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Sunk Costs, Market Contestability, and the Size Distribution of Firms

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Abstract

This paper offers a new economic explanation for the observed inter-industry differences in the size distribution of firms. The empirical estimates—based on three temporal (1982, 1987, and 1992) cross-sections of the four-digit United States manufacturing industries—indicate that increased market contestability, as signified by low sunk costs, tends to reduce the dispersion of firm sizes. These findings provide support for one of the key predictions of the theory of contestable markets: that market forces under contestability would tend to render any inefficient organization of the industry unsustainable and, consequently, tighten the distribution of firms around the optimum.

Sunk Costs, Market Contestability, and the Size Distribution of Firms

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1 Introduction

This paper seeks to provide a new, economic explanation for the observed inter-industry differences in the size distribution of firms. Its main testable hypothesis is that increased market contestability, as signified by low sunk costs, tends to reduce the dispersion of firm sizes.

Seller concentration is perhaps the most frequently quantified and scrutinized element of market structure.[1] It plays a central role in evaluating market power, especially in the context of mergers or potential anti-competitive behavior such as collusion and predation. Concern about bigness and rising concentration has been a recurring theme of public policy and a source of considerable debate in the United States and elsewhere (White, 1981; 2002).

Concentration depends on two key characteristics of the size distribution of firms: their number (fewness) and the inequality of their sizes (dispersion).[2]   Previous

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[0] This paper–a product of the Environment and Energy Team of the Development Research Group–is also being published in the Review of Industrial Organization.

[1] There is a vast theoretical and empirical literature on market structure and its various elements such as the 4-firm concentration ratios. See among others: White (1982), Scherer and Ross (1990), Schmalensee (1989), Berry and Reiss (2007).

[2] High levels of concentration may be achieved in two different ways. The number of firms operating in the industry might be very small. In that case, concentration will be high, even if the firms' market shares are approximately equal. Alternatively, the number of firms may be large, but their market shares could be very unequal, leading again to high concentration (Sutton, 1998).

empirical studies have focused on the technological explanation of concentration, underscoring the significance of the cost curve (especially the minimum efficient scale of production) and barriers to entry by new firms (Davies and Lyons, 1982). Implicitly these studies have emphasized the *numbers equivalent* component of concentration. This paper departs from mainstream practice by focusing on the observed inter-industry differences in the dispersion of firm sizes–the *variance equivalent* component of concentration.

The paper invokes one of the fundamental welfare properties of contestable markets, which refers to the absence of any sort of inefficiency in production in industry equilibrium. Any unnecessary cost, like any excess profit, would constitute an invitation to entry and render incumbents vulnerable to being displaced by more efficient entrants (Baumol, 1982). Thus, in contestable industries with U-shaped average cost curves, we should observe a very low dispersion in the size distribution of firms–i.e., firms could stay in the market only if they produce at the minimum point of the average cost curve, or its neighborhood. In markets that are not contestable, on the other hand, inefficient industry structures characterized by a large dispersion of firms around the minimum point could be sustainable even in the long run. Moreover, the extent to which an industry is contestable depends critically on the magnitude of sunk costs–i.e., the irreversible costs that must be borne by an entrant but are mostly bygone for the industry's incumbent firms (Martin, 1989).

We recognize that the assumption of U-shaped average cost curves is far from being universally valid. Indeed, a widely accepted empirical fact is that the observed average cost curves in many industries appear to be linear for a wide range of output. However, as we argue below, although the implied effect of contestability will be weaker in industries with U-shaped cost curves with a flat bottom or L-shaped curves, it will not entirely break down.

Our econometric model relates measures of firm size dispersion to proxies for industry-specific sunk costs. The results of the paper, which are based on a cross-section of four-digit US manufacturing industries, lend support for the hypothesis that the structure of markets depends continuously on the degree to which they exhibit imperfect contestability–smaller dispersions of firm sizes are observed in industries whose share of investment that is composed of sunk capital is low (i.e., industries exhibiting high degrees of contestability).[3] The paper's empirical findings are robust to reasonable changes in model specification as well as to variations in the measures of firm size dispersion and sunk costs.

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[3] The finding that sunk costs influence the size distribution of firms is also consistent with the predictions of the Stackelberg-Spence-Dixit model of entry deterrence. Sunk costs allow early entrants to exploit their headstart and limit the scale of entry of other firms by strategically investing beyond their steady-state Nash levels.

2 The Size Distribution of Firms Reconsidered: The Impact of Sunk Costs

A long established feature of industrial economics is that most industries are characterized by a fairly skewed size distribution of firms. The resilience of this empirical regularity has motivated a vast literature on stochastic models of firm growth that began with the seminal contribution of Gibrat (1931). Gibrat assumed that the number of firms is fixed and their growth rates are independent of their size–i.e., the probability of a given proportionate change in size during a specified period is the same for all firms in a given industry, regardless of their size at the beginning of the period ("Gibrat's Law" of proportionate effect).

One of the main drawbacks of the Gibrat model is that it has no steady state; the size distribution of firms approaches a lognormal with unbounded mean and variance (de Wit, 2005). Subsequent work refined Gibrat's model by integrating a process of entry and exit into the traditional growth-of-firms formulation and imposed a variety of ancillary assumptions (e.g., firms are born at a constant rate as the industry evolves, there exists a minimum size of firms above which unit costs are constant, firms cannot decline below a certain minimum size) and stability conditions to the underlying random walk process (Kalecki, 1945; Simon, 1955, 1960; Simon and Bonini, 1958; Ijiri and Simon, 1977; Steindl, 1965; Levy and Solomon, 1996; Sutton, 1997; Gabaix, 1999; Malcai et al., 1999). Although the assumption that enterprise growth is a random walk conflicts with economic intuition and the most fundamental theories of the firm, early studies found that stochastic processes adhering to Gibrat's law generate highly skewed size distributions that conform fairly closely to real-world ones.

More recently, there have been several empirical tests of Gibrat's law based on diverse data sets and employing careful statistical techniques. The results of these studies have been rather mixed, however. Some of them find that firms' growth rates do indeed follow a random walk and therefore Gibrat's Law holds (Del Monte and Papagni, 2003; Geroski et al., 2003). Others, however, suggest that Gibrat's Law is not confirmed for new entrants, incumbent firms tracked over long time periods, firms in specific industries and different countries (Lotti et al., 2009; Aslan, 2008; Cefis et al., 2007; Oliveira and Fortunato, 2006; Chen and Lu, 2003).

As a complement to the technological explanation, the stochastic approach has made a valuable contribution to the analysis of market structure. However, the main weakness of the stochastic description is that it lacks economic content. The assumptions that underlie the size-growth relationship and the role of stochastic mechanisms as a driver of skewness are not guided by a formal economic model. In fact, the law of proportionate effect, as it has been applied in the existing models,

does not take into account industry-specific characteristics. These models, therefore, are not designed to explain the important inter-industry differences in the degree of inequality in the size distribution of firms.

In recognition of the fundamental weaknesses of the stochastic approach, a richer class of models has been constructed in recent years. These models seek to incorporate fundamental economic mechanisms into the stochastic process that governs the firm's size. However, the size distributions that are derived seem to depend on largely unobservable features of these models, thus limiting considerably the empirical testing of their predictions (Sutton, 1998).

This paper focuses on the efficiency attributes of long-run equilibria in perfectly contestable markets and the implications of deviations from the conditions of perfect contestability for the size distribution of firms. One of the most fundamental and novel features of the theory of contestable markets is the explicit recognition that the structure of an industry is determined primarily by economic forces. The number of firms, the dispersion in their sizes, and so on, are determined endogenously and simultaneously with the vectors of the industry's prices and outputs.[4]

Under perfect contestability, the opportunity for costless entry and exit guarantees the absence of any inefficiency in production in industry equilibrium; i.e., it renders any inefficient organization of the industry unsustainable. The incumbent firms must operate in an efficient manner because any unnecessary costs, like any excess profit, would simply invite entry and lead to their displacement by entrants who can supply the same output at lower cost. Thus the incumbent firms must minimize costs, and total industry output must be divided among its firms so as to minimize the industry's total production cost (Baumol, 1982).

In the single-product case and under the assumption of a unique point of minimum average cost, intuition suggests, in essence correctly, that market forces will enforce the optimal number of firms with approximately equal outputs.[5] Firms locating to the right or left of the minimum point would exhibit higher unit costs and be vulnerable to displacement by potential entrants. Under perfect contestability, a market structure that is characterized by a dispersion of firm sizes around the unique minimum point would not be consistent with industry equilibrium in the long run. Thus, the role of contestability is to tighten the distribution of firms around the optimum.

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[4]The novelty of the theory of contestable markets in explicitly recognizing the endogeneity of market structure should not be overstated. In his excellent exposition of the theory of contestable markets, Martin (2000) correctly points out that "the literature before contestability did not treat market structure as exogenously given."

[5]It is important to note that even in the single-product case and with a U-shaped average cost, the optimal solution will not always involve equal outputs by all firms. Baumol and Fischer (1978), and Baumol et al. (1982), chapter 5, give an example.

Perfect contestability, like perfect competition, is only a useful theoretical benchmark. In markets where the elements of contestability are not present and entry is less than ultra free, inefficient equilibrium industry structures characterized by large dispersions in the sizes of enterprises might obtain. Our basic hypothesis, then, is that the dispersion in the sizes of firms around the optimum, and consequently the structure of a market, will depend on the degree of imperfection in its contestability.

Perfect contestability requires that: (i) all entry investment is fully reversible, i.e., there are no sunk costs; (ii) all producers have access to the same technology; (iii) incumbents cannot adjust their prices instantaneously, i.e., there must be a positive price response lag; and (iv) there is no consumer goodwill, i.e., consumers respond instantly to price differentials. Clearly, alternate representations of imperfect contestability in real world markets could be based on violations of any of the above conditions.

This paper focuses on condition (i) and employs the degree of sunkenness of the entry investment as the primary criterion for contestability. The economic significance of sunk costs has received considerable attention in the industrial organization literature. Sunk costs lower the quasi-rents that the entrant can expect to earn by committing resources to the market; diminish the rate at which entry responds to positive incumbent profits or to unnecessary incumbent costs; and, like entry barriers, impede the establishment of new firms.[6] By shielding inefficient incumbents from the pressures of competition, sunk costs can constrain market structure and may allow an inefficient industry configuration, characterized by a large dispersion of firm sizes around the optimum, to persist.[7]

Entry frequently entails irrecoverable physical capital investments that are primarily determined by the underlying technological characteristics of the industry's production–i.e., tangible sunk costs that are largely exogenous. In many industries, however, there are crucial cost components related to intangible capital that reflect strategic decisions by the incumbent firms. The two most obvious examples of discretionary sunk cost expenditures are advertising and R&D outlays (Kwoka and White, 2001). Indeed, there is empirical evidence that in some (primarily consumer goods) industries, advertising as a sunk cost is even more important to the total entry barrier than tangible sunk costs (Kessides, 1986). Entry and competition in knowledge-intensive industries requires large R&D expenditures. Although

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[6]In a recent paper, Cabral and Ross (2008) question the received wisdom that sunk costs create a barrier to entry. They argue that by providing entrants with a commitment power, sunk investments may soften the reaction of incumbents.

[7]In a recent paper, Ghosal (2007) argues that given a level of uncertainty (sunk costs), higher sunk costs (uncertainty) reduce the number of smaller firms, leave larger firms unaffected, and increase market concentration–the inference being that they make the firm size distribution less skewed. See also Ghosal (1996, 2003a, 2003b).

these investments generate valuable knowledge-based assets, such assets are largely intangible and highly firm-specific (O'Brien and Folta, 2009).

Intangible sunk costs could play an important role in explaining cross-industry differentials in firm size dispersion. Their impacts, however, are more complex and their causal mechanism requires careful attention. Advertising, for example, constitutes a sunk cost barrier to entry. For the potential entrant, the need to advertise leads to an unrecoverable entry cost in the case of failure. Large sunk investments in advertising may allow incumbents credibly to preempt potential entrants (Thomas, 1996). On the other hand, by providing information about the existence of alternative products and their price-quality characteristics, advertising reduces the search costs that are faced by consumers, thereby decreasing their loyalty and inertia. It may also allow firms to operate in differentiated product niches. Thus, entrants could perceive a greater likelihood of success in markets where advertising plays an important role. In that case, advertising may actually facilitate entry and enhance market contestability (Martin, 2002). Similar arguments could be made for R&D. Which of these two countervailing effects dominates is clearly an empirical question.[8]

The effect of contestability in tightening the distribution of firms around the optimum will be most pronounced in industries with average cost curves that have a smooth U shape and are thus characterized by a unique minimum point. Clearly, this effect will be somewhat diluted in industries with U-shaped curves with a flat bottom (depending on the relative length of the flat portion of the curve). However, it is important to note that the effect will not break down even in industries with L-shaped average cost curves. First, contestability will influence the number of firms locating in the sub-optimal sector, i.e., firms of size less than MES. In the long run, under perfect contestability, the density of the suboptimal sector will be reduced to zero. Second, the factors that affect the degree of contestability ultimately determine the probability of entry. Firm size inequality is affected by the probability of entry. The higher is the rate of entry, the smaller are size inequalities (Simon and Bonini, 1958; Davies and Lyons, 1982). Thus, the degree of contestability will be related to the size distribution of firms even when average costs are L-shaped.

3 Measuring Dispersion of Firm Sizes

To obtain a measure of the inequality in firm size distribution, we first focus on the relationship between concentration and the number of firms. Let C_{mi} denote the m-firm concentration ratio in industry i. Then it is easy to show that

$$C_{mi} = \frac{m}{N_i} + m\frac{\bar{Q}_{mi} - \bar{Q}_i}{Q_i}, \tag{1}$$

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[8]We would like to thank an anonymous referee for higlighting the importance of this issue.

where in industry i, N_i is the number of firms, $\bar{Q}_{mi}$ represents the average firm output of the largest m firms, $\bar{Q}_i$ is average firm output computed over all the firms in the industry, and Q_i is total industry output. The quantity $\dfrac{\bar{Q}_{mi} - \bar{Q}_i}{Q_i}$ represents the relative distance between the industry-wide mean firm size and that of the largest m firms in the industry; i.e., it is a measure, albeit a simplified one, of firm size dispersion. This decomposition is intuitively appealing in that it signifies the dependence of the single summary measure of concentration C_{mi} on two key characteristics of the size distribution of firms: their number (fewness), represented by N_i, and the inequality of their sizes (dispersion), represented by $\dfrac{\bar{Q}_{mi} - \bar{Q}_i}{Q_i}$.

If there is no size dispersion (e.g., in the case of a U-shaped average cost curve, all firms in industry i locate at the minimum point), then the second term on the right hand side of (1) will be zero and $C_{mi} = \dfrac{m}{N_i}$; i.e., the m-firm concentration ratio depends entirely on the number of firms (fewness). If, on the other hand, there exists a dispersion in firm sizes, $\dfrac{\bar{Q}_{mi} - \bar{Q}_i}{Q_i}$ will be positive, and thus $\dfrac{m}{N_i}$ will underestimate the m-firm concentration ratio in industry i.

Rearranging (1) we obtain

$$\frac{\bar{Q}_{mi} - \bar{Q}_i}{Q_i} = \frac{1}{m}\left(C_{mi} - \frac{m}{N_i}\right) \tag{2}$$

for our first proposed measure of the inequality in firm size distribution of a given industry that is expressed in terms of observable structural parameters.

It may be argued that the term $\dfrac{\bar{Q}_{mi} - \bar{Q}_i}{Q_i}$ is not an accurate measure of firm size dispersion because it ignores potentially important within-group size differentials for the largest m and remaining $N_i - m$ firms in industry i. The basis for a more comprehensive measure of size dispersion in industry i is provided by the variance of market shares

$$V_i(s) = \frac{1}{N_i}\sum_{j=1}^{N_i}(s_{ij} - \bar{s}_i)^2, \tag{3}$$

where in industry i, s_{ij} is the market share of firm j, $\bar{s}_i$ is the average market share, and as before N_i is the number of firms.

Noting that the *Herfindahl-Hirshman Index* H_i is the sum of the squared share values, we obtain

$$V_i(s) = \frac{1}{N_i}\left(H_i - \frac{1}{N_i}\right), \tag{4}$$

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which expresses size dispersion in terms of industry structural parameters that are observable.

Rearranging (4) leads to the decomposition

$$H_i = \frac{1}{N_i} + N_i V_i(s), \qquad (5)$$

which again is intuitively appealing because it distinguishes two aspects of the single summary measure H_i of concentration: fewness, represented by N_i, and size dispersion, represented by $V_i(s)$. If there is no size dispersion, then $H_i = \frac{1}{N_i}$; i.e., H_i depends entirely on the fewness of firms (Kelly, 2001).

4 Sunk Costs: Measurement and Correlates

Lack of detailed data on the availability of resale markets for durable inputs precludes direct evaluation of the unavoidable sunk costs that face an entrant. Such measurement is further complicated by the fact that fixed costs that are firm-specific are in general more sunk than those that are just industry-specific. Still, readily available measures suggested by theory permit us to construct meaningful proxies for these costs (Kessides, 1990).

Assume that entry into industry i requires K_i^e units of capital that can be purchased at a price of β_i per unit. Let ρ_i^e denote the portion of the capital that the entrant can rent. Assume further that the entrant exercises its disinvestment option after a period of length τ during which its capital depreciates by d_{ki}^τ percent. If the entrant can scrap its capital at the end of the period for a salvage price of α_i^τ, then the expression

$$SUK_i^e = (1 - \rho_i^e)[(1 - d_{ki}^\tau)\beta_i - \alpha_i^\tau]K_i^e \qquad 0 < (1 - d_{ki}^\tau)\beta_i - \alpha_i^\tau < 1 \quad (6)$$

represents the portion of the entry investment that is irrecoverable if exit takes place after a period of length τ–i.e., the effective sunk costs facing the entrant.

The divergence between the undepreciated portion $(1 - d_{ki}^\tau)\beta_i$ of the original investment and the salvage price α_i^τ will depend on the characteristics of the capital that is employed in the industry: the degree to which such capital is firm- rather than industry-specific, its lumpiness, technological complexity, and so on. It can be plausibly argued that the intensity of the resale market in the industry can serve as an indicator variable for these largely unobservable capital characteristics. One should expect an active resale market in industries in which the capital employed is industry- rather than firm-specific. Lumpy capital, on the other hand, which is costly to relocate becomes by default firm-specific and does not lend itself to resale

unless the firm is acquired. Thus, the portion of the entry investment $1 - \dfrac{\alpha_i^\tau}{(1 - d_{ki}^\tau)\beta_i}$ that is sunk is assumed to be a decreasing function of the intensity of the resale market ψ_i in the industry; i.e.,

$$SUK_i^e = (1 - \rho_i^e)(1 - d_{ki}^\tau)\beta_i K_i^e g(\psi_i), \qquad (7)$$

where $g'(\psi_i) < 0$. For the sake of analytic simplicity we adopt the flexible functional form $g(\psi_i) = \gamma \psi_i^{-\delta}$, where $\gamma, \delta > 0$.

We assume that the entrant's capital has approximately the same composition as that of the industry. Then ρ_i^e may be proxied with $\dfrac{RK_i}{r_i K_i}$ where RK_i represents the total rental payments made for the use of capital in industry i, K_i is the industry's capital, and $r_i K_i$ is its maximum rental value. We also propose to use as a proxy for intensity of the resale market ψ_i: the portion $\dfrac{UK_i}{UK_i + NK_i}$ of the industry's total capital expenditure that consists of used plant and equipment, where UK_i and NK_i are the industry's used and new capital expenditures, respectively. Then, the share of entry investment that is composed of sunk capital (i.e., the sunkenness of the entry investment) in industry i will be given by

$$SUNK_i = \frac{SUK_i^e}{\beta_i K_i^e} = (1 - \frac{RK_i}{r_i K_i})(1 - d_{ki}^\tau)\gamma(\frac{UK_i}{UK_i + NK_i})^{-\delta}. \qquad (8)$$

The above measures relate to tangible sunk costs arising from investment in physical capital. We assume now that in addition to investment in physical capital, entry into industry i requires A_i^e and RD_i^e outlays in advertising and R&D respectively. If the entrant's investments in advertising and R&D depreciate by d_{ai}^τ and d_{ri}^τ percent during the time interval τ, then the expressions

$$SUA_i^e = (1 - d_{ai}^\tau)A_i^e \qquad (9)$$

and

$$SURD_i^e = (1 - d_{ri}^\tau)RD_i^e, \qquad (10)$$

provide a measure of the portion of the entry investment in advertising and R&D that might be unrecoverable in the event of exit. In general, the assets created by investments in advertising and R&D are intangible and highly firm-specific, with little value outside their current applications (O'Brien and Folta, 2009; Helfat, 1994). Thus, SUA_i^e and $SURD_i^e$ should be very close to the true sunk cost of advertising and R&D. Still, if the exiting firm is taken over by one of its competitors, then these expressions might overestimate the true sunk costs. This is because advertising and R&D expenditures can create assets with some future value that will generally be reflected in the firm's sale price.

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We assume that the entrant's capital structure encompasses the same mix of tangible and intangible components as that of the industry. Then, taking into account both tangible and intangible sunk cost expenditures, our proposed measure of sunkenness of the entry investment is modified as follows:

$$SUN_i = (1 - \frac{RK_i}{r_i K_i})(1 - d_{ki}^\tau)\gamma(\frac{UK_i}{UK_i + NK_i})^{-\delta} + (1 - d_{ai}^\tau)\frac{A_i}{\beta_i K_i} + (1 - d_{ri}^\tau)\frac{RD_i}{\beta_i K_i}, \quad (11)$$

where A_i and RD_i are the advertising and R&D outlays in industry i.

5 Specification and Estimation Issues

Our basic hypothesis is that contestable markets, as signified by low sunk costs, yield an efficient (cost-minimizing) market structure characterized by a tight distribution of firms around the optimum; i.e., contestability will reduce the dispersion of firm sizes. Because tangible sunk costs can be proxied more easily than can intangible ones, we will first estimate the impact of tangible sunk costs. Thus, our basic model takes the form:

$$\Omega_i = f(SUNK_i) = f(REN_i, DEP_i, RES_i), \quad (12)$$

where Ω_i is firm size dispersion and $REN_i = \dfrac{RK_i}{r_i K_i}$ is the intensity of the rental market, $DEP_i = d_{ki}^\tau$ is the rate of depreciation, and $RES_i = \dfrac{UK_i}{UK_i + NK_i}$ is the intensity of the resale market for the capital employed in industry i. Given that our model is not explicit as to the functional form of f, we adopt the flexible form

$$\Omega_i = f(SUNK_i) = \zeta_0 SUNK_i^{\zeta_1} \qquad\qquad \zeta_0, \zeta_1 > 0, \quad (13)$$

which taking into account (8) reduces to

$$\Omega_i = \zeta_0 \gamma^{\zeta_1} (1 - REN_i)^{\zeta_1} (1 - DEP_i)^{\zeta_1} RES_i^{-\delta\zeta_1}. \quad (14)$$

We first focus on the measure of dispersion defined in (2). Setting $\dfrac{\bar{Q}_{mi} - \bar{Q}_i}{Q_i}$ equal to Ω_i in (14) points to the estimating equation

$$C_{mi} - \frac{m}{N_i} = b_0(1 - REN_i)^{b_1}(1 - DEP_i)^{b_2} RES_i^{b_3} e^{u_i}, \quad (15)$$

where as before C_{mi} is the m-firm concentration ratio and N_i is the number of operating firms in industry i. The u_i are assumed to be independently and identically distributed random variables with zero mean and variance σ_u^2. The multiplicative stochastic terms specification is chosen because REN_i, DEP_i, and RES_i are measured with error and therefore a purely additive stochastic specification would be inappropriate. A comparison of (2), (14), and (15) indicates the following relationships between the estimating coefficients and the parameters of the model:

$$b_0 = m\zeta_0\gamma^{\zeta_1}, b_1 = b_2 = \zeta_1, \text{ and } b_3 = -\delta\zeta_1. \qquad (16)$$

Thus, with respect to (15) the hypothesis of interest is:

$$H_{01} : b_1 = b_2 \text{ against } H_{11} : b_1 \neq b_2. \qquad (17)$$

In addition, it should be noted that the parameter δ measuring the elasticity of sunkenness is identified but not the parameter γ. The role of contestability in tightening the distribution will be supported if the estimated coefficients b_1 and b_2 are significantly positive and b_3 is significantly negative.

The potential role of contestability in tightening the size distribution of firms can be assessed more accurately by utilizing the measure of dispersion $V_i(s)$ which represents the variance of market shares in industry i. Thus, setting Ω_i equal to $V_i(s)$ in (14) points to the estimating equation

$$V_i(s) = c_0(1 - REN_i)^{c_1}(1 - DEP_i)^{c_2}RES_i^{c_3}e^{\epsilon_i}, \qquad (18)$$

where the error components ϵ_i are assumed to be distributed according to $N(0, \sigma_\epsilon^2)$. The contestability hypothesis will be supported if c_1 and c_2 are significantly positive while c_3 is significantly negative. A comparison of (14) and (18) indicates that with respect to (18) the hypothesis of interest is:

$$H_{02} : c_1 = c_2 \text{ against } H_{12} : c_1 \neq c_2. \qquad (19)$$

To evaluate the potential impact of intangible sunk costs and taking into account (11), (15), and (18), we adopt the parsimonious specifications

$$C_{mi} - \frac{m}{N_i} = a_0 + a_1(1 - REN_i)(1 - DEP_i)RES_i^{a_2} + a_3\frac{A_i}{\beta_i K_i} + a_4\frac{RD_i}{\beta_i K_i} + \nu_i \quad (20)$$

and

$$V_i(s) = d_0 + d_1(1 - REN_i)(1 - DEP_i)RES_i^{d_2} + d_3\frac{A_i}{\beta_i K_i} + d_4\frac{RD_i}{\beta_i K_i} + \xi_i, \qquad (21)$$

where the error components ν_i and ξ_i are assumed to be distributed according to

$N(0, \sigma_\nu^2)$ and $N(0, \sigma_\xi^2)$ respectively.

6 Data and Measurement Issues

Equations (15) and (18) are fit to 1982, 1987, and 1992 Census and Annual Survey of Manufactures (ASM) data on four-digit US manufacturing industries. After 1992,

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the Census ceased reporting the classification of capital expenditures into new and used. Thus, after that year, proxies for the intensity of the resale market RES could not be constructed. However, even in 1992, it is not possible to construct RES for a large number of industries. To ensure that the three cross-sections are comparable in terms of their sample size, the variables used for the 1992 cross-section are averages of 1987 and 1992. Summary statistics for the key variables are provided in the appendix.

Under rental payments, RK, manufacturing establishments are requested to report payments made for the use of all items for which depreciation reserves would be maintained if they were owned by the establishment–e.g., structures and buildings, production equipment and transportation equipment. Establishments also report: the depreciation, DK, charged during the year against fixed assets; their new expenditures for buildings and equipment NK; the value of all used plant and equipment UK purchased during the year; and their fixed depreciable assets K. To facilitate estimation, we drop r since it is just a normalization.[9] We also restrict the length of the period τ at the end of which the entrant exercises its disinvestment option, to being the same across industries and set it equal to one year. Then, we can compute the following proxies: $REN = \dfrac{RK}{K}$; $DEP = \dfrac{DK}{K}$; and $RES = \dfrac{UK}{UK + NK}$.

To estimate equation (15), we set $m = 4$ and thus employ the four-firm concentration ratio C_4. These concentration ratios were taken unadjusted from the Census listings. For each four-digit industry, the Census also reports the values of the truncated Herfindahl index H, representing the sum of squared market shares of the largest 50 firms in the industry or the entire universe, whichever is lower. The census also reports the values of the 50-firm concentration ratio C_{50}. From the values of H and C_{50} we can derive $V(s)$, the variance of market shares of the largest 50 firms or the entire universe, whichever is lower. This will permit us to estimate equation (18). It can be easily shown that[10]

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[9] It should be noted that dropping r leads to a change in units and could affect the testing of H_{01} in (17) and H_{02} in (19) . Moreover, established firms are more likely to buy their own capital, so $(1 - \dfrac{RK}{rK})$ is likely to overstimate sunkenness.

[10] The variance of market shares of the largest N firms in an industry is given by

$V(s) = \dfrac{1}{N}\sum_{j=1}^{N}(s_j - \bar{s})^2 = \dfrac{1}{N}(H_N + N\bar{s}^2 - 2\bar{s}C_N) = \dfrac{1}{N}(H_N - \dfrac{C_N^2}{N})$ where $H_N = \sum_{j=1}^{N} s_j^2$, $\bar{s}$ is the

average market share of the largest N firms, and $C_N = \sum_{j=1}^{N} s_j$. If an industry contains more than 50 firms, then we compute the variance of the market shares of the largest 50 firms from the values of the truncated Herfindahl index H_{50} and the 50-firm concentration ratio C_{50} that are reported by the census, i.e., $V(s) = \dfrac{1}{50}(H_{50} - \dfrac{C_{50}^2}{50})$. If, on the other hand, an industry contains N firms where $N < 50$, then $C_N = 1$ and $V(s) = \dfrac{1}{N}(H_N - \dfrac{1}{N})$.

$$V(s) = \frac{1}{50}\left[H_{50} - \frac{C_{50}^2}{50}\right] \text{ if } N \geq 50 \tag{22}$$

$$= \frac{1}{N}\left[H_N - \frac{1}{N}\right] \text{ if } N < 50,$$

where $H_N = \sum_{j=1}^{N} s_j^2$.

For advertising we employ the 1982, 1987, and 1992 input-output tables from the Bureau of Economic Analysis (BEA). Two input industries are used to calculate advertising: advertising, and signs and advertising displays. We supplement the advertising data from input-output tables with data from Schonfeld & Associates.

7 Empirical Findings

We first focus on assessing the impact of tangible sunk costs. Table 1 presents the ordinary least squares (OLS) estimates of equations (15) and (18), along with the values of the ordinary and adjusted R^2 statistics. As noted above, to estimate (15) we employ the four-firm concentration ratio, thus setting $m = 4$. Separate regressions were estimated for the census years 1982, 1987, and 1992. Overall, these results strongly support the hypothesis that sunk costs influence the size distribution of firms.

The results of equation (15) indicate that the intensities of the rental and second-hand markets and the rate at which capital depreciates are significant determinants of $\frac{\bar{Q}_{4i} - \bar{Q}_i}{\bar{Q}_i}$, the difference in mean size between the four largest and all firms in industry i. We find that the stronger is the second-hand market for the capital employed in an industry, the faster is the rate at which such capital depreciates, and the easier is the leasing of that capital (i.e., the lower is the sunkenness of the capital employed in the industry), the smaller is the dispersion in firm size within the industry. Moreover, the parametric restrictions implied by the model are not rejected by these data, which provides a measure of confidence in the model and the measure of sunkenness proposed in (8). The likelihood ratio test indicates that the maintained hypothesis $H_{01} : b_1 = b_2$ is not rejected at the 5 percent level in all three temporal cross-sections (1982, 1987, and 1992).[11]

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[11] For the 1982 cross-section, $F = .07 < F_{1,396}^{.95} = 3.87$, and the probabality level at which a standard F-test rejects the restriction is .79; for 1987, $F = .07 < F_{1,426}^{.95} = 3.86$ and the probability level at which a standard F-test rejects the restriction is .78; for 1992, $F = .18 < F_{1,425}^{.95} = 3.86$, and the probability level at which the standard F-test rejects the restriction is .67.

Table 1 OLS Estimates of the Determinants of Dispersion in Firm Sizes

Equation (15): $\quad C_{4i} - \dfrac{4}{N_i} = b_0(1 - REN_i)^{b_1}(1 - DEP_i)^{b_2}RES_i^{b_3}e^{u_i}$

Parameter Estimates	b_0	b_1	b_2	b_3	
1982 cross-section	56.83***	6.89***	7.53***	-.09***	$R^2 = .25$
	(1.83)	(1.32)	(1.50)	(.02)	$\bar{R}^2 = .25$
1987 cross-section	25.28***	5.03***	4.37***	-.29***	$R^2 = .30$
	(1.02)	(1.10)	(1.57)	(.03)	$\bar{R}^2 = .29$
1992 cross-section	21.76***	3.83***	2.93*	-.32***	$R^2 = .28$
	(1.06)	(.82)	(1.58)	(.03)	$\bar{R}^2 = .27$

Equation (18): $\quad V_i(s) = c_0(1 - REN_i)^{c_1}(1 - DEP_i)^{c_2}RES_i^{c_3}e^{\epsilon_i}$

Parameter Estimates	c_0	c_1	c_2	c_3	
1982 cross-section	1.17***	11.74***	17.19***	-.24***	$R^2 = .23$
	(.22)	(2.84)	(3.56)	(.06)	$\bar{R}^2 = .22$
1987 cross-section	3.00***	11.61***	10.67***	-.72***	$R^2 = .31$
	(.87)	(2.63)	(3.75)	(.07)	$\bar{R}^2 = .30$
1992 cross-section	1.93*	8.55***	(6.10)*	-.79***	$R^2 = .29$
	(1.02)	(1.87)	(3.66)	(.08)	$\bar{R}^2 = .28$

Number of Observations = 400 in 1982, 430 in 1987, 429 in 1992

Standard Errors in Parentheses; ***$p < .01$, **$p < .05$, *$p < .1$

The significance of the effect of contestability in tightening the size distribution of firms is also confirmed by the analysis of a more accurate measure of dispersion that is derived from (4). The estimates from equation (18) indicate that the factors that determine the sunkenness of capital are also important determinants of firm size dispersion, as measured by the variance of the market shares of the largest 50 firms in each industry. We find again that the lower is the sunkenness of the capital that is employed in an industry, the smaller is the dispersion and hence, the tighter is the distribution of firms around the optimum. The parametric restrictions that are implied by the model are confirmed by these data. Indeed, the maintained hypothesis $H_{02} : c_1 = c_2$ is not rejected at the 5 percent level in all three temporal cross-sections.[12]

Table 2 presents estimates of (15) and (18) using the pooled data from the 1982, 1987, and 1992 censuses. Both OLS and the asymptotically more efficient

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[12]For the 1982 cross-section, $F = .07 < F_{1,396}^{.95} = 3.87$, and the probability level at which a standard F-test rejects the restriction is .79; for 1987, $F = .03 < F_{1,426}^{.95} = 3.86$, and the probability level at which a standard F-test rejects the restriction is .87; for 1992, $F = .25 < F_{1,425}^{.95} = 3.86$, and the probability level at which a standard F-test rejects the restriction is .62.

feasible generalized least squares (FGLS) were employed. The null hypothesis of homoscedasticity is not rejected at conventional levels of significance.[13] However, the test derived by Wooldridge (2002), suggests that the null hypothesis of no first-order autocorrelation is rejected in favor of AR(1).[14] The inferences drawn from the 1982, 1987, and 1992 temporal cross-sections are supported by the pooled data. Both OLS and FGLS regressions produce statistically significant parameter estimates. We again find that firm size dispersion decreases with increasing levels of rental and resale market activity and higher rates of capital depreciation. When (15) and (18) are estimated with OLS, the maintained hypotheses $H_{01} : b_1 = b_2$ and $H_{02} : c_1 = c_2$ are not rejected at the 5 percent level.[15] However, we do note a difference in the estimated parameters when equations (15) and (18) are estimated with OLS and when they are estimated with FGLS. This is not surprising since OLS and FGLS are different estimation procedures; and, in any case, it is not easy to determine whether such differences are statistically significant.[16]

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[13]We perform the Bickel (1978) version of the Breusch-Pagan test on (18). This tests for both within and between heteroscedasticity. We regress the squared residuals on $\kappa-$powers of the predictions: for $\kappa = 5$, $F =1.03$ and $Prob > F = .39$. Thus for $\kappa = 5$, the null hypothesis of homoscedasticity cannot be rejected at the 5% level. For $\kappa = 6$ to 10, we find that the null hypothesis of homoscedasticity cannot be rejected at the 10% level.

[14]When we apply the Wooldridge test on (18) we obtain $F = 57.31$ and $Prob > F = 0.00$.

[15]For H_{01}, $F = .73 < F_{1,819}^{.95} = 3.85$, and the probabality level at which a standard F-test rejects the restriction is .39; for H_{02}, $F = 1.09 < F_{1,819}^{.95} = 3.85$, and the probabality level at which a standard F-test rejects the restriction is .30.

[16]In the presence of serial correlation, FGLS is preferred because it is more efficient and its test statistics are at least asymptotically valid.

Table 2 OLS and FGLS Estimates of the Determinants of Dispersion in Firm Sizes
(pooled 1982, 1987, and 1992 data)

Equation (15): $\quad C_{4i} - \dfrac{4}{N_i} = b_0(1 - REN_i)^{b_1}(1 - DEP_i)^{b_2}RES_i^{b_3}e^{u_i}$

Parameter Estimates	b_0	b_1	b_2	b_3	
OLS	20.09***	2.57***	1.99***	-.23***	$R^2 = .20$
	(.54)	(.41)	(.45)	(.02)	$\bar{R}^2 = .20$
FGLS	25.53***	1.63***	.88***	-.10***	
	(.39)	(.31)	(.29)	(.02)	

Equation (18): $\quad V_i(s) = c_0(1 - REN_i)^{c_1}(1 - DEP_i)^{c_2}RES_i^{c_3}e^{\epsilon_i}$

Parameter Estimates	c_0	c_1	c_2	c_3	
OLS	1.77***	5.86***	4.21***	-.55***	$R^2 = .19$
	(.56)	(.96)	(1.05)	(.05)	$\bar{R}^2 = .19$
FGLS	3.19***	3.72***	1.67**	-.23***	
	(.35)	(.73)	(.68)	(.04)	

Number of Observations = 828

Standard Errors in Parentheses; ***$p < .01$, **$p < .05$, *$p < .1$

In assessing the impact of intangible sunk costs on firm size dispersion, we limit our attention to advertising. The potential role of R&D could not be evaluated due to insufficient data. Table 3 presents the nonlinear least squares estimates of the parameters in equations (20) and (21). We find that in all temporal cross-sections, a_1 and d_1 are significantly positive and a_2 and d_2 are significantly negative. These parameter estimates once again confirm the role of contestability, as signified by low tangible sunk costs, in tightening the distribution of firms. We also find that a_3 and d_3 are significantly positive in all temporal cross-sections, with the exception of d_3 in 1992. Thus, higher levels of advertising intensity are associated with increased firm size dispersion.

These findings could be interpreted as implying that advertising gives rise to a sunk cost barrier, and thus it augments the role of tangible sunk costs in reducing market contestability and in allowing inefficient industry configurations characterized by a large dispersion of firm sizes around the optimum to persist. However, our finding that a_3 and d_3 are significantly positive is also consistent with the view that advertising may allow firms to operate in differentiated product niches and away from the minimum point of the average cost curve without being vulnerable to displacement by potential entrants.

Table 3 Nonlinear OLS Estimates of the Determinants of Dispersion in Firm Sizes (tangible and intangible sunk costs)

Equation (20):
$$C_{mi} - \frac{m}{N_i} = a_0 + a_1(1 - REN_i)(1 - DEP_i)RES_i^{a_2} + a_3\frac{A_i}{\beta_i K_i} + \nu_i$$

Parameter Estimates	a_0	a_1	a_2	a_3
1982 cross-section	-214.35***	268.80***	-.01***	28.21***
	(36.38)	(40.38)	(.004)	(9.96)
1987 cross-section	-103.26***	129.02***	-.07***	17.96**
	(23.23)	(25.79)	(.01)	(8.52)
1992 cross-section	-124.06***	154.55***	-.06***	44.22***
	(23.75)	(26.83)	(.01)	(12.54)

Equation (21):
$$V_i(s) = d_0 + d_1(1 - REN_i)(1 - DEP_i)RES_i^{d_2} + d_3\frac{A_i}{\beta_i K_i} + \xi_i$$

Parameter Estimates	d_0	d_1	d_2	d_3
1982 cross-section	-136.72***	155.11***	-.02***	20.00**
	(33.25)	(36.88)	(.008)	(9.10)
1987 cross-section	-68.12***	68.94***	-.09***	14.02***
	(15.09)	(16.56)	(.019)	(5.54)
1992 cross-section	-120.48***	127.38***	-.06***	26.03
	(33.82)	(38.10)	(.02)	(18.47)

Number of Observations = 241 in 1982, 291 in 1987, 311 in 1992

Standard Errors in Parentheses; ***$p < .01$, **$p < .05$, *$p < .1$

8 Robustness Analysis

This paper's key testable hypothesis is that contestability tightens the distribution of firms around the optimum. The extent to which costs are sunk is central to the contestability of markets. Thus, there is an implied causal link between the variables that determine the sunkenness of the industry's capital–i.e., the rate of depreciation and the intensity of the rental and resale markets–and the dispersion of firm sizes in the industry. However, one potential objection to our interpretation of these results is that the variables that determine sunkenness might themselves be affected by market structure–i.e., that a reverse causal link might be present in the estimated relationships. In exploring the potential reverse causation, it will be easier to focus on equation (15).

The available empirical evidence does not support the conjecture that there are significant differences in the choice of accounting policies with respect to depreciation

by firms in concentrated and unconcentrated industries (Hagerman and Senbet, 1976; Zmijewski and Hagerman, 1981). In fact, if there is any relationship at all, it suggests that a larger percentage of firms in very concentrated industries use more frequently accelerated depreciation in comparison to firms in unconcentrated industries, pointing to a probable positive correlation between concentration and depreciation. This finding seems to rule out the possibility that our established negative relationship between concentration and depreciation in equation (15) is driven by an accounting bias.

One may plausibly argue that the intensities of the rental and resale markets are apt to be higher in industries that are large. If concentration and industry size are negatively correlated, then the possibility arises that the established correlation between concentration and the rental and resale market variables is spurious – there may be an omitted variable (industry size) that is correlated with both the concentration and the rental and resale market variables, and with different causal implications. When we use industry sales as a measure of industry size, we find that the correlations between size and concentration, and also between size and rental and resale variables, are very weak or insignificant. We can therefore rule out the possibility that the correlation between the dispersion in firm size and the rental and resale variables arises because industry size (as measured by industry sales) determines the intensities of the rental and resale markets, and industry size is strongly correlated with concentration.

Finally, one may argue that technology causes an industry to have a large number of small firms, many of which are undercapitalized and therefore must rent. This possibility would again suggest that the causation runs in the opposite direction. However, we find that the correlation between the rental variable REN_i and capital intensity as measured by the capital-sales ratio is statistically insignificant. In addition, if the rental variable serves as a proxy for technology in equation (15), its effect should fade into insignificance once technology is controlled for. However, there is no statistically significant shift in the estimated coefficient of the rental variable when technology is controlled for by introducing MES into the concentration equation.[17] Hence, a potential omitted variables problem related to technology must also be ruled out.

Sunk costs can have both industry-specific and firm-specific components (Ghosal, 2009). Our measure of sunkenness is based on industry-specific variables. We do not have information to construct meaningful proxies for firm-specific sunk costs. Thus, there is an implicit assumption that the capital employed by all firms (small and large) in an industry and potential entrants is characterized by the same degree of sunkenness. In some industries, the firm-specific component of sunk costs

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[17] These results are available from the authors upon request.

could be important, and our proxies of sunkenness are likely to contain significant measurement errors. Such mismeasurement leads to inconsistent estimates and to potential attenuation bias.

Our model and its measure of sunkenness lead to tightly specified equations (15) and (18). Still, it would be important to assess the robustness of our empirical findings to alternative functional specifications of the basic estimating equations. For this we adopt a simple linear specification where the dependent variable as well as all explanatory variables appear in their natural form. For 1982, we obtain the following parameter estimates (standard errors in parentheses):

$$C_{4i} - \frac{4}{N_i} = \quad 73.95^{***} \quad -195.55^{***} \, REN_i \quad -375.01^{***} \, DEP_i \quad -23.84^{**} \, RES_i \quad \bar{R}^2 = .21$$
$$(4.29) \qquad (45.40) \qquad\qquad (59.13) \qquad\qquad (9.68)$$
$$V_i(s) = \quad 29.87^{***} \quad -78.83^{***} \, REN_i \quad -199.38^{***} \, DEP_i \quad -13.07^{**} \, RES_i \quad \bar{R}^2 = .13$$
$$(2.95) \qquad (27.81) \qquad\qquad (40.51) \qquad\qquad (6.11)$$

Thus, we again find that there is a statistically significant relationship between the variables determining sunkenness and firm size dispersion.[18]

The main focus of this paper has been to assess the impact of tangible sunk costs on firm size dispersion. We have also made an effort to take into account intangible sunk costs. Still, it would be important to ascertain whether the omission of intangible sunk costs from our basic estimating equations gives rise to a significant bias. Overall, we do not find a significant difference in the parameter estimates for REN_i, DEP_i, and RES_i when intangible (advertising) sunk costs are included in or excluded from (15), (18), (20), and (21). When we do find a difference, it appears that the statistical significance and quantitative importance of the variables that determine tangible sunk costs are actually enhanced when intangible sunk costs are taken into account. For example, in Table 3, when advertising is omitted from (20) and (21), we obtain the following parameter estimates (standard errors in parentheses) for 1982:

$a_0 = -190.55(35.91)$, $a_1 = 245.64(40.13)$, $a_2 = -.013(.005)$; $d_0 = -119.68(32.62)$, $d_1 = 138.51(36.40)$, $d_2 = -.021(.009)$. A comparison with the parameter estimates in Table 3 reveals that the effects of REN_i, DEP_i, and RES_i are more pronounced when advertising sunk costs are taken into account. Moreover, when we divide our sample into consumer and producer goods industries, we find no statistically significant difference in the effects of the variables that determine sunk costs (tangible and

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[18]We also find highly statistically significant relationships in the 1987 and 1992 cross-sections.

intangible) across the two groups.[19]   Also, the inclusion of the capital/sales variable makes no significant difference in the estimated coefficients of REN_i, DEP_i, and RES_i.

We have employed influence diagnostic techniques to identify observations that could be considered as outliers with respect to the true underlying regression model or observations that exert a strong influence on the position of the fitted regression. Our regression diagnostics rule out the possibility that our results are driven by a few outliers.

9 Summary

The evidence that is presented in this paper indicates that increased market contestability, as signified by low sunk costs, tends to reduce the dispersion of firm sizes.

One of the key predictions of the theory of contestable markets is that market forces under contestability would tend to render any inefficient organization of the industry unsustainable, and consequently, tighten the distribution of firms around the optimum.   The extent to which an industry is contestable depends on the sunkenness of the capital that it employs.[20]   Thus sunk costs should give rise to an important non-stochastic component in the forces determining size inequalities.[21] Other theoretical models also suggest that sunk costs are an important dimension of barriers to entry and have important effects on market structure.   The empirical testing of these predictions, however, has been hindered by the lack of industry-level, and especially firm-level, data on sunk costs.

We employ industry-level data to construct meaningful proxies for sunkenness and thus directly to quantify contestability.   These proxies are based on reported measures of the intensities of the second-hand and lease markets for the industry's capital and the rate at which that capital depreciates.   We find that the stronger is the resale market for the capital employed in a given industry, the easier it is to lease such capital; and the more rapidly that it depreciates (i.e., the lower is sunkenness),

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[19]We first used A/S (advertising-to-sales) ratio of .01 as the cutoff point in separating the sample. We subsequently employed the Chow test to test for the equality of coefficients across the two sub-samples in (15), (18), (20), and (21). For example, for the 1982 cross section with A/S included in the right-hand side of (15), the Chow $F = .21 < F_{4,242}^{.95} = 2.41$, and the probability level at which the F-test rejects the equality of coefficients across the two sub-samples is .93; similarly, in (18) the Chow $F = .33 < F_{4,242}^{.95} = 2.41$, and the probability level at which the F-test rejects the equality of coefficients is .85.

[20]We have employed the estimated values of c_1, c_2, and c_3 in (18) to construct an index of sunkenness for the 4-digit U.S. manufacturing industries.   This ranking of sunkenness is available from the authors upon request.

[21]Cabral (1995) examines the role of sunk costs in the context of a theoretical model analyzing the relationship between firm growth and firm size.

the smaller is firm size dispersion within the industry. These findings are robust to alternative measures of firm size dispersion, the time period chosen, estimation procedures, and functional specification. Both tangible and intangible sunk costs have a statistically significant influence on the size distribution of firms.

This paper provides indirect support for one of the most fundamental welfare properties of contestable markets: the absence of any sort of inefficiency in production in industry equilibrium. Incumbents whose outputs differ substantially from the minimum scale of operation cannot withstand the pressure of potential entrants who, in the presence of low sunk costs, can effectively exploit the opportunities offered by the presence of inefficiency and waste in production through hit-and-run entry. Thus the forces of contestability, facilitated by low sunk costs, continuously work to weed out inefficient firms through a process of "creative destruction". Our findings provide specific guidance for the design of appropriate public policies towards investment and changes in regulatory regimes to enhance the contestability of markets. Accelerated depreciation policies, favorable tax treatment of leasing operations, and the removal of regulatory restrictions on the types of capital (e.g., new versus used) deployed by entrants are some obvious candidates.[22]

Appendix

Our sample consists of all 4-digit U.S. manufacturing industries for which a complete set of variables could be obtained. Since the estimation of our basic equation entails a logarithmic transformation, some industries were eliminated because of zero values of the RES variable.[23] Industries were also excluded because: they were badly defined; their data were not comparable to prior years due to changes in industry classification; data on DEP and RES were not available, or did not meet census publication standards. Our final sample consisted of: 400 industries in 1982, 430 in 1987, and 367 in 1992. In the pooled data, we eliminated those industries that do not appear in all three (1982, 1987, and 1992) census years. The final sample consisted of 828 observations.

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[22]For example, two decades ago, entrants into ocean shipping in Peru were required to employ new rather than used vessels if they were to be accorded a national carrier status.

[23]However, under a linear specification where such zero values are permitted, their exclusion does not appear to introduce a bias.

Summary Statistics

	1982		1987		1992	
Variable	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
DEP	.07	.02	.08	.02	.08	.02
REN	.03	.02	.03	.02	.04	.03
RES	.11	.11	.10	.07	.09	.05
$\frac{A}{K}$	.09	.11	.08	.10	.06	.09
$V(s)$	13.71	23.63	13.11	21.77	11.37	15.84
$C_4 - \frac{4}{N}$	37.86	18.39	37.27	19.03	37.03	18.06

Spearman Correlation

Correlation between	1982 and 1987	1987 and 1992	1982 and 1992
DEP	.66	.59	.50
REN	.89	.90	.84
RES	.22	.43	.25
$\frac{A}{K}$	.90	.56	.57
$V(s)$	.93	.94	.88
$C_4 - \frac{4}{N}$	.93	.95	.90

Number of observations=400 in 1982, 430 in 1987, 367 in 1992

(for $\frac{A}{K}$: 274 in 1982, 320 in 1987, 283 in 1992)

References

[1] Aslan, A. (2008). Testing Gibrat's law: empirical evidence from panel unit root tests of Turkish firms. *International Research Journal of Finance and Economics, 16*, 137-142.

[2] Baumol, W. (1982). Contestable markets: an uprising in the theory of industry structure. *American Economic Review, 72*(1), 1-15.

[3] Baumol, W., & Fischer, D. (1978). Cost-minimizing number of firms and determination of industry structure. *Quarterly Journal of Economics, 92*, 439-467.

[4] Baumol, W., Panzar, J., & Willig, R. (1982). *Contestable markets and the theory of industry structure*. San Diego: Harcourt Brace Jovanovich.

[5] Berry, S., & Reiss, P. (2007). Empirical models of entry and market structure. In M. Armstrong & R. Porter (eds.), *Handbook of industrial organization*, vol. III. Netherlands: Elsevier Science Publishers.

[6] Bickel, P. (1978). Using residuals robustly I: tests for heteroscedasticity, nonlinearity. *Annals of Statistics, 6*, 266-291.

[7] Cabral, L. (1995). Sunk costs, firm size and firm growth. *The Journal of Industrial Economics, XLIII*(2), 161-172.

[8] Cabral, L., & Ross, T. (2008). Are sunk costs a barrier to entry? *Journal of Economics and Management Strategy, 17*(1), 97-112.

[9] Cefis, E., Ciccarelli, M., & Orsenigo, L. (2007). Testing Gibrat's legacy: a Bayesian approach to study the growth of firms. *Structural Change and Economic Dynamics, 18*(3), 348-369.

[10] Chen, J., & Lu, W. (2003). Panel unit root tests of firm size and its growth. *Applied Econometrics Letters, 10*(6), 343-345.

[11] Davies, S., & Lyons, B. (1982). Seller concentration: the technological explanation and demand uncertainty. *The Economic Journal, 92*, 903-919.

[12] de Wit, G. (2005). Firm size distributions: an overview of steady-state distributions resulting from firm dynamics models. *International Journal of Industrial Organization, 23*, 423-50.

[13] Del Monte, A., & Papagni, E. (2003). R&D and the growth of firms: an empirical analysis of a panel of Italian firms. *Research Policy, 32*(6), 1003-1014.

[14] Gabaix, X. (1999). Zipf's law for cities: an explanation. *The Quarterly Journal of Economics,114*(3), 739-767.

[15] Geroski, P., Lazarova, S., & Walters, F. (2003). Are differences in firm size transitory or permanent? *Journal of Applied Econometrics, 18*(1), 47-59.

[16] Gibrat, R. (1931). *Les inegalites economiques.* Paris: Sirey.

[17] Ghosal, V. (1996). Does uncertainty influence the number of firms in an industry? *Economics Letters, 50*, 229-236.

[18] Ghosal, V. (2003a). Impact of uncertainty and sunk costs on firm survival and industry dynamics. Wissenschaftszentrum Berlin für Sozialforschung, Markets and Political Economy Working Paper No. SP II 2003-12. Retrieved from http://bibliothek.wzb.eu/pdf/2003/ii03-12.pdf.

[19] Ghosal, V. (2003b). Firm and establishment volatility: the role of sunk costs, profit uncertainty and technological change. CESifo Working Paper No. 980. Retrieved from http://www.cesifo-group.de/DocCIDL/cesifo_wp980.pdf.

[20] Ghosal, V. (2007). Small is beautiful but size matters: the asymmetric impact of uncertainty and sunk costs on small and large businesses." MPRA Paper No. 5461. Retrieved from http://mpra.ub.uni-muenchen.de/5461/1/MPRA_paper_5461.pdf.

[21] Ghosal, V. (2009). The role played by sunk costs in real-options models. 10th CESifo Venice Summer Institute, 6-11 July 2009. Retrieved from http://www.cesifo-group.de/link/vsi09_ou_Ghosal.pdf.

[22] Hagerman, R., & Senbet, L. (1976). A test of accounting bias and market structure. *Journal of Business, 46*, 509-514.

[23] Helfat, C. (1994). Firm-specificity in corporate applied research and development. *Organization Science, 5*(2), 173-184.

[24] Ijiri,Y., & Simon, H. (1977). *Skew distributions and the sizes of business firms.* Amsterdam: North-Holland.

[25] Kalecki, M. (1945). On the Gibrat distribution. *Econometrica, 13*(2), 161-170.

[26] Kelly, W. (2001). A generalized interpretation of the Herfindahl index. *Southern Economic Journal, 48*(1), 50-57.

[27] Kessides, I. (1986). Advertising, sunk costs, and barriers to entry. *The Review of Economics and Statistics, 68*(1), 84-95.

[28] Kessides, I. (1990). Towards a testable model of entry: a study of the US manufacturing industries. *Economica, 57*, 219-238.

[29] Kwoka, J., & White, L. (2001). The new industrial organization and small business. *Small Business Economics, 16*(1), 21-30.

[30] Levy, M., & Solomon, S. (1996). Power laws are logarithmic Boltzmann laws. *International Journal of Modern Physics, C 7*(04), 595-601.

[31] Lotti, F., Santarelli, E., & Vivarelli, M. (2009). Defending Gibrat's law as a long-run regularity. *Small Business Economics, 32*(1), 31-44.

[32] Malcai, O., Biham, O., & Solomon, S. (1999). Power-law distributions and Levy-stable intermittent fluctuations in stochastic systems of many autocatalytic elements. *Physical Review, E 60*(2), 1299-1303.

[33] Martin, S. (1989). Sunk costs, financial markets, and contestability. *European Economic Review, 33*, 089-1113.

[34] Martin, S. (2000). The theory of contestable markets. Purdue University. Retrieved from http://www.krannert.purdue.edu/faculty/smartin/aie2/contestbk.pdf.

[35] Martin, S. (2002). *Advanced Industrial Economics.* Malden, Mass.: Blackwell Publishing.

[36] O'Brien, J., & Folta, T. (2009). Sunk costs, uncertainty and market exit: a real options perspective. *Industrial and Corporate Change, 18*(5), 807-833.

[37] Oliveira, B., & Fortunato, A. (2006). Testing Gibrat's law: empirical evidence from a panel of Portuguese firms. *International Journal of the Economics of Business, 13*(1), 65-81.

[38] Scherer, F., & Ross, D. (1990). *Industrial market structure and economic performance.* 3rd edn., Boston: Houghtn Mifflin.

[39] Schmalensee, R. (1989). Inter-industry studies of structure and performance. In R. Schmalensee and R. Willig (eds.), *Handbook of industrial organization,* vol. II. Netherlands: Elsevier Science Publishers.

[40] Simon, H. (1955). On a class of skew distribution functions. *Biometrika, 52,* 425-440.

[41] Simon, H. (1960). Some further notes on a class of skew distributions. *Information and Control, 3,* 80-88.

[42] Simon, H., & Bonini, C. (1958). The size distribution of business firms. *American Economic Review, 48*(4), 607-17.

[43] Steindl, J. (1965). *Random processes and the growth of firms: a study of the Pareto law.* London: Griffin and Company.

[44] Sutton, J. (1997). Gibrat's legacy. *Journal of Economic Literature, 35,* 40-59.

[45] Sutton, J. (1998). *Technology and market structure.* Boston: The MIT Press.

[46] Thomas, L. (1996). Advertising sunk costs and credible spatial preemption. *Strategic Management Journal, 17*(6), 481-498.

[47] White, L. (1981). What has been happening to aggregate concentration in the United States. *The Journal of Industrial Economics, XXIX(3),* 223-230.

[48] White, L. (1982). The determinants of the relative importance of small business. *The Review of Economics and Statistics, 64*(1), 42-49.

[49] White, L. (2002). Are giant companies taking over the U.S. economy? should we care? *Milken Institute Review,* Second Quarter, 60-68.

[50] Wooldridge, J. (2002). *Econometric analysis of cross section and panel data.* Boston: The MIT Press.

[51] Zmijewski, M., & Hagerman, R. (1981). An income strategy approach to the positive theory of accounting standard setting/choice. *Journal of Accounting and Economics, 3,* 129-149.