The Entrepreneurial Regime, Learning, and Industry Turbulence

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ABSTRACT. The role which the technological regime and learning play in determining the extent of industry turbulence, or the amount of firm movements into, within, and out of an industry, is examined. The entrepreneurial regime, in which firms outside of the industry incumbents have the innovative advantage, is found to promote industry turbulence. By contrast, the routinized regime, in which the existing incumbents have the innovative advantage, is identified as impeding industry turbulence. The determinants of small-firm turbulence are found to differ from those for large-firm turbulence. Small-firm turbulence is particularly high in capital-intensive industries, where firms must quickly learn or else face extinction.

I. Introduction

While a heated debate has been raging over the last decade on what exactly constitutes a barrier to entry (see Stiglitz, 1987), empirical studies have consistently compiled a rather startling result — entry by new firms into an industry is apparently not substantially deterred in capital-intensive industries.[1] In our 1989a and 1989b papers we find that even small firms are not significantly deterred from entering industries which are relatively capital intensive. This raises several questions at the heart of intra-industry dynamics: How is it that small firms are able to enter an industry at sub-optimal scale? And how are they able to survive subsequent to entry?

The answers to these questions are implied to some extent by two quite different literatures. Winter (1984) and Gort and Klepper (1982) argue that the technological conditions determine the relative ease with which firms outside of the industry are able to innovate and therefore enter. 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, in order to obtain the opportunity to learn and subsequently expand if successful.

In fact, the technological regime characterizing the industry along with the role which learning by doing plays may explain a considerable amount of industry turbulence, or the extent of firm movements into, within, and out of an industry. The purpose of this paper is to explore the roles of the technological regime and learning in determining industry turbulence, and to examine whether the determinants of industry turbulence vary for large and small firms.

By combining two new sources of data we are able to construct novel measures of both the technological regime as well as the extent of industry turbulence. In the second section of this paper we introduce the concept of turbulence and intra-industry dynamics. In the third section we develop a model relating the technological regime to industry dynamics. The manner in which the concepts of turbulence and the technological regime is measured is explained in the fourth section, and the hypothesis is tested in the fifth section.

Finally, in the last section a summary and conclusions are presented. We find that when the

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knowledge obtained from actual experience in the industry is a crucial input in producing innovative activity, fewer firms will attempt to enter the industry and subsequently fewer will fail, leading to relatively low rates of turbulence. However, when knowledge from outside of the industry is a key input into the innovative production function, entry is more likely to occur. Of course, those firms which are unable to successfully learn and adopt will subsequently fail, so that the turbulence rate will be relatively high. Consistent with this is the finding that small-firm turbulence is actually greater in capital-intensive industries. Small firms that successfully innovate will become viable, but many of the remaining firms will recede and ultimately fail. Thus, small-firm turbulence is particularly high in capital-intensive industries, where firms must quickly learn or else face extinction.

II. Intra-industry dynamics

Alfred Marshall (1920, p. 263) described the process of industry evolution by analogy, where one can observe "... the young trees of the forest as they struggle upwards through the benumbing shade of their older rivals." Marshall's view of industry dynamics is not so different from the prevalent view held by most economists in industrial organization today, although this process has gone under the guise of various terms. Roughly speaking, the extent to which firms enter, grow, decline, and exit and industry has been termed 'mobility', 'turnover', 'dynamic evolution', and 'turbulence', depending upon the author. We adopt the term turbulence here to avoid confusion with the European meaning of 'turnover', which is widely used to mean sales, and 'mobility', which has most recently come to refer to movement of firms between strategic groups within an industry (see, for example, Oster, 1982). Instead, we draw upon the concept of turbulence (Beesley and Hamilton, 1984; and Gudgin, 1978) which we define as the extent of movements of firms within as well as into and out of an industry.

The extent of intra-industry firm movement is important for several reasons. For example, Simon and Bonini (1958, p. 616) argued that, "As a matter of fact, a measure of mobility ... would appear to provide a better index of what we mean by 'equality of opportunity' than do the usual measures of concentration." Grossack (1965) similarly argued that a measure of intra-industry firm movements may provide important dynamic information than can supplement the strictly static measure of market concentration.

The 1971 Bolton Committee in the United Kingdom argued that new firms in an industry would promote new products and ultimately shape the evolutionary path of the industry, as well as constrain any market power excercised by the entrenched firms:

> We believe that the health of the economy requires the birth of new enterprises in substantial number and the growth of some to a position from which they are able to challenge and supplement the existing leaders of industry. ... This 'seedbed' function, therefore, appears to be a vital contribution of the small firm sector to the long-run health of the economy. We cannot assume that the ordinary working of market forces will necessarily preserve a small firm sector large enough to perform this function in the future (Bolton Report, 1971, p. 85).

Caves and Porter (1977, p. 241) argued that the theory of entry be extended to a more "... general theory of mobility of firms among segments of an industry, thus encompassing exit and intergroup shifts as well as entry." While the traditional analysis suffers from neglecting structural restraints on the ability of firms to change their market share, the ease with which market share can be altered should be constrained by the "... same type of structural forces that deter the firm from increasing its output from zero to positive (entry) as from small share to large share (mobility)" (Caves and Porter, 1977, p. 250).

Despite the recognition that the process by which firms enter, grow, recede, and exit plays a crucial role in the evolution of industrial markets, there have been only a few empirical studies actually attempting to measure the extent of intra-industry firm movements. Most of these (Kaplan, 1954; Collins and Preston, 1961; Mermelstein, 1971; and Bond, 1975) have been oriented towards making inter-temporal comparisons of the largest U.S. corporations. The conclusion of these studies was unequivocal: the rate of turnover, at least among the largest corporations, has been declining over a long period of time. For example, Collins and Preston (1961, p. 1000) found that, "... in spite of the stability of the usual concentration measure there has been a significant decline in equality of opportunity in the upper reaches of the U.S. economy since the turn of the century."

While there are no unambiguous criteria for judging the extent of turbulence (Scherer, 1980, p. 55), there have been at least three important issues raised concerning the empirical methodology.[2] First, measures of intra-industry firm movements over a period as long as a decade obscure changes for shorter periods. For example, Boyle (1971) found that the coefficients for measures for paired years differ significantly from the ones for decades. Second, the preoccupation with changes among the 100 largest corporations has no unique economic significance. The relevant measure should include a wide spectrum of firm sizes (Boyle and Sorenson, 1971; and Porter, 1976). According to Boyle (1971, p. 165), virtually no studies "... have paid sufficient attention to the admonition in recent years." Third, and perhaps most significant, is the criticism that the appropriate unit of observation for examining turbulence should be the industry and not the aggregation of the largest firms (Stigler, 1956; and Kamerschen, 1971). Stigler (1956, p. 35), for example, warns, "The statistical universe of the 100 or 200 largest corporations is inappropriate to studies of monopoly and competition and we may hope that Kaplan will be the last study to fall prey to its dramatic irrelevance. For Kaplan's central ideal — that the extent of instability in the relative fortunes of the leading firms is an informative symptom of competition — is important and deserves to be applied on a correct industry basis."

III. A model of industry turbulence

Like Gort and Klepper (1982), Winter (1984), and Helmstädter (1986), our model is evolutionary in nature. The driving force of the dynamic evolution of the model is what Winter termed as the 'technological regime'. According to Winter (1984, p. 297), "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." Thus, the probability of making an innovation for any given firm, *i*, can be viewed as being influenced from the extent to which an industry can be characterized by an entrepreneurial regime, α, or a routinized regime, β:

$$i = \frac{k}{l + \beta e^{-\alpha t}}, \qquad (1)$$

where k is a constant determining the asymptotic conditions and t represents the time period.

Based on Gort and Klepper (1982), α and β can be viewed as being determined by the underlying sources of information about new product technology. These two sources of information are from firms already in the market and from firms outside the set, or on the fringe, of the major incumbent producers. The first information source, which determines β, is the product of experience and contains both transferable and non-transferable components. Gort and Klepper emphasize that the accumulated stock of non-transferable information is the product of learning by doing, which firms outside the industry, by definition, cannot possess. The greater is the role which the accumulated stock of non-transferable information plays, the higher will be the value of β, and the greater will be the extent to which innovative activity emanates from the major incumbents.

When β is relatively small and α is large, new firms will tend to have the innovative advantage. By contrast, incumbents will tend to be more innovative when β is large and α is small. In fact, we found in our 1987 and 1988 papers that there is considerable empirical evidence supporting the existence of these distinct technological regimes.

In Gort and Klepper's (1982) model, entry behavior is derived directly from these technological regimes, such that the probability of any given firm entering, $P(E)$, is given by

$$P(E_t) = f(\alpha_t, \beta_t, \Pi_t), \qquad (2)$$

where Π_t is defined as the profit of incumbent producers at time t. the variables α_t and β_t represent the influence of the technological regime on the probability of entry. Gort and Klepper essentially assume that $\partial f/\partial \alpha_t > 0$ and $\partial f/\partial \beta_t < 0$. When β_t is relatively high and α_t is relatively low, innovation as a vehicle for entry is less of a viable alternative for firms either outside of or on the fringe of the market. However, entry by outside firms is encouraged when the second source of innovation-producing information is relatively more important. Arrow (1962), Mueller (1976), and Williamson (1975) have all pointed out 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 has no choice other than to enter the industry in order to exploit the market value of his/her knowledge.[3]

Subsequent to entering an industry, a firm must decide whether to maintain output at the same level, expand, contract, or exit. The probability of a firm remaining in the industry in period t, or $P(Q_{it} > 0)$, is essentially determined by the extent to which a firm is burdened with an inherent size disadvantage, the profitability of the incumbents (Π), and the probability of innovative activity:

$$P(Q_{it} > 0) = g(i_t, \Pi_t, c(Q_i) - c(Q^*)), \qquad (3)$$

where $c(Q_i)$ is the average cost of producing at a scale of output Q_i, and $c(Q^*)$ is the average cost of producing at the minimum efficient scale of output (MES), or the minimum level of production required to exhaust scale economies, Q^*.

The firm's actual level of output in period t is determined by its actual innovative activity,[4] I_t, plus some factor of its output in the previous period, $\overline{Q}_t$,

$$Q_{it} = \overline{Q}_t + Q(I_t), \qquad (4)$$

where

$$\overline{Q}_t = \lambda(Q_o + Q_{it-l}), \qquad (5)$$

and Q_o is an autonomous level of output and λ represents the portion of the previous period's output that can be maintained in the market. Factors such as market growth influence the value of λ.

Thus, equations (3)—(5) essentially represent the learning process by entrepreneurs which has been described by Jovanovic (1982) among others. In particular, Jovanovic assumes that individuals are unsure about their ability to manage a business and prospects for success. While they may enter a market based on a vague sense of expected profitability, they discover their ability to manage in the given environment once their business is established. With the passage of time, they alter their behavior as they learn to disentangle their inherent ability from random business fluctuations. Those entrepreneurs who discover that their ability exceeds their expectations expand the scale of their business, while those discovering they have less inherent talent than expected contract the scale of output or possibly even exit from the industry. An implication of the model is that firms begin at a small scale and then, if merited by subsequent performance, expand. Pakes and Ericson (1987) build on Jovanovic's model by arguing that firms can actively accelerate the learning process by investing in R&D, thereby endogenously raising the value of I_t. Those firms which are successful grow, while those that are not successful either remain small or else exit from the industry (Audretsch and Acs, 1990).

An important implication of the above model is that firms are more likely to enter an industry, even at sub-optimal scale, if the technology is such that there is a greater chance of new products coming from firms outside the incumbents. If firms successfully learn and adopt, they grow into viably sized enterprises. If not, they stagnate and may ultimately exit. An implication is that the amount of industry turbulence should be positively related to the potential that new and fringe firms have for becoming successful and at the same time the extent to which those less successful firms are forced to decline and/or exit the market.

IV. Measurement

We use the dynamic measures from the USELM file of the U.S. Small Business Data Base (SBDB) introduced in our 1989b paper to construct turbulence measures that most closely resemble the measure used by Beesley and Hamilton (1984).

Specifically, we define turbulence as the absolute value of all employment and contractions within an industry (or firm-size class) between 1976 and 1980. That is, a given amount of market growth will dictate a corresponding amount of additional employment presumably from both existing firms as well as from new entrants. However, to the extent that existing firms experience employment reductions as well as exit from the industry, the greater will be the overall amount of expansion and entry, and subsequently, the overall amount of turbulence.

In order to standardize turbulence for industry size, the turbulence rate for firm-size class j, TR_j, is defined as:

$$TR_j = (EXP_j + CONTR_j + BIRTH_j + +DEATH_j)/(EMPL76_j), \qquad (6)$$

where EXP_j is the amount of employment expansion in firm-size class j between 1976 and 1980, $CONTR_j$ is the amount of employment contraction in firm-size class j between 1976 and 1980, $DEATH_j$ is the amount of employment lost due to firm exits, $BIRTH_j$ is the amount of employment in new firms entering the industry, and $EMPL76_j$ is the amount of employment in firm-size class j in 1976.

More precisely, expansion is defined as the number of jobs in a specific firm-size class that emanate from new positions generated by firms *in existence during the initial period.* By definition, expansion is bounded by zero, which would indicate that the firms in that size class that were in existence during the first year did not create any employment beyond that amount already in effect in the initial period. Contraction is defined as the number of jobs in a specific firm-size class that were eliminated by firms which were in existence during the entire period. Contraction is also bounded by zero, which would indicate that none of the firms in that size class that were in existence during the initial year decreased the number of jobs over the relevant period. Of course, if a firm exits from the industry, the loss of employment will not be included in the contraction measure. However, a separate variable, deaths, measures the amount of employment in the firm-size class that is lost due to firm exits.

It should be emphasized that boundary crossings over time do not create a problem when the USELM file of the SDBD is used. That is, a firm's expansion or contraction is classified according to the size-class based on the firm's employment in 1976, regardless of any subsequent upward or downward movements of the firm into adjoining size class.

As Beesley and Hamilton (1984) note, factors which have a symmetrical effect on entry and exit, or expansion and contraction, will have little impact on TR. There is also reason to suspect that the determinants of small-firm turbulence are considerably different from those for all firms. In fact, for the 247 four-digit standard industrial classification (SIC) industries included in the sample, the small-firm (fewer than 500 employees) turbulence rate exceeds the large-firm (at least 500 employees) turbulence rate by 35.10 percent.

Winter's (1984) concept of distinct technological regimes and Gort and Klepper's (1982) notions of the accumulated stock of non-transferable information acquired from learning by doing, and innovative knowledge from firms outside the industry do not lend themselves to exact measurement. However, it is perhaps not unreasonable to consider the measures of small- and large-firm innovation which we introduced in our 1987 and 1988 papers and 1990 study as proxy measures indicating the extent to which firms outside the major producers are able to innovate. The small-firm innovation rate (SIE) is defined as the number of innovations contributed by firms with fewer than 500 employees divided by small-firm employment. The large-firm innovation rate is defined as the number of innovations contributed by firms with at least 500 employees divided by large-firm employment. When SIE is high relative to the overall innovation rate (TIE), the technological and knowledge conditions may dictate a market which is more conducive to entry by innovation. Under such an entrepreneurial regime, α would be expected to be relatively high and β relatively low. However, when SIE is small relative to TIE, technology and knowledge are better characterized by a routinized regime, where presumably α is low and β is high.

Of course, those new firms entering but not able to innovate or otherwise learn and adopt may be forced to contract and ultimately exit. Thus, TR should be positively related to SIE and negatively to TIE.

The extent of skilled labor comprising the labor force (SKILL) may also reflect the degree to which knowledge particular to the existing firms in the industry is crucial to innovative activity, and would therefore be expected to be negatively related to TR. Gort and Klepper (1982) also argued and found evidence suggesting that markets are most accessible to outside firms in the early stage of the life cycle, when the growth rate is high. Therefore, the mean annual real growth rate between 1972 and 1977 (GR) is expected to be positively related to turbulence.

One of the implications of the passive and active learning models by Jovanovic (1982) and Pakes and Ericson (1987) is not only that those firms which do not learn and adopt must exit the industry, but that the greater the cost disadvantage incurred by firms not able to successfully learn and adopt, the more rapid will be their decline and departure. This implies that industries which are capital-intensive and where scale economies play an important role may be particularly subject to high rates of turbulence, at least among the small firms.

The technology and knowledge conditions inherent in α and β may provide outside firms with the opportunity for entry and growth through successful innovation. However, the typical entrant in a high MES industry is at a sub-optimal scale and therefore must either successfully innovate or else depart from the industry. Thus, high MES industries may be particularly subject to a high degree of turbulence among small firms which are hoping to discover the successful innovative strategy, but many of which will be forced to exit the industry. This suggests that TR, at least for small firms, is expected to be positively influenced by the minimum efficient level of output as a share of total industry sales (MES/S), capital-intensity or 1977 gross assets divided by employment (K/L), and the amount of capital required for a firm to produce the MES level of output (KREQ).

Recent studies (Acs and Audretsch, 1989a and 1989b) have identified advertising intensity to serve as a greater impediment to small-firm entry than capital-intensity. Therefore, the advertising-sales ratio (AD/S) may promote industry stability more than turbulence and is expected to be negatively related to TR.

Industry profitability, measured by the 1977 price-cost margin (PCM), is expected to be negatively related to TR, since firms are more likely to survive in highly profitable industries. As Beesley and Hamilton (1984) point out, industry profitability may promote entry without a concomitant positive effect on exits and, in fact, may reduce the number of industry exits, thereby reflecting less and not more turbulence.

Berry (1974) and Beesley and Hamilton (1984) argue that turbulence for large firms, but not for small firms, may be higher in concentrated than in non-concentrated markets, because "... only large firms are able to encroach — via the setting up of dependent units — into areas already dominated by other large firms" (Beesley and Hamilton, 1984, p. 227). Thus, TR is hypothesized to be positively related to CON, except in the case of small firms. All variables are explained in more detail and data sources are provided in the appendix.

V. Empirical results

Table I shows the regression results for estimating the turbulence rates of all firms (Equation 1), small firms (Equation 2), as well as the small-firm turbulence rate divided by the turbulence rate for all firms (Equation 3), and the small-firm turbulence rate divided by the large-firm turbulence rate (Equation 4). The regressions were estimated using 247 four-digit SIC industries, and a small firm is defined here as having fewer than 500 employees.[5]

There are four important results in Table I. First, as the positive coefficient of SIE in the first two equations indicates, there is substantial evidence supporting the hypothesis that there is relatively more turbulence in markets where small firms are able to implement a strategy of product innovation, but relatively less turbulence in markets where they are not able to innovate. Further, as the negative coefficient of TIE suggests, holding the small-firm innovation rate constant, increases in the overall innovative activity of the industry lead to less and not more turbulence. This is consistent with Gort and Klepper's (1982) notion that markets in which the knowledge accumulated from experience plays a crucial role in innovative activity will tend not to be accessible to new firms, while markets in which such knowledge is relatively less important in producing innovations will generate much more activity from outside and fringe firms. These results apply for small firms as well as all firms.

Second, as the positive coefficient of KREQ in

TABLE I
Regression results for turbulence rates (*t*-statistics listed in parentheses)[a]

	(1) All firms	(2) Small firms	(3) Small firms/all firms	(4) Small firms/large firms
PCM	−0.0028	−0.0726	−3.8776	−4.1381
	(0.0073)	(2.0714)**	(0.4809)	(−0.3887)
GR	7.3606	1.6066	−0.3450	−1.4332
	(1.3533)	(3.2922)**	(−0.3074)	(−0.9498)
SIE	1.2997	0.1379	−0.0847	−0.0708
	(2.8471)**	(3.3672)**	(−0.8990)	(−0.5590)
TIE	−2.6193	−0.1277	0.2535	0.2677
	(−2.3489)**	(−1.2767)	(1.1020)	(0.8651)
SKILL	−2.2735	0.3114	1.6117	2.0173
	(−0.3365)	(0.5137)	(1.1563)	(1.0763)
AD/S	−4.0130	−0.3234	1.6307	2.3437
	(−1.7626)*	(−1.5830)	(3.4716)**	(3.7105)**
CON	8.7681	−0.1719	−1.8887	−2.8133
	(4.2011)**	(−0.9177)	(−0.4386)	(−0.4859)
K/L	−1.2750	−0.2700	2.7775	2.4669
	(−0.6229)	(−1.4703)	(0.6577)	(0.4344)
MES/S	−6.9018	−1.2359	0.0418	0.0547
	(−0.6766)	(−1.3503)	(1.9881)**	(1.9334)*
KREQ	−7.7122	4.6689	1.1294	1.2954
	(−0.5074)	(3.4235)**	(3.6014)**	(3.0719)**
Intercept	0.4847	1.7395	0.9071	0.8477
	(0.3441)	(13.7640)**	(3.1214)**	(2.1693)**
R^2	0.148	0.217	0.186	0.167
F	4.091**	6.546**	5.406**	4.727**

* Statistically significant at the 90 percent level of confidence, two-tailed test.
** Statistically significant at the 95 percent level of confidence, two-tailed test.
[a] Small firms are defined as having fewer than 500 employees.

Equation 2 indicates, there is at least some evidence that the extent of turbulence within smaller firm-size classes is positively related to capital intensity. However, the negative (and statistically insignificant) coefficient of KREQ in Equation 1 implies that capital intensity does not stimulate turbulence in general. The positive coefficients of KREQ, MES/S, and K/L in Equations 3 and 4 substantiate the hypothesis that while capital intensity may promote higher rates of turbulence among small firms, it does not among larger ones. This is consistent with the notion previously discussed that at least under certain technological conditions smaller firms may still enter markets with substantial scale economies and capital requirements, but those firms not able to successfully learn and adopt are quickly forced to decline and exit. The larger firms, which Evans (1987a and 1987b) found to be older and more experienced, have already survived some of this learning process, and thus experience lower rates of turbulence. The negative and statistically significant coefficient of AD/S in Equation 1 along with the positive and statistically significant coefficients of AD/S in Equations 3 and 4 also imply that advertising intensity is negatively related to the extent of turbulence, although its impact is stronger for large than for small firms.

Third, as the positive coefficient of CON in Equation 1 suggests, there is actually more, not less turbulence in concentrated markets. Further, as the negative (and non-significant) coefficient of CON in Equation 2 implies, the turbulence rate among smaller firms may not be as strongly affected by market concentration as that of their larger counterparts. Finally, the negative coefficients of PCM and positive coefficients of GR in the first two equations are consistent with the hypothesis that turbulence rates are diminished in highly profitable industries but stimulated in growing markets. As the statistically non-significant coefficients of PCM and GR in the last two equations suggest, PCM and GR apparently have similar effects on the turbulence rates of large and small firms.

VI. Conclusions

A fundamental question concerning the evolutionary nature of markets, or intra-industry dynamics, has been raised in this paper: "What determines the extent of turbulence, or firm movements into, within, and out of an industry, and do these determinants vary for large and small firms?" By utilizing some of the dynamic variables made possible by the SBDB data, we are able to construct relatively novel measures of intra-industry dynamics in order to answer this question.

We find evidence supporting the hypothesis of Gort and Klepper (1982) that the source of knowledge which produces innovations plays a key role in intra-industry dynamics. If innovative activity is particularly dependent upon knowledge which can be accumulated only through experience in the industry, the existing producers will have the innovative advantage, and new and fringe firms will not find the industry to be especially accessible. Because relatively few firms will attempt entry into such an industry, there will also be a correspondingly low number of exits, resulting in a low rate of turbulence. On the other hand, if the knowledge required to produce innovations emanates largely from outside of the industry, or outside of the main producers in the industry, the market will be accessible to new and fringe firms.

However, just because the structure of knowledge and technology creates a market which is accessible, it does not imply that entrants and expanding fringe firms will automatically survive. Rather, the learning-by-doing theory suggests that only those firms which are able to successfully learn and adopt will grow and/or survive. Not only do the empirical results in this paper support the hypothesis that there will be a greater extent of turbulence in industries in which small firms are able to implement a strategy of innovation, but that, unless the small firms are able to participate in the ongoing innovative activity, the turbulence rate will be relatively low. In addition, we find that the turbulence rate for small firms, but not for large firms tends to be greater in capital-intensive industries. This is consistent with the hypothesis that in such industries the small firms which successfully innovate and otherwise adopt (or are just plain lucky) grow to become viable entities, while the less fortunate small firms quickly decline and exit from the market. Because the larger firms tend to have accumulated more experience, the extent of turbulence among large firms is considerably less in capital-intensive industries.

Thus, the results from this paper confirm the key role which the nature of technology and the process of learning play in the evolutionary nature of markets. As panel data sets are assembled, more evidence will hopefully be accumulated about intra-industry dynamics and how market structures evolve.

Appendix

Data sources and further explanations

The innovation data for the number of small-firm innovations and total innovations which are used to construct the innovation rates, SIE and TIE come from the U.S. Small Business Administration Innovation Data Base. This is explained in detail in Acs and Audretsch (1988).

The U.S. Department of Commerce, Bureau of the Census, Annual Survey of Manufactures, 1977, *Industry Profiles*, Washington, D.C.: U.S. Government Printing Office, issued 1981, is the source of the capital-labor ratio (K/L), four-firm concentration ratio (CR), annual growth rate (GR) (the 1972 Survey was also used to calculate GR), and value-of-shipments (S), and minimum efficient scale (MES). The MES is measured as the mean size of the largest plants accounting for one-half of the industry value-of-shipments. KREQ is measured as the amount of capital required to produce the MES level of output, defined as total industry assets, divided by value-of-shipments, multiplied by MES.

The employment data by firm size, births (BIRTH), deaths (DEATH), expansion (EXP), and contraction (CONTR) are from the U.S. Small Business Administration, Office of Advocacy, Small Business Data Base. More detailed description of the data can be found in Boden and Phillips (1985).

The advertising-sales ratio was derived by using the 1977 value-of-shipments data described above, and advertising from the United States Input-Output Table. The measure of skilled labor (SKILL) is from the U.S. Department of Commerce, Bureau of the Census, Census Population 1970, Subject Report PC (2)—7c, *Occupation by Industry*, issued 1972. SKILL is measured as the percentage of employment consisting of professional and kindred workers, plus managers and administrators, plus craftsmen and kindred workers.

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Notes

[1] For a review of these studies see Acs and Audretsch (1989a).

[2] Most of the theoretical criticisms of attempts to measure industry turnover or mobility are discussed in Stigler (1956), Mermelstein (1971), Kamerschen (1971), and Boyle (1971).

[3] For further explanations see Mueller and Tilton (1969) and Tilton (1971).

[4] It should be noted that $E(i_t) = I_t + \mu_t$, where μ is stochastic.

[5] It should be noted that the coefficient of GR, SIE, TIE, and the intercept have been divided by 100, the coefficients of AD/S have been divided by 10,000, and the coefficients of KREQ have been multiplied by 10,000 for presentation purposes in Equations 1 and 2. Similarly in Equations 3 and 4 the coefficients of K/L and CON have been multiplied by 100, the coefficients of PCM have been multiplied by 10,000, and the coefficient of KAPR by 10,000.

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