g \geq 0$ measures the strength of per-unit scale economies.[3] Equivalently, variable cost is $C(q_i) = (c - gq_i)q_i = cq_i - gq_i^2$, and hence the marginal cost is $C'(q_i) = c - 2gq_i$.[4] Each active firm incurs a fixed entry cost, $F > 0$.

Firm i's variable profit, when it sets price p_i and rivals set prices p_{-i}, is

$$\pi_i(p_i,p_{-i}) = [p_i - (c - g\,q_i(p_i,p_{-i}))]\,q_i(p_i,p_{-i}). \tag{1}$$

Assumption 1 (*Scale Economies Not Too Strong*). $gL < t$.

Assumption 1 ensures a well-behaved interior pricing equilibrium (strict concavity of profits in own price). The assumption requires that differentiation forces are sufficiently strong relative to the aggregate scale effect gL.

3. Analysis

3.1. Equilibrium for a given number of firms

Standard calculations imply that firm i's demand is linear in its own price and depends on the prices charged by its two nearest neighbours:

$$q_i(p_{i-1},p_i,p_{i+1}) = L\left(\frac{1}{N} + \frac{p_{i-1}+p_{i+1}-2p_i}{2t}\right). \tag{2}$$

Because the per-unit cost depends on q_i, a firm's price affects both its markup and its cost level through the induced quantity. Substituting (2) into (1) and solving for the symmetric profit-maximizing pricing solution, we establish the following result.

Proposition 1. *Suppose $N \geq 2$ is fixed exogenously. The price game has a unique symmetric Nash equilibrium*

$$p^*(N) = c + \frac{t}{N} - \frac{2gL}{N}.$$

Relative to the standard Salop price $c + t/N$, per-unit scale economies reduce the equilibrium price by $2gL/N$. A higher price reduces a firm's demand and hence its scale, which raises its own unit cost. At the same time, the diverted demand expands its rivals' scale and lowers their unit costs. Anticipating this effect, firms price more aggressively to protect market share and keep costs low when g is increasing. Note also that, by symmetry, each firm produces $q^*(N) = L/N$ in equilibrium.

Two further comparative statics findings follow: (i) for a fixed N, a larger market size L allows for stronger scale economies, reduces unit and marginal cost, and consequently also market prices whenever $g > 0$ (whereas in the standard Salop model with constant marginal cost, p^* does not depend on L for given N), and (ii) the effect of N on price is ambiguous: p^* falls in N if $t > 2gL$ but rises in N if $t < 2gL$. Note that Assumption 1, $t > gL$, does not rule out the region $gL < t < 2gL$, in which p^* increases in N. This can happen because entry splits total demand across more firms, so each firm serves fewer consumers. As each firm sells less, unit costs increase. This weakens price competition and can more than offset the direct pro-competitive effect of additional firms.

Firms' variable profits (gross of the fixed entry cost, F) are

$$\pi^*(N) = \frac{L(t-gL)}{N^2}. \tag{3}$$

Thus, stronger scale economies reduce variable profits. For $g > 0$, profits are non-monotone in market size L: they increase with L when $L < t/2g$, are maximized at $L = t/2g$, and decrease when $L > t/2g$. A larger market initially raises demand and profits, but beyond a certain point, the scale-driven intensification of price competition dominates and profitability decreases.

3.2. Free entry

In the first stage, entry is endogenous. A mass of potential entrants may enter by paying a fixed cost $F > 0$. Then firms locate symmetrically and compete in prices as above. The free-entry equilibrium is thus implicitly given by $\pi^*(N) = F$, where $\pi^*(N)$ is given by (3).[5]

Proposition 2. *Suppose entry occurs prior to price competition and each active firm pays a fixed cost $F > 0$. The free-entry equilibrium number of firms is*

$$N^{FE} = \sqrt{\frac{L(t-gL)}{F}},$$

and the corresponding equilibrium price is

$$p^{FE} = c + \frac{t-2gL}{N^{FE}} = c + (t-2gL)\sqrt{\frac{F}{L(t-gL)}}.$$

The next proposition collects our comparative statics findings.

Proposition 3. *In the free-entry equilibrium of Proposition 2:*

(i) N^{FE} is strictly decreasing in g and F.
(ii) N^{FE} is non-monotone in L (for $g > 0$), with

$$\frac{\partial N^{FE}}{\partial L} \gtrless 0 \iff L \lessgtr \frac{t}{2g}.$$

(iii) Firm size $q^{FE} = L/N^{FE} = \sqrt{\frac{LF}{t-gL}}$ is strictly increasing in L.
(iv) The equilibrium price is strictly decreasing in market size, i.e., $\partial p^{FE}/\partial L < 0$.

Part (i) shows that stronger scale economies and higher fixed entry costs both constrain the number of active firms. The former mechanism operates by intensifying price competition and compressing variable profits, leaving room for fewer entrants. The latter effect necessitates softer competition (and thus fewer firms) to ensure margins are high enough to compensate for the entry cost. Part (ii) highlights the new trade-off: market expansion raises demand but also strengthens scale economies and intensifies effective competition, so entry may eventually fall with L. In the standard Salop model without scale economies

[3] We impose that unit costs are positive, $\bar{c}(q_i) > 0$. This can be ensured by assuming that c is sufficiently large.

[4] Because scale economies are modelled through a concave variable cost function, marginal cost is below average variable cost for $q_i > 0$.

[5] As is standard, we treat N as a continuous variable.

($g = 0$), the free-entry number of firms is unambiguously increasing in L: a larger market always accommodates more firms. With scale economies, this monotonicity breaks down. When $L < t/(2g)$, the conventional demand effect dominates and market expansion attracts entry. Beyond $L = t/(2g)$ however, further growth in market size intensifies price competition induced by scale economies so severely that variable profits are shrinking and the market can sustain fewer firms.[6] However, as shown in part (iii), firms become larger as market size grows, implying that unit cost falls due to scale economies. Part (iv) shows that prices fall with market size L even when N^{FE} decreases, because the productivity gains from larger firm size and stronger scale economies outweigh the weaker competition associated with fewer firms.

Under free entry, per-unit scale economies make average cost endogenous. At firm size q^{FE}, unit cost equals

$$\bar{c}^{FE} = c - gq^{FE}.$$

Firms' markup is therefore

$$p^{FE} - \bar{c}^{FE} = \frac{t - gL}{N^{FE}} = \sqrt{\frac{F(t - gL)}{L}}.$$

It is easy to show that the markup is strictly increasing in F and t, and strictly decreasing in L and g. A higher entry cost F reduces the number of active firms, while a higher transportation cost t softens price competition. Both effects weaken competitive pressure and therefore raise markups. By contrast, a larger market size L and stronger per-unit scale economies g increase equilibrium firm size, lower unit costs, and intensify competition, which leads to lower markups.

4. Welfare and efficient entry

4.1. Efficient level of entry

This section analyses the welfare properties of the free-entry equilibrium. Social welfare corresponds to gross consumer utility less aggregate transportation, production and fixed entry costs. Under symmetric firm locations, total transportation costs are $tL/4N$ and aggregate variable production costs are $(c - gL/N)L$. Social welfare with N firms is hence given by

$$W(N) = (v - c)L + \frac{gL^2}{N} - \frac{tL}{4N} - NF.$$

The welfare effects of entry can be decomposed into three forces. First, more firms reduce consumers' transportations costs. Second, each additional entrant incurs the fixed cost F. Third, the key novelty in the social welfare function under economies of scale is the term gL^2/N: greater market concentration (a lower N) increases firm size and improves productive efficiency, which directly enhances welfare. The following proposition characterizes the welfare-maximizing number of firms.

Proposition 4. *If $gL < t/4$, the welfare-maximizing number of*

$$N^W = \sqrt{\frac{L(t - 4gL)}{4F}}.$$

If $gL \geq t/4$, welfare is decreasing in N and welfare is maximized at the minimal feasible number of firms.

Proposition 4 demonstrates that when aggregate scale economies are sufficiently strong ($gL \geq t/4$), social welfare strictly decreases with the number of firms, N. In this regime, the efficiency loss from smaller firm sizes dominates the benefits of reduced transportation costs. Conversely, when scale economies are relatively weak ($gL < t/4$), there exists an interior welfare-maximizing number of firms. Below this optimal level, further entry increases overall welfare because the savings in transportation costs outweigh the corresponding loss in productive efficiency.

Additionally, when $gL < t/4$, the welfare-maximizing number of firms N^W is strictly decreasing in both per-unit scale economies (g) and fixed entry costs (F). The effect of market size L on efficient entry, however, is non-monotonic. It increases optimal entry when aggregate scale economies are weak ($gL < t/8$) but decreases it when they grow relatively strong ($gL > t/8$).

4.2. Excess entry

Comparing equilibrium and welfare-maximizing entry yields the following results.

Proposition 5.

(i) *Suppose $gL < t/4$. In this regime, free entry results in excess entry characterized by the following ratio:*

$$\frac{N^{FE}}{N^W} = 2\sqrt{\frac{t - gL}{t - 4gL}} > 2.$$

Furthermore, this excess-entry ratio is strictly increasing in both g and L, but strictly decreasing in t.

(ii) *Suppose $t/4 \leq gL < t$. Entry remains socially excessive, but the magnitude of this excess entry strictly decreases in g.*

When aggregate scale economies are moderate ($gL < t/4$), entry generates a negative externality not present in the standard Salop model: by fragmenting demand, new entrants reduce the equilibrium scale of existing firms, which drives up unit and marginal production costs. This scale-fragmentation channel widens the wedge between private and social entry incentives, amplifying the standard excess-entry result. In other words, the conventional business-stealing effect is magnified because each new entrant also inflates aggregate production costs.

Conversely, when scale economies are strong ($t/4 \leq gL < t$), excess entry still occurs because the unconstrained free-entry equilibrium exceeds the socially optimal market structure, which is simply the minimum feasible number of firms ($N = 2$). Interestingly, within this regime, stronger scale economies actually mitigate the problem: higher values of g intensify price competition and restrict profitable entry, meaning the magnitude of excess entry shrinks as g increases.

5. Discussion

Our main insight is also robust to allowing firms to invest endogenously in scale economies. In such an extension, free entry remains socially excessive: by fragmenting demand across firms, entry reduces operating scale and thereby weakens incentives for cost-reducing investment. As a result, excessive entry is accompanied by inefficiently low investment in technologies that allow for scale economies.

We also note that, although the analysis has been conducted under a linear-quadratic cost specification, the underlying mechanism is more general. With a general variable cost function exhibiting economies of scale, entry continues to fragment demand across firms and thereby reduce firm size, lowering productive efficiency whenever average cost declines with output. This generates the same qualitative wedge between private and social entry incentives as in our baseline formulation: entrants do not internalize that their entry reduces rivals' scale and raises industry production costs. The linear-quadratic specification is adopted primarily for tractability and for the derivation of closed-form expressions for prices, entry, and welfare.[7]

[6] As discussed above, the literature has identified alternative mechanisms that also lead to such non-monotonicities (e.g., Vives, 2008).

[7] For brevity, we omit the formal analysis of these extensions, but derivations are available from the authors upon request.

Data availability

No data was used for the research described in the article.

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