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Does the market deliver the right technology?

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HIGHLIGHTS

- Firms choose the technology that maximizes their profit.
- The size and the mass of firms/varieties vary with the technology choice.
- Firms do not internalize the effect of the technology choice on the mass of varieties.
- Under monopolistic competition, the mass of varieties affects welfare.
- Under conditions identified in the paper, firms choose the wrong technology.

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ABSTRACT

We show that the market does not systematically deliver the right technology under monopolistic competition. (i) Firms might rush on large-scale technology, pushing to the exit many desirable varieties produced by small firms. (ii) Firms might shun large-scale technology, though that technology would benefit the society through lower prices. (iii) A bias towards small-scale technology in some stage of development, and a bias towards large-scale technology in another stage is also a possibility.

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1. Introduction

Consider two technologies: a large-scale technology with low marginal costs and high fixed costs, and a small-scale technology with high marginal costs and low fixed costs. Similarly, consider an old technology that can be upgraded through a fixed investment in R&D that reduces variable costs of production, as in Vives (2008). Is the technology chosen by firms the best for the society? This is a recurring question in our societies. Some argue that we should favor small-scale farming instead of industrial farming, artisanal products instead of industrial products, corner shops instead of supermarkets, independent booksellers instead of large online bookstore, independent taxi drivers instead of Uber, authors' movies instead of Hollywood blockbusters, ... Others argue that policies that foster large-scale technology allow to enhance production and to bring more prosperity to citizens because of economies of scale. Citizens with some economic knowledge may think that firms will adopt the technology that is the most desired by the society, because otherwise they would be thrown out of the market. What to think of those presumptions?

Since perfect competition is incompatible with fixed costs, a precise answer to this question requires considering imperfectly competitive markets. Therefore, we consider monopolistic competition in which firms sell differentiated varieties to consumers who love variety. On the one hand, lower marginal costs of the large-scale technology push down prices, benefiting the consumers. On the other hand, its higher fixed costs reduce firms' profitability and thus they contribute to decrease the number of varieties, which is detrimental to consumers. The balance between the benefits and the costs depends on the fixed and marginal costs and on the preferences of consumers. We show that under constant elasticity of

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substitution (CES) preferences, firms' technological choice coincides with consumers preferred technology. By contrast, the market does not systematically deliver the right technology under non-CES preferences: (i) Firms might rush on large-scale technology, pushing to the exit many desirable varieties produced by small firms. (ii) Firms might shun large-scale technology, though that technology would benefit the society through lower prices. (iii) A bias towards small-scale technology in some stage of development, and a bias towards large-scale technology in another stage is also a possibility.

Starting with Spence (1976) and Dixit and Stiglitz (1977), a large literature studies the (in)efficiency of the number of varieties delivered by the market. It is well known that the market achieves the optimum when the utility is CES. Recently, Parenti et al. (2016) prove that the market can also deliver the optimum under non-additive and non-homothetic preferences. In general however, the market does not deliver the right number of varieties. We complement this literature by showing that the market might not only select the wrong number of varieties but also the wrong type of firms when preferences are additive. Ohkawa et al. (2005) is probably the paper with the closest focus to ours. They show that under asymmetric Cournot oligopoly the market also selects the wrong technology in the long run. They focus on homogeneous products whereas we emphasize the role played by the love for variety of diversified products.

2. The model

We consider an economy endowed with L identical workers whose wage is chosen as the numeraire. There is a continuum N of firms, each producing a single variety indexed by $i \in [0, N]$. Each worker spends her entire income on the continuum of horizontally differentiated varieties.

2.1. Preferences

As in Zhelobodko et al. (2012), we build on additive preferences.[1] Each consumer chooses her consumption x_i, to maximize her utility given her unit wage and the prices p_i:

$$\max_{x_i} \int_0^N u(x_i)\, di \quad \text{s.t.} \qquad \int_0^N p_i x_i di = 1 \quad \forall i$$

where $u(.)$ is thrice continuously differentiable, strictly increasing and strictly concave. The relative love for variety is

$$r_u(x) \equiv -\frac{xu''(x)}{u'(x)} > 0. \tag{1}$$

The inverse demand function is

$$p_i = u'(x_i)/\lambda \quad \text{where } \lambda = \int_0^N x_i u'(x_i)\, di. \tag{2}$$

Under monopolistic competition, each firm is negligible to the market and treats the Lagrange multiplier λ as an exogenous aggregate variable.

2.2. Technology choice in the market solution

Firm i faces a fixed cost f_i and produces q_i units of the variety i at constant marginal costs c_i. It sells its output to the L identical consumers: $q_i = Lx_i$. Hence, $p_i = u'(q_i/L)/\lambda$ and firm i's profit is

$$\pi_i(q_i) = \left(\frac{u'(q_i/L)}{\lambda} - c_i\right) q_i - f_i. \tag{3}$$

[1] See Parenti et al. (2016) for a discussion on the properties of additive and homothetic preferences.

Firm i chooses its production q_i to maximize its profit. At the equilibrium,

$$\begin{aligned}&(q_i^*/L)\, u''(q_i^*/L) + u'(q_i^*/L)\\ &= \lambda^* c_i \Leftrightarrow \left[1 - r_u(q_i^*/L)\right] u'(q_i^*/L) = \lambda^* c_i\end{aligned} \tag{4}$$

where a star denotes the equilibrium value. Note that the *second order condition* requires that the left hand side of those expressions is decreasing in q_i, that is, $-(q_i/L)\, r_u' < r_u(1 - r_u)$. Therefore, firms with lower marginal costs c_i must produce more in order to restore the equality in (4).

We now limit the technology set to two technologies: the *large-scale* and the *small-scale*, denoted with subscripts l and s respectively. The large-scale technology entails high fixed costs f_l and low marginal costs c_l whereas the small-scale technology is characterized by smaller fixed costs $f_s < f_l$ and higher marginal costs $c_s > c_l$.

By symmetry, firms with the same technology sell the same quantities at the same prices. This allows us to replace the subscript i with the subscript $t \in \{l, s\}$ that identifies the firm with its technology. To be clear, we consider two prices, p_l and p_s, and two possible output, q_l and q_s. All firms face the same aggregate conditions; they thus share the same Lagrange multiplier.

At a free entry equilibrium, all firms will choose the same technology. This claim is easily proved by contradiction, as in general, there is no solution to a system of four equations with three unknowns. An equilibrium in which the two technologies are used would indeed require to find the three unknowns q_l, q_s and λ that simultaneously satisfy two zero-profit conditions ($\pi_s(q_s) = 0$ and $\pi_l(q_l) = 0$) and two first order conditions ((4) with $i = l$ and (4) with $i = s$).

Without loss of generality, let us *characterize an equilibrium in which all firms adopt the small-scale technology*. Let λ_s^* denote the Lagrange multiplier faced by all firms when they all adopt technology s. First, the aggregate statistics λ_s^* adjusts to make $\pi_s(q_s^*) = 0$ in (3). Equating this Lagrange multiplier with the value of the same multiplier found in (4) (with $i = s$), we find the output of a typical firm:

$$q_s^* = \frac{f_s}{c_s} \frac{1 - r_u(q_s^*/L)}{r_u(q_s^*/L)} \iff r_u(q_s^*/L) = \frac{f_s}{c_s q_s^* + f_s}. \tag{5}$$

At the equilibrium, the share of fixed costs in the total costs is thus equal to the relative love for variety. We also find the equilibrium value of the Lagrange multiplier:

$$\begin{aligned}\lambda_s^* &= \frac{1 - r_u(q_s^*/L)}{c_s} u'(q_s^*/L)\\ &= \frac{q_s^*}{f_s} u'(q_s^*/L)\, r_u(q_s^*/L).\end{aligned} \tag{6}$$

Second, by (2), we find the optimal price and the number of firms:

$$\begin{aligned}&p_s^* = \frac{c_s}{1 - r_u(q_s^*/L)} \quad \text{and}\\ &\lambda_s^* = \frac{N_s^* q_s^*}{L} u'(q_s^*/L) \iff N_s^* = \frac{L}{f_s} r_u(q_s^*/L).\end{aligned} \tag{7}$$

Third, by ensuring that a firm makes losses if it deviates from the equilibrium by choosing the large-scale technology, we find the following lemma, which will be further discussed in the next section.

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