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DOES ENTRY SIZE MATTER? THE IMPACT OF THE LIFE CYCLE AND TECHNOLOGY ON FIRM SURVIVAL*

RAJSHREE AGARWAL† AND DAVID B. AUDRETSCH‡

A wave of empirical studies has recently emerged showing that smaller-scale entry is confronted with a lower likelihood of survival than their larger counterparts. The purpose of this paper is to examine whether the relationship between size of a firm when entering an industry and the likelihood of survival holds under different technological conditions and across the different stages of the industry life cycle. The empirical evidence suggests that the relationship between firm size and the likelihood of survival is shaped by technology and the stage of the industry life cycle. While the likelihood of survival confronting small entrants is generally less than that confronting their larger counterparts, the relationship does not hold for mature stages of the product life cycle, or in technologically intensive products. In mature industries that are still technologically intensive, entry may be less about radical innovation and possibly more about filling strategic niches, thus negating the impact of entry size on the likelihood of survival.

1. INTRODUCTION

A RICH BODY of empirical evidence, spanning numerous countries and time periods, has provided sufficient evidence for several leading scholars (Caves [1998], Sutton [1997], Geroski [1995]) to infer stylized facts and stylized relationships about the basic elements concerning firm dynamics and industry evolution, or the manner in which firms enter into an industry, grow or stagnate and ultimately survive or exit from the industry. The stylized facts emerging from the new literature have been sufficiently compelling as to contradict what was previously classified as a Law—Gibrat's Law, which assumes that firm growth is independent of size—and motivate an entire article in the *Journal of Economic Literature* by Sutton [1997], explaining how something as certain as a Law could be refuted when subjected to empirical scrutiny.

The reconciliation of the Law with the empirical evidence is based on

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what Geroski [1995] (p. 434) finds so convincing that it constitutes what he terms as a stylized result: 'Both firm size and age are correlated with the survival of entrants.' Because small firms have a lower likelihood of survival than their larger counterparts, and the likelihood of small-firm survival is directly related to growth, firm size is found to be negatively related to growth, thereby refuting Gibrat's Law.

While these relationships have now taken on the status of Stylized Results, they also challenge a number of other widely held theories in addition to Gibrat's Law. For example, the theory of small-firm strategic niches, posited by Porter [1979] and Caves and Porter [1977] argues that by occupying strategic niches, small firms do not need to grow in order to survive. Rather, small firms can remain small and avoid being confronted by a lower likelihood of survival by occupying a strategic niche.

The purpose of this paper is to reconcile these two views about the role of small firms in industry dynamics. We suggest that both views are, in fact, correct, but that each view tends to be specific for a particular phase of the industry life cycle, and to the technological intensity of the industry. What has emerged as a Stylized Result in Geroski's impressive review of the literature—that the likelihood of survival is greater for larger firms than for small firms—should hold in the formative stages of the life cycle but not in the mature stages, and in products that are relatively low in technological intensity. By contrast, the theory of strategic niches—which holds that firms can remain small and face no disadvantage with respect to the likelihood of survival—should hold in the mature phase of the life cycle, and in products characterized as high-technology.

In the second section of this paper, we present the theories and evidence suggesting that the likelihood of survival is positively related to firm size. In the third section, we link together recent theories and empirical evidence about the dynamics of firms over the industry life cycle and argue that the role of entrants evolves over the life cycle in such a way as to influence the post-entry performance of entrants. The data base, measurement issues and estimation techniques are presented in the fourth section. In the fifth section we compare survival and hazard rates for high-technology and low-technology firms over different stages of the industry life cycle. In the final section a summary and conclusions are provided.

II. ENTRY SIZE AND FIRM SURVIVAL

As both Geroski [1995] and Sutton [1997] emphasize in their surveys on intra-industry firm dynamics, a large body of empirical evidence has consistently found that the likelihood of firm survival is not independent of firm size. Virtually every study undertaken has found that firm size is positively related to the likelihood of survival. The only study that has not

confirmed a positive relationship is for the five new Bundesländer in the former East Germany, which is clearly a special case (Harhoff and Stahl [1994]).

As Sutton makes clear in his article, these studies are generally specified so that size in period t , typically the entry year, is linked to growth in the subsequent time period. This lagged specification follows from the basic assumption underlying Gibrat's Law, that the 'probability that the next opportunity is taken up by any particular active firm is proportional to the current size of the firm' (Sutton, 1997, p. 43). These studies span a wide range of time periods and countries, such as the United States (Dunne, Roberts and Samuelson [1988 and 1989], Audretsch [1991 and 1995], Audretsch and Mahmood [1995], Doms, Dunne and Roberts [1995], Agarwal [1997]); Canada (Baldwin [1995], Baldwin and Rafiquzzaman [1995]); Portugal (Mata, Portugal, and Guimaraes [1995], Mata and Portugal [1994]); and Germany (Wagner [1994]).

The major theoretical interpretation of the observed positive relationship between firm size and the likelihood of survival first builds on the model of noisy selection introduced by Jovanovic [1982] and extended by Ericson and Pakes [1998]. Jovanovic, and Ericson and Pakes present a theory in which the entrants face costs that are not only random but also differ across firms. A central feature of the models is that an entrant does not know its own cost structure. Rather, the relative efficiency of each entrant is discovered through the process of learning from actual market experience. The true ability of the managerial competence of the entrepreneurs is only discovered subsequent to entry into the industry. Those entrepreneurs who discover that their ability exceeds their expectations expand the scale of their business, whereas those discovering that their post-entry performance is less than commensurate with their expectations will contract the scale of output and possibly exit from the industry.

Thus, the major function of an entrant is to gain a toehold in the industry in order to provide a platform for learning about or discovering the viability of the ideas and competence upon which the firm was founded. Evidence from the United States (Audretsch [1995], Dunne, Roberts and Samuelson [1988 and 1989]); Portugal (Mata and Portugal [1994]) and Germany (Wagner [1994]) suggests that the mean size of entrants is remarkably small. While the minimum efficient scale (MES) varies substantially across industries, and even to some degree across various product classes within any given industry, the observed size of most new manufacturing firms is sufficiently small to ensure that the bulk of entrants are operating at a suboptimal scale of output.

An implication of the theory of firm selection is that firms may enter at a small, even suboptimal, scale of output and then, if merited by subsequent performance, expand. Those entrants that are successful will grow, whereas those that are not successful will remain small and may ultimately

be forced to exit from the industry if they are operating at a suboptimal scale of output.

The greater the entry size in a given industry, the less will be the cost disadvantage imposed by an inherent size disadvantage, and the greater will be the likelihood of survival confronting the new entrant. As Geroski (1995, p. 23) points out, 'Perhaps the most striking thing that we know about entry is that small-scale, *de novo* entry seems to be relatively common in most industries, but that small-scale, *de novo* entrants generally have a rather short life expectancy. That is, entry appears to be relatively easy, but survival is not.' This interpretation is certainly consistent with a second observation by both Sutton [1997] and Geroski [1995] drawn from the empirical literature testing the validity of Gibrat's law—firm growth is negatively related to size. The consequences of not growing, in terms of a cost disadvantage, are negatively related to entry size. The larger the size of the firm, the higher is the likelihood of survival for any given growth rate.

III. THE ROLE OF THE INDUSTRY LIFE CYCLE

Recent theories and empirical evidence (Agarwal and Gort [1996], Agarwal [1998], Klepper [1996], and Klepper and Miller [1995]) on industry evolution suggest that the role of entrants may not be invariant to the stage of the industry life cycle. Rather, the underlying reason motivating entry evolves over the life cycle of the industry. As Utterback and Anthony [1975] point out, in the formative stage of the life cycle, no singular product design or concept dominates the industry. Firms must experiment with the product design in short production runs, making significant modifications after observing consumer response. According to Williamson (1975, p. 215), 'The first or early formative stage involves the supply of a new product of relatively primitive design, manufactured on comparatively unspecialized machinery, and marketed through a variety of exploratory techniques. Volume is typically low. A high degree of uncertainty characterizes business experience at this stage.' Thus, in the formative stages of the life cycle, firms enter principally to compete for the dominant product design for that industry.

By contrast, as the industry evolves towards the mature and declining stages, the product design becomes more standardized and uniform, and the premium attached to technological superiority recedes. According to Williamson (1975, p. 216), in the mature and declining stages, 'Management, manufacturing, and marketing techniques all reach a relatively advanced degree of refinement. Markets may continue to grow, but do so at a more regular and predictable rate. Established connections with customers and suppliers (including capital market access) all operate to buffer changes and thereby to limit large shifts in market shares. Significant innovations tend to be fewer and are mainly of an improvement

variety.' As Audretsch [1995] shows, mature industries, such as automobiles, tend to be characterized by a relatively low ratio of new product innovations per R&D dollar expended. By contrast, emerging industries are characterized by a high ratio of new product innovations relative to R&D expended. Agarwal [1998] finds that patenting activity increases in the initial stages of the life-cycle, and subsequently declines during the mature period.

Many of the recent conclusions about the role of entrants ignore the influence of the industry life cycle. But the industry life-cycle theory suggests that, in fact, the role of entry as a vehicle for new innovations evolves systematically over the life-cycle. This is because the underlying knowledge conditions vary systematically over the industry life cycle. In the mature and declining stages of the life cycle, new economic knowledge generating innovative activity is relatively routine and can be commercialized within the context of the incumbent hierarchical bureaucracies. By contrast, in the formative life cycle stages, innovations come from knowledge that is not of a routine nature and therefore tends to be rejected by the hierarchical bureaucracies of incumbent corporations. Nelson and Winter [1982] describe these different underlying knowledge conditions as reflecting two distinct technological regimes: 'An entrepreneurial regime is one that is favorable to innovative entry and unfavorable to innovative activity by established firms; a routinized regime is one in which the conditions are the other way around' (Winter [1984]).¹

Gort and Klepper [1982] argue that the relative innovative advantage between entrants and incumbent enterprises depends upon the source of information generating innovative activity. If information based on non-transferable experience in the market is an important input in generating innovative activity, then incumbent firms will tend to have the innovative advantage over entrants. This is characteristic of mature industries, where the accumulated stock of non-transferable information is the product of experience within the market—which, by definition, firms outside of the main incumbent organizations cannot possess.

By contrast, when information outside of the routines practiced by the incumbent firms is a relatively important input in generating innovative activity, entrants will have the innovative advantage over incumbent firms. Arrow [1962], Mueller [1976], and Williamson [1975] have all emphasized that when information created outside of the incumbent firms cannot be easily transferred to those incumbent enterprises, presumably due to agency and bureaucracy problems, the holder of such knowledge must enter the industry by starting a new firm in order to appropriate the expected value of that knowledge.

¹ See also Malerba and Orsenigo [1996], and Dosi *et al.* [1995].

There is considerable evidence that the role of innovation in motivating entrants varies between the entrepreneurial and routinized technological regimes (Audretsch [1995]). Because these technological regimes correspond to the formative and mature stages of the industry life cycle, entry is more likely to be based on innovative activity in the formative stages than in the mature stages. Thus, Geroski's [1995] pronouncement that 'entry is often used as a vehicle for introducing new innovations' certainly should reflect the formative stages of the industry life cycle but not the mature or declining stages. In the formative stage, entrants are vying for the dominant product design. While the likelihood is low, success brings subsequent high rates of growth.

By contrast, in the mature stage, the window of opportunity for setting product standards through innovative activity has been closed. Entry in the mature stage of the life cycle is less about (radical) innovative activity and more about occupying a strategic niche. The theories of Porter [1979], Caves and Porter [1977] and Newman [1978], that small and large enterprises co-exist simultaneously in an industry because of the ability of small firms to occupy strategic niches are most applicable in the mature phase of the life cycle.² According to the theory of strategic niches, firms can remain small and maintain levels of profitability in excess of those enjoyed by large firms by occupying product niches that are inaccessible to their larger counterparts. By occupying a strategic niche in the mature stage of the life cycle, an entrant is able to avoid the inherent scale disadvantages confronting small firms in earlier stages of the life cycle. Thus, size should be an advantage in reducing the likelihood of failure in the formative stages of the industry life cycle, but not in the mature phase. If this is not the case, and product differentiation plays a more important role prior to the emergence of a dominant design in the earlier life cycle stages, this should be verified by the failure of a statistical relationship to emerge between firm size and the likelihood of survival in the formative stages.

IV. DATA, MEASUREMENT AND ESTIMATION TECHNIQUES

The greatest impediment to examining how the technological regime impacts the relationship between firm size and the likelihood of survival has been an inability to identify the industry life cycle stage and link such a measure to firm-specific longitudinal observations. The data base used in this paper to accomplish both of these elements is based on the identification of the entry and exit of firms listed in *Thomas Register of American Manufacturers*. The *Thomas Register*, which dates back to 1906, is used

² As Geroski [1995] points out, occupying a niche can be interpreted as an innovative activity, since the small firm is engaging in some type of economic activity not pursued by larger counterparts.

primarily by purchasing agents. Lavin [1992], in extensively describing various sources of business information, states that the *Thomas Register* is the best example of a directory which provides information on manufacturers by focusing on products.³ According to Lavin, 'The *Thomas Register* is a comprehensive, detailed guide to the full range of products manufactured in the United States. Covering only manufacturing companies, it strives for a complete representation within that scope.'

This study includes, as listed in Appendix 1, a sub-set of 31 of the 46 the products selected from the *Thomas Register* by Gort and Klepper [1982]. In addition, two new products—contact lenses and video cassette recorders—are included as they have gained prominence over the last two decades.⁴

A total of 3,431 firms is pooled across products for the survival analysis. Firms are subjected to checks to ensure actual entry rather than a renaming/relocation of existing firms.⁵ A change in the name of the firm is tracked by checking its address, and vice versa for a change in address.⁶ A change in both name and address, however, is treated as a new entry, since no other checks are possible for verifying prior existence. The margin of error is assumed to be small for such cases. When identifiable, mergers between two firms are treated as an exit of the smaller and continuance of the larger firm.⁷ Thus, an important qualification of this database is that

³ The importance of imports in manufacturing has increased over the last few decades. The *Thomas Register* includes foreign manufacturers of the product if the firm maintains an office or distribution channel for its product in the United States.

⁴ While the study draws from the same pool of products as the Gort-Klepper study, the data are developed independently. Fifteen of the 46 products in the Gort-Klepper study could not be used for new data development for various reasons. Some products, like Nylon, Telemeters, Computers and Solar Batteries had breaks in consistency either because the listing was missing in the *Thomas Register*, or due to substantial changes in definition of product over the years. Products like DDT and cryogenic tanks were omitted since they were discontinued over the years for which the analysis was extended (from 1973 to 1991). Other categories like streptomycin and penicillin were discarded in favor of a broader product group Antibiotics. Finally, a few products were not included in the analysis due to time limitations on the development of data.

⁵ To minimize possible data-entry errors, the database of firms for each product was developed independently by two sets of research assistants. The databases were then compared to rectify mistakes and ensure that the records were accurate.

⁶ For instance, a firm (AMETEK) dropped out of a market in the same year that another firm appeared in the same city and state with a slightly different street address. An inspection of the name KETEMA confirmed the idea that it was one and the same firm (Ketema is an anagram (spelled backwards) of Ametek).

⁷ In some cases, we were able to identify mergers between two firms due to a change in listing that either (a) clearly identified one of the firms as a subsidiary of the other, or (b) consisted of a name change that combined the names of individual firms. Some of the mergers and acquisitions may represent failing firms, while others may be highly successful. Data limitations do not allow us to make a distinction between the two types of firms. To the extent that the newly created firm represents the capitalized value of both firms that merged, the survival rates would reflect the attributes of both firms.

exit includes mergers and acquisitions. This qualification applies to almost every study undertaken analyzing exit, both in the cross section (Dunne, Roberts and Samuelson [1988 and 1989], Hall [1988]) and time series (Klepper [1995], Klepper and Miller [1995]). Virtually all of the studies included in the comprehensive literature reviews by Caves [1998] in the *Journal of Economic Literature*, Geroski [1995] in the *International Journal of Industrial Organization*, and Sutton [1996] in the *Journal of Economic Literature*, include only studies that suffer from this important data qualification. Only preciously few studies, such as Harhoff, Stahl and Woyvode [1998], have developed a data base distinguishing among the different types of exit. While their important data base and analysis paves the road for future research, it is almost unique in terms of the studies comprising the literature up to now (see also Holmes and Schmitz [1995], and Schary [1995]). We should also emphasize that, as in the Klepper [1996] and Gort and Klepper [1982] studies, the unit of observation for entry includes de novo firms as well as new businesses by existing firms.

We measure the entry size of the firm by the current dollar asset size reported in the *Thomas Register* at its time of entry. Since the time period over which firm entry is sampled encompasses almost the entire twentieth century, we first adjust the asset categories for inflation and express them in 1982 dollars, and then classify them into five categories.⁸ These asset categories, expressed in 1982 dollars are (1) less than \$2 million, (2) \$2 to 4 million, (3) \$4 to 6 million, (4) \$6 to \$8 million, and (5) greater than \$8 million.⁹ In the empirical analysis that follows, we identify size in two ways. We use the above size categories as ordinal measures of entry size in the proportional hazards regression. For the survival rate analysis, we distinguish between 'small' and 'large' firms by classifying firms as small if they are in the real value adjusted smallest asset category (55 percent of the firms are in this entry size category).¹⁰

The stage of the product life cycle is identified by the net entry of firms into the product market. Following Gort and Klepper [1982], and Agarwal and Gort [1996], we define the formative stages of the product life cycle to be the period of positive net entry, while the mature stages reflect the period of shake-out of firms (negative net entry) and the ensuing stable

⁸ The producer price index (all commodities) is used as a deflator, since it is the only PPI that dates back to the beginning of the century. Using the consumer price index as a deflator does not change the results in the paper.

⁹ The choice of the threshold values on the open ended lowest and highest asset category is restricted by the available information on current asset size for the early years in the study.

¹⁰ We also experimented with alternative operationalizations of size by identifying firms as small if their size is less than the 60th percentile of the size distribution for all firms entering in a given decade; using midpoints of the size intervals and their logarithmic transformations. The results are robust to the different specifications.

period (approximate zero entry). Appendix 2 describes the general discriminant analysis procedure that was used to identify the appropriate classification of the years in the product life cycle stage. Appendix 1 presents the year that each product entered the mature stage, and in addition reports the number of firms within the formative and mature stages for every product in the analysis.

The stage of the product life cycle, as explained earlier, captures differences in an entrepreneurial regime vs. a routinized regime. Thus, the stage proxies for differences over time in the level of technological intensity within a product category. However, product categories can also differ in technological intensity levels, i.e. while more major innovations occur during the formative stages of all product, products may also have higher or lower levels of overall technological intensity over the entire product life cycle. Accordingly, we classify the products cross-sectionally as high-technology or low-technology based on their technological intensity in the *mature stage* of the product life cycle. Choosing the mature rather than the formative stage for the cross-sectional distinction, we believe, is a better indication of cross-sectional differences in technological intensity, since it is more representative of the 'steady state' level of the product. We use the study by Hadlock, Hecker and Gannon [1991] which uses the proportion of R&D employment in the corresponding 3-digit SIC code as a basis for distinction.¹¹ Appendix 1 tabulates the technological index of each product. About two-thirds of the products are classified as being high-tech, while one-third is low-tech.

To examine whether the relationship between firm size and the likelihood of survival is invariant to the stage of the life cycle, we use life-table analysis and the Cox proportional hazards regression. The effect on survival of the variable of interest, entry size, may well be attenuated by the growth of the firm. Accordingly, we restrict our analysis to the first ten years of the firm's survival. Thus firms that survive eleven years or more are treated as right censored, as are firms less than ten years of age that still existed in 1991, the last year for which data were compiled.

Life-table analysis allows us to compute both survival rates and hazard rates for the firms. A τ -year survival rate is defined as the fraction of the total number of firms that survived at least τ years. The hazard rate gives the number of firms that die conditional on their age, i.e., it represents the probability of failure given that the firm has survived τ years. Three tests for homogeneity, the non-parametric Log-rank and Wilcoxon tests, and the parametric Likelihood ratio tests are conducted to check for significance of differences between large and small entry size

¹¹ The study classifies industries based on technological intensity using data in 1987, by which time all products in the sample had reached the mature stage.

survival rates within the different competitive environments based on stage and technological activity.

The Cox proportional hazards regression is used to estimate the effect of entry size, stage and level of technological activity and to compute risk ratios for each of the variables of interest. The hazard function of a firm $h_f(t)$ is expressed as:

$$(1) \quad h_f(t) = h(t; x_f) = h_0(t) \exp(x_f' \beta)$$

where $h_0(t)$ is an arbitrary and unspecified baseline hazard function reflecting the probability of failure conditional on the firm's having survived until time t after entry into the market, x_f is a vector of measured explanatory variables for the f th firm, and β is the vector of unknown regression parameters to be estimated. Negative coefficients and risk ratios less than one imply that the hazard rate decreases and the probability of survival increases with increases in the value of the variable, while positive coefficients and risk ratios greater than one imply an increase in the hazard rate function and a decrease in the probability of survival.

Finally, we use kernel estimated hazard rates for a graphical depiction of the relationship of the size and age of firm to survival in the context of the different competitive environments. The hazard rates generated from the life-table analysis are smoothed using kernel estimation, a powerful non-parametric technique that identifies regularities in hazard rate patterns without imposing a particular structure as a result of parametric restrictions. We use a gaussian density function for the kernel, and the parameter that controls the width of the kernel is held constant at 0.25 across all kernel estimations to ensure comparability of hazard rate functions across the different competitive environments (see Silverman [1986] for details on kernel estimation techniques).

V. EMPIRICAL RESULTS

Table I presents descriptive statistics on the key variables used in the analysis. On an average, firms tracked for the first ten years survived seven years. Sixty-two percent of the firms entered in the formative stage, and seventy percent of entrants were in high-tech industries. The ordinal entry size shows a skewed distribution towards smaller firms (mean = 2.10), which is also reflected by the fact that 55 percent of the firms in the sample are classified in the smallest asset category.

Table II presents results from the life table analysis. Survival rates for small and large entrants are distinguished based on their stage of entry and the level of technological intensity. The first row shows that when neither the time of entry nor the technological intensity is distinguished, survival rates for large entrants are significantly higher than for the small entrants in the sample. This result is certainly consistent with Geroski's

TABLE I
DESCRIPTIVE STATISTICS

Variable	Number	Mean	Std. Deviation	Minimum	Maximum
Span of survival	3431	7.07	3.80	1	11
Life cycle Stage (Formative = 1)	3431	0.62	0.48	0	1
Technological Intensity (High Tech = 1)	3431	0.70	0.45	0	1
Ordinal Size	3431	2.10	1.46	1	5
Small firm Dummy (Small = 1)	3431	0.55	0.49	0	1

[1995] stylized fact about the positive relationship between firm size and the likelihood of survival. However, what the following rows show is that when the competitive environment within which the firms operate are classified by product life cycle and technological intensity, the survival rates for small and large entrants diverge significantly from this stylized fact.¹²

For products in the formative life-cycle stage, 93 percent of the small entrants survived one year; 67 percent survived five years, and about one-half survived a decade. By contrast, the survival rates of the larger entrants in the formative-stage products were all higher—96 percent for one year, 74 percent for five years, and 54 percent for ten years. One sees a strong and consistent support for the stylized result that the likelihood of survival is greater for larger entrants in the formative years of the product life cycle, and all three tests reject the hypothesis of homogeneity at the one-percent level.

The advantage that size bestows on the likelihood of survival disappears, however, in the mature life-cycle stage. All of the three tests of homogeneity fail to reject the hypothesis of homogeneity, with the ten year survival rate for small entrants actually being slightly higher than their larger-sized counterparts. Thus, the theory of strategic niches might be more applicable in mature industries.

Table II shows that the impact of firm size at entry on survival also varies between low- and high-technology products. Size clearly bestows an advantage to larger entrants in low-tech products. All three tests reject the hypothesis of homogeneity. Small entrants start with a survival rate

¹² The tests for homogeneity check for significant differences across entry size within the competitive environment the firm faces based on life cycle stage and technological intensity. The fact that survival rates differ significantly across life cycle stages and technological intensity has been documented in Agarwal [1996] and Agarwal [1997].

TABLE II
SURVIVAL RATES OF SMALL AND LARGE ENTRANTS

Survival Rates (standard errors) for	Small Entry Size				Large Entry Size				Tests of Homogeneity		
	Number	1 year	5 year	10 year	Number	1 year	5 year	10 year	Log-Rank (<i>p</i> -value)	Wilcoxon (<i>p</i> -value)	Likelihood-Ratio (<i>p</i> -value)
All Firms	1880	92.51 (0.61)	66.03 (1.12)	48.66 (1.22)	1551	94.95 (0.56)	71.41 (1.19)	50.85 (1.37)	5.21 (0.02)	10.12 (0.001)	4.63 (0.03)
Formative Stage	1175	92.91 (0.75)	67.43 (1.38)	50.82 (1.50)	972	95.55 (0.66)	74.07 (1.42)	54.43 (1.65)	5.99 (0.01)	10.01 (0.002)	5.68 (0.02)
Mature Stage	705	91.84 (1.05)	63.50 (1.93)	44.29 (2.13)	579	93.93 (1.01)	66.44 (2.13)	43.20 (2.49)	0.14 (0.71)	0.92 (0.34)	0.05 (0.82)
Low-Tech Product	592	90.24 (1.23)	60.94 (2.07)	45.63 (2.20)	420	93.00 (1.25)	69.72 (2.32)	49.77 (2.63)	4.61 (0.03)	8.25 (0.004)	4.70 (0.03)
High-Tech Product	1288	93.56 (0.68)	68.36 (1.33)	50.06 (1.47)	1131	95.68 (0.61)	72.04 (1.39)	51.25 (1.61)	1.44 (0.22)	3.03 (0.08)	1.17 (0.28)
Formative, Low-Tech	412	94.22 (1.40)	62.39 (2.40)	47.62 (2.54)	277	94.22 (1.40)	70.59 (2.75)	52.72 (3.09)	3.82 (0.05)	6.29 (0.01)	3.89 (0.05)
Formative, High-Tech	763	94.33 (0.83)	70.18 (1.67)	52.58 (1.85)	695	96.08 (0.73)	75.49 (1.66)	55.11 (1.95)	3.31 (0.07)	3.55 (0.06)	3.44 (0.06)
Mature, Low-Tech	180	90.12 (2.28)	56.97 (4.07)	39.46 (4.46)	143	90.55 (2.50)	68.06 (4.09)	42.27 (4.92)	1.13 (0.28)	2.14 (0.14)	1.25 (0.26)
Mature, High-Tech	525	92.41 (1.17)	65.57 (2.18)	45.83 (2.43)	436	95.03 (1.06)	65.95 (2.46)	43.59 (2.88)	0.03 (0.85)	0.04 (0.84)	0.11 (0.73)

that is approximately three percent lower than larger entrants in the first year of their existence, and the situation worsens to a nine percent difference in five year survival rates. After ten years, the disadvantage persists, with small firm survival rate at 46 percent, while 50 percent of large firms survive the interval. However, the differences between the small and large firm survival rates are considerably less in high-tech products than for low-tech products, and only one of the three tests reject the hypothesis at the ten-percent level. More importantly, the differences in survival rates are not as dramatic as observed in low-tech products. The differential between small and large entrants, at its highest, is less than four percent (for five-year survival rates). In addition, comparing firms that enter in low-tech vs. high-tech products, we see that survival rates are consistently higher for small firms that enter high-tech products, while there is little difference in survival rates of large sized entrants. Thus, the one, five and ten-year rates show that not only do small entrants enjoy survival rates almost equal to the large firms in high-tech products, they also have a comparative advantage in high-tech areas when compared to their counterparts in low-tech products.

When the products are classified according to both life-cycle stage and technological intensity, we see that large entrants have a comparative advantage in the formative years of both low and high-tech markets, as all three tests uniformly reject the hypothesis of homogeneity. It is also worth noting that while entering in the formative years of high-tech products gives a small entrant a lower probability of survival relative to larger firms, the absolute levels of survival are the highest among small firm survival rates across other environments. In the mature period of low-tech markets, while larger firms seem to have higher survival rates than smaller entrants, none of the tests show statistical significance. For mature high-tech products, survival rates of small and large entrant firms are roughly the same, and again, all three tests fail to reject the hypothesis of homogeneity.

Hazard rate analysis provides a more cogent picture of the above results. We present the kernel smoothed hazard rates in Figures 1 and 2, and provide the empirical analysis using proportional hazards regressions in Table III.¹³ Figure 1 shows the hazard rates of small and large entrants for the life cycle stages and level of technology for products separately, while Figure 2 takes into account interaction effects of stage and technology. In Table III, we provide the results from the Cox proportional hazards regression, which allows us to assess the effect of the relevant

¹³ We use a two class categorization for the graphs in Figures 1 and 2 similar to the analysis in Table 2, with small firms being those that are in the lowest real asset category. For the proportional hazards regressions, an ordinal measure of size based on all available categories is used.

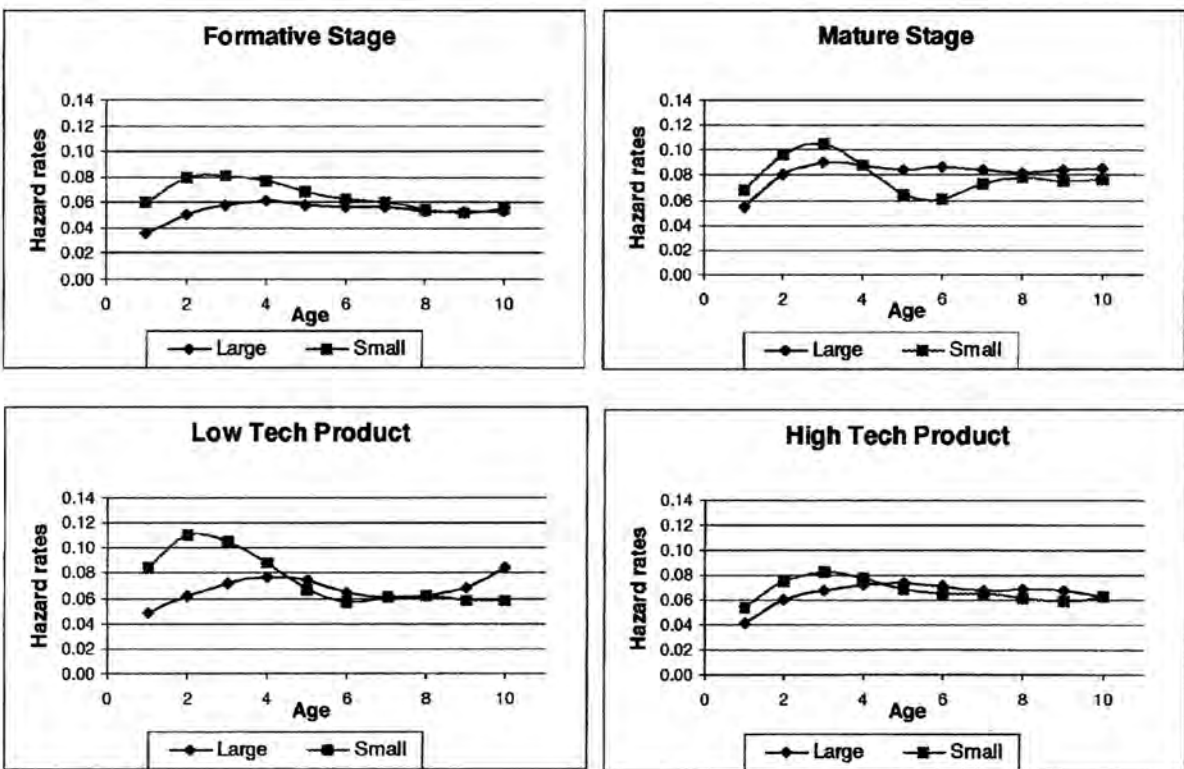


Figure 1
Small and Large Entrant Hazard Rates by Stage and Technology

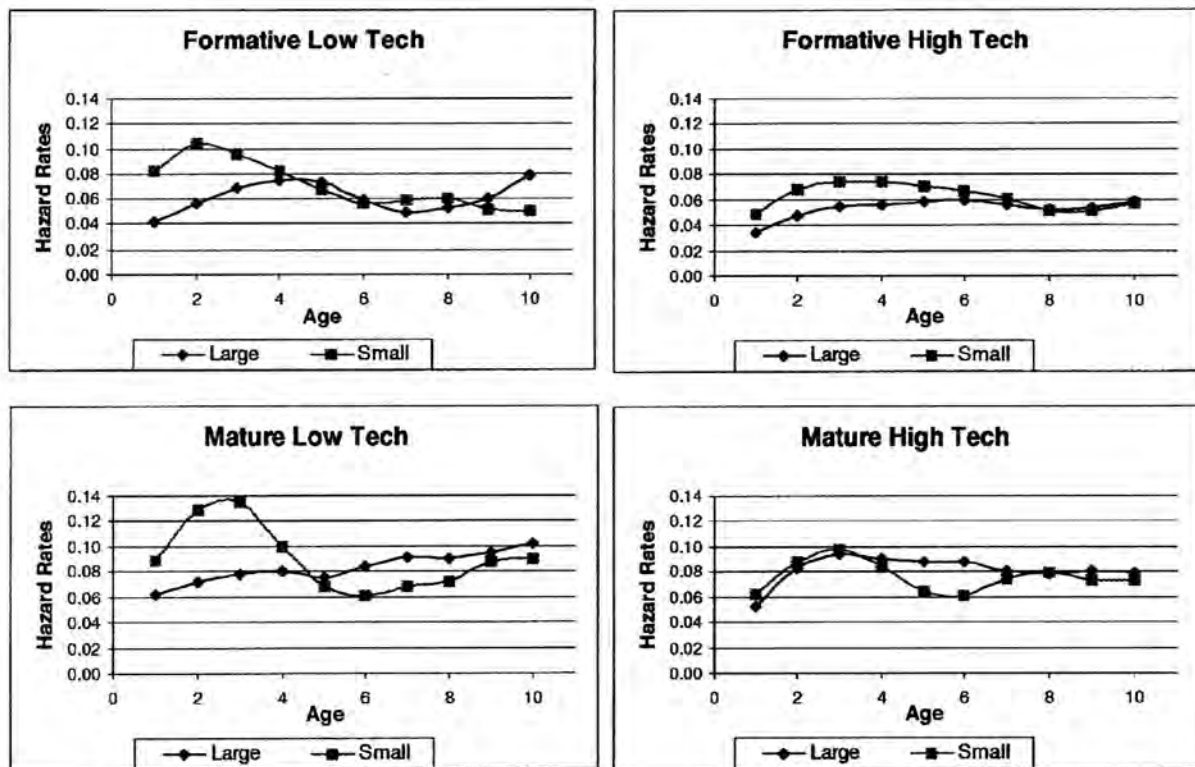


Figure 2
Small and Large Entrant Hazard Rates by Stage and Technology Interaction

TABLE III
COX PROPORTIONAL HAZARDS REGRESSIONS

Regression	Variable	Coefficient (Standard Error)	Risk Ratio	Industry Effects Chi-Square	Model Chi- square (<i>p</i> value)
1	Entry size	-0.05** (0.02)	0.95	—	29.75 (0.0001)
	Stage of entry	-0.21** (0.05)	0.81		
	Tech. intensity	-0.13* (0.06)	0.88		
2	Entry size	-0.04* (0.02)	0.96	97.98 (0.0001)	112.03 (0.0001)
	Stage of entry	-0.17** (0.06)	0.85		
3	Entry size in formative stage	-0.05* (0.02)	0.95	114.56 (0.0001)	118.91 (0.0001)
4	Entry size in mature stage	-0.03 (0.03)	0.97	46.08 (0.02)	46.96 (0.03)
5	Entry size in low-tech product	-0.08* (0.04)	0.92	23.74 (0.008)	29.69 (0.001)
6	Entry size in high-tech product	-0.03** (0.02)	0.97	69.63 (0.0001)	71.82 (0.0001)
7	Entry size in formative, low-tech	-0.04** (0.04)	0.96	29.20 (0.001)	28.13 (0.003)
8	Entry size in formative, high-tech	-0.07** (0.03)	0.94	80.18 (0.0001)	86.19 (0.0001)
9	Entry size in mature, low-tech	-0.08 (0.07)	0.92	9.16 (0.51)	10.15 (0.52)
10	Entry size in mature, high-tech	-0.02** (0.03)	0.98	35.85 (0.005)	36.31 (0.006)

Regressions 2 through 10 include industry dummies. The Chi-square values reported in the second last column represent regressions with only industry dummies, while the model chi-square values represent regressions that include the variables specified in the equation and industry dummies. * denotes statistical significance at the .05 level and **denotes statistical significance at the .01 level.

variables on the entire hazard rate function, and computes the risk ratio for the variable in question.

Before we begin with the analysis by stage and technological activity, it is worth emphasizing that what is now termed the *Jovanovic Effect*—the fact that firms need time to discover their own efficiency levels—is seen in the rise of mortality rates in the infant years for all of the firm hazard rates in Figures 1 and 2. In addition, the effect of entry size on hazard rates

erodes over the age of the firm, and in all cases, the hazard rates tend to overlap after eight years at the latest, indicating most probably the effects of growth on continued survival. Thus, small entrants that survive past the first six or seven years seem to be at no greater risk than firms that enter with a larger size. This finding is also implicit in the tests of homogeneity in Table II, since the Wilcoxon test statistics are usually the most significant.¹⁴ The infant mortality rate, however, is uniformly higher for small entrants relative to their larger counterparts in every case. After the initial rise though, both the levels and the patterns of the hazard rates differ substantially across the different environments defined by life cycle stage and technological intensity. Finally, the model chi-squares reported in Table III for regressions when only industry dummies are included show that hazard rates differ significantly across the products in almost all the environments.

Table III summarizes the results from several regressions. We present the coefficient estimates, their *p*-values, the risk ratio and the model chi-square for each regression. Note that a negative coefficient implies decreases in hazard rate, and the effect of the variable on the hazard rate is captured by the deviation of the risk ratio from 1. In order to ensure that the results are not an artifact of industry composition effects, all the regressions except for the first one include industry fixed effects. Regression 1 shows the multivariate results for entry size, technological intensity, and stage of product life cycle. Since the technological intensity for the product is measured at the industry level, Regression 1 excludes the industry dummies. The effect of entry size and stage in the presence of industry dummies are reported in Regression 2. All the coefficients are negative and strongly significant, indicating that hazard rates are lower in formative stages, in high-tech products, and for larger entry sizes. Entering a high-tech product reduces a firm's hazard rate by 12 percent. From Regressions 1 and 2, we see that increases in size bestow an advantage by reducing the hazard rate by four to five percent, and entering in the formative years decreases the hazard rate by 15 to 19 percent. The above results are all consistent with the established stylized facts on technological intensity, life-cycle and size effects.

More importantly though, the effect of entry size on survival changes dramatically when the life-cycle stage and technological intensity are included in the estimation. As seen already in Table I, size at time of entry matters in the formative years, and in low-tech products. Regressions 3 and 4 show the effect of entry size across stage of product life cycle. As was seen in Table II, while larger entrants benefit in the formative years

¹⁴ Note that the Wilcoxon test statistic gives more weight to deviations between survival rates during the early years (age).

with a five percent decrease in hazard rate, there is no significant difference in hazard rates for the mature stages. Figure 1 shows that small entrants begin with a higher mortality rate relative to larger entrants in the formative stage, but as firms age, the gap declines slowly and the hazard rates overlap past age six. In contrast, small firm mortality rates in the mature period have a lower differential relative to larger entrants, the hazard rate rapidly declines and after crossing the large firm hazard rate at age four, is consistently lower at later ages.

Size matters in low-tech products; Regression 5 shows that increases in entry size results in a eight percent decrease in hazard rates. However, there is no significant difference attributable to entry size in high-tech products, as is evidenced in Regression 6. Thus, smaller firms are not disadvantaged relative to their larger counterparts in high-tech products. Figure 1 reveals the pattern of hazard rates in high and low technological products; large entrants seem to have a roughly similar hazard rate function at about six to seven percent in both types of products, while small entrant hazard rates experience different hazard rates. In low-tech products, small firm hazard rates experience the highest infant mortality rates, but then decline monotonically to cross the hazard rates of larger entrants around age five. In high-tech products, the divergence between large and small entrants is low, and the overlap between the two occurs earlier, around age four.

Finally, the results in Regressions 7 through 10 in Table III, and Figure 2 focus on the effect of entry size in environments that represent the interaction of technological intensity and stage. Consistent with the observations in Table II, there is no advantage bestowed by increases in entry size in the mature period of high-tech markets. Figure 2 shows that hazard rates of small firms are roughly the same as those of large entrants at infancy, but rapidly decline in this environment and are consistently lower after age four. The results in Regression 10 mirror the finding of no significant statistical difference, and in addition show a risk ratio of 0.98, the lowest observed effect of size on hazard rates. Surprisingly though, a larger size aids survival by decreasing hazard rates with statistical significance only in the formative years of high-tech products (Regression 8). This result becomes clearer when one sees the pattern that the hazard rates follow in Figure 2. For firms entering in the formative years of high-tech products, while the initial differential between large and small entrants is not as high as those observed in other environments, the disadvantage faced by small entrants persists for a longer time; the hazard rates do not overlap until age 7. In contrast, while the small entrant hazard rates in low-tech markets, both during the formative and mature stage, are much higher than large entrant hazard rates during infancy, they rapidly decline to intersect large firm hazard rates at age 5 and are slightly lower from then on. It is worth noting though, that while the relative differential between small and

large entrants is significant in the formative years of high-tech products, small entrants seem to have the lowest *absolute* level of hazard rates when compared to small entrants in other environments.

Collectively, the regressions and the graphical analysis indicate that small entry size is a disadvantage in general, but small entrants that enter in high-tech markets, or in mature years of the product life cycle, show no significant differences in their hazard rates relative to larger entrants. Further, smaller entrants have the least size disadvantage in the mature stages of high-tech markets relative to large firms (with hazard rates actually lower after age four). And while smaller entrants have a relative disadvantage of size in the formative years of high-tech markets, they enjoy the highest absolute level of survival rate relative to other small counterparts in this environment. This seems to lend more credence to the hypothesis that while size and ability to undertake high R&D expenditures increase the probability of survival in product markets characterized by uncertainty, small firms have the greatest likelihood of survival where opportunities for niche marketing abound, as in the case of high-tech products in the mature period.

VI. CONCLUSIONS

An empirical regularity—that small firms are confronted with a lower likelihood of survival than their larger counterparts—has recently emerged with such consistency that it has been given the status of a Stylized Result. (Geroski [1995], Caves [1998], and Sutton [1997]). In this paper, we find that this Stylized Result holds—but not for all industries and situations. Rather, technology and the industry life cycle are instrumental in shaping industry dynamics and, in particular, the role that entrants in an industry play.

Survival rates for large entry size firms are significantly higher for both the formative years, and the low-tech products. On the other hand, advantages bestowed by size seem to be less relevant in the mature stage, or in highly technical products.

In the formative stages of an industry, entrants do tend to play the role that is characterized by this Stylized Fact. The entrant is typically competing for a viable product—success brings about growth, which is a requisite for survival. By contrast, in the mature phase of the life cycle, and particularly in technically advanced industries, small firms are no longer under pressure to grow in order to increase the likelihood of survival. Rather, they enjoy the same likelihood of survival as their larger counterparts. Presumably, this reflects the ability of small firms to occupy strategic niches in mature high-tech industries in a manner that is less typical in the formative stages of the life cycle.

Thus, the evidence found in this paper suggests that general pro-

nouncements about small and large firm survival are hazardous. This is because the role of new and incumbent firms varies considerably over the industry life cycle and with the technological demands of that industry. Because entrants are motivated by a different force and are responding to a different stimulus in the formative stages of the life cycle than in the mature stages, their role in industry dynamics is also different. Future research needs to pay more attention to the heterogeneity introduced by the evolution over time that exists not just within an industry but also across industries.

APPENDIX A

PRODUCTS IN STUDY, YEAR OF INTRODUCTION, CORRESPONDING SIC CODE AND TECHNOLOGICAL INDEX

Product Name	Year of Commercial Introduction ¹	Industry SIC Code ²	Tech. Index ³	Year of Onset of Mature Stage	Number of Entrants in Formative Stage	Number of Entrants in Mature Stage
Antibiotics	1948	283	1	1961	36	35
Artificial Xmas Trees	1938	399	0	1952	44	22
Ball-point Pens	1948	395	0	1983	162	59
Betaray Gauges	1956	382	1	1972	13	8
Cathode Ray Tubes	1935	367	1	1962	65	60
Combination Locks	1912	342	0	1977	68	35
Contact Lenses	1936	385	0	1981	52	21
Electric Blankets	1916	363	0	1964	42	15
Electric Shavers	1937	363	0	1943	52	26
Electrocardiographs	1942	384	1	1961	20	21
Freezers	1946	363	0	1957	83	44
Freon Compressors	1935	358	0	1975	66	8
Gas Turbines	1944	351	1	1959	138	36
Guided Missiles	1951	376	1	1964	231	99
Gyroscopes	1915	381	1	1969	77	44
Heat Pumps	1954	358	0	1969	48	59
Jet Engines	1948	372	1	1967	39	40
Microfilm Readers	1940	386	1	1975	94	36
Nuclear Reactors	1955	344	1	1966	49	33
Outboard Motors	1913	351	1	1923	23	65
Oxygen Tents	1932	384	0	1961	35	13
Paints	1934	285	1	1969	129	62
Phonograph Records	1908	365	1	1928	95	131
Photocopying Machines	1940	386	1	1970	42	57
Piezoelectric Crystals	1940	367	1	1962	59	34
Polariscopes	1928	381	1	1959	27	15
Radar Antenna Assemblies	1952	366	1	1965	62	51
Radiant Heating Baseboards	1947	363	0	1963	37	21
Radiation Meters	1949	382	1	1967	29	36
Recording Tapes	1952	365	1	1980	99	40
Rocket Engines	1958	372	1	1969	21	22
Styrene	1938	282	1	1984	66	20
Video Cassette Recorders	1974	365	1	1985	44	16

¹ Based on the *Thomas Register of American Manufacturers*.

² SIC Codes obtained from the *Alphabetical list of SIC codes, Census of Manufactures 1987 Manual* and from *Predicasts*.

³ Technological Index based on Hadlock, Hecker and Gannon [1991] classification of 3-digit SIC industries as technological by the proportion of R&D employment using data for 1987.

APPENDIX B

PROCEDURE TO IDENTIFY FORMATIVE AND MATURE STAGES

The procedure that we used to identify the formative and mature stages is the same as the generalization of the standard discriminant analysis used in Gort and Klepper [1982] to separate the five stages in the product life cycle. To distinguish between the formative stage (positive net entry) and the mature period (negative net entry with ensuing period of approximately zero net entry), we first examined the data on annual net entry rates for each product. To determine the cut-off year for each product, we first partitioned the series into three categories—the first and third category contained the years where the net entry rate clearly reflected the formative and mature stages respectively. The net entry rates of the T consecutive 'in-between' years of the second category were then labeled x_1, x_2, \dots, x_T . The problem was then to choose an optimal dividing year j such that observations x_1, x_2, \dots, x_j are classified in the formative stage, and $x_{j+1}, x_{j+2}, \dots, x_T$ are classified in the mature stage. This was accomplished using a three step procedure:

1. For each $j = 1, 2, \dots, T$, we computed

$$(1) \quad \begin{aligned} d_1(j) &= \sum_{i=1}^j x_i/j \\ d_2(j) &= \sum_{i=j+1}^T x_i/(T-j) \end{aligned}$$

2. The choice of the dividing year was limited to those values of j for which

$$(2) \quad \begin{aligned} |d_1(j) - \mu_1| &\leq |(\mu_1 - \mu_2)/2| \\ |d_2(j) - \mu_2| &\leq |(\mu_1 - \mu_2)/2| \end{aligned}$$

where μ_1 and μ_2 represent the mean rate of net entry in categories 1 and 2. If there were no values of j satisfying (2), then all observations were classified in the formative stage if $|d_1(T) - \mu_1| < |d_1(T) - \mu_2|$ and in the mature stage otherwise.

3. If there were multiple values of j satisfying (2), then we selected the value of j from this set that maximized $|d_1(j) - d_2(j)|$

Step 2 requires that the mean of the observations classified in each of the two stages is closer to the sample mean of the observations initially classified in those stages than in the alternative stage. Step 3 ensures that, among the classifications that would satisfy 2, the classification that is chosen maximizes the difference between the means of the points classified in the two alternative stages.

REFERENCES

- Agarwal, R., 1998, 'Evolutionary Trends of Industry Variables', *International Journal of Industrial Organization*, 16, pp. 511–526.
 Agarwal, R., 1997, 'Survival of Firms over the Product Life Cycle', *Southern Economic Journal*, 3, pp. 571–584.

- Agarwal, R., 1996, 'Technological Activity and the Survival of Firms', *Economics Letters*, 52, pp. 101–108.
- Agarwal, R., 1998, 'Small Firm Survival and Technological Activity', *Small Business Economics*, 11, pp. 215–224.
- Agarwal, R. and Gort, M., 1996, 'The Evolution of Markets and Entry, Exit and Survival of Firms', *Review of Economics and Statistics*, 78, pp. 489–498.
- Arrow, K. J., 1962, 'Economic Welfare and the Allocation of Resources for invention', in R. R. Nelson (ed.), *The Rate and Direction of Inventive Activity* (Princeton University Press, Princeton), pp. 609–625.
- Audretsch, D. B., 1995, *Innovation and Industry Evolution* (MIT Press, Cambridge).
- Audretsch, D. B., 1991, 'New Firm Survival and the Technological Regime', *Review of Economics and Statistics*, 73, pp. 441–450.
- Audretsch, D. B. and Mahmood, T., 1995, 'New Firm Survival: New Results Using a Hazard Function', *Review of Economics and Statistics*, 76, pp. 97–103.
- Baldwin, J. R., 1995, *The Dynamics of Industrial Competition* (Cambridge University Press, Cambridge).
- Baldwin, J. R. and Rafiqzaman, M., 1995, 'Selection versus Evolutionary Adaptation: Learning and Post-Entry Performance', *International Journal of Industrial Organization*, 13, pp. 501–522.
- Caves, R. and Porter, M. E., 1977, 'From Entry Barriers to Mobility Barriers', *Quarterly Journal of Economics*, 91, pp. 241–261.
- Doms, M., Dunne, T. and Roberts, M. J., 1995, 'The Role of Technology Use in the Survival and Growth of Manufacturing Plants', *International Journal of Industrial Organization*, 13, pp. 523–542.
- Caves, R. E., 1998, 'Industrial Organization and New Findings on the Turnover and Mobility of Firms', *Journal of Economic Literature*, 36, pp. 1947–1982.
- Dosi, G., Marsili, O., Orsenigo, L. and Salvatore, R., 1995, 'Learning, Market Selection and the Evolution of Industrial Structures', *Small Business Economics*, 7, pp. 411–436.
- Dunne, T., Roberts, M. J. and Samuelson, L., 1988, 'Patterns of Firm Entry and Exit in U.S. Manufacturing Industries', *Rand Journal of Economics*, 19, pp. 495–515.
- Dunne, T., Roberts, M. J. and Samuelson, L., 1989, 'The Growth and Failure of U.S. Manufacturing Plants', *Quarterly Journal of Economics*, 104, pp. 671–698.
- Geroski, P. A., 1995, 'What Do We Know About Entry?' *International Journal of Industrial Organization*, 13, pp. 450–456.
- Gort, M. and Klepper, S., 1982, 'Time Paths in the Diffusion of Product Innovations', *Economic Journal*, 92, pp. 630–653.
- Hadlock, P., Hecker, D. and Gannon, J., 1991, 'High Technology Employment: Another View', *Monthly Labor Review*, 114, pp. 26–30.
- Harhoff, D. and Stahl, K., 1994, 'Unternehmensentwicklung in den neuen Bundesländern—Erste empirische Ergebnisse', in Heinz Koenig and Viktor Steiner (eds.), *Arbeitsmarktdynamik und Unternehmensentwicklung in Ostdeutschland* (Nomos Verlagsgesellschaft, Baden-Baden), pp. 207–244.
- Harhoff, D., Stahl, K. and Woyvode, 1998, 'Legal Form, Growth and Exit of West German Firms', *Journal of Industrial Economics*, 67, pp. 434–452.
- Holmes, T. and Schmitz, J., 1995, 'On the Turnover of Business Firms and Business Managers', *Journal of Political Economy*, 103, pp. 1005–1038.
- Jovanovic, B., 1982, 'Selection and Evolution of Industry', *Econometrica*, 50, pp. 649–670.

- Klepper, S., 1995, 'Evolution, Market Concentration and Firm Survival', (revised as 'Firm Survival and the Evolution of Oligopoly', 1999), unpublished manuscript.
- Klepper, S., 1996, 'Entry, Exit, Growth and Innovation over the Product Life Cycle', *American Economic Review*, 86, pp. 560–581.
- Klepper, S. and Miller, J. H., 1995, 'Entry, Exit and Shakeouts in the United States in New Manufactured Products', *International Journal of Industrial Organization*, 13, pp. 567–591.
- Lavin, M. R., 1992, *Business Information: How to Find It, How to Use It*, 2nd ed. (Oryx Press, Phoenix).
- Malerba, F. and Orsenigo, L., 1996, 'The Dynamics and Evolution of Industries', *Industrial and Corporate Change*, 5, pp. 51–88.
- Mata, J. and Portugal, P., 1994, 'Life Duration of New Firms', *Journal of Industrial Economics*, 27, pp. 227–246.
- Mata, J., Portugal, P. and Guimaraes, P., 1995, 'The Survival of New Plants: Start-up Conditions and Post-Entry Evolution', *International Journal of Industrial Organization*, 13, pp. 459–481.
- Mueller, D. C., 1976, 'Information, Mobility, and Profit', *Kyklos*, 29, pp. 419–448.
- Nelson, R. R. and Winter, S. G., 1982, *An Evolutionary Theory of Economic Change* (Harvard University Press, Cambridge).
- Newman, H., 1978, 'Strategic Groups and the Structure-Performance Relationship', *Review of Economics and Statistics*, 61, pp. 214–227.
- Pakes, A. and Ericson, R., 1998, 'Empirical Applications of Alternative Models of Firm and Industry Dynamics', *Journal of Economic Theory*, 79, pp. 1–45.
- Porter, M. E., 1979, 'The Structure within Industries and Companies' Performance', *Review of Economics and Statistics*, 61, pp. 214–227.
- Schary, M., 1991, 'The Probability of Exit', *Rand Journal of Economics*, 22, pp. 339–353.
- Silverman, B. W., 1986, *Density Estimation for Statistics and Data Analysis* (Chapman and Hall, New York).
- Sutton, J., 1997, 'Gibrat's Legacy', *Journal of Economic Literature*, 35, pp. 40–59.
- Thomas Register of American Manufacturers* (Thomas Publishing Co., New York).
- Wagner, J., 1994, 'The Post-Entry Performance of New Small Firms in German Manufacturing Industries', *Journal of Industrial Economics*, 62, pp. 141–154.
- Utterback, J. and Abernathy, 1975, 'A Dynamic Model of Process and Product Innovation', *OMEGA*, 3, pp. 639–656.
- Williamson, O. E., 1975, *Markets and Hierarchies: Antitrust Analysis and Implications* (The Free Press, New York).
- Winter, S. G., 1984, 'Schumpeterian Competition in Alternative Technological Regimes', *Journal of Economic Behavior and Organization*, 5, pp. 287–320.