

The Strategic Management of Research and Development

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Research and Development has changed forever. At one time, laboratories were filled with PhDs who were hired by corporations to develop new technology and address a very general, perceived future need. Today, all that has changed. R&D has become a strategic, competitive tool for corporations to gain market, as well as market share, through new products or innovative processes. In this paper we discuss the R&D challenges that corporations are facing for developing a competitive strategy in an age of global capitalism.

INTRODUCTION: OPENING NEW MARKETS

When one thinks of how a company develops opportunities for a new market/product, one of the first ideas which comes to mind, is Research and Development. Research and Development (R&D) is very often thought of as hi-tech, futuristic thinking that results in innovation and strategic advantage. There is a broad spectrum of ideas and concepts that are contained within the term “Research and Development” and the various steps that are taken in the process of converting an idea into a product or process.

These processes are costly and the decision to support any of them competes with investment opportunities that often have more immediate benefits. The biggest debate within industrial organizations, universities and government is deciding how much capital should be devoted to R&D. Different industries

invest differently in R&D, but the common theme remains the same: How long will it take to recover our investment?

While some observers lament that the US technological position has declined rapidly in key industrial sectors since 1979 (Schwartz, 1992), the challenge of incorporating R&D into the corporation’s competitive strategy has become greater than ever. Current research has highlighted a crucial link between business competitive strategy and technological innovations (Knoedler, 1990), yet there is growing discontent between scientists and management in corporate America (Gaines, 1994).

Managing R&D is an area of business performance directly linked to the different ways of generating financial resources to support R&D projects. This includes funding by private corporations, joint ventures, arrangements between industries and universities, government funding to universities and industries, and venture capitalists.

The manner in which companies handle the process of R&D depends largely on the type and size of the company. The majority of companies fall into the following two classifications and have been found to have an important influence on the approaches that are followed (Compton, 1997:448).

Large National/ Multinational Mature Companies	High-Tech Companies
Large companies experience difficulty in being entrepreneurial	May or may not be entrepreneurial
Multi-disciplinary teams may be difficult	Multi-disciplinary teams are frequent
Technology often focuses on development and continuous improvement	Technology derived internally or externally
Small Mature Companies	Entrepreneurial Companies
Entrepreneurial approach is uncommon	Emphasizes entrepreneurial approach
Small size fosters multidisciplinary teams	Multi-disciplinary teams are common
Technology often derived externally	Technology often derived internally.

In order for companies to stay successful and competitive in today’s global marketplace, each must determine the right formula for their business structure. Even companies of the same size in the same industry have varying approaches for managing R&D.

CORPORATE FUNDED R & D

One of the most common methods of funding R&D is for a private corporation to use existing financial and technical resources. This can be considered high-risk but hi-tech companies that show repeated successes using R&D for new products usually win the support of Wall Street investors when these new ideas are publicly released.

Even in tough economic times, many companies look to R&D as a possible competitive advantage. A hi-tech recession may be impacting Taiwan Semiconductor Manufacturing Co. (TSM), but these are nonetheless busy times for Shang-Yi Chiang, TSMC's senior vice-president for research and development. The slowdown in chip production has made it possible for his 460 engineers to accelerate their research on next-generation chip making techniques. "During a recession, people have much more energy to spend on R&D," according to Shang-Yi Chiang. While the rest of TSMC is under a hiring freeze, Chiang is expanding his staff by 10% (BWO, 2001).

This is a very effective way to utilize human resources during periods of economic slow-down without losing a competitive advantage by downsizing employees. However, this approach is not always possible for all companies. Battelle Labs, which normally is contracted to provide technical analysis and R&D support to companies, is changing how it does business in the competitive R&D environment. CEO Douglas E. Olesen has also redirected the institute to "cash-in" on its intellectual property. Where in the past Battelle may have received \$50,000 for a contract to help a company launch a \$50-million-a-year product, Battelle may now develop the product itself in one of the small companies it has spawned.

An outstanding example is Battelle Pulmonary Therapeutics, a for-profit venture that is conducting clinical trials on inhalation chemotherapy treatment for lung cancer patients. A team of 300 physicists, engineers, toxicologists, and other specialists helped develop this pioneering device (Bylinsky, 2000).

COLLABORATIVE PARTNERSHIP

Interest in corporate R&D ventures is by no means dead (Drucker, 1991). In a few exceptional cases, such as Xerox Corporation's Palo Alto Research Center (PARC) and within the major chemical companies such as DuPont, basic research continues. Ever since the cost-cutting excesses of the mid-1980's triggered a bloodbath at the big research labs, corporate R&D has been shifting more and more from the "R" part of the equation toward the "D." Even the U. S. Department of Defense was forced to scale back in R&D spending.

This trend has continued even though overall R&D spending has rebounded. According to the Industrial Research Institute, an organization of FORTUNE 1,000 research directors, corporate R&D budgets increased from

\$97 billion in 1994 to \$166 billion in 2001. However, the innovative content of corporate research has been greatly diminished in favor of work that supports short-term goals, such as improvement of existing products. Over the past fifteen years, some companies simply closed their R&D labs while others atomized central labs by assigning the research to wholly owned divisions.

Companies with R&D labs are trying to enrich their research activities in other ways. Many are collaborating with national labs, private research institutions and universities. MIT used to get two-thirds of its outside support from government and one-third from industry. Now the proportions have been reversed. While five years ago MIT received \$565 million in research funds from corporations for sponsored research on campus, last year the figure reached a record \$73 million.

Unfortunately, purchasing research conducted by others is not a panacea. "Buying from the outside is risky unless you have enough in-house expertise," says Arthur Chester, president of the Hughes Research Laboratory in Malibu, Calif. "And technology developed elsewhere usually needs adaptation and additional development before you can use it in your business." In-house expertise is also becoming harder to acquire. According to Karl Koster, director of corporate relations at MIT, "Big companies used to have their pick of MIT students. Now they are having a hell of a time recruiting them" (Bylinsky, 2000).

New players are stepping forward to create innovative technologies outside of corporate labs. One of the most exciting technologies of the new millennium is currently moving closer to the mass market. This technology is fuel cells, almost universally seen as an energy-conserving, low-pollution way to power millions of tomorrow's motor vehicles. Standing in the way is economics, which can be overcome only by chipping away at manufacturing costs and building plants large enough to realize economies of scale. Though Daimler Chrysler and others still plan to sell the first fuel-cell cars in California in 2004, mass production by the auto industry isn't likely to begin any earlier than 2008.

The big carmakers have collectively committed more than \$1 billion to this dream. Meanwhile, the emergence of fuel-cell products for other uses, though produced in far smaller volumes than those foreseen for motor vehicles, is significantly advancing the manufacturing know-how that the automakers will need:

- Production engineers at Ballard Power Systems in Vancouver, working closely with Daimler Chrysler and Ford, are revving up to produce fuel cells that will be the heart of a small portable electricity-generating device. Sunbeam Corporation's Coleman Powermate unit plans to have it in stores for this year's Christmas selling season.
- Plug Power in Latham, N.Y., which has a distribution agreement with General Electric, has just begun shipping the first fuel-cell generating

units designed to make a home or small business largely independent of the electric-power grid.

- International Fuel Cell in South Windsor, Conn., which already makes large 200-kilowatt fuel-cell generators for commercial use, will roll out a new version in 2003 which will cost two-thirds less as the result of design and manufacturing improvements (Brown, 2001).

The prime benefit of collaborative partnerships is the sharing of the extraordinary high cost of developing an alternative energy source. Few people realize how important venture capital has become for innovation in the United States. Although universities, national labs, and corporations continue to develop important new technologies, it is the role of the venture capitalist that has become the most crucial.

Last year total venture funding reached \$100 billion and accounted for 55% of the money spent in the U.S. on R&D, according to the National Science Foundation and Venture Economics. By comparison, venture funding made up only 4% of the overall research spending in 1990—a period of slow economic growth. What's more, venture firms are extremely effective at bargaining innovative ideas to market. According to Josh Lerner, a professor at Harvard Business School, venture financing leads to three to five times more innovations than corporate or university funding where too many of the research labs are more academic than commercial (Green, 2001).

According to a recent report (Green, 2001), the following table demonstrates how R&D monies have been distributed over different industries.

A Few Tech Sectors Get Most of the Funding...		
Industry	Number of Companies Funded in 1st Quarter 2001	Amount invested in Billions
Computer Software	207	\$2.06
Internet E-Commerce/ Content/Services	264	\$2.03
Internet Communications	71	\$1.31
Fibre Optics	37	\$0.95
Data Communications	55	\$0.73

Data: Venture Economics

INTELLECTUAL PROPERTY

Intellectual property now accounts for a major part of American economic growth and interest by investors in R&D has grown (Schacht, 2000). To promote further economic growth in cooperative R&D, the U. S. government

has enacted legislation (Bayh-Dole) which allows intellectual property that has government sponsorship to be retained by the contractor performing the R&D. (Tassey, 1995). The intent of this legislation is to protect a company's R&D from competition.

The World Intellectual Property Organization (WIPO) defines subcategories under intellectual property as follows: "Literary, artistic and scientific works; performances of performing artists, phonographs and broadcasts; industrial designs; trademarks; service marks and commercial names and designations; and all other rights resulting from intellectual activity in the industrial, scientific, literary and artistic fields" (WIPO, 1967).

From an R&D perspective, the definition of intellectual property would focus on the literary (e.g. manuals & software) and scientific works. A company's intellectual property may include trademarks and commercial names, but majority of the R&D intellectual property falls under literary and scientific works.

Intellectual property rights are defined as legally protected rights that enable owners of intellectual property to exert monopoly control of their intellectual property, usually for commercial gain. These rights prevent others from exploiting intellectual property for a fixed period of time or, in some cases, indefinitely. Intellectual property rights include patents, copyrights, registered and unregistered design rights, trademarks, and know-how.

The patent system (a "monopoly of monopolies" (Noble, 1977)), gives exclusive rights to the owner that excludes members of the public from making, using or selling the item subject to the patent. In order to be patentable, an invention must pass four tests:

1. The invention must fall into one of the five "statutory classes" of things that are patentable:
 - a. Processes,
 - b. Machines,
 - c. Manufacturers (that is, objects made by humans or machines), composition of matter, and
2. The invention must be "useful". One aspect of the "utility" test is that the invention cannot be a mere theoretical phenomenon.
3. The invention must be "novel", that is, it must be something that no one did before.
4. The invention must be "unobvious" to "a person having ordinary skill in the art to which said subject matter pertains". This requirement is the one on which many patentability disputes hinge.

Excluded from patent protection are mathematical algorithms, methods of treatment of human or animal body by surgery or therapy, or methods of diagnosis. Terms for patents vary from 14 to 20 years depending on the type of patent and, under exceptional circumstances when pharmaceutical products are involved, an extension of 5 years may be granted. Patents are published and give the full details of the invention.

Copyright is a category of intellectual property for the protection of literary or artistic work and computer software. Copyrights can be registered (U.S. Copyright Office) or unregistered and fall under the general protection of copyright laws. In the United States, unregistered works are protected under copyright laws when the original work is fixed in a tangible medium. In short, the first time an unregistered work is saved to a media storage device the work is copyrighted. The term for copyright protection of a literary work is 50 years beyond the author's death, 50 years from the end of the calendar year in which the software was created, and 25 years for typographical arrangements.

Register Design Rights are composed mainly of aesthetic objects where the appearance is unique. Registered Design Rights have a term of 5 years and are renewable on application for up to four further periods of 5 years each. From the perspective of R&D Intellectual property, Register Design Rights do not apply. Unregistered Design Rights are engineering components of architectural drawings. Unregistered Design Rights normally expire 15 years from the end of the calendar year in which the design drawing was first recorded or the design object made. R&D intellectual property for unregistered Design Rights would be limited to engineering components.

TradeMarks are product brand names or company logos and can be maintained indefinitely. Under U.S. trademark law, the C-in-a-circle symbol (©) may only be used in connection with a mark if that mark is a federally registered trademark. Federally registered means that the trademark owner has not only filed a trademark registration application with the U.S. Patent & Trademark Office but has been granted a registration from that office. From the perspective of R&D Intellectual property, trademarks do not apply. Know-how consists of trade secrets or background techniques, and can persist indefinitely. Know-how protection is achieved by keeping the information secret but can be licensed like other items of intellectual property.

ECONOMIC VALUE OF R&D

When dealing with the economic value of R&D, many researchers want to know where the company will be in 15 or 20 years. To address this issue, the common procedure is to investigate the established goals of the company's R&D department and then the support that the company gives to those goals. Technology goals are usually looked at first. A technology goal is defined as how a company seeks to fill a need, a niche or simply invent. The

second, and more prolific goal, is the constant drive for profit. This search for profit is at the crux of all improvements in product features, manufacturing techniques, raw material and processes, and has changed entire industries by transforming a company into a top competitor in its industry.

The December 2001 issue of *IndustryWeek.com*, lists 29 R&D developments to watch in the next few years (IW, 2002). Of the 29 projects listed, 24 involve cutting-edge new technology. The company that sponsors and supports this type of R&D is the company that will become the next household name. Pfizer, Bell Labs and DuPont all support new technology as a routine part of their business. Many of the products we use and interact with each day were once, and may still be considered, new technology.

This type of R&D function opens up new markets. It also contains the highest risk because very often, simultaneous development is underway by at least two independent entities. There is still lingering doubt as to the true inventor of the telephone and the light bulb. Often, inventors of projects that have taken tremendous resources to develop have been beaten to the patent office by mere hours, negating the entire project and the potential for and financial return.

Although new technology holds the limelight of the press and public, there is a much greater portion of R&D that is in the background. This is the R&D of manufacturing and product improvement. There is often a combination of technologies applied to improve a process or solve a problem. For instance, Millennium Pharmaceuticals in Cambridge Massachusetts, has been able to incorporate a new technology platform for conduction experiments (Thomke, 2001). Another example is BMW, which has utilized crash test simulations with computers in order to predict accurate, and sometimes surprising, results at a fraction of the cost of building prototypes.

Conducting R&D is not just a goal of many companies; it can also become a force that changes the goals of companies. The R&D work at BMW to develop the simulated crash tests enabled BMW to reorganize and rethink its old methods of design development and information transfer. Such a rethinking, and subsequent adoption of new design methods, essentially slashed development costs and boosted innovation.

Despite these attributes, researchers often debate whether R&D can be a strategic asset to a company. Obviously, it depends on the company and how the R&D function is managed. There is often a large gap between management expectations and the output of the R&D function. There may also exist organizational conflicts, unrealistic expectations and a basic inability to understand the unique problems of the R&D function.

In so doing, the effectiveness and productiveness of the R&D function depends on the company's needs measured in terms of both innovation and

manufacturing reliability. In other words, a well-managed R&D function will balance its goals between new technology and high value products and the appropriate location of such a balance depends upon the company's strategic goals.

THE SOCIAL VALUE OF R&D

One stakeholder of any business is the general public. As such, it is prudent that companies spend R&D dollars not only on making better products, but also by improving the quality of life with those products. Often it becomes a requirement to produce a product that is in line with current social issues and political thinking (Blackburn, Green, and Liff, 1982). In the pursuit of appealing to such issues, better products are often made and new markets opened up.

For example, many of our packaging containers today are made from biodegradable and recycled products. This is due not only to a social trend towards a "greener" earth, but also as a result of seeking more cost-effective packaging. An entire industry has sprung up since the early 1970's just to deal with recycling what was once thrown away. Fisheries Research and Development Corporation (FRDC), a statutory Australian corporation formed in 1991, is responsible for the planning, funding and managing of R&D programs. It also facilitates the dissemination, adoption and commercialization of the results of R&D. FRDC's stakeholders include the fishing industry, the governments of the commonwealth, and the people of Australia.

The National Aeronautics and Space Administration (NASA) is a huge R&D group and contributes hundreds of new products, materials and applications each year to the government and the general public. The NASA 1999 commercial invention of the year is a thermoplastic material. It was developed at NASA's Langley Research Center in Hampton, Virginia. The thermoplastic offers protection from UV radiation as a coating for art and outdoor statues, can be used as an additive to lipstick and paint, and has electronic manufacturing uses as well due to its temperature resistant properties.

The benefits of R&D to our society are numerous, however; society has different ways for defining what is beneficial and what is not. Human cloning is technically a reality today but there exists no general social acceptance of the technology for such a purpose. The atomic bomb, while leading to many highly beneficial innovations and technology, is considered the pinnacle of man's evil to man. Simply because something can be made and developed does not mean it should. The first question every shareholder of R&D should ask is not "Can we?" but rather "Should we?"

Stakeholders of any R&D group are the sponsors, the local and national governments, the general public and the financial organizations now and in the future. R&D must exist for all stakeholders of the organization, not just for

purposes of the bottom-line. Meeting those challenges requires careful organization, planning and management.

DOWNSIZING AND CORPORATE R&D

Downsizing, rightsizing, reengineering, and “lean and mean” — all refer to reducing the workforce to match the mission of the corporation. In times of high economic growth and low unemployment, corporations tend to keep employees for a number of reasons, even when they are out of touch with the technical needs of the corporation or business unit (Crease, 1991; Budiansky, 1993).

Generally, the level of over-employment remains until an outside force pushes the corporation to critical mass. The outside force can come from competition redefining a like product offering. This new definition might include a low cost product without services, which may be amenable to some customers. The lack of a competitive edge in the area of new technology might drive a competitor to accept that weakness and turn it around with an across-the-board price cut. This move may help sales and improve competition. At worst, the company with the innovative R&D group will have to live with lower profit margins by matching the lower prices (assuming that the overhead of its R&D effort is larger than the competition), or look for other ways to differentiate itself in the market. If it fails to sell its value to the customer, it may decide to downsize to quickly cut costs.

During the past two years, Proctor and Gamble has laid off over 17,000 people due to the competitive nature of the home care and personal care business, “where several companies are saddled with less-than-desirable earnings and are under pressure to control costs” (Watkins, 2001). Automotive companies are requiring their vendors to come up with new technological solutions to meet the market needs in the future. At the same time, some of these same automotive original equipment manufacturers (OEM) have cut back on their technical groups to save costs. In these situations, the end customer is telling all its vendors to do more with less (and for less!). In fiercely competitive markets, there always seems to be a company that will fill the end customer’s needs.

There are many negative impacts to downsizing, however. With some companies, the first step to downsizing is a voluntary program. Separation packages for senior employees may make later, mandatory lay-offs less painful. One issue that can develop, is that during a voluntary separation program, some of the most valuable employees leave the corporation. There is a real interruption in “organizational memory” as a result.

The key resources for some of the survivors are lost. Many R&D functions over the years generate a network of coworkers as sounding boards or historical resources before proceeding with new ideas. The indirect use of the most talented, senior technical employees have always been there, but are not

generally acknowledged. In some cases, it is necessary for the corporation to hire back these employees as consultants for a short time, generating another mixed message to the survivors.

Another result of downsizing the R&D function of a corporation is the perceived lack of value that employees feel for themselves and their work. Displaced workers and survivors alike feel that the corporation views them only as indirect costs, overhead, or a “bottom-line” savings potential, but not as people contributing, to the best of their ability, to the corporation’s success. The secrecy that exists prior to a downsizing announcement and the suddenness of the announcement, further add to the survivor’s insecurity and lack of worth. In many cases, this causes a potential loss of trust of the individual employee to their direct manager and to the corporation itself (Mishra, 1998). Morale generally drops significantly as employees feel that they have lost control of their own destinies within the corporation. Invariably when a corporation downsizes, the workload doesn’t immediately lower. The survivors are usually left to cover for their displaced coworkers, sometimes taking over for more than one. For the motivated professional, this can take “the wind out of their sails” and burnout is not uncommon.

Private industry is not the only area affected by R&D downsizing. In March of 1999, NASA documented its Workforce Restructuring Plan. At NASA budgets are controlled by the Senate and the House of Representatives and subject to political whims. NASA approaches this with an aggressive redefinition of itself to survive in the 21st century. It was NASA’s vision to come out of restructuring with a more focused workforce, releasing responsibilities that were best delivered by other vendors. NASA chose to lose some of the control it previously had, and return the agency back to its roots as a “premier” R&D organization.

NASA recognized early that an organization could not do the same work with less people, but that it would need to focus “internal efforts on technology development, transferring operational activities to commercial contractors as appropriate”. By defining a clean separation of what it would, and more importantly would not do, it is able to redeploy its efforts to fit its new organizational goals. Of course, the rigid approach that NASA took was not always easy. NASA wanted to use attrition and buyouts (early retirement, etc) to manage the reduction guidelines in lieu of major lay-offs. A hiring freeze prevented some managers from filling positions that had specific skill requirements. This is a concern in any downsizing action. If the survivors cannot meet the requirements of their new responsibilities, managers must be aware of these limitations, and provide additional training or education.

All in all, downsizing R&D in a corporation or government facility has long-term ramifications. Managers and employees are both affected, and the relationship between them can be strained for long periods of time. Such bot-

tom-line savings are momentary and superficial while the effects on the workforce can last for years. People are emotional creatures, and the fears and uncertainty that downsizing create are difficult to overturn. The more corporations are able to “over-communicate” during times of downsizing, the better the effects are on the survivors. And, corporations must always be mindful to their missions. If broad R&D efforts are not in line with these goals (in a particular department or business unit), a smaller more manageable redeployment of people to other opportunities within the corporation will result in the least disruptive working environment for the people involved in R&D.

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