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Abstract

This paper offers a theoretical explanation of the recent sales concentration in the U.S. economy. The model is based on in-house R&D, which is involved in scale economies. An R&D subsidy helps the expansion of larger firms and allows them to take higher markups. Thus, it induces a concentrated market structure.

JEL Classification Codes: D61; L11; L13; L16; O3

Keywords: Endogenous Sunk Cost; Firm Size Distribution; Heterogenous Firms; Markup; Quality Upgrading

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1 Introduction

The structure of the U.S. market has changed. Firms have increased markup rates[1] (De Loecker and Eeckhout, 2017) and sales are concentrated in a limited number of firms (Autor et al., 2017a,b).[2] An increase in the markup and sales concentration seem correlated: the markup is increasing in sectors with an increasing share of mega-firms employing more than 10,000 workers (Hall, 2018).

I offer a theoretical explanation for these phenomena. The theory is based on scale economies attributable to in-house R&D. Since 1990, the R&D subsidy has increased (Impullitti, 2010), which stimulates R&D investments. The resource concentrates on the small number of firms because R&D is involved in scale economies.[3] Support for this hypothesis is that the increase in industry concentration is positively correlated with the increase in patent intensity (Autor et al. (2017b)).

This paper works with the hypothesis that scale economies attributable to R&D are a source of the recent concentration. This view is highly indebted to the concept of endogenous sunk cost (Shaked and Sutton, 1983; Ellickson, 2007; Etro, 2014). However, most studies on endogenous sunk cost use the homogeneous firm model, which is inappropriate for the present purpose because I am interested in the distribution of sales across firms. Thus, I use the theoretical

[1]One skeptical view is taken by Traina (2018). However, many studies agree on the increase in markups (see, e.g., Gutiérrez and Philippon (2018)).

[2]Comin and Mulani (2006) also report that the volatility of firm-level sales growth is increasing.

[3]See, e.g., Atkeson and Burstein (2010), Dasgupta and Stiglitz (1980), Dhingra (2013), and Vives (2008) for studies involving in-house R&D.

model offered by Antoniades (2015), who embedded endogenous sunk costs into the heterogeneous firm model of Melitz and Ottaviano (2008). He examines the patterns of international trade, whereas I focus on market concentration.

Compared with previous studies examining the consequence of the increase in markups (Barkai, 2016; Eggertsson et al., 2018), the contribution of the present study is to offer an explanation of the cause of the change in market conditions. These previous studies assume an exogenous decrease of substitutability across goods, which can be interpreted as a less competitive market, and obtain its implication for factor returns. However, the assumption counterfactually predicts the decrease in sales concentration (see appendix). Lower substitutability makes sales less sensitive to productivity, which reduces sales dispersion. In contrast, the present study can simultaneously explain the increase in markup and sales concentration.

The increase in markups affects resource allocation.[4] The implication of this fact for efficiency in the present model is ambiguous because technology is endogenous. On the one hand, R&D investment increases markup dispersion, which strengthens misallocation. On the other hand, it reduces misallocation by allowing large firms, which undersupply goods, to expand. It is worth noting that this ambiguity is consistent with the two empirical observations of Baqaee and Farhi (2017): (i) allocative efficiency is increasing; (ii) firms that charge a higher markup is expanding. If technology is exogenous, these observations seem para-

[4]Since the study of Hsieh and Klenow (2009), resource misallocation has become an important topic in economics; see, e.g., Dhingra and Morrow (2012), Edmond et al. (2015), Epifani and Gancia (2011), and Peters (2013) for studies involved in misallocation attributable to markups.

doxical because allocative efficiency improves when markup distortion becomes larger. However, these observations are compatible (although an examination of the efficiency properties of the model is beyond the scope of this paper) with the view in the present paper.

Although this study only examines the cause of concentration, concentration is considered to be related to the recent increase in earnings inequality because each firm's sales are positively correlated with the wages that the firm pays (Helpman et al., 2017).[5] Indeed, Berlingieri et al. (2017) report that the increase in wage dispersion is mainly attributed to the increasing inequality of performance across firms. Gabaix and Landier (2008) and Edmans et al. (2008) show theoretically and empirically that firm size is positively correlated with CEO compensation. The present study complements these studies by theoretically examining a potential cause of inequality across firms.

The question of this study is what firms gain from a change in market conditions. In this sense, this study is related to studies involved in the economics of superstars, which examined how market conditions—technological change (Rosen, 1981) or international trade (Manasse and Turrini, 2001)—affect the distribution of economic rent. This paper also relates studies of biased technical change[6], which examines how market conditions change the earnings distributions across workers, whereas I focus on the distributional issues across firms.

[5]Some theoretical studies associate profit with entrepreneurial income (Jones and Kim, 2014; Nocke, 2006; Pokrovsky et al., 2014).

[6]See, e.g., Acemoglu (1998), Burstein and Vogel (2017), Epifani and Gancia (2008), Galor and Moav (2000), Krusell et al. (2000), Matsumoto (2018), Matsuyama (2007), and Parro (2013).

Section 2 exposits the model. Section 3 applies the model to examine the effect of R&D cost subsidies on concentration. Section 4 concludes the paper.

2 Model

2.1 Consumers

Specification of the demand side is a variant of Ottaviano et al. (2002). Consumers have identical utility over homogeneous goods $q(0)$ and a continuum of differentiated goods indexed by $v \in \Omega$:

$$U = q(0) + \int_{v\in\Omega} (\alpha + z(v))q(v)dv - \frac{\gamma}{2}\int_{v\in\Omega} q^2(v)dv - \frac{\eta}{2}(\int_{v\in\Omega} q(v)dv)^2 \quad (1)$$

where $z(v)$ is the quality of v. I normalize the homogeneous goods price and the wage to one. Each agent has the budget constraint

$$p(0)q(0) + \int_{v\in\Omega} p(v)q(v)dv = h - T + \Pi$$

where $p(v)$ is the price of v. h is the efficiency units of labor supply of each consumer.[7] Wage is normalized to one. Homogeneous goods are competitively supplied and its labor productivity is one, which implies that the homogeneous goods price is one ($p(0) = 1$). T is the lump sum tax seized by the government and Π is the firm's profit distributed to each household.

[7]To avoid a corner solution, I assume that h is sufficiently high. Whenever both goods are consumed, the resource constraint does not need to be considered explicitly.

The demand of each consumer is

$$p(v) = \alpha + z(v) - \gamma q(v) - \eta Q \tag{2}$$

where $Q \equiv \int_{v \in \Omega} q(v)dv$ denotes total differentiated goods consumption.

2.2 Firms

Following the assumption made by Melitz and Ottaviano (2008), the distribution of a firm's labor productivity c follows a Pareto distribution with support on $[0, 1]$:

$$G(c) \equiv \mathbb{P}[\text{labor productivity} \leq c] = c^k, \quad 0 \leq c \leq 1 \tag{3}$$

For simplicity, I assume $k > 2$. The firm, which supplies one good monopolistically, maximizes profits:[8]

$$\pi(c) = (p(c) - c)y(c) - (1 - \tau_\theta)\frac{\theta}{2}z^2(c) \tag{4}$$

where $y \equiv qL$ is the output and L is the number of consumers. The term $\frac{\theta}{2}z^2$ represents the sunk R&D cost for quality upgrading and τ_θ represents the R&D subsidy rate.[9] To maintain the concavity of the profit maximization problem, I assume $2\gamma(1 - \tau_\theta)\theta > L$.

[8] I use v and c for interchangeable indexes of goods.

[9] R&D subsidies are paid by lump sum tax for consumers: $\int_{v \in \Omega} \frac{\tau_\theta \theta}{2} z^2(v)dv = TL$.

By profit maximization,

$$\frac{\partial \pi}{\partial q} = 0 : \quad p(c) - c = \gamma q(c) \tag{5}$$

$$\frac{\partial \pi}{\partial z} = 0 : \quad (1 - \tau_\theta)\theta z(c) = y(c) \tag{6}$$

Because R&D is involved in scale economies, larger output induces stronger R&D efforts, which is roughly consistent with Cohen and Klepper (1996) and Blundell et al. (1999).

Firms exit if and only if $\pi(c) < 0$: this is equivalent to

$$c < c_m \equiv \alpha - \eta Q$$

I assume that the exit cutoff c_m is lower than 1 in equilibrium.[10] Inverse demand (2) can be rewritten as

$$p(c) = c_m + z(c) - \gamma q(c) \tag{7}$$

(5), (6), and (7) allow us to rewrite z as a function of c_m:

$$z(c) = \lambda(c_m - c) \tag{8}$$

where $\lambda \equiv (2\gamma(1 - \tau_\theta)\theta/L - 1)^{-1} > 0$ is quality intensity. So far, I use λ as a measure of R&D subsidy because λ is increasing in τ_θ. Correspondingly, one

[10] A sufficient condition for $c_m < 1$ is $\alpha < 1$.

obtains prices and quantities:

$$p(c) = \frac{1}{2}((1+\lambda)c_m + (1-\lambda)c)) \tag{9}$$

$$y(c) = q(c)L = \frac{(1+\lambda)L}{2\gamma}(c_m - c) \tag{10}$$

The main interest of this study is how the reduction in λ affects the distribution of profit $\pi(c)$ and sales $S(c) \equiv p(c)y(c)$.

$$\pi(c) = \frac{(1+\lambda)L}{4\gamma}(c_m - c)^2 \tag{11}$$

$$S(c) = \frac{(1+\lambda)L}{4\gamma}((1+\lambda)c_m + (1-\lambda)c)(c_m - c) \tag{12}$$

2.3 Measures of Market Condition

I use six measures to evaluate the market condition. The first measure is the average markup:[11]

$$\mathbb{E}[\frac{p(c)}{c}|c \leq c_m] \equiv \int_0^{c_m} \frac{p(c)}{c} dG(c|c \leq c_m) \tag{13}$$

where $G(c|c \leq c_m) = (\frac{c}{c_m})^k$ denotes the cumulative distribution conditional on $c \leq c_m$. This measure is related to the resource misallocation across sectors (differentiated goods and homogeneous goods sectors). The second measure is the variance of the markup, which is relevant for evaluating the misallocation

[11] Antoniades (2015) uses the absolute markup $\mathbb{E}[p(c) - c|c \leq c_m]$, but the markup measure I use is more appropriate for comparing the result with empirical studies.

within the sector:

$$\mathbb{V}[\frac{p(c)}{c}|c \leq c_m] \equiv \mathbb{E}[(\frac{p(c)}{c} - \mathbb{E}[\frac{p(c)}{c}|c \leq c_m])^2|c \leq c_m]$$

The third and fourth measures are the profits of the largest firms and the average profit:

$$\pi(0) = \frac{(1+\lambda)L}{4\gamma}{c_m}^2 \tag{14}$$

$$\mathbb{E}[\pi(c)|c \leq c_m] = \frac{(1+\lambda)L}{2\gamma(k+1)(k+2)}{c_m}^2 \tag{15}$$

The fifth and sixth measures are the profit and sales inequalities:

$$\frac{\pi(c_1)}{\pi(c_2)} = (\frac{c_m - c_1}{c_m - c_2})^2 \tag{16}$$

$$\frac{S(c_1)}{S(c_2)} = \frac{(1+\lambda)c_m + (1-\lambda)c_1}{(1+\lambda)c_m + (1-\lambda)c_2}\frac{c_m - c_1}{c_m - c_2} \tag{17}$$

A similar measure of inequality is often used in the assignment model (Sampson, 2014; Grossman and Helpman, 2018).

Because these measures depend on c_m, considering how c_m is determined is needed. However, this is not the case for the markup distribution, which depends only on λ:[12]

$$\mathbb{E}[\frac{p(c)}{c}|c \leq c_m] = \frac{2k-1+\lambda}{2(k-1)}, \quad \mathbb{V}[\frac{p(c)}{c}|c \leq c_m] = \frac{(1+\lambda)^2 k}{4(k-2)(k-1)^2}$$

Thus, both the average markup and the markup dispersion increase as the R&D subsidy increases $d\mathbb{E}[\frac{p(c)}{c}|c \leq c_m]/d\lambda > 0$ and $d\mathbb{V}[\frac{p(c)}{c}|c \leq c_m]/d\lambda > 0$.

3 R&D Subsidy and Concentration

To concentrate on the effect of in-house R&D, I consider the case that the entry is restricted: the number of potential firms N is fixed. Nonetheless, the main result continues to hold even if the free entry of new firms is allowed (see appendix). The total output is

$$Q = N\mathbb{E}[q(c)] = N\int_0^{c_m} q(c)dG \tag{18}$$

Because $c_m = \alpha - \eta Q$, one obtains

$$c_m = \alpha - \frac{\eta(1+\lambda)N}{2\gamma(k+1)} c_m^{k+1} \tag{19}$$

[12] Two effects induced by the reduction in c_m affect the distribution of the markup. First, the markup decreases because each firm faces stronger competition. Second, the markup increases because low markup firms exit. Nonetheless, they are exactly offset when the cost distribution is Pareto. The markup distribution depends only on λ:

$$\mathbb{P}(\frac{p(c)}{c} \geq \mu|c \leq c_m) = (\frac{1+\lambda}{2\mu-(1-\lambda)})^k$$

for $\mu \geq 1$. Intuitively, the self-similarity of the distribution of c ensures the result (See also Arkolakis et al. (2018)).

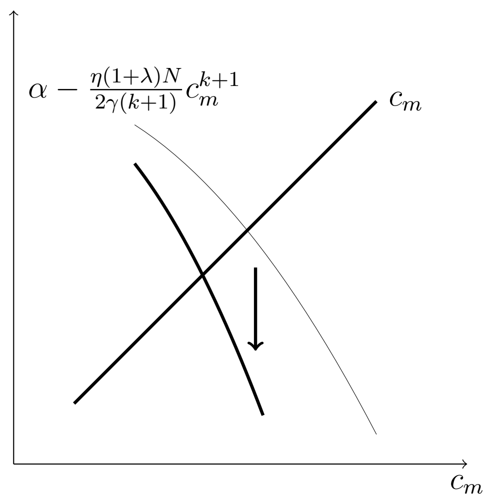

Figure 1: Effect of the increase in λ

(19) determines unique values of c_m because the left-hand side is increasing in c_m, whereas the right-hand side is decreasing in c_m. As shown in Figure 1, the increase in λ reduces the cutoff c_m. Intuitively, the increase in the R&D subsidy would hurt small firms by strengthening competition, and these unproductive firms must exit from the market.

From (19), one can obtain the effect of R&D subsidies. The average and the top firm profits increase by the direct effect of R&D subsidies and decrease by strengthening competition:

$$\frac{d \log \pi(0)}{d \log(1+\lambda)} = \frac{d\mathbb{E}[\pi(c)|c \leq c_m]}{d \log(1+\lambda)} = 1 + 2\frac{d \log c_m}{d \log(1+\lambda)}$$

The second effect dominates because $d \log c_m / d \log(1+\lambda) > -1/(k+1)$.[13] Thus, R&D subsidies increase the average profit and the profit of the most productive firms.

Because large firms gain and small firms lose, within-firm inequality also increases:

$$\frac{d}{d\lambda} \log(\frac{\pi(c_1)}{\pi(c_2)}) = 2(\frac{1}{c_m - c_1} - \frac{1}{c_m - c_2})\frac{dc_m}{d\lambda} > 0 \tag{20}$$

$$\begin{aligned} \frac{d}{d\lambda} \log(\frac{S(c_1)}{S(c_2)}) = & \frac{2c_m(c_2 - c_1)}{\prod_{i=1,2}((1+\lambda)c_m + (1-\lambda)c_i)} \\ & + \frac{dc_m}{d\lambda}(c_2 - c_1)(\frac{1-\lambda^2}{\prod_{i=1,2}(c_m + c_i + \lambda(c_m - c_i))} - \frac{1}{\prod_{i=1,2}(c_m - c_i)}) \\ > & \, 0 \end{aligned} \tag{21}$$

for $c_1 < c_2$.[14] The increase in R&D subsidies induces a more concentrated market

[13] By the total derivative of (19), one obtains

$$c_m d \log c_m = -\frac{\eta(1+\lambda)N}{2\gamma(k+1)} {c_m}^{k+1}(d \log(1+\lambda) + (k+1) d \log c_m)$$

This equation can be rewritten as

$$0 > \frac{d \log c_m}{d \log(1+\lambda)} = -\frac{1}{k + 1 + \frac{2\gamma(k+1)}{\eta(1+\lambda)N} {c_m}^{-k}} > -\frac{1}{k+1}$$

[14] To obtain the inequality in (21), it is sufficient to show

$$\frac{1-\lambda^2}{\prod_{i=1,2}(c_m + c_i + \lambda(c_m - c_i))} < \frac{1}{\prod_{i=1,2}(c_m - c_i)}$$

This is indeed satisfied for all $\lambda \geq 0$ because (i) this inequality is satisfied at $\lambda = 0$ and (ii) the left-hand side is decreasing in λ whenever it takes a positive value.

structure.

4 Conclusion

This paper examines the implication of endogenous sunk costs for the recent concentration phenomena. Because R&D is involved in scale economies, subsidy works in favor of large firms and disproportionately expands the sales and profits of large firms.

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A CES Demand and Exogenous Decrease in Substitutability

Representative households have the utility

$$U = (\int_{v\in\Omega} y(v)^{\frac{\rho-1}{\rho}} dv)^{\frac{\rho}{\rho-1}}$$

where $\rho > 1$ denotes the elasticity of substitution across goods. By utility maximization, the demand is

$$y(v) = \frac{p(v)^{-\rho}}{P^{1-\rho}} E, \quad P \equiv \int_v p(v)^{1-\rho} dv$$

where E denotes the total expenditure. Each monopolistic firm has heterogeneous labor productivity c. A firm's profit is $p(c)y(c) - cy(c)$ and profit maximization implies

$$p = \frac{\rho}{\rho - 1} c, \quad py = \frac{E}{P^{1-\rho}} (\frac{\rho}{\rho - 1} c)^{1-\rho}$$

Wage is normalized to one. In this specification, the decrease in ρ implies higher markups ($\frac{d}{d\rho}\frac{p}{c} < 0$). However, it also implies a decrease in the sales inequality:

$$\frac{d}{d\rho} \log \frac{p(c_1)y(c_1)}{p(c_2)y(c_2)} > 0, \quad c_1 < c_2$$

Another measure of sales dispersion entails the same result. To see this, suppose that c follows the Parato cumulative distribution function with support on $[0, 1]$:

$$G(c) = c^k$$

The standard deviation of the log of sales—this measure is used by Bernard et al. (2003) and Ghironi and Melitz (2005)—is

$$\sqrt{\mathbb{V}[\log(p(c)y(c))]} = (\rho - 1)\sqrt{\mathbb{V}[\log c]} = (\rho - 1)/k$$

This measure decreases as ρ decreases. Thus, although the decrease in ρ is compatible with the recent increase in markups, it counterfactually predicts a reduction in sales dispersion.

B Free Entry

Entrants pay f_E units of the labor cost and, after paying f_E, draws c from a Pareto distribution: $G(c) = c^k$. Free entry ensures that the expected post entry profit equals the entry cost:

$$\mathbb{P}(c \leq c_m)\mathbb{E}[\pi(c)|c \leq c_m] = f_E \tag{B.1}$$

This condition implies

$$c_m = (\frac{2\gamma(k+1)(k+2)f_E}{(1+\lambda)L})^{1/(k+2)} \tag{B.2}$$

Correspondingly, the elasticity of the cutoff is

$$\frac{d\log c_m}{d\log(1+\lambda)} = -\frac{1}{k+2} \tag{B.3}$$

Thus, all of the results in this paper remain intact:

$$\frac{d\log\pi(0)}{d\log(1+\lambda)} = \frac{d\mathbb{E}[\pi(c)|c \leq c_m]}{d\log(1+\lambda)} \geq 1 - \frac{2}{k+2} > 0$$

$$\frac{d}{d\lambda}\log(\frac{\pi(c_1)}{\pi(c_2)}) = 2(\frac{1}{c_m - c_1} - \frac{1}{c_m - c_2})\frac{dc_m}{d\lambda} > 0$$

$$\frac{d}{d\lambda}\log(\frac{S(c_1)}{S(c_2)}) > 0$$

for $c_1 < c_2$.