



# The industry life-cycle of the size distribution of firms <sup>☆</sup>

Emin M. Dinlersoz <sup>a,1</sup>, Glenn MacDonald <sup>b,\*</sup>

<sup>a</sup> Cornerstone Research, 1919 Pennsylvania Ave, NW, Suite 600, Washington, DC 20006, United States

<sup>b</sup> Olin Business School, Washington University in St. Louis, Campus Box 1133, One Brookings Drive, St. Louis, MO 63130-4899, United States

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## ABSTRACT

This paper analyzes the evolution of the distributions of output and employment across firms in U.S. manufacturing industries from 1963 until 1997. The firm size distribution changes significantly as an industry goes through stages of its life-cycle. The evolutions of the employment and output distributions also differ significantly, but display strong inter-industry regularities, including that the nature of the evolution depends on whether the industry is experiencing growth, shakeout, maturity, or decline. The observed patterns have implications for theories of industry dynamics and evolution.

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## 1. Introduction

The size distribution of firms has been the subject of a large body of theoretical and empirical research.<sup>2</sup> This attention is well-deserved because firm size distribution, measured appropriately and in conjunction with other data, can aid in understanding the degree and type of competition among firms. Knowledge of the general evolution of firm size heterogeneity is also relevant for any industry policy that may affect firms of different sizes disparately. Such policies include many types of regulation, taxation, subsidies, measures designed to influence job creation and destruction, and trade barriers like tariffs and quotas. So far, empirical work on the evolution of firm heterogeneity has been largely confined to the study of the time-path of industry concentration.<sup>3</sup> Concentration ratios used in these studies describe the entire size distribution using a single summary statistic. This approach is simple, intuitive, and adequate for many purposes. But it also dispenses with much useful information and can be misleading. A given change in a concentration ratio can be consistent with many types

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\* Corresponding author.

E-mail addresses: [edinlersoz@cornerstone.com](mailto:edinlersoz@cornerstone.com) (E.M. Dinlersoz), [macdonald@wustl.edu](mailto:macdonald@wustl.edu) (G. MacDonald).

<sup>1</sup> This paper was written in part when this author was affiliated with the Department of Economics of the University of Houston.

<sup>2</sup> See, e.g., Gibrat (1931), Simon and Bonini (1958), Ijiri and Simon (1964, 1974, 1977), and Lucas (1978); and more recently, Sutton (1991, 1997), Kumar et al. (2002), Axtell (2001), Rossi-Hansberg and Wright (2007).

<sup>3</sup> See, e.g., Mueller and Hamm (1974) and White (2002).

**Table 1**

Summary of trends in firm size statistics as a function of trend in industry firm count.

Statistic	Trend in industry firm count when industry output is growing:			
	Growing number of firms		Declining number of firms	
	Firm employment	Firm output	Firm employment	Firm output
Mean	-	+	+	+
Median	-	+	+	+
Standard Deviation (S.D.)	-	+	+	+
Coefficient of Variation (C.V.)	+	+	0	+
Skewness	+	+	-	-
Kurtosis	+	+	-	-

of changes in firm size distribution. By examining, instead, the behavior of the firm size distribution itself and several of its moments, we can offer more comprehensive evidence on the evolution of firm size heterogeneity.

Despite the importance of understanding the evolution of firm size distribution, not much is known about whether continuing firm turnover and growth during the life-cycle of an industry lead to a stable firm size distribution, or to one that exhibits significant changes, even for mature industries. When all U.S. firms are lumped together, the distribution of firm size (with size measured either by employment or value of output) changes little over time, and resembles a Pareto distribution.<sup>4</sup> In contrast, empirical findings on industry life-cycles, theoretical models of industry life-cycles and dynamics, and empirical patterns of firm and industry dynamics collectively suggest that the shape of the size distribution should change as an industry ages.<sup>5</sup> These evolutions may not be discernible under broad aggregations of firms. Analysis of narrowly defined industries is required to uncover whether the predicted evolutions are actually there.

In this paper, we explore the relationship between the evolution of the firm size distribution and the general evolution of an industry. Table 1 summarizes the most important findings which emerge from the detailed analysis to follow later. The table focuses on 218 (75%) of the 284 industries we study, namely those in which industry output increases steadily through the sample period, and in which firm numbers are either generally increasing (127 industries) or steadily decreasing (91 industries). Of the remaining industries, two-thirds also display increasing output but have no obvious trend in firm numbers, and the rest are dying industries in which both output and firm numbers are in decline.

Measuring firm size by *output*, both mean and median firm size increase over time irrespective of whether firm numbers are rising or falling. Moreover, heterogeneity among firms—as measured by either the standard deviation of output or the coefficient of variation—also grows irrespective of which time path firm numbers take. However, in those industries in which firm numbers are rising, the distribution of firm size becomes more “right skewed” (positive and increasing skewness) and more “fat tailed” (growing kurtosis), whereas the opposite is true where firm numbers are falling.<sup>6</sup>

Measuring firm size by *employment*, the story is quite different. For industries in which firm numbers are growing, mean and median firm size fall over time. Firm heterogeneity also shrinks, but by less than mean firm size, so that the coefficient of variation grows. The firm size distribution also becomes more right skewed and fat tailed. For industries in which firm numbers are falling, mean and median firm size grow over time. Firm heterogeneity also grows, and roughly as fast as mean firm size, so that the coefficient of variation shows no trend. However, the distribution becomes less right skewed with a thinner tail.

Altogether, (i) measures of skewness and tail thickness evolve in the same direction as firm numbers no matter how size is measured, (ii) when size is measured by output, measures of both typical firm size and heterogeneity increase steadily, irrespective of the pattern in firm counts, and (iii) when size is measured by employment, measures of both typical firm size and heterogeneity move in the direction opposite to the direction of firm counts.

Knowledge of how the moments of firm size change over time is useful for several reasons. The evolution of the standard deviation is important for understanding the evolution of firm size heterogeneity, which is critical for research on regulations and policies that differentially impact firms of varying sizes, e.g., policies intended to create jobs. The coefficient of variation is important because it quantifies how fast heterogeneity evolves relative to the evolution of average firm size. This information is helpful for untangling whether growth in heterogeneity is merely a by-product of firms' generally growing. Skewness, which captures the degree of asymmetry in firm size distribution, is a central and ubiquitous feature of firm size distributions. A highly positively skewed distribution may indicate that the mean is heavily influenced by a few large firms, even though they constitute a small fraction of all firms. Skewness can thus be viewed as a measure of inequality. In fact, for positively skewed distributions such as the log-normal distribution, skewness and the Gini coefficient, a frequently used measure of inequality, tend to move together; see, e.g., Bendel et al. (1989). In the context of positively-skewed distributions such as firm size distributions, kurtosis measures the thickness of the right tail and the height of the peak at the left of

<sup>4</sup> See, e.g., Ijiri and Simon (1964, 1974, 1977), Sutton (1997), and Axtell (2001). Axtell (2001) reports stability in firm employee size distribution in the form of a Zipf's Law for the entire population of U.S. firms. See also Rossi-Hansberg and Wright (2007) for a study of establishment (not firm) size dynamics and a discussion on the applicability of Zipf's Law.

<sup>5</sup> For empirical analysis of industry life-cycles, see, e.g., Gort and Klepper (1982) and Agarwal (1998). For theoretical models of industry evolution, see, e.g., Jovanovic (1982), Jovanovic and MacDonald (1994a, 1994b). For empirical patterns of firm growth, entry and exit, see, e.g., Dunne et al. (1988, 1989).

<sup>6</sup> As we discuss below, the rates of growth of the various moments of the firm size distribution do depend on whether firm numbers are rising or falling.

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