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Source: *The Review of Economics and Statistics*, Aug., 1991, Vol. 73, No. 3 (Aug., 1991), pp. 441-450

Published by: The MIT Press

Stable URL: https://www.jstor.org/stable/2109568

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NEW-FIRM SURVIVAL AND THE TECHNOLOGICAL REGIME

David B. Audretsch*

Abstract—The survival rates of over 11,000 firms established in 1976 are compared across manufacturing industries. The variation in ten-year survival rates across industries is hypothesized to be the result of differences in the underlying technological regime and industry-specific characteristics, especially the extent of scale economies and capital intensity. Based on 295 four-digit standard industrial classification industries, new-firm survival is found to be promoted by the extent of small-firm innovative activity. The existence of substantial scale economies and a high capital-labor ratio tends to lower the likelihood of firm survival. However, these results apparently vary considerably with the time interval considered. Market concentration is found to promote short-run survival, while it has no impact on long-run survival.

I. Introduction

A rather startling result has emerged in the empirical literature of industrial organization—entry by new firms into an industry is apparently not substantially deterred in capital-intensive industries where scale economies play an important role. For example, Acs and Audretsch (1989a and 1989b) found that even small firms are not significantly deterred from entering industries which are relatively capital-intensive. This raises a fundamental question at the core of intra-industry dynamics: What happens to new firms subsequent to entry? And how are they able to survive?

In fact, little is known about the ability of firms to survive subsequent to entry. In trying to test the validity of Gibrat's Law, both Hall (1987) and Evans (1987a and 1987b) found that not only do smaller firms have significantly higher growth rates, but they also have a substantially greater propensity to exit the industry than do their larger counterparts. Evans (1987a), for example, was able to use the U.S. Small Business Data Base (compiled by the U.S. Small Business Administration) to identify the existence of a strong positive relationship between the likelihood of survival and firm size in 81 of the 100 four-digit standard industrial classification (SIC) industries he examined.

Phillips and Kirchhoff (1989) also used the U.S. Small Business Data Base to confirm Evans' (1989a) finding that firm survival tends to increase with enterprise age.[1] Based on 200,000 plants that were classified by the U.S. Census of Manufactures as being established between 1966 and 1977, Dunne et al. (1989) found that failure rates tend to decrease as plant size increases and decrease along with an increase in the age of the plant.

However, none of these studies provide any insight as to whether the ability of firms to survive varies across industries, and if so, to which factors such variation in firm survival can be attributed.[2] The absence of any such studies is particularly striking since a growing body of literature on firm entry, exit, mobility, and turbulence has shown that industry-specific characteristics play an important role in explaining intra-industry dynamics.[3]

The purpose of this paper is to fill this gap in the literature by identifying the extent to which new-firm survival varies across a broad spectrum of manufacturing industries, along with the determinants of new-firm survival. In particular, the hypothesis introduced by Winter (1984) and Gort and Klepper (1982) that the technological and knowledge conditions determine the relative ease with which new firms are able to innovate and therefore survive is tested. In addition, the models of learning-by-doing introduced by Jovanovic (1982) and Pakes and Ericson (1987) suggest that firms may enter an industry at sub-optimal scale

Received for publication March 6, 1990. Revision accepted for publication November 30, 1990.
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I wish to thank two anonymous referees, and Bo Carlsson, Tim Dunne, and Paul Geroski for their suggestions, and Jianping Yang for his computational assistance with this paper. All errors and omissions remain my responsibility.

[1] Preisendörfer et al. (1989) also find that firm survival tends to increase with enterprise age for over 100,000 West German firms established between 1980 and 1984.

[2] Dunne et al. (1989) do analyse the relationships between plant age, size, and probability of failure for twenty broadly defined two-digit SIC industry sectors. However, they make no attempt to relate variations in the failure rate to sector-specific characteristics.

[3] For a comprehensive group of studies relating firm entry and exit to industry-specific characteristics, see Geroski and Schwalbach (1991). Oster (1982) provides a careful study of intra-industry mobility between strategic groups, and Beesley and Hamilton (1984) and Acs and Audretsch (1990, chapter seven) relate intra-industry turbulence to market structure.

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in order to obtain the opportunity to learn and subsequently expand if successful. An implication tested in this paper is that, especially in the presence of substantial scale economies and capital intensity, those firms unable to successfully learn and adapt will be forced to exit the industry.

In the second section of the paper the manner in which new-firm survival is measured along with the underlying data base is explained. The hypotheses that firm survival rates are related to the technological regime and industry-specific characteristics, especially the extent of scale economies and capital intensity, are developed in the third section. The U.S. Small Business Data Base is used to estimate survival rates of 295 four-digit SIC industries for varying periods between 1976 and 1986 in the fourth section. Finally, a summary and conclusion are provided in the fifth section. New-firm survival rates are found to be positively related to the extent of small-firm innovative activity. In addition, the existence of scale economies and capital intensity is identified as decreasing the likelihood of firm survival. However, these relationships are considerably different when four-year survival rates are examined rather than ten-year survival rates.

II. Measuring New-Firm Survival

The greatest obstacle to directly measuring firm survival has been the lack of panel data sets tracking the evolution of firms subsequent to their birth.[4] The USELM file of the U.S. Small Business Data Base (SBDB) is a relatively new source of data that enables newly-created firms and plants to be followed over time. The SBDB has been used by Evans (1987a and 1987b) to analyse the relationships between firm growth, age, and size; Phillips and Kirchhoff (1989) to examine the relationship between small-firm growth and size; and Acs and Audretsch (1989a, 1989b, and 1990) to investigate intra-industry dynamics, including entry across firm-size classes and the extent of turbulence within an industry.

The SBDB data have been derived from the Dun and Bradstreet (DUNS) market identifier file (DMI). The essential unit of observation in the data base is an establishment, defined as an economic entity operating at a specific and single location. Establishments are then linked by ownership to their parent firms. Over the period of 1976 to 1986, the SBDB provides biennial observations on about 4.5 million U.S. business establishments. While the raw data provided by Dun and Bradstreet have been criticized for several weaknesses, such as missing branch records (Armington and Odle, 1982; Storey and Johnson, 1987), the U.S. Small Business Administration, in conjunction with the National Science Foundation and the Brookings Institution has restructured, edited and supplemented the SBDB with data from other sources.[5]

To measure new-firm survival, all establishments that were classified by the SBDB as being founded in 1976 were identified. Those new establishments belonging to an established firm or identified as a branch or subsidiary of a new firm were then discarded. The remaining establishments thus represent newly created firms. Most of these are single-plant firms, although some are multi-plant firms.

Table 1 shows that the number of new firms established in 1976 varied considerably across two-digit SIC manufacturing industries. For example, 16.18% of the new firms were in the printing sector, 13.62% were in the non-electrical machinery sector, 8.62% were in fabricated metal products, and 7.75% were in the apparel sector. Thus, nearly 50% of all new firms were established within these four industrial sectors.

The number of these newly formed firms that were still in existence over the ensuing decade is also shown in table 1. The survival rate in each year is defined as the number of firms still in existence, as a percentage of the total number of new firms that were established in that industry in 1976. There are four important points that emerge from the survival patterns over time. First, and least surprising, the probability of a firm surviving over any given time period is negatively related to the length of that time period. That is, for the entire cohort of firms established in 1976, slightly more than three-quarters were still in existence after two years, slightly fewer than

[4] The major data base which has been used to track the evolution of plants over time is the U.S. Census of Manufactures (Dunne et al., 1989 and 1988).

[5] The procedures used by the U.S. Small Business Administration to adjust the raw data provided by Dun and Bradstreet are explicitly explained in detail in U.S. Small Business Administration (1987), Boden and Phillips (1985), and Acs and Audretsch (1990, chapter two).

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TABLE 1.—NEW-FIRM (1976) SURVIVAL RATES OVER TIME BY MANUFACTURING SECTOR

	Year					
Sector	1976	1978	1980	1982	1984	1986
Food	474	340 (71.7)	277 (58.4)	203 (42.8)	152 (32.1)	144 (30.4)
Tobacco	2	2 (100.0)	2 (100.0)	1 (50.0)	1 (50.0)	1 (50.0)
Textiles	308	225 (73.1)	165 (53.6)	111 (36.0)	88 (28.6)	84 (27.3)
Apparel	864	622 (72.0)	477 (55.2)	332 (38.4)	256 (29.6)	236 (27.3)
Lumber	794	601 (75.7)	514 (64.7)	349 (44.0)	267 (33.6)	256 (32.2)
Furniture	531	393 (74.0)	310 (58.4)	196 (36.9)	161 (30.3)	141 (28.4)
Paper	126	99 (78.6)	80 (63.5)	67 (53.2)	58 (46.0)	57 (45.2)
Printing	1,805	1,482 (82.1)	1,255 (69.5)	931 (51.6)	799 (46.0)	768 (45.2)
Chemicals	322	248 (77.0)	197 (61.2)	146 (45.3)	119 (37.0)	114 (35.4)
Petroleum	41	27 (69.5)	18 (43.9)	14 (34.1)	11 (26.8)	11 (26.8)
Rubber	430	341 (79.3)	280 (65.1)	207 (48.1)	181 (42.1)	176 (40.9)
Leather	124	89 (71.8)	75 (60.5)	41 (33.1)	33 (26.6)	30 (24.2)
Stone, Clay, Glass	545	429 (78.7)	341 (62.6)	246 (45.1)	197 (36.1)	182 (33.4)
Primary Metals	168	135 (80.4)	108 (64.3)	82 (48.8)	74 (44.0)	72 (42.9)
Fabricated Metal Products	962	758 (78.8)	638 (66.3)	493 (51.2)	414 (43.0)	394 (41.0)
Machinery (non-electrical)	1,519	1,243 (81.8)	1,054 (69.4)	820 (54.0)	708 (46.6)	675 (44.4)
Electrical Equipment	635	489 (77.0)	378 (59.5)	259 (40.8)	220 (33.1)	196 (30.9)
Transportation Equipment	420	304 (72.4)	229 (54.5)	144 (34.3)	103 (24.5)	97 (23.1)
Instruments	312	251 (80.4)	205 (65.7)	147 (47.1)	123 (39.4)	120 (38.5)
Miscellenous	772	559 (72.4)	432 (56.0)	272 (35.2)	200 (25.9)	185 (24.0)
Total	11,154	8,637 (77.4)	7,035 (63.1)	5,061 (45.4)	4,155 (37.3)	3,949 (35.4)

Note: The survival rate is defined as the number of firms surviving in an industry in a given year, as a percentage of the total number of new firms established in 1976.

one-half were still operating after six years, and about one-third had survived ten years.

Second, as Evans (1987a and 1987b) found, the probability of survival generally increases with the age of the firm. Thus, firms which were two years old in 1978 had an 81.45% chance of surviving until 1980; those firms that were four years old in 1980 had a 71.94% chance of surviving until 1982; six-year old firms in 1982 had an 82.10% chance of surviving another two years; and eight year old firms in 1984 had a 95.04% chance of surviving until 1986. Of course, these aggregate survival rates in no way control for the business cycle—a qualification which will be made more explicitly in the concluding section of this paper. Still, the overall trend generally confirms the stylized fact identified by Evans that the probability of a firm surviving an additional increment of time increases with the amount of time that the firm has already survived.

Third, the survival rate apparently varies considerably across manufacturing sectors. For exam-

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ple, the ten-year survival rate is relatively high in paper, non-electrical machinery, primary metals, and fabricated metal products, all of which had survival rates in 1986 exceeding 40%.[6] By contrast, over the same time interval the survival rate is relatively low in the petroleum, apparel, furniture, transportation equipment, and leather sectors. None of these sectors experienced a ten-year survival rate in excess of 27%.

Finally, there is no apparent relationship between the number of newly created firms and the probability of surviving. Both the paper and non-electrical machinery sectors had ten-year survival rates of about 45%. However, the non-electrical machinery sector experienced the greatest number of newly established firms, while there were only 126 new firms established in the paper sector. Similarly, in both the chemical and textile sectors there were slightly more than three hundred new firms established in 1976. However, the ten-year survival rate in the chemical sector was nearly one-third greater than the survival rate in the textile sector.

III. The Technological Regime and Firm Survival

It has been widely observed (Scherer, 1980, p. 248; Phillips and Kirchhoff, 1989; Acs and Audretsch, 1990) that most new entrants are small and tend to operate at a suboptimal scale of output, at least in capital-intensive industries.[7] Thus, the greatest detriment to the survival of new firms may be the extent to which scale economies play an important role in the industry. That is, the greater the minimum efficient scale (MES) level of output, the less likely a firm is to survive, unless it experiences sufficient growth to attain MES.

However, Weiss (1976 and 1979) has argued that the existence of suboptimal capacity firms, that is those firms operating at a scale of output less than the MES level, is promoted in industries where price has been elevated above the minimum level of average costs (for firms with output exceeding the MES). To the extent that price exceeds the minimum average cost of the most efficient firms, the probability of a newly established firm surviving will be higher.

Each firm must decide whether to maintain its output at the same level, expand, contract, or exit from any industry, i. The probability of any given firm, j, of age t, remaining in industry i, or Pr $(Y_{it}^j > 0)$, is essentially determined by the extent to which a firm is burdened with an inherent size disadvantage, the degree to which the industry price is elevated beyond average cost at the MES level of output, and the probability of innovative activity:

$$\Pr(Y_{it}^j > 0) = f(I_t, P_i - c(Y_i^*), c(Y_i) - c(Y^*)) \quad (1)$$

where I_t is the probability of a firm with t years of experience making an innovation, $c(Y_i)$ is the average cost of producing at a scale of output Y_i, P_i is the price level in industry i, and $c(Y_i^*)$ is the average cost of producing at the MES level of output, or the minimum level of production required to exhaust scale economies, Y^*.

The probability of making an innovation, I, affects a firm's decision to remain in, or exit from, an industry because innovative activity is a vehicle by which a firm can grow and attain the MES level of output.[8] An implication of the Jovanovic (1982) and Pakes and Ericson (1987) learning-by-doing models is that firms begin at a small scale of output and then, if merited by subsequent performance, expand. While entrepreneurs may be unsure about their ability to innovate upon establishing a new firm, this becomes clearer with the passage of time. Those firms which successfully innovate can expect future sales growth, while those that face only dim prospects of innovating are more likely to exit from the industry.

The ability of a firm to innovate after t years of experience in the industry is influenced by what Nelson and Winter (1974 and 1982) term as the underlying technological regime: "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, p. 297). At least some

[6] Because only two new firms were established in the tobacco sector (SIC 21), it is excluded from these comparisons among two-digit SIC sectors.

[7] Of the 11,662 establishments started in 1976, only 589 (5.05%) had more than 50 employees. Thus, virtually all new establishments can be considered to be small.

[8] Caves and Pugel (1980) found that a strategy of product innovation is an instrument used by small firms to compete in high-MES industries.

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empirical evidence was provided by Acs and Audretsch (1987, 1988, and 1990) supporting the existence of these two distinct technological regimes.

Gort and Klepper (1982) posited, and found evidence, that the relative innovative advantage between newly established enterprises and incumbent firms depends upon the source of information leading to 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 new firms. This is consistent with Winter's (1984) notion of the routinized regime, where the accumulated stock of non-transferable information is the product of experience within the market, which firms outside of the industry, by definition, cannot possess.

By contrast, when information outside of the industry is a relatively important input in generating innovative activity, newly established firms will tend to have the innovative advantage over the incumbent firms. Arrow (1962), Mueller (1976), and Williamson (1975) have all emphasized that when such information created outside of the industry cannot be easily transferred to those firms existing within the industry, perhaps due to organizational factors, the holder of such knowledge must enter and expand in the industry in order to exploit the market value of his/her knowledge.

Thus, the probability of a given firm making an innovation, I, is dependent upon the extent to which an industry can be characterized by an entrepreneurial regime, u, or a routinized regime, r, as well as the age of the firm, t:

$$I = A/(1 + re^{-ut}) \qquad (2)$$

where A is a constant determining the asymptotic conditions.

Under the routinized regime, r is relatively large and u is relatively small, implying that the probability of a firm making an innovation increases as t increases, or as the firm gains experience in the industry. Under the entrepreneurial regime the opposite technological conditions hold —r is relatively small and u is relatively large—so that the probability of a firm making an innovation decreases as t increases.

One implication of the passive and learning models by Jovanovic (1982) and Pakes and Ericson (1987) is not only that firms that are unable to learn and adapt must exit the industry, but that the greater the cost disadvantage incurred by such firms, the more rapid will be their departure. This implies that industries which are capital-intensive and where scale economies play an important role may be particularly subject to low rates of survival. High-MES industries may be particularly subject to a low rate of survival, because those newly established firms unable to innovate, or find some other vehicle for growth, will be forced to exit.

IV. Empirical Results

To test the hypotheses that new-firm survival is attributable to the technological regime, market structure, and the extent of scale economies characterizing an industry, survival rates for firms established in 1976 were calculated for 295 four-digit SIC industries for 1978, 1980, 1982, 1984, and 1986. While the concept of technological regimes does not lend itself to precise measurement, the major conclusion of Acs and Audretsch (1987, 1988, and 1990) was that the existence of these distinct regimes can be inferred by the extent to which small firms are able to innovate relative to the total amount of innovative activity in an industry. That is, when the small-firm innovation rate is high relative to the total innovation rate, the technological and knowledge conditions are more likely to reflect the entrepreneurial regime. The routinized regime is more likely to exhibit a low small-firm innovation rate relative to the total innovation rate.

The total innovation rate is defined as the total number of innovations recorded in 1982 divided by industry employment. The small-firm innovation rate is defined as the number of innovations contributed by firms with fewer than 500 employees divided by small-firm employment.[9] The rates

[9] The innovation data are from the U.S. Small Business Administration's Innovation Data Base. The data base consists of 8,074 innovations introduced into the United States in 1982. Of the manufacturing innovations for which firm size could be identified, 55.81% came from large firms (with at least 500 employees), while 44.19% came from small firms (with fewer than 500 employees) (Acs and Audretsch, 1990, p. 19). A detailed analysis of the distribution of innovations according to significance levels and firm size can be found in Acs and Audretsch (1990, chapter 2).

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are used to standardize the amount of innovative and small-firm innovative activity in an industry for the size of that industry (as Acs and Audretsch do in their 1987 and 1990 studies). Since high small-firm innovation rates, given a total innovation rate, presumably reflect the entrepreneurial regime, the small-firm innovation rate is expected to have a positive influence on new-firm survival.

The challenge presented in measuring the extent of scale economies has been discussed in some detail in Scherer (1980), and Caves et al. (1975). As a proxy measure for MES, the Comanor-Wilson (1967) approach is adapted, where MES is measured as the mean size of the largest plants accounting for one-half of the industry value-of-shipments. To transform the MES measure into the share of the market required to exhaust scale economies, MES is divided by the 1977 industry value-of-shipments. In addition, the 1977 capital–labor ratio is included as an explanatory variable, since, as White (1982) points out, higher capital–labor ratios tend to be associated with greater scale economies.[10] This is partially because capital equipment tends to be "lumpy" in nature. Also, by enabling firms to take advantage of increased specialization and greater rates of utilization, the use of larger machines tends to reduce costs per unit of output. Since newly established enterprises generally operate at a suboptimal scale in capital-intensive industries where MES is high, both of these measures are expected to have a negative influence on the survival rate.

Advertising intensity, measured as industry expenditures on advertising divided by 1977 value-of-shipments, is also expected to be negatively related to new-firm survival for at least two reasons. First, the effect of advertising on firm revenues is subject to economies of scale that result from the increasing effectiveness of advertising message per unit of output.[11] Second, to the extent that scale economies exist in either production or advertising, the need to obtain funds for advertising will tend to aggravate the inherent size disadvantage of newly established firms.

As explained in the previous section, factors contributing to the elevation of price above the long-run average cost for firms at the MES level of output may facilitate the survival of suboptimal scale firms. According to Weiss (1976 and 1979) the existence of suboptimal scale firms may be promoted in concentrated industries, where the price level is more likely to be elevated.[12] Thus, ceteris paribus, the 1977 four-firm concentration ratio is expected to have a positive influence on new-firm survival rates. Similarly, Bradburd and Caves (1982) found that industry growth has a positive influence on the price-cost margin. The 1976–1986 industry growth rate (measured as the percentage change in value-of-shipments) is therefore expected to exert a positive effect on new-firm survival rates.

One of the more striking results to emerge in the Dunne et al. (1989) study is that plant growth and failure is influenced by the ownership structure of the firm. They found that the expected growth rate tends to decline with size for single-plant firms, whereas expected growth increases with size for plants owned by multiplant firms. Therefore, the share of newly established firms in 1976 accounted for by single-plant firms is also included as an explanatory variable. A negative coefficient would be consistent with the Dunne et al. findings. All data sources and further explanations are provided in the data appendix.

Table 2 shows the regression results estimating the ten-year survival rates for firms established in 1976. Because the dependent variable can vary only between 0 and 1 by definition, ordinary least squares estimation would produce inefficient variances of the estimated coefficients, rendering the appropriate hypothesis tests unreliable. Following the procedure recommended by Judge et al. (1980), this statistical inefficiency is corrected by using the logit estimation.

The regression results provide considerable support for the hypothesis that new-firm survival is influenced by the technological regime. The positive and statistically significant coefficient of the small-firm innovation rate in equations (1)–(3) suggests that, holding the total amount of innovative activity in the industry constant, an increase

[10] It should be recognized that the production function is not homothetic.

[11] The hypothesis that there are scale economies in advertising has been challenged by Arndt and Simon (1983), Boyer (1974), and Simon (1970).

[12] For a comprehensive group of studies providing at least some evidence that the price level tends to be elevated in concentrated industries see Weiss (1990).

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TABLE 2.—LOGIT REGRESSIONS OF NEW-FIRM SURVIVAL RATES, 1976–1986
(t-statistics listed in parentheses)

	(1)	(2)	(3)	(4)
Intercept	67.8190	63.9800	73.0430	70.5430
	(7.408)[b]	(7.539)[b]	(6.430)[b]	(6.268)[b]
Innovation Rate	−4.959	−4.6525	−5.4503	—
	(−0.592)	(−0.555)	(−0.648)	
Small-Firm Innovation Rate	0.6070	0.6080	0.6372	—
	(2.019)[b]	(2.021)[b]	(2.100)[b]	
Small-Firm/Total Innovation Rate	—	—	—	1.2045
				(1.758)[a]
Scale Economies	−2.2565	−2.2632	−1.6447	−1.8035
	(−1.915)[a]	(−1.920)[a]	(−1.160)	(−1.257)
Capital Intensity	−0.4148	−0.4063	−0.3764	−0.3661
	(−2.138)[b]	(−2.095)[b]	(−1.879)[a]	(−1.825)[a]
Concentration	—	—	−0.1905	−0.2477
			(−0.778)	(−0.984)
Advertising/Sales	27.1970	22.998	30.213	30.870
	(0.942)	(0.803)	(1.036)	(1.055)
Growth	1.7336	1.8601	1.7619	1.1644
	(0.479)	(0.514)	(0.487)	(0.320)
Single-Plant Share	−3.9765	—	−4.1132	−3.9493
	(−1.116)		(−1.152)	(−1.105)
Log-Likelihood	−299.973	−300.611	−299.662	−300.030
Sample Size	295	295	295	295

Note: The dependent variable has been multiplied by 100 for presentation purposes.
[a] Statistically significant at the 90% level of confidence, two-tailed test.
[b] Statistically significant at the 95% level of confidence, two-tailed test.

in the ability of small firms to innovate leads to a higher survival rate. By contrast, when the small-firm innovation rate is relatively low, the survival rate tends to be lower. This is also consistent with the positive and statistically significant coefficient of the ratio between the small-firm innovation rate and the total innovation rate in equation (4).

There is also evidence that, as expected, the survival rate is negatively influenced by the extent of scale economies and capital intensity characterizing an industry. In equations (1) and (2) both the measure of MES and the capital–labor ratio are negative and statistically significant. When the four-firm concentration ratio is included in the regression in equations (3) and (4), the coefficient of the MES measure remains negative but can no longer be considered statistically significant.[13] Although the growth rate has a positive coefficient and the share of firms consisting of single-plant enterprises has a negative coefficient, as expected, neither coefficient can be inferred to be statistically different from zero.

[13] It should also be reported that when the scale economies variable and both the scale economies and capital intensity variables are dropped from equations (3) and (4) in table 2, the four-firm concentration ratio is found to exert a negative and statistically significant influence on new-firm survival rates.

Survival rates for shorter time periods are substituted as the dependent variable in table 3. The first two equations estimate the four-year survival rates between 1976 and 1980. Two striking differences emerge between the determinants of the four- and ten-year survival rates. As the low t-statistics for the total innovation rate and small-firm innovation rate suggest, the technological regime apparently has no significant influence on survival within the first four years subsequent to establishment of a new firm. Second, as the positive and statistically significant coefficients of the measures of scale economies, capital-intensity, and market concentration all indicate, high-MES markets exert a positive influence on the ability of new firms to survive in the short run. All three of these measures have been usually identified as being positively related to industry price–cost margins (Schmalensee, 1988). It may be that the elevated price–cost margins enable new and presumably suboptimal scale firms to survive in the short run, but not in the longer run.

In fact, none of these variables is significantly different from zero in equation (3), where the time period has been lengthened to six years. Extending the time period further in equation (4) yields a negative and statistically significant rela-

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TABLE 3.—LOGIT REGRESSIONS OF NEW-FIRM SURVIVAL RATES FOR VARYING TIME PERIODS
(t-statistics listed in parentheses)

	1976–1980		1976–1982	1976–1984	1978–1982	1980–1984
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	−52.5330	−66.1610	12.0060	53.8720	−7.6916	−37.2850
	(−5.951)[b]	(−6.243)[b]	(−1.424)	(5.727)[b]	(−0.167)	(−1.300)
Innovation Rate	4.9880	6.2177	−2.5144	1.6693	13.8140	−7.5336
	(0.681)	(0.853)	(−0.331)	(0.198)	(1.235)	(−0.906)
Small-Firm	0.1096	0.0324	0.1437	−0.0091	0.2294	0.8709
Innovation Rate	(0.415)	(0.123)	(0.525)	(−0.030)	(0.689)	(3.152)[b]
Scale Economies	2.866	1.2972	−0.5808	−1.6072	3.1614	5.3727
	(2.771)[b]	(1.050)	(−0.542)	(−1.355)	(1.947)[a]	(2.660)[b]
Capital Intensity	0.4950	0.3969	0.1430	−0.3587	−0.0320	0.0827
	(2.912)[b]	(2.280)[b]	(0.810)	(−1.838)[a]	(−0.131)	(0.381)
Concentration	—	0.4879	—	—	—	—
		(2.286)[b]				
Advertising/Sales	39.6470	31.8110	56.1270	37.3370	−9.7024	27.5830
	(1.566)	(1.254)	(2.130)[b]	(1.283)	(−0.272)	(1.023)
Growth[c]	−3.1061	−3.001	3.1576	2.8424	−2.0817	1.1503
	(−0.631)	(−0.615)	(0.807)	(0.733)	(−1.177)	(0.234)
Single-Plant Share	1.2150	1.5661	−1.9080	−3.5004	1.4825	7.1377
	(0.388)	(0.504)	(−0.588)	(−0.975)	(0.339)	(0.235)
Log-Likelihood	−261.587	−258.915	−272.130	−302.083	−259.730	213.087
Sample Size	295	295	295	295	236	232

Note: The dependent variable has been multiplied by 100 for presentation purposes.
[a] Statistically significant at the 90% level of confidence, two-tailed test.
[b] Statistically significant at the 95% level of confidence, two-tailed test.
[c] Industry growth is measured over the relevant time period corresponding to the dependent variable.

tionship between capital-intensity and the eight-year survival rate.[14] Thus, there is considerable evidence that, just as the technological regime affects the ability of new firms to survive over a fairly long period but has no influence in the short run, the existence of high market concentration, scale economies and capital intensity facilitates survival shortly following the establishment of a new firm, but impedes survival in the longer run.

One qualification about the generality of the statistical results is the impact that the stage of the business cycle has on the pattern of survival rates across manufacturing industries. In order to shed at least some light on the extent to which macroeconomic volatility affects cross-section survival rates, the four-year survival rate for firms established in 1978 is estimated in equation (5) and for firms established in 1980 in equation (6). The results are generally consistent with those in equation (1). The presence of scale economies is found to increase the survival rate for all three time periods. However, while the small-firm innovation rate exerts no impact on the ability of firms to survive for the first two time periods, it has a positive and statistically significant effect during the 1980–1984 period. This ambiguity would suggest that the relationship between survival rates across industries and the business cycle needs to be more thoroughly examined in subsequent research.

[14] Including the four-firm concentration ratio in equations (3) and (4) results in a coefficient that is not statistically significant.

V. Conclusions

The findings of this paper provide at least some resolution to the apparent paradox that the entry of new firms is not substantially deterred in capital-intensive industries which exhibit scale economies. While entry may still occur in such industries, the likelihood of survival is considerably less. This is consistent with the observation that most new firms are sufficiently small as to operate at a suboptimal scale of output in high MES and capital-intensive industries. According to Jovanovic's (1982) theory, only those firms that are somehow able to adapt and grow will survive, while the others will be forced to exit from the industry.

One instrument that may enhance the survival of new firms, at least under the entrepreneurial regime, is innovative activity. As the empirical results imply, those technology and knowledge conditions conducive to small-firm innovation tend to promote the survival of new firms. Under

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the routinized regime, where small firms are at an innovative disadvantage, the survival rate is distinctly lower.

However, the influence of the technological regime and market structure on firm survival apparently varies considerably with the time interval considered. Just as the technological regime has no impact on four-year survival rates, the extent of scale economies and capital-intensity has a positive effect on the ability of firms to survive in the short run. In addition, the four-year survival rate for 1976–1980 is positively related to concentration. This is consistent with the hypothesis posited by Weiss (1976 and 1979) and others that factors associated with higher price-cost margins will tend to promote the entry of suboptimal scale firms. As the ten-year survival results indicate, however, this is a short-run and not a long-run effect.

These results need to be qualified by several considerations. First, the likelihood of survival is conditional upon an enterprise having already made the decision to enter an industry. However, the decision to establish a new enterprise is surely not independent of the probability of survival. To some extent there is a self-selection bias affecting the cohort of firms established in any given year —presumably those potential entrants which actually do establish a new firm would be expected to be influenced by their prospects of survival. The interaction between the decision to enter and the likelihood of survival needs to be explicitly examined in future research.

Second, there is at least some evidence that the observed survival rates are affected by the business cycle. In order to disentangle observed survival rates from business cycle effects, panel data sets with frequent observations must be constructed over long time intervals. The results from this paper make it clear, however, that the technological regime and market structure play an important role in explaining the variation in firm survival across manufacturing industries.

APPENDIX

Data Sources and Further Explanations

The data on firm survival and the share of new firms accounted for by single-plant firms come from the USELM file of the U.S. Small Business Data Base. More detailed description of the data can be found in Phillips and Kirchhoff (1989), Acs and Audretsch (1990, Chapter two), Boden and Phillips (1985), and U.S. Small Business Administration (1987). The innovation data for the number of small-firm innovations and total innovations, which are used to construct the innovation rates, come from the U.S. Small Business Data Base. This is explained in detail in Acs and Audretsch (1988 and 1990, chapter two).

The measures of MES (scale economies), capital–labor ratio (defined as gross fixed assets divided by total employment (thousands)), value-of-shipments, and the four-firm concentration ratio come from the U.S. Department of Commerce, Bureau of the Census, Census of Manufactures, 1977, Washington, D.C.: U.S. Government Printing Office. The growth measure is derived from the U.S. Department of Commerce, Bureau of the Census, Annual Survey of Manufactures, Industry Profiles, Washington, D.C.: U.S. Government Printing Office, various years.

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