STRATEGIC TRANSFORMATION
and the
SUCCESS of HIGH TECHNOLOGY COMPANIES

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Strategic Transformation and the Success of High Technology Companies*

by

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Abstract

Longitudinal study focused upon the strategic differences of the "super-successes" among 21 Greater Boston high-technology firms that had already survived for five years or more and attained sales of at least $5 million. Multiple evidences of market-oriented transformation of these technology-based companies seem to dominate the high performers. Aggressive forward integration, formal strategic planning and market research, organizational recognition of the importance of marketing, and market-oriented control of the new product development process all correlate significantly with corporate success measures. Surviving original founder-CEOs as a group perform as well as the large number of replacement CEOs who were brought in following externally generated "critical events". The replacement CEOs brought about strategic market-oriented transformations that account for their success. No separate explanations account for the success of the surviving original CEOs.

Keywords: entrepreneurship; technological entrepreneurship; high-technology companies; corporate success; corporate strategy; strategic transformation; market-orientation; CEO role; executive succession

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What does it take to go beyond the better and become the best? How does a technology-based firm that has already achieved some degree of success go on to the realm of "super-success"? This article tries to identify the strategic actions needed through an intensive investigation of high technology companies in the Greater Boston area that had already survived for at least five years and had attained sufficient sales to be deemed by many as successful. The evidence supports the notion that to find "super-success" most high-technology firms must transform themselves toward a marketing-oriented strategy.

Prior Research on High-Technology Company Strategies

Strategic aspects of high-technology companies are perhaps the least developed area of entrepreneurship research. The limited studies carried out thusfar in the domain of strategy go beyond the non-strategic correlates of entrepreneurial success that are more prevalent in the literature: demographic and personal characteristics of the entrepreneur, venture capital and other financing considerations, sales/marketing activities of the young firm. My earlier work on product strategy in high-technology firms (Meyer & Roberts, 1986, 1988) fits into this overall strategic dimension. Other recent strategic research on technology-based entrepreneurial firms falls into several typologies: overall corporate strategies or marketing strategies; organization structures; decision-making processes; and executive influences. A useful overview of many of the issues treated here is presented by Tushman & Romanelli (1985), who link together the disparate literatures on organizational evolution, executive leadership and strategic reorientation (and in later work apply their framework to research on the minicomputer industry).

Romanelli (1987) sorted the strategies of young minicomputer firms into four groups aligned into specialist-generalist, aggressive-conservative clusters. She found that early strategies categorized in this manner tend to persist, even though environmental conditions of the industry change, but she did not relate the specific strategies to success or failure. Similarly Eisenhardt & Schoonhoven (1989) conclude for semiconductor ventures "that founding conditions have a persistent effect on the shape of subsequent

structures and processes within firms" (p. 2), referring specifically to founding top management team composition and external market conditions. Sandberg (1986) also suggested from analysis of 17 selected ventures in several fields that early-stage entrants in an industry need to employ different strategies from later-stage entrants. Smith & Fleck (1987) provided a qualitative assessment of principle strategies of 12 Cambridge, England high-technology firms and found them lacking explicit long-term plans but behaving consistently as highly specialized niche-market players, trying to minimize both in-house manufacturing and use of outside capital in order to preserve founder financial control. The exploratory work of Slevin & Covin (1987) in comparing high- and low-tech industries found few significant differences in the competitive tactics of high and low performing firms and concluded that effectiveness of implementation rather than tactics alone may explain performance. In contrast to these empirical studies of overall entrepreneurial strategies most of the marketing strategy papers tend to be anecdotal, describing the authors' experiences in companies they started or for whom they have consulted (e.g., Esher & Stone, 1987; McKenna, 1987).

Miller & Friesen with Mintzberg (1984) organized a large collection of public case studies and business press information on transformations that occurred in major corporations (neither young nor high-technology oriented) and discussed organizational strategies, associated behaviors and performance outcomes. Six different "transformation archetypes" accounted for 84 percent of the firms assessed. However, of relevance to our focus on entrepreneurial firm strategies and our own broad hypothesis, they characterized their largest cluster, 32 percent of their sample, as engaged in "entrepreneurial revitalization". Miller & Friesen found that new CEOs in those firms pursue "new market opportunities, ... become more aggressive and innovative in dealing with competitors and more imaginative in meeting the needs of customers", increasing both "proactiveness and product-market innovation". (pp. 133, 134) Bahrami & Evans (1988), referring to a survey of fifteen high-technology firms, argue that entrepreneurs seek to design organizational structures that "emphasize fluidity and flexibility, while retaining cohesion across interdependent functional and technological activities." (p. 3)

The research on executive decision-making in high-tech firms is

dominated by Eisenhardt and her co-authors (1989; Bourgeois & Eisenhardt, 1987, 1988; Eisenhardt & Bourgeois, 1988), focusing on the microcomputer industry. This stream of studies presents in-depth discussions of the decision styles and consequences in "high velocity environments", demonstrating that "fast decision-making" can be carried out with good use of data and careful consideration of alternatives.

Also related to high-tech executives, but more to their competencies and backgrounds than their explicit decision-making processes, Tushman and his students have carried out extensive studies of the evolution of a sample of minicomputer firms, focusing their attention on the causes and consequences of executive succession and strategic reorientation of these companies. They find that new CEOs (and other top managers), when also accompanied by multi-dimensional strategic change, lead to performance improvement in these companies. (Tushman, Virany & Romanelli, 1985, 1987). Furthermore, top management characteristics "shift over time -- in their early years, hiring a large portion of executives with engineering expertise and shifting their recruiting emphasis over time toward sales and marketing." (Virany & Tushman, 1986, p. 264) The Tushman et al. research in particular relates closely to the point of view as well as some of the findings that will be described in this article.

In prior work (Roberts, 1989) I have indicated that within a few years of their founding many technology-based firms begin transitional evolution from a primarily inward orientation focused upon internal technical inventiveness into more balanced operations, increasingly devoting their attentions to customers and market. I now hypothesize that in search of ultimate success the technological enterprise must complete this transformation: it can no longer be primarily an exploiter of its technical origins and hopefully continuing strengths; it must become a servant of its customer's needs, practicing what might be regarded as true marketing-oriented management. This is consistent with Peter Drucker's classic perspective: "Marketing is ... the whole business seen from the point of view of its final results, that is from the customer's point of view." (Drucker, 1973) Of course, technological innovation must continue to play a key competitive role for the still relatively small firm, differentiating it from its larger rivals in providing product performance in servicing its customers'

priorities. This broad strategic hypothesis is explored in the data analyses now reported.

Methodology and Measurements

Sample Development

To explore this broad hypothesis of the need for complete market-oriented transformation in the high-tech company we employed a cohort based longitudinal design. All Greater Boston firms were identified in two high technology Standard Industrial Codes (SIC), electronic computing equipment (3573) and medical instrumentation (3811), both prominently represented in the Boston area, that were from 5 to about 20 years old and which had already attained sales of from 5 million to more than one hundred million dollars. Semiconductor firms are included in the first SIC category along with computer and computer peripheral companies. The Standard & Poor and Dun & Bradstreet directories, supplemented by the telephone Yellow Pages, provided the bases for accumulation of the candidate firms. Further checking by telephone for possible errors in date of founding, current address, and whether or not the firm did indeed develop and manufacture hardware products (software and service companies were excluded from this study) led to the identification of 34 companies in total. Telephone solicitation of the CEOs of these firms brought agreement to participate by 21 companies, with 13 declining, as indicated in the Appendix. No obvious bias was apparent among the dropouts but no followup study was undertaken to check on this possibility.

The detailed interview structure was developed and pretested in discussions with senior officers of several venture capital companies as well as with academic entrepreneurs whose firms were not included in the study. Once the interview approach was finalized, in-person structured interviews were conducted by a three person interviewing team at all 21 participating firms, gathering data from an average of four persons in each firm, including the CEO plus Vice Presidents of marketing, finance, and corporate development or their equivalents. An average of 5 hours was spent in each company in these interviews. In addition to questionnaire responses to a wide variety of inquiries, time series of annual financial data were gathered

from the financial statements on a large number of balance sheet and operating statement variables.

Degrees of Success

In line with our sampling approach all of the companies were at least five years old, with the median company being in business thirteen years since incorporation. At the time of the study six of them had already achieved current year sales of over 100 million dollars. (No correlation exists between the age of the firms and their sales revenues.) Yet size alone is not a sufficient measure of success. Discussions with the presurvey participants as well as the interviewed corporate executives led to agreement that although the personal goals of the technological entrepreneur may vary widely as a function of the individual's motives, the financial goals of the high technology firm are generally seen as twofold: growth and profitability. Both variables are perceived as essential to maximize the shareholder's short and long term returns. The growth dimension was measured using the annual average compounded increase in sales. Profitability was measured as the average annual return on equity, including retained earnings in the equity figure. In the few cases of negative equity balance resulting from cumulative losses, return on equity was calculated by dividing average annual loss by the original equity investment.

Some of the analyses required "standards" for the degrees of growth and profitability that would constitute success. From the presurvey and company interview participants we concluded that 30% was a generally accepted successful year-to-year growth rate of sales. Although some firms hoped for and even realized higher growth, and other firms targeted lower growth, the consensus was that 30% growth was a good target that with effort could be controlled and managed. Similarly, 15% return on equity was perceived as a successful standard of continuing profitability over a several year period, although returns in any given year, especially of high inflation, might be considerably higher.

These success measures were used to divide the participating companies into four clusters, as shown in Figure 1. Type 1 includes the most successful seven firms, with both high growth (averaging 60%) and high

Figure 1. Success Matrix for Sampled Companies

RETURN ON EQUITY	GROWTH >30%	GROWTH <30%
>15%	++: Type 1 7 firms Av. Growth: 60% Av. ROE: 25%	+-: Type 3 3 firms Av. Growth: 23% Av. ROE: 21%
<15%	-+: Type 2 2 firms Av. Growth: 57% Av. ROE: 10%	--: Type 4 7 firms Av. Growth: 20% Av. ROE: -9%

return (averaging 25%). The five Type 2 and 3 companies are reasonably successful, but moreso on one dimension than on the other. Based on the criteria established for this special study of "super-success", the seven Type 4 firms are not successful overall, with both less growth (20%) and negative average returns (-9%). (Two privately held companies in the sample could not provide adequate financial time series for the several year averages that were used in setting up this matrix, but their omission did not appear to introduce any additional bias in the data.) Thus, although all 21 companies had reached at least $5 million in sales, assessing their success in terms of growth rate, essentially a projection of their likely future development, and their return on equity, a measure both of financial solidity and potential returns to their stockholders, one third of the sampled firms appear to be "survivors", rather than successes. In fact statistical analyses of the firms' current sales against these financial success measures show no significant correlation.

The logical approach to developing a single simple measure of success is to combine ROE and growth rate. But their very different mean values would weight the growth parameter too heavily if just a simple addition were used. Based on the data success is therefore defined:

SUCCESS = 2 (ROE) + GROWTH,

where ROE and GROWTH are expressed in percentages. Once the assembled data set from the company interviews was correlated with this measure of financial success, the sensitivity of the correlations were checked with other weightings of the two components:

1. 3.5 (ROE) + GROWTH
2. 3 (ROE) + GROWTH
3. ROE + GROWTH
4. ROE + 2 (GROWTH)

These alternative weights were selected from inspection of the ROE and GROWTH data. The means of ROE and GROWTH are 10.78 and 37.68, respectively, with standard deviations of 28.2 and 27.3. The approximately 3.5:1 ratio of the means suggests equation 1 as an alternate formulation of SUCCESS. Further inspection of the data revealed one ROE data point to be an outlier. Removing it generated a new ROE mean of 14.97, with a new standard deviation of 17.10. The resulting new ratio of the mean ROE to the mean GROWTH is now closer to 3:1, suggesting equation 2. Equations 3 and 4 give more weight to growth and also seem to be viable alternatives to test.

Fortunately, correlation analyses performed with these four alternative financial success measures agree in general with the results determined from the initial formulation of SUCCESS = 2 (ROE) + GROWTH, except for some shifting among the .01, .05 and .10 significance levels. Within these levels 22 of the 48 coded variables show statistically significant correlations with SUCCESS. In light of the small sample size, the slight changes among the significance levels were considered trivial. The consistent results with respect to all variations of the success factor add confidence to our use of the original success factor equation. In addition, SUCCESS also correlates significantly with each of its components, ROE and GROWTH, as well as with return on assets and profitability, as measured by the earnings/sales ratio, in the entire sample of 21 firms as well as in several smaller subclusters that were studied, lending still further support to this choice of a success measure.

IN SEARCH OF SUCCESS

The Marketing Side of the Technological Enterprise

In Ted Levitt's oft-cited "Marketing Myopia" he observed "that the top-heavy science-engineering production orientation of so many electronics companies works reasonably well ... because the companies are in a position of having to fill, not find markets; of not having to discover what the customer needs and wants, but of having the customer voluntarily come forward." (Levitt, 1960) This may indeed still be true during the early days of a technological firm's existence, when it is bringing new technology to the marketplace to serve new needs or to better serve old ones. But as the company grows in sales, satisfies its initial niche, and begins to encounter competitors, it tends to face a substantially different market. The CEOs and various Vice Presidents interviewed among these 21 firms that have been around for an average of thirteen plus years identified a number of critical issues that have emerged in the last decade that challenge their future success. These concerns include:

1. shorter product life cycle;
2. increased competition, both domestically and especially internationally;
3. difficulty in maintaining state-of-the-art technology in all areas of business;
4. decreased product differentiation;
5. shift to non-engineering customer base;
6. problems in maintaining a growth atmosphere in their companies.

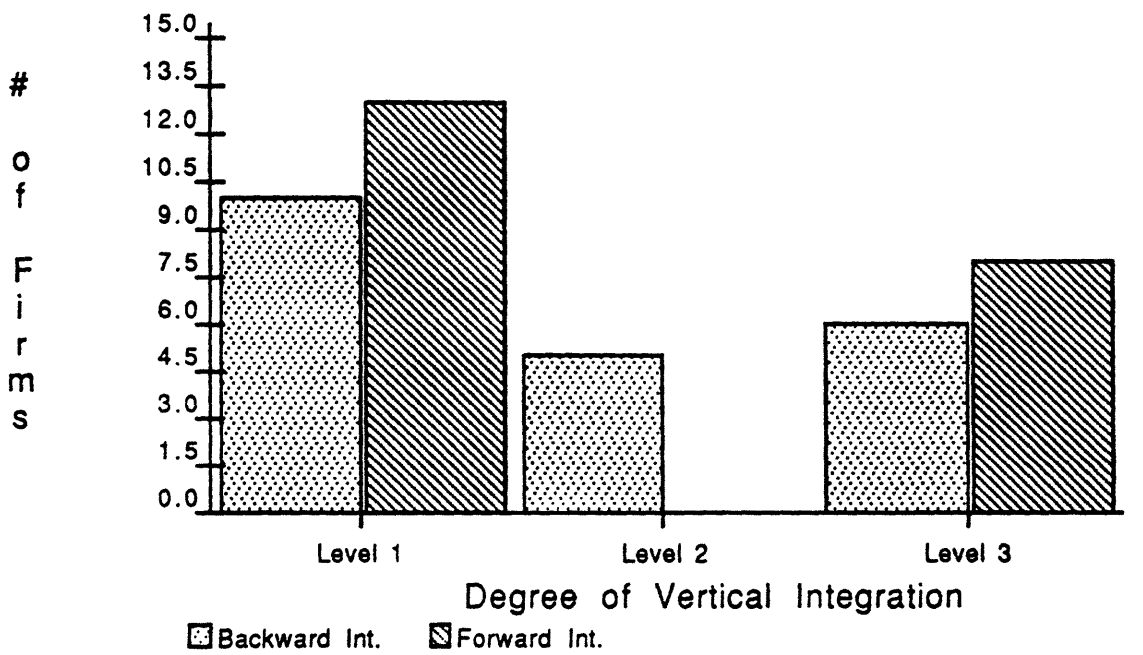
To evaluate the marketing perspectives and activities of these high technology companies, data were collected and are reported below on issues related to: corporate objectives and growth strategies, market planning and research, and market change and product line structure. The CEO and/or the Vice President of Marketing/Sales provided the information in almost all cases, permitting the classification of answers into various levels of complexity for each of the specific areas mentioned. Each area was analyzed statistically against the financial success measure, using five year compounded averages for the ROE and GROWTH variables.

Corporate Objectives and Strategies. Corporate objectives define a firm's business domain, generally in market-related terms such as market share, growth in sales, or profitability. All but one of the companies studied identified sales growth as one of their key objectives. Lack of growth was cited as leading to loss of entrepreneurial engineers and managers, leaving the door open to technical obsolescence, a fate second in fear only to bankruptcy in the eyes of the executives interviewed. Real growth estimates for the firms, adjusting for their estimates of inflation, range from zero to over 50 percent per year, and correlate significantly with SUCCESS ($r=.488$, $p=.05$) for the entire sample of firms.

All but three of the companies are attempting to pursue some form of integrative growth strategy. In a *horizontal integration strategy* the company seeks ownership and/or increased control over its competitors in one broad product line that meets increasing portions of its customers' needs. Only 6 of the 21 firms claim they have an aggressive policy of horizontal integration, and yet utilization of this policy correlates significantly (.10) with overall financial success. Of course all 21 of the companies seek continuing growth through product line and/or market expansion. When asked to prioritize their sources of future growth, 4 companies anticipated their primary growth as coming from new products through acquisitions, 8 firms planned mostly to develop new products internally, and 9 companies intended to emphasize expansion of their existing markets.

Many more of the firms follow *vertical integration strategies*, attempting *backward integration* by seeking increased control over their suppliers, and/or *forward integration*, by trying to gain ownership or control of their distribution systems. Conventional wisdom dictates that high market share businesses tend to be more vertically integrated. They "make" rather than "buy" their components and they attempt to control their products' access to their customers. Yet the firms in our sample are clearly split on their adoption of vertical integration strategies, as shown in Figure 2. Only 5 of these high technology companies are following aggressive backward integration policies while 8 of 21 are pursuing aggressive forward integration policies. These two approaches are quite different in orientation and different outcomes might be expected.

Figure 2. Growth Strategies: Vertical Integration Policies (n=21)
(Level 1: No Integration; Level 2: Some Integration;
Level 3: Aggressive Integration)



Our research reveals two related strategic motives for integrating backwards. Some firms perceive that the number or quality of certain key suppliers is declining. Other firms feel that a certain component is the key to maintaining their competitive advantage. The perceived benefits from backward integration include tighter quality control and decreased effort in maintaining vendor relations. In many areas of the computer field final product performance is seen as especially dependent upon critical components or semiconductor chips, supplied increasingly by vertically integrated overseas competitors, increasing local companies' concerns about availability and price of supplies in the future. However, on the negative side backward integration ties up more of the firms' assets in brick and mortar and makes them more dependent upon a particular technology. Utterback (198x) has argued that in an age of rapid technological changes this may be more of an

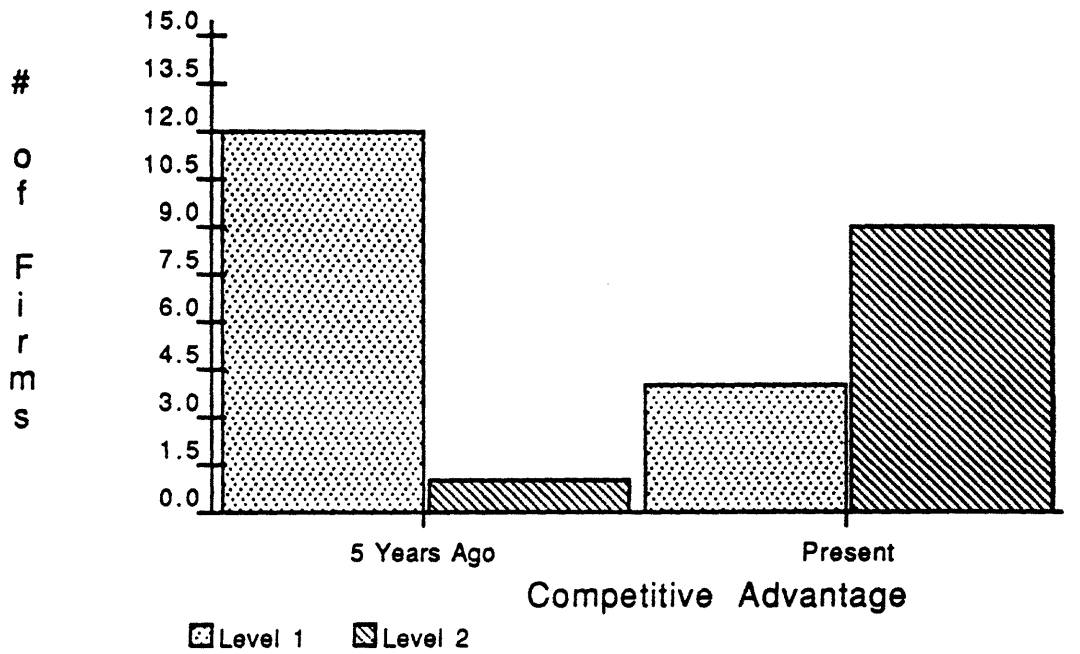
albatross than a blessing. The statistical analyses of our data support this negative view of backward integration, with greater financial success correlating (r=.495) with lesser degrees of backward integration. (.05)

Forward integration on the other hand allows a firm to seek higher value-added and correspondingly higher profit margin products. It requires that a firm's products be differentiated from their competitors', whether achieved through product characteristics, service or image. Not a mere coincidence, forward integration reflects a marketing-oriented perspective of getting closer to the customer whereas backward integration tends to focus upon a technological point of view of securing the technical base for building a product. Consistent with our overall hypothesis that market-oriented transformation leads to ultimate company success, the statistical results show significant correlation (r=.457) between aggressive forward integration and financial success. (.05)

The external strategic environment is seen by most firms surveyed as undergoing dramatic change. For example, thirteen of the twenty-one companies sense both the number and activity of their competitors as increasing relative to five years ago; four firms see competition as diminishing, with only four firms perceiving a stable competitive setting. Interestingly those companies that see increasing competition are also likely to be more successful (.05), perhaps suggesting that competition is being attracted to rapidly growing market opportunities, this argument supported by the close link between company growth in revenues and an increasing sense of competition (r=.539, p=.02).

In line with this shift is the repeated testimony that sales used to be much easier to make. Several executives attribute this change to more buying of total solutions, placing higher emphasis on cost-benefit relationships. As shown in Figure 3 the companies believe that their competitive advantage five years ago was primarily in the area of technological innovation and product quality. Today these same firms see their competitive advantage as having shifted toward price/performance and customer service. This should not be construed as a lessening of the importance of high technological quality but rather as a signal that today's customers have a wider selection of products from which to choose and are thus becoming more interested in

Figure 3. Shift in the Perception of Competitive Advantage
(Level 1: Technical Innovation, Quality; Level 2: Price/Performance, Service)



price and service. This shift in company perception of customer priorities no doubt also reflects the aging and growth of these firms over the past five years, beyond the initial market niches they may have "owned" outright into more general competitive arenas. This phenomenon is indicative of a market with declining product differentiation, such as occurs in the mature stages of most product life cycles, more representative of today's situation for these high technology firms than for their condition in years past.

All but one of the firms have developed written strategic plans, featuring a wide variety of thoroughness of coverage as well as a wide disparity in the length of the planning horizon. This is in contrast with Smith & Fleck's (1987) observation of no written plans in British high-tech firms, perhaps due to their generally younger and smaller status. For those 20 firms preparing plans four durations were observed: one year (3 firms); three years

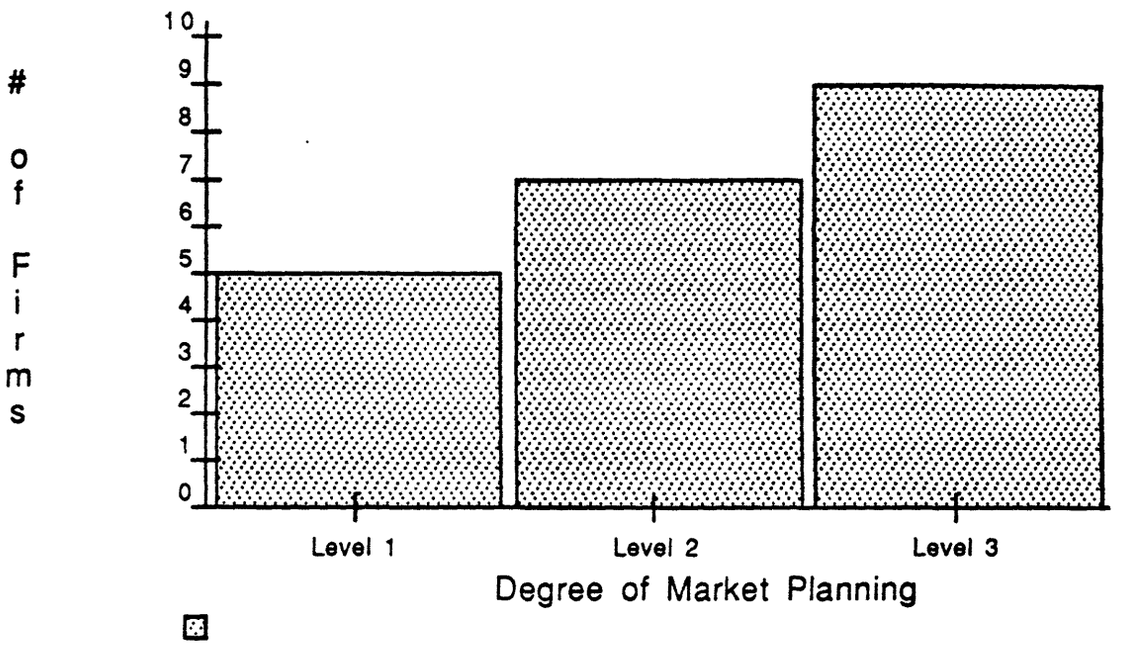
(7 firms); five years (9 firms); and ten years (one firm). Self-assessment of the adequacy or accuracy of the plans was hard to elicit from the company executives. When pushed for replies, about half thought their strategic planning was very accurate; the other half seemed to be divided evenly between thinking their plans were grossly inadequate, admitting that their performance surpassed their most optimistic predictions, or offering no comment. We formed no independent measure of the quality of these twenty strategic plans and no correlation was found between the firms' planning horizon and their computed success measure. As part of our overall research program on technological entrepreneurship we did carry out a separate pilot longitudinal research study on the strategic planning of eight other technology-based firms. In that unpublished study we also found little correspondence between their initial expectations and what actually occurred during the life of the firm and no correlation between planning quality and later overall company success. However, my prior research (Roberts, 1983) did point out strong links between good initial business plans and a company's ability to get venture capital funding!

Market Planning and Research. In a more specific vein, technology-based companies in the sampled fields of semiconductors, computers and biomedical instrumentation have widely accepted the concept of the product life cycle as characterizing the distinct changes in the sales history of their products. Except for a few products such as semiconductors, most of those interviewed see the maturity phase of their product lives as extremely short, with the decline phase setting in with a rapid drop in sales. Logically this product change environment might be expected to engender strong appreciation of the need for market planning, a process of market-oriented goal setting, competitor analysis, strategic positioning, market/product opportunity analysis, and associated programs, budgets and controls. The interviews divide the sample firms into three levels of adoption of market planning:

1. an informal system of discussions among top management;
2. a formal planning system tied in with the sales forecasts and budgets; or
3. a formal system integrated with the strategic planning process of the firm, with formality measured crudely by whether the plans are committed to paper.

Note from Figure 4 that less than 50 percent of the companies coordinate

Figure 4. Formality of the Planning Process
(Level 1: Informal Discussions; Level 2: Formal Planning Tied to Sales Forecasts; Level 3: Formal System Integrated with Strategic Planning)



their marketing activities with their strategic planning process. This is more true for firms with shorter product life cycles, as expected, but not significantly so.

In the five firms that are at Level 1 in regard to market planning often the only input was from the CEO. Interviews suggest that they maintain a "we know best; the customers do not know what they want" attitude. As no written plan ever appears, the companies argue they can move with the state-of-the-art of technology, and are not tied down by inflexible plans. Level 2 companies make some effort to incorporate data from their employees about future product needs. Generally Level 2 executives speak as if planning involves managers all the way down the line. In essence, however, the market plan is generally written by one person, usually the VP of Sales, with inputs

from a few key salespeople. Little evidence suggests that R&D or Engineering or Manufacturing personnel are involved. Level 2 plans tend to be generated once each year, with no formal system for interim updates to reflect new competitor data or economic trends.

In contrast the planning process in Level 3 companies usually involves people representing each of the key functional areas: R&D, Engineering, Manufacturing, Marketing/Sales, Finance, and Personnel. Their market planning is an integral part of the three to five year strategic plan and is updated yearly. A formal system, such as special forms/reports or departmental meetings, encourages employee participation throughout the organization. Periodic meetings to review any new material or revised information are held regularly on a monthly or quarterly basis. The degree of formal market planning, as capstoned by Level 3 practices, correlates significantly (.10) with financial success of the sampled high technology firms. Stronger focus upon market planning is perhaps propelled by pressures from a declining product life cycle, which changes correlate significantly (.10).

Not surprisingly the adoption of market planning also strongly correlates ($r=.725$) with the formalization of market research in the companies. Yet most of the companies have not wholly committed themselves to rigorous practices of understanding who are their customers and what do they need. Six firms carry out no or only informal market research. In some ways they hold tightly to the belief that superior technology products will sell themselves. Half of the sample, 10 companies, purchase outside data on market size, growth potential and/or industry trends. Some of these companies assert that they are using the purchased data as phase 1 in the formulation of a more elaborate market research scheme, as financial resources permit. Others in this group suggest they had only acquired the data to see what information their competitors might have used in their goal setting! Only 4 companies have instituted internal market research departments, believing that their own groups would be best suited to keeping up with the rapidly changing technological and market environment. Some report that purchased reports are often outdated as soon as they are published. The extent of formalization of market research was found to correlate significantly (.10) with financial success.

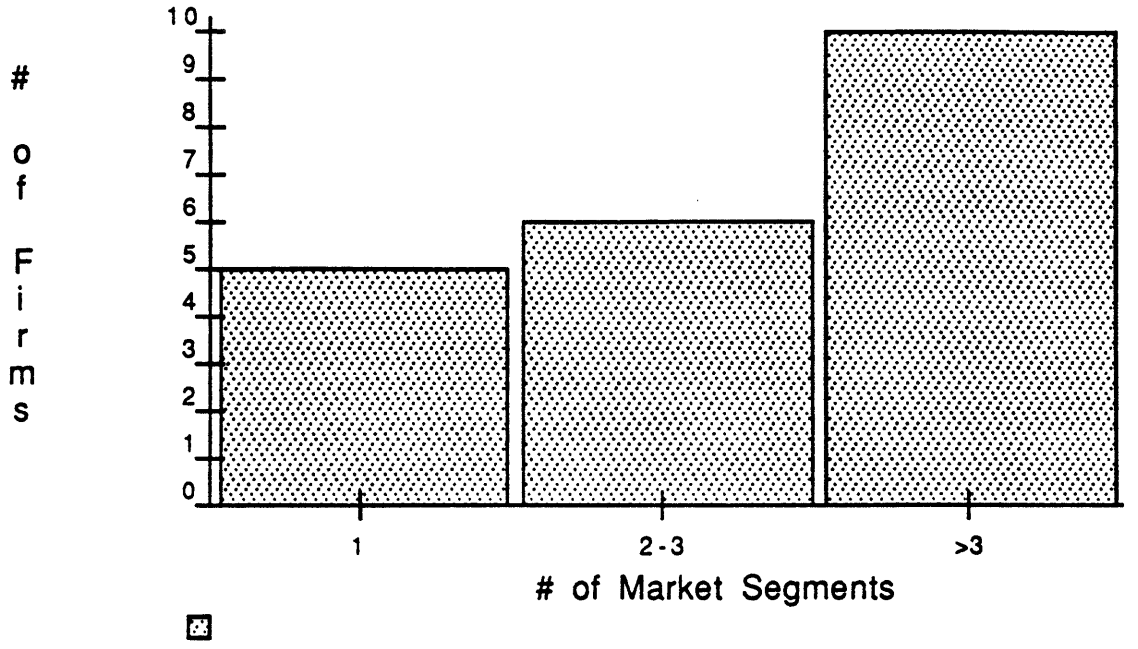
Consistent with these specific aspects is the more general issue of whether the differences between marketing and sales are appreciated in the firm. To probe this the interviewers examined whether marketing was identified on the organization chart and whether a separate marketing budget could be found, distinct from a sales budget. Based on the responses the firms were divided into three levels: eight companies that have no identifiable marketing activities -- only sales; nine firms in which marketing and sales activities function together, with no separate personnel or budgets; and four companies that have separate marketing and sales organizations, which usually report to one vice president. As might be expected this rank-ordered measure of separate treatment of the marketing role correlates significantly (at the .01 level) with the extent of both market planning and market research and, more importantly, with financial success ($r=.417$, $p=.10$).

All of the above dimensions of formal marketing -- the separate organization, formal planning and formal market research -- also correlate significantly (.05) with increasing intensity of competition, perhaps the driving force behind the adoption of a heavier marketing presence.

Market Change and Product Line Structure. As high technology firms grow most begin to serve distinctly different market segments of customers with distinctly different needs, posing severe problems for the young technology-based company that is usually better able to absorb technical change than market-oriented change. Figure 5 shows the range of market segmentation in our 21 sample firms. Most of the firms under $150 million in sales concentrate on several market niches, each in the range of $5 to $20 million in sales per year, in the oft-repeated hope that the narrow markets will cause the "big guys to leave us alone".

Logically the number of market segments served might be assumed to relate to some extent to the number of main product lines that the company produces. A main product line consists of a family of products with the same technology base that perform basically the same function, but perhaps for somewhat different applications or customers. For example, a word processor designed for analytical laboratories (one market segment) is in the

Figure 5. Market Segmentation



same product line as a word processor designed for office workers (a second and different market segment). Limiting the definition to main product lines that are more than one year old and account for at least five percent of revenues, only five firms were found to have more than three product lines, eleven have two or three, and five firms still have only one main product line. To our surprise the number of products and the number of markets do not at all relate statistically. Indeed, the number of products is most strongly related only to the age of the firm (.05), suggesting product line proliferation as the firm gets older.

One change that is occurring is in the customer base of the companies. Earlier in their lives most of these companies' revenue streams tended to be dominated by original equipment manufacturers (OEMs). But increasingly a shift toward end users has been taking place. Eight of the companies still rely primarily upon OEMs, with four firms now focused directly on the other

extreme, the end user. The bulk of the sample, nine companies, now serve a mix of OEMs and end users. The shift is requiring different sales techniques (no longer engineers just selling to engineers) and increased emphasis on quality control issues such as debugging (new customers being less tolerant of equipment operating problems). Several firms said the combination of these changes has led to higher sales costs and increased R&D spending, the latter claim being supported significantly (.05) by the data.

None of the elements described in this section -- the number of market segments or product lines, or the customer base -- relates statistically to the financial success of the companies.

Technology and Product Development

The sampled firms are all high technology product developers and manufacturers. Their roots were usually technological as was the training and experience base of most of their founders. To learn more about the technical aspects of these firms, data were gathered on research and development expenditures as well as on the process of new product development. The R&D data proved difficult to use, given the wide variance in reporting practices of the companies. Some firms do much of their R&D on government contracts, which often does not show up in the R&D figure quoted in their annual reports. Different practices in allocating field and manufacturing research also cause concerns. In the end the only useful measure seemed to be whether the absolute R&D spending over the past five years has been increasing (13 firms) or decreasing (8 firms). With some degree of personal satisfaction I can report that the analyses show that increasing R&D expenditures do correlate very strongly with the financial success of the companies. ($r=.66$, $p=.01$)

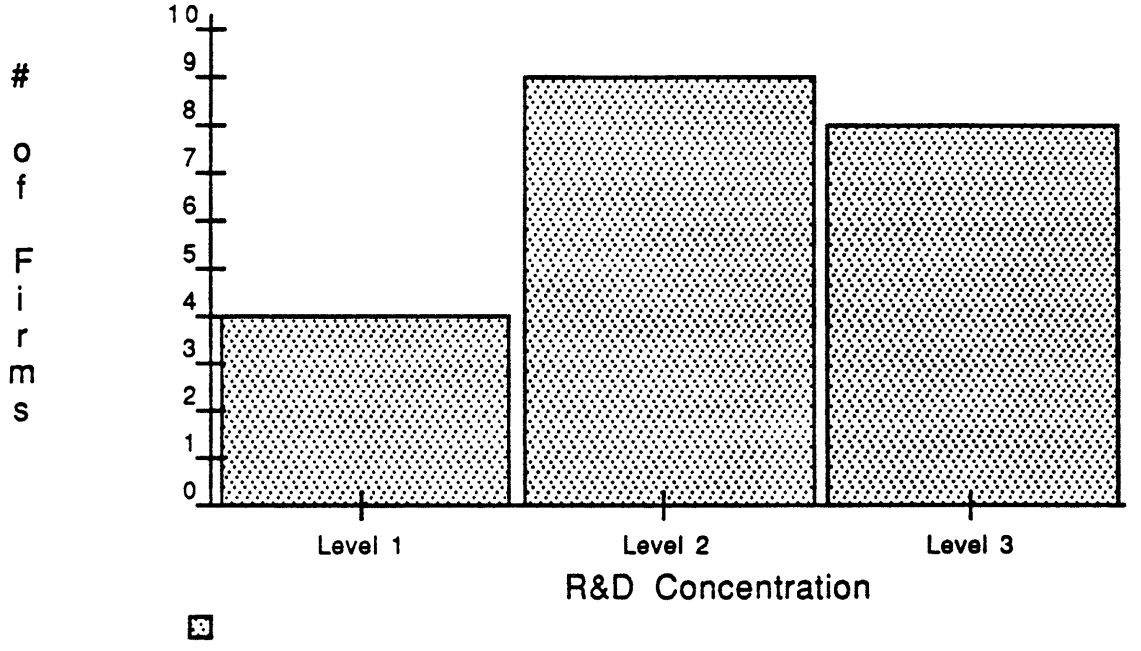
The areas of concentration of R&D spending were also examined, and categorized into three clusters:

1. redesign of existing products (minor changes such as in physical attributes);
2. different versions of existing products (technical changes such as range or alteration of specs so that the product can be used by a new market segment); or

3. totally new product concepts (new technologies utilizing a firm's expertise, such as a move from computer graphics to robotics).

Figure 6 shows how the firms are distributed in regard to the thrust of their R&D expenditures. The orientation of R&D spending by itself does not

Figure 6. Primary Thrust of R&D Expenditures
(Level 1: Redesign of Original Features;
Level 2: Different Versions of Same Product; Level 3: Totally New Products)



relate to overall financial performance. As shown in our earlier work (Meyer & Roberts, 1986, 1988) strategic product focus is needed in order for the young technical firm to continue its growth. The new data on the 21 older and successful firms seem to continue to rebuff the assumption that technological companies ought to obsolete their base businesses with wholly new products. But stronger focus on totally new products does correlate significantly with the number of market segments being served as well as the degree of forward integration, both forces demanding new products to satisfy

new customers.

The final elements of product development that seem of strategic interest are their sources of direction and control. Who decides what products the firm will develop? Examination of the informal process rather than the organization charts determined the person or group who controls new product ideas and the one who controls the new product development process. In each case one of three players has been dominant: top management, usually the CEO and an occasional right hand man; the key engineering decisionmaker; or the key marketing decisionmaker. In several companies the key decisionmaker is not the vice president or department head but rather a senior engineer or the "old timer" in the organization. The "idea control" dimension emphasizes the "valve" that permits or restricts the flow of new product ideas to the company from both internal and external sources. The "process control" dimension emphasizes the source of resolution of conflicts when product development negotiations between departments stalemate. At both stages the role is informal and had to be discovered through open discussion with the interviewees. In line with the overall hypothesis on the need for market-oriented transformation these concepts led to documentation of the distribution of the firms along a six-stage progression from total technologically oriented product development toward marketing oriented product development within a technological firm. Table 1 depicts this progression and the breakdown of the sample firms.

Table 1. Stages in New Product Control

Stage	Idea Control	Process Control	# of Firms
I	CEO	CEO	3
II	CEO	ENG	8
III	ENG	ENG	3
IV	ENG	MKTG	3
V	MKTG	ENG	2
VI	MKTG	MKTG	2

Except in Stages I and II all the firms responded that new product

ideas and process control is a shared role between engineering and marketing. Probing into the informal structure was needed to elicit where the dominance lay. Firms in Stages I and II were clear in identifying (and not at all apologetic about) the strong control exercised by their CEO. Both in terms of influence upon the idea generation process (.05) and control over the product development process (.01), increasing marketing orientation correlates significantly with financial success of these firms.

Financial Management

An analysis of overall capital structure of the companies was carried out by averaging each firm's financial ratios and then computing averages for the firms in each of the four performance type categories displayed in Figure 1. Those data are presented in Table 2, along with equally weighted industry averages for 25 electronics firms available from the Compustat Annual Industrial Tape.

Table 2. Financial Ratios for Electronics Companies

	Type 1 (++)	Type 2 (+G,-ROE)	Type 3 (-G,+ROE)	Type 4 (--)	Total Sample	Industry Average
Sales Growth(GROWTH)	.60	.57	.23	.20	.39	
Return on Equity(ROE)	.25	.10	.21	-.09	.10	.05
Std. Dev. ROE	.17	.21	.26	97.18	35.93	
Long Term Debt/Eq(LTDE)	.77	.48	1.30	.19	.60	.50
Total Debt/Equity(TDE)	2.2	1.5	2.6	2.6	2.3	1.07
Current Ratio(CR)	2.5	2.1	2.8	2.4	2.5	3.17
Times Intrst Earned(TIE)	17.7	10.3	6.4	4.0	10.1	5.22
Return on Assets(ROA)	.20	.15	.20	.11	.16	.04
Earnings/Sales(E/S)	.07	.04	.07	.00	.04	.01

Comparison of the total sample with the industry averages reveals two general trends. The sample of Greater Boston high technology companies have a significantly higher degree of financial leverage than their industry counterparts, as indicated by all three measures of leverage in the table: LTDE, TDE and CR. This runs counter to the conventional wisdom that young

technological firms should be financed mainly by equity. (Brealey and Myers, p. 394) The resolution of this apparent contradiction may be found in the second observable trend, that they operate far more profitably than the industry, whether measured by TIE, ROA or E/S, even including in the sample the seven firms that were judged to be not successful. This profitability generates a high level of confidence for investors who are considering lending money to these firms.

Those firms with higher return on equity are especially likely to be highly leveraged through debt, as reinforced in Table 3. What is not clear is the cause and effect. Are firms with higher debt to equity ratios able through leverage to increase the returns to their stockholders? Or are more profitable firms better able to obtain debt? Discussions with corporate management reassure that an iterative process is at work. Initially the high tech firm is essentially equity funded until some profit record is established, at which time investors become willing to debt finance the company, enabling debt-based investments in further growth of sales and profits.

Table 3. Return on Equity and Use of Debt

	High ROE		Low ROE	
	Type 1	Type 3	Type 2	Type 4
Long Term Debt/Equity	.77	1.3	.48	.19
Total Debt/Equity	2.2	2.6	1.5	2.6

Further discussions with corporate management revealed that the choice of capital structure was not simply based on the financial capability of the company. Indeed it often reflects personal convictions, also a contradiction to the modern financial theory that asserts that all managers have the same utility function and accept risk to the extent the stockholder is compensated for it. Some entrepreneurs simply did not want any debt, feeling their high degree of business risk does not allow them also to accept the increased risk associated with financial leverage. Some felt rather moralistic that a policy of no debt or only short term debt forces an appropriate pay-as-you-go situation in which present management cannot encumber future management's actions or responsibilities. Others match the theoretical

expectations and have sought to obtain the maximum leverage possible to increase the potential returns to equity owners. Note that Smith & Fleck (1987) observed that British entrepreneurs sought to minimize outside equity in order to maintain control, a behavior also observed frequently among U.S. technological entrepreneurs.

Only one of these 21 hardware firms has ever issued a dividend, reinvesting all their earnings in anticipation of future growth and the capital gains treatment of an increased stock value. Successful software and service companies, however, both types omitted from the sample, often generate high cash flow without comparable need for equipment and inventory investments, and therefore may follow quite different financial policies. Also the elimination of preferential treatment of capital gains occurred after our data collection and therefore did not figure into the behavior recorded in this study.

Unfortunately, despite these interesting differences between the capital structure of the high technology companies in our study and the electronics industry as a whole, no consistent relationships between capital structure variables and overall corporate success were uncovered except for the rather obvious ones mentioned earlier. Financial success strongly correlates to ROE, ROA, earnings/sales ratio, and times interest earned, all more-or-less in line with the definition of the success measure. The strongest correlation of the financial variables to success is the negative correlation ($r=-.71$, $p=.01$) with the standard deviation of the return on equity ratio. Less successful firms somewhat obviously have greater variability over the years, generating both positive and negative returns in various years. In contrast the most successful companies produce only positive returns from year to year, resulting in much lower variability and calculated standard deviation.

Overall Corporate Development: The Human Side

The continuing search for critical success factors and evidences of strategic orientation brought us to a number of softer dimensions on the human side of the firm: the role of the board of directors, the overall management of human resources, and the evolution of the CEO and the senior management team. The importance of the Board of Directors to the success of the firm received comments in just about every interview. Specific data were collected on board

size, composition, role and changes in these. The typical board has six or seven members and all have both inside and outside members. The outside board members most heavily include someone from the financial community, someone from business, with consulting, academia and law filling the other positions. Although the variety of backgrounds on the boards is fairly consistent among the firms, the ratio of outside to inside members varies widely, splitting about evenly into three clusters which have: (a) 30 to 50 percent outsiders; (b) 50 to 80 percent outside members; and (c) more than 80 percent. After the fact most CEOs consider boards successful when they have always been active and influential, although one must wonder whether the thirteen original CEOs no longer in those positions would agree with this assertion. However, no significant relationship was discovered between any of the board-related variables and company success.

Despite turnover rates of 20-25 percent for both engineers and managers being cited as usual, and despite strongly voiced appreciation of the criticality of creative and entrepreneurial human resources in these organizations, no personnel-related factor could be found that correlates with success among these 21 companies. Their perquisites packages are different from each other in varying ways, their performance assessment and reward systems also show unique qualities, and their orientation approaches for new employees reflect differing levels of formalization. But none of the differences relates quantifiably to financial success.

Prominent in the folklore on entrepreneurship is the identification of "Founder's Disease", the inability of the founding CEO to grow in managerial and leadership capacity as rapidly as his firm's size and further potential grow. In many cases the "disease" is "cured", for the firm at least, by the founder stepping down or being ousted by outside board members who inevitably replace the founder with a new CEO, usually brought in from the outside. Eisenhardt (1989) evidences several instances of CEO changes in her sample of eight microcomputer companies. Tushman et al. (1985, p. 308) indicates that ten out of sixteen high-performing minicomputer firms had experienced executive succession, but senior managers in addition to the CEO were included in that count. Our 21 company sample contains much evidence of the instability of the Chief Executive's job in high technology firms. Only eight of the founders were still in office at the time of the data collection, and those

primarily in the older firms for some inexplicable reason. Ten companies had changed CEOs once and three of the companies had more than one change of CEO.

But statistical analyses found no relationship at all between the number of CEOs in a company and the overall company financial performance: the surviving original founder-CEOs as a group performed as well in generating even ultimate corporate success as did their replacement CEOs. The folklore clearly needs to be adjusted: our data indicate that for every two stories of a Steve Jobs being replaced by a John Scully in the search for continuing onward and upward company performance there is about one story of a Ken Olsen maintaining his founder CEO role into the period of greatness of his firm. Careful examination of the evolution and size of senior management similarly produced lots of interesting stories but no relationship with success of the variables we were able to quantify.

The "Critical Event" and Corporate Transformation

In analyzing the data an unanticipated phenomenon was noted that we label here the "critical event", defined as a period of time during which a series of actions occur which bring about comprehensive changes in the management structure, the financial, marketing and planning processes, and eventually in corporate success. The discovery of the critical event did not come about directly, but rather as a result of the "war stories" and discussions of how the firm got to where it is today. The critical event was distinctive because it was promulgated by outside stimuli, i.e. outside directors, outside management from an acquiring company, an act of God. Several different patterns are apparent. Most frequently the critical event happened when one or two of the outside directors on the board instigated an ouster of the CEO and then brought in an experienced manager to become the new Chief Executive. In five cases an acquisition triggered the changes -- either the company acquired another firm, or was acquired, or in one situation reacquired itself. In one company an act of God was responsible for the critical event when the founder-CEO was killed in an accident. Of great interest is that Tushman et al. (1985) have also identified "environmental discontinuities", brought about by external forces, as promulgating executive succession and strategic reorientation in minicomputer firms.

Applying this definition of critical event to the data collected, 16 of the 21 firms are classified as having critical events. Company scenarios preceding the critical events are far from uniform, including cases of steadily increasing revenues, erratic revenues, stable and/or declining revenues, all patterns that are also observable in the companies that did not experience the so-called critical events.

All five of the companies in the sample that have not yet experienced a critical event still have their founder as CEO, as well as three of the sixteen critical event firms. Most of the new CEOs, brought in from the outside, have strong marketing backgrounds; most of the displaced CEOs have heavy technical backgrounds. Following every critical event a dramatic change in management structure was completed within one to three years. Of the approximately 100 senior management positions traced in the 16 critical event companies, only seven of the positions have been filled by promotions from within since the event occurred. Part of this is no doubt due to the increased departure of managers and technical personnel after installation of the new CEOs.

Strategic planning processes tended to be installed where none existed prior to the critical event, gradually extending in planning horizon. Shifts in strategy tended to follow, most frequently changes in product line or growth strategy, often including increased horizontal integration. Across the board restructuring and reorientation usually resulted, in many ways reflecting dramatic shift from a more technological to a more marketing oriented strategic perspective. This matches Miller & Friesen's description of the "entrepreneurial revitalization" transformation: "A new CEO attempts to revive his enterprise by increasing innovation, pursuing new market opportunities, and devising more adaptive strategies." (1984, p. 133) Of most importance is that the occurrence of the critical event divides the sampled companies into two groups, with significantly higher financial success for the 16 "event" firms. ($r=.399$, $p=.10$) Along with this correlation are several supporting findings, including strong links between overall success and the creation of a new management team post-event (.05) as well as the hiring of new senior management staff (.02).

Many of the managers interviewed suggest that a firm experiences two distinct phases of organizational development. Some refer to these as the

shift from an entrepreneurial to an organizational phase. Post hoc the stages seem more to reflect the technology and marketing stages of a firm's life. The technological phase is the period when the firm is developing its core technology or technologies, from founding through early successful product growth. The firm is learning the capabilities of its technologies, their applications, strengths and weaknesses. The horizons of discovery are primarily internal to the firm.

The marketing phase occurs for most firms after a critical event that shakes up the company or forces it to change. The firm does not lose its core of technical innovation. Rather the critical event transforms the company's rather singular emphasis on state-of-the-art technology to include the importance of marketing as well. In all the critical event companies in our sample, control of the flow of new product ideas as well as the new product development process shifted toward marketing, but in no case did the product line shift to a new base technology. The horizons of discovery become predominately external during this phase, secondarily internal to the firm. The shift in product development control can, however, become the leverage point for gradual erosion of technological competitiveness. The firms in which more than one CEO change occurred are too few to test whether later problems might arise eventually, following the initial critical event, demanding another altered focus resulting in and/or produced by a second critical event.

But our earlier finding that the eight surviving original CEOs, with mostly technical backgrounds, perform as well as the new CEOs now sharpens the strategic question. Is a critical event truly necessary for producing super-success? For many companies (perhaps two thirds) it would appear so. But some companies clearly achieve financial success without an externally induced critical change or without all the dimensions of transformation suggested above. Four alternative explanations seem plausible. (a) Some technology-based firms might change toward the hypothesized needed marketing perspective through internal gradual evolution of their original management team. Prior studies (Roberts, 1989) clearly evidence that this evolution begins for many firms during their earliest years. Their CEOs may be the exceptions who do eventually make it from founding to greatness. (b) Other companies may even have the right market orientation from day one, and have no need to change. (c) Still others may have a technological orientation from

the outset, sell largely technological advances perhaps primarily to OEMs, and build continually growing and profitable firms with that singular and unchanging strategy, a strategy that might indeed be labelled by some as market-oriented, once the very different needs of the specific OEM customer are properly taken into account. (d) Alternatively, Virany & Tushman (1986) demonstrate that "particularly visionary executives" led the highest performing companies in the minicomputer industry, were not ousted from their roles as CEOs, and implemented internal changes as needed to continue corporate growth and success. Their "visionary" leadership may have had little to do with either technological or market orientation per se. As Slevin & Coven (1987, p. 94) suggest, the outstanding company performance may reflect "doing things right" rather than just "doing the right things". Unfortunately, neither the Virany & Tushman data set nor our 8 company sample of no CEO change nor our 5 company sample of non-critical event companies is large enough to generate further meaningful explanations of company performance or to provide empirical support for these alternative pathways to greater corporate success.

Summary

This article attempts to advance the strategic understanding of high-technology firms by examining longitudinally a cluster of 21 Boston-area firms that had already survived for at least five years and had already attained at least $5 million in annual sales. The cohort is drawn from SIC codes 3573 and 3811 and includes hardware companies developing and manufacturing semiconductors, computers, computer peripherals and medical instrumentation, averaging thirteen years old and all based in rapidly advancing technologies. The findings are therefore constrained both by the regional limits of the sample as well as by the narrow industrial population represented. Interview teams collected detailed data from an average of four persons in each firm, including the Chief Executive Officer and representative Vice Presidents. Corporate success was measured for the sample by combining sales growth averages with calculated return on equity, with the highest third of the performers averaging 60 percent growth with ROE of 25 percent.

The broad hypothesis that a market-oriented strategic transformation is needed for "super-success" led to in-depth probes of many dimensions of managerial change. Backward integration toward self-sourcing a firm's

components was found generally detracting from successful performance, while aggressive forward integration toward the firm's ultimate customers strongly correlates with success. Competitive advantages were seen as having shifted over time from technological uniqueness toward price/performance and customer service dimensions, no doubt reflecting both the aging and growth of the firms, their markets and their core technologies. Formal market planning, integrated with strategy, formal market research, and formal organization of marketing were all found to be significant factors in success. Most firms are gradually shifting from OEMs as their customers to end users, with attendant complications in selling, servicing and even engineering. New products are vital for these firms and increasing R&D expenditures as well as marketing-oriented control of new product idea flow and the resultant development process all correlate significantly with financial success.

Financial managers of these high-technology firms generated higher financial leverage than their electronic industry counterparts, perhaps due to the greater profitability of the sampled firms. Dividends were almost never issued, all earnings being reinvested toward future growth. But no aspects of capital structure help to explain overall corporate success.

13 of the 21 founding CEOs had been displaced by new CEOs by the time of data collection on their firms, the replacements usually being brought in after some set of externally generated "critical events". But the eight surviving original founder-CEOs as a group performed as well as the replacement CEOs. The new CEOs tended to have marketing backgrounds, in contrast with the engineering backgrounds of the first-generation CEOs. The new CEOs dramatically transformed their firms toward the marketing-orientation described above, achieving corporate success by means of that transformation. But, similar to the findings of Virany & Tushman (1986) in the minicomputer industry, no additional correlates explain the comparable degree of success achieved by the few survivors. Their accomplishments remain as a deep mystery for later researchers to fathom.

REFERENCES

H. Bahrami & S. Evans, "Stratocracy in high-technology firms", *I.E.E.E. Engineering Management Review*, vol. 16, no. 4 (December 1988), 2-8.

L. G. Bourgeois & K. Eisenhardt, "Strategic decision processes in Silicon Valley: The anatomy of a 'living dead'", *California Management Review*, vol. 30 (1987), 143-159.

L. G. Bourgeois & K. Eisenhardt, "Strategic decision processes in high velocity environments: Four cases in the microcomputer industry", *Management Science*, vol. 34 (1988), 816-835.

R. Brealey & S. Myers, *Principles of Corporate Finance* (New York: McGraw Hill Book Company, 1981).

P. F. Drucker, *Management: Tasks, Responsibilities, Practices* (New York: Harper & Row, 1973).

K. M. Eisenhardt, "Making fast strategic decisions in high velocity environments", *Academy of Management Journal*, vol. 32 (1989), in press.

K. M. Eisenhardt & L. G. Bourgeois, "The politics of strategic decision making in top management teams: A study in the microcomputer industry", *Academy of Management Journal*, 1988.

K. M. Eisenhardt & C. B. Schoonhoven, "Organizational growth: Linking founding team, strategy, environment and growth among U.S. semiconductor ventures (1978-1988)", unpublished paper, June 1989.

E. M. Esher Jr. & M. Stone, "Fast-track marketing: Stages of growth in Ashton-Tate", *High Technology Marketing Review*, vol. 1, no. 2 (1987), 41-47.

T. J. Levitt, "Marketing myopia", *Harvard Business Review*, October 1960.

R. McKenna, "Why high-tech products fail", *High Technology Marketing Review*, vol. 1, no. 2 (1987), 1-10.

M. H. Meyer & E. B. Roberts, "New product strategy in small technology-based firms: A pilot study", *Management Science*, vol. 32, no. 7 (July 1986), 806-821.

M. H. Meyer & E. B. Roberts, "Focusing product technology for corporate growth", *Sloan Management Review*, vol. 29, no. 4 (Summer 1988), 7-16.

D. Miller & P. H. Friesen with H. Mintzberg, *Organizations: A Quantum View* (Englewood Cliffs, NJ: Prentice-Hall, 1984).

E. B. Roberts, "Business planning in the start-up high-technology enterprise", in J. A. Hornaday et al. (editors), *Frontiers of Entrepreneurship Research, 1983* (Wellesley MA: Babson College, 1983), 107-117.

E. B. Roberts, "Evolving toward product and market-orientation: The early years of technology-based firms", MIT Sloan School of Management Working Paper #1915-89, February 1989.

E. Romanelli, "New venture strategies in the minicomputer industry", *California Management Review*, Fall 1987, 160-175.

W. R. Sandberg, *New Venture Performance: The Role of Strategy and Industry Structure* (Lexington MA: Lexington Books, 1986).

D. P. Slevin & J. G. Covin, "The competitive tactics of entrepreneurial firms in high- and low-technology industries", in N. C. Churchill et al. (editors), *Frontiers of Entrepreneurship Research, 1987* (Wellesley MA: Babson College, 1987).

J. G. Smith & V. Fleck, "Business strategies in small high-technology companies", *Long Range Planning*, April 1987.

M. Tushman & E. Romanelli, "Organizational evolution: A metamorphosis model of convergence and reorientation", *Research in Organizational Behavior*,

vol. 7 (1985), 171-222.

M. L. Tushman, B. Virany & E. Romanelli, "Executive succession, strategic reorientations, and organization evolution: The minicomputer industry as a case in point", *Technology In Society*, vol. 7 (1985), 297-313.

M. L. Tushman, B. Virany & E. Romanelli, "Effects of CEO and executive team succession: A longitudinal analysis", unpublished paper, July 1987.

J. M. Utterback, "Innovation and industrial evolution in manufacturing industries", 198x.

B. Virany & M. L. Tushman, "Top management teams and corporate success in an emerging industry", *Journal of Business Venturing*, vol. 1 (1986), 261-274.

APPENDIX

A. Firms That Particated in the Research

Analog Devices
Analogic Corporation
Applicon, Inc.
Block Research and Engineering Division, Bio-Rad Laboratories
CL Systems, Inc.
Computer Devices, Inc.
Computervision Corporation
Damon Corporation
Data Printer Corporation
Data Terminal Systems
Datatrol, Inc.
Dynatech Corporation
GCA Corporation
GRI Computer Corporation
Haemonetics Corporation
Helix Technology Corporation
Modicon, Division of Gould
Prime Computer, Inc.
Semicon, Inc.
Silicon Transistor Corporation (BBF Inc.)
Xylogics, Inc.

B. Firms Declining to Participate

Alpha Industries
American Science and Engineering
Cambex
Centronics
Compugraphic
CSP, Inc.
Data General
Entwistle Company
Ionics
Inforex
Intertel, Inc.
Micro Communications Corp.
Sigma Instruments, Inc.