R&D Expenditures As Resource Buffers: Managing The Capacity To Innovate

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Abstract

This article develops an argument for the use of "resource buffers" as an explanatory construct in the study of product innovation and corporate strategy. Much of the largely descriptive rhetoric developed in the study of innovative behavior within the firm can be translated into more meaningful terms when framed with this context. A study of the pharmaceutical industry is provided to illustrate the contribution of resource buffers to the dynamics of successful product innovation.

Introduction

There exist elements in both the internal and external environments of the firm which are determinants of corporate innovative behavior. From a strategic standpoint, conditions favorable to product innovation are created to the extent that a "good fit" is achieved between the operative forces in both environments. It would be erroneous, however, to conclude that the potential for successful innovative behavior can be derived from simply adjusting one's internal corporate environment to better mesh with the external forces of the market. The interface of the corporation's internal and external environs is inherently complex and dynamic, given the interaction between these two spheres, and fraught with uncertainty. Hence, "men involved in technical innovation within a corporation confront a situation in which the need for action is clear, but there is both danger and opportunity, and it is by no means clear what to do" (Kamien and Schwartz, 1982). Yet in many industries (electronic capital goods, aircraft manufacturing, pharmaceuticals, etc.), profitability has been demonstrated to be largely dependent on a firm's continued innovative success. Thus, it is essential in some instances that individual firms maintain a "capacity" to innovate in the face of formidable uncertainty. Resource buffers or "slacks" should be maintained to provide managers with the flexibility to respond effectively to environmental opportunities and threats. Consequently, maximum internal efficiency must be sacrificed to provide a cushion or buffer of underutilized corporate resources.

A corporation may find difficulty operating in uncertainty, though it may be reasonably well equipped to cope with risk. It may be, from at least one point of view, an organization designed to uncover, analyze, evaluate, and

operate on risks, as suggested by Rothberg (1981). Accordingly, the innovative work of a corporation consists in converting uncertainty to risk-taking decisions. Within this perspective, the notion of a "capacity to innovate" should not seem out of place. It is precisely this "excess" capacity which reduces the threats posed by environmental uncertainties to tolerable levels. To the extent that the "inputs" of the innovation process can be identified, it is possible to critically analyze and manage a firm's capacity to innovate. Consistent with this view, a simple analogy can be drawn to the study of production and operations management.

Production managers are typically charged with the responsibility of coordinating specific processes within the firm's internal environment (production) with their external counterpart (buyer demand). Since demand is usually assumed to be fluctuating and uncertain, managers frequently make provisions for unexpectedly high demand relative to planned production levels by building slack or "buffers" into the system. Some of the more commonly used buffers in production management include: the use of longer lead times; working employees overtime; keeping relatively large inventories of both inputs and finished goods; and, leaving a portion of capital assets idle. Similarly, "resource buffers" refer to the underutilization of any resource within the firm in anticipation of unforeseen contingencies.

Resource buffers require, by definition, planned inefficiency over the short run of a firm's operations which contributes to both increased costs and reduced risk. Innovation within the firm, and R&D specifically, is also characterized by these qualities. Unfortunately, the failure

of managers to understand the nature of the cost/benefit tradeoffs of the innovation process may result in unfavorable attitudes toward innovation and, in some instances, the "fear of innovation." To the extent that an analogy to production management might be better understood by corporate planners, the organization's attitudes toward innovation, (one important prerequisite to successful innovation), might improve. Further, to the extent that managers are able to appreciate their own limitations in anticipating technological and market changes in their sphere of influence, they must confront their inability to manage and control an effective program of innovation. In light of their own uncertainty, the use of resource buffers as a risk reducing corporate strategy may be more intuitively appealing than the adoption of an amorphous collection of organizational traits described in a textbook. That is, the incorporation of slack resources in the firm's operating strategy may be more agreeable (especially if viewed as a risk reduction effort), than would the notion of relinquishing managerial control to facilitate greater creativity within the organization.

Using Steiner's taxonomy of characteristics attributed to creative organizations, it is possible to illustrate how innovative "capacity" can be described with respect to resource buffers. For example, Steiner (1981) cites the following as attributes of creative organizations: has "idea men"; heterogeneous personnel policies; assigns nonspecialists to problems; includes marginal, unusual types; and, allows eccentricity. A corporate executive might, understandably, have difficulty following this prescription. Conversely, the suggestion that the firm's capacity to innovate might be augmented by the addition of research personnel with diverse backgrounds seems to make sense. Nonspecialists are, however, inefficient relative to their expert counterparts - at least over the short run. To the extent that these members of the research staff are underutilized, they represent resource buffers within the organizational system.

Steiner's suggestions that the creative component of the firm not be run as a "tight ship", be "organizationally autonomous" and enjoy "open channels of communication" might be less well received than if couched in terms of resource buffers. The general lack of control implied by Steiner's recommendations fails to suggest any offsetting benefits. The resource buffer perspective emphasizes the nature of the tradeoffs being made between creativity enhancement (a benefit) and the resulting decrease in managerial control (a cost).

The presentations made by others on this subject are no more appealing from a managers's perspective. One primary advantage to invoking the "buffer" or underutilized resources construct is that it appeals to an established frame of reference understood by most managers and permits rational decisions on the nature of cost/benefit tradeoffs involved. Whether these costs and benefits are

evaluated in dollars or in some psychic sense depends largely on the nature of environments facing the decision maker. Part of the widespread ambivalence toward innovation is due to the failure of corporate managers to understand the importance and value of the innovative enterprise. The characteristic mode of change in Western industrialized countries has been integrative. U.S. firms have emphasized internal coordination and control mechanisms to facilitate the completion of complex, interrelated tasks (Miles, 1989). One consequence of this drive for greater managerial efficiency has been the loss of critical resource buffers. This narrow perspective on organizational effectiveness has typically produced partial equilibrium solutions which are only efficient within a very limited context. In the face of growing international competition, these traditional notions of short run efficiency are growing increasingly less appropriate. Sustained long term competitive success and profitability requires a greater appreciation of the contribution of resource buffers to the process of product innovation.

Assessing The Contribution Of Resource Buffers To Product Innovation Within The Pharmaceutical Industry

Industry Structure

The U.S. pharmaceutical industry is characterized by the coexistence of a few relatively large firms with a large number of smaller ones. Since 1980, the five largest firms have accounted for an average of 37 percent of domestic sales annually while the remaining 63 percent market share has been generated by more than 600 smaller firms. Yet despite the apparent dominance of market leaders, this is a very dynamic industry. Between 1960 and 1985, the average absolute change in market share rankings of the twenty largest pharmaceutical firms was 6.1 positions. Nine firms improved their market rank, some by eight to ten positions. Eleven firms either failed to improve their market positions or dropped in rank. Only the petroleum industry has had a higher turnover rate than pharmaceuticals. Since 1960, the rate of return on invested capital in the drug industry, based on the largest firms only, has ranked 9th overall among major manufacturing industries. The mean rate of return on investment for the pharmaceutical industry over this period was 17.02 percent or approximately 1.33 times the mean for all other industries (The Fortune Directory 1960-1986).

The patent protection afforded pharmaceutical innovations represents a substantial barrier to both competition within the industry and to potential entrants. Patents force potential competitors either to remain out of the market or to obtain a license from the patent holder to produce the drug. Such licensing arrangements, however, permit the patent holder to extract the monopoly profits which may be derived from sales of the drug. The potential contribution of product innovations to firms' financial performance may

be substantial. The degree to which pharmaceutical manufacturers rely on a relatively small number of products for a substantial portion of total sales reflects the industry's dependence on successful innovation. Since 1970, the percentage of total domestic pharmaceutical sales provided by each firm's three best selling products has averaged 46% for the 14 largest firms (National Research Council, 1988.)

R&D: Intensity and Productivity

Research and Development is the cornerstone of the pharmaceutical industry since the pattern of future corporate earnings and growth is primarily contingent on sustained product innovation. R&D within the industry represents the primary input to the process of innovation. The contribution of new drugs to corporate performance is essential to the growth of every major firm. The successful introduction of new prescription drugs may produce sales in excess of \$300 million annually for the inventive firm (Cutaia, 1987). Consequently, the pharmaceutical industry has historically been the most research-intensive segment in the private sector. Only recently has the industry's first place ranking on this dimension been challenged by the so-called "high tech" groups (The Business Week Survey of R&D Spending 1976-1985).

Research and development in the pharmaceutical industry is a very high risk venture. An average of one in 10,000 to 20,000 studies on new chemical compounds will yield a marketable drug (Business Week, 1985), although recent trends toward research on narrowly targeted drugs may improve these odds marginally. Further, the industry composite of R&D expenditures represents more than 99 percent of drug research funding, in contrast to all other industries in the U.S. which average a 42 percent level of government funding for all research and development efforts. Due to the very high costs and risks associated with research and development in this industry, fewer than 15 percent of pharmaceutical manufacturers engage in new drug research (Grabowski, 1983). Research tends to be limited to relatively large firms by the high costs of research per new chemical entity. The average cost incurred in developing a new medicine reached \$100 million in the 1980's as total industry expenditures on new drug R&D eclipsed \$4.7 billion in 1986 - more than double the 1980 level of R&D spending (The Economist, 1987.)

Firm Size and Innovation Potential.

The relationship between innovation inputs and firm size follows a reliable "S-curve" pattern. That is, expenditures on research and development tend to increase with sales up to a point and then level off before declining at the level of the largest firms in the industry.

The "S-curve" finding has been supported by the

analysis of research to firm size elasticities which assess the rate of change in research and development expenditures with respect to changes in firm size (Jarrell, 1983; Loeb and Lin, 1977; Mansfield et al., 1971). These elasticities, which correspond to the slope of the line relating firm size to R&D expenditures, have been shown to be significantly less than unity for market leaders. Hence, it may be assumed that the very largest firms in the industry are not pursuing new product innovations as vigorously as their closest competitors. Table 1 illustrates the relationship between market position and average R&D expenditures for the period from 1975 to 1986. For both unadjusted dollar expenditures and total R&D as a percentage of sales, maximum research intensity occurs at the level of the fifth and sixth largest firms. Relative to their smaller rivals, the three highest ranking firms exhibit relatively little research effort. The average R&D expenditures for the three largest firms (3.97% of sales) is significantly below the average of 7.13 for the next 11 firms ($p < .01$).

Table 2 illustrates the relationship between R&D effort (as a percentage of sales and expenditures per employee) and industry performance as reflected by changes in market position for the 7 most R&D intensive firms among the 14 market leaders. The market rank for each of these firms is given for 1975, 1980 and 1985. None of the four largest firms in the pharmaceutical industry were among the most research intensive through the 11 year period under investigation. Seven firms did spend significantly more on R&D as a percentage of sales than the average for the 14 largest manufacturers. These 7 firms realized an average net improvement in market rank of 1.9 positions since 1975. In contrast, those 7 firms which spent less than the average on R&D lost an average 2.1 market positions over this period. Relative to all other industries, pharmaceutical manufacturers operate within a very volatile environment.

Since 1975, the average absolute change in market position for the 14 largest firms in all other major U.S. industries was .72, less than one full rank. Further, the changes in market rank within the pharmaceutical industry reflect a substantial shift in relative sales volumes between firms. The rate of growth in total sales since 1975 for the most R&D intensive firms (285.1%) was significantly greater than that achieved by the seven less research-oriented companies (126.6%, $p < .01$).

Conclusion

Although the R&D expenditures made by pharmaceutical manufacturers contribute to each firm's capacity to innovate, the rapid rate of change within health care environments requires a sustained commitment to innovation. Within this context, R&D expenditures are the primary resource buffers which reduce long term risks to tolerable levels. Each of the largest drug makers in the U.S. has

Table 1

AVERAGE R&D EXPENDITURES BY MARKET RANK: 1975-1986

Market Rank	R&D Expenses (Millions of Dollars)	R&D Expenses as a Percentage of Sales	R&D Expenses Per Employee
1	122.61	3.13	\$3393
2	143.52	4.05	2434
3	154.37	4.72	3532
4	205.52*	6.71	4286
5	207.64*	8.16*	8427*
6	211.39*	8.62*	8125*
7	166.41**	6.62	6567
8	124.68	6.05	3939
9	130.51	7.52**	8228*
10	126.27	7.73*	3989
11	84.65	5.82	2470
12	92.48	7.14**	4961
13	28.53	5.97	2899
14	17.75	8.13*	9132*
Average:	129.74	6.35	5170

* Significantly above 14-firm average expenditure $p < .01$

** significantly above 14-firm average expenditure $p < .05$

DATA: Standard & Poor's CompuStat Services, Inc.
SEC Annual Reports - Form 10K

Table 2

MARKET PERFORMANCE OF THE SEVEN MOST RESEARCH INTENSIVE FIRMS: 1975-1986

Firm Name	R&D Expenditures As A % of Sales		R&D Expenditures Per Employee		Market Position Within The Industry			Net Change 1975-1986	% Change in Sales 1975-1986
	1975-79	1980-86	1975-79	1980-86	1975 Rank	1980 Rank	1986 Rank		
Upjohn	8.82	10.53	\$5377	\$10604	10	10	9	+1	177.13
Lilly	8.27	9.19	5392	10402	6	6	7	-1	201.46
Merck	8.20	8.51	5298	11036	5	5	4	+1	197.11
Smith Kline	7.82	8.52	4359	8407	12	8	6	+6	535.82
Schering	6.21	7.89	3234	5791	11	10	9	+2	202.52
Abbott	5.85	7.03	2585	5213	9	7	5	+4	304.57
Marion	5.43	7.09	3537	13796	14	14	14	0	376.19
Average	7.23	8.40	4255	9321	-	-	-	+1.9	285.10
Average for the 7 less R&D Intensive	3.26	5.21	2134	4979	-	-	-	-2.1	126.60
Average for the 14 largest manufacturers	5.25	6.81	3195	7150	-	-	-	0	205.90

spent enormous sums to develop an infrastructure which is capable of supporting continuous research in the quest for new prescription drugs. The nature of product innovation and the lag times created by clinical trials and regulatory delays requires that annual research budgets must serve as resource buffers. Current R&D resources are necessarily underutilized in the short run. The funds allocated to R&D in each successive quarter contribute to developing the critical mass which will produce a breakthrough drug. Inefficient in the short term, the failure to make these commitments will ultimately reduce the competitive strength of any major manufacturer.

The future of the U.S. pharmaceutical industry is absolutely dependent on greater levels of product innovation. By the end of this century, the patent protection covering nearly all of the top 200 prescription drugs in the U.S. will have expired (The Economist, 1987). Although several hundred new chemical entities are in various phases of development and testing, U.S. drug manufacturers have increasingly focused their efforts on price competition within the generic or "off-patent" prescription drug market. This year, however, patent drug sales may account for more than one-third of the \$100 billion world pharmaceutical market (Chemical Marketing Reporter, 1985). Whether these new medicines are developed in the United States or by foreign competitors will depend on the commitment of domestic firms to sustained research and product development. A greater appreciation of the role of R&D as a resource buffer will provide managers in all industries a greater understanding of the commitments required to reduce long term risks to tolerable levels.

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