

TOWARD THE INNOVATIVE FIRM - CHALLENGE FOR R&D MANAGEMENT

An analysis of the changing character of international competition shows how and why success is increasingly dependent upon the R&D function.

OVERVIEW: Industrial strategies for multinationals have undergone profound changes. Underlying causes are to be found in new market factors, technological developments and intensified competition. More and more, it is recognized that companies are confronted with increasing demands for efficiency, quality and flexibility. Product prices are under continuous pressure, ever-higher quality standards are simply a must, and the rate of product renewal has increased considerably. Under these conditions, it is increasingly difficult for companies to distinguish themselves from competitors. Innovation proves to be the magic word. This places R&D in the midst of the competitive battle, dramatically changing the role of the R&D function.

Until the early 1960s, the successful firm was the Efficient Firm, having a hierarchic, bureaucratic and rational organization. The Efficient Firm directs its main efforts toward increasing efficiency; consequently, the firm is internally oriented. Adherence to standard procedures is called for, with negative sanctions as the means of control. Organizational design is based on the creation of routine tasks. Investments in Manufacturing are primarily focused upon growth and efficiency improvements, with much attention being paid to the output of machines. Little thought is given to viewing Manufacturing as a total, integrated system. The whole resembles a well-oiled, smoothly running machine. The message to the customers is, "We are cheaper." This is in line with the sellers' market conditions prevailing during this period.

Effective trade barriers result in hardly any international competition, and demand almost always exceeds supply. Although growth rates are high, the environment can be called static. Large companies can reliably predict their sales turnover, both in terms of volume as well as in mix. This well-known "archetype" of the large industrial company was highly successful until the mid-1960s.

R&D in the Efficient Firm

The distance between Marketing and R&D is large in the Efficient Firm, but this is hardly seen as a weakness in the absence of market-pull. Product renewal takes place at a moderate rate. It is the task of Manufacturing just to produce according to the designs of R&D. The walls between R&D and Manufacturing are taken for granted, if noticed at all. There are few, if any, contacts between R&D and customers. Product design and process engineering take place separately and consecutively. Indeed, the whole product creation process is functionally split, with the various activities taking place serially. Due to the many interfaces between R&D and Manufacturing, R&D has to spend considerable time assisting Manufacturing, especially during the first months after introducing a new product.

Incremental improvements do take place during the many years of the life-cycle of a product. The majority of such improvements are directed toward the short term, and the development activities associated with them are generally divided among a great many small projects. Actually, the term R&D is not clear, as Research and Development differ very much in nature. Development activities are heavily influenced by the efforts to drive costs down that so much typify the Efficient Firm. Extensive price calculations, aimed at minimum factory cost prices of new product designs, form an essential part of the development phase. Research, on the other hand, is generally viewed as a creative process, needing an open, unhurried atmosphere, preferably situated in some beautiful countryside far away from the day-to-day troubles of the manufacturing operation. Of course, this is not to say that Research does not function well--many great inventions have come out of this period. However, Research can "take its time" in analyzing and perfecting laboratory work.

Transition To Quality

The breaking down of trade barriers signals the beginning of a series of changes, still going on today, that will leave no part of the organization unaltered. The first effect of the growth in international trade flows is an intensified competition on price as companies can produce in one country and sell their products throughout the world. Complete industries disappear to low-wage countries, which use price as a competitive weapon. The intensified competition rapidly changes the sellers' market into a buyers' market, with supply outstripping demand. Subsequent price wars and dwindling profits cause leading companies to search for a new competitive weapon. By making this strategic choice for quality, these leading companies set their products apart from those offered by the Efficient Firms, which are still operating according to the belief that price is the one-and-only market factor.

The reaction of the Efficient Firm typically passes through three stages:

1. At first, quality is denied as the new market demand. Efficient Firms react to this new competition by intensifying the price war, and the pursuit of efficiency is given new life. These campaigns meet their goal with respect to lowering costs and increasing efficiency. But they are not successful because market shares do not increase; neither do profit margins. The new competitors conquer ever-larger market shares with their higher-quality products.
2. After a while, almost all Efficient Firms recognize they have a quality problem. And, like every problem, this one can be solved by "scientific" management: Responsibility for solving the problem is allocated to designated experts--the quality department. Quality campaigns are started, generally in the form of tightened discipline, more rules, procedures, testing, checking and rechecking. The results are clear: The quality of products delivered improves considerably, but at high cost. Moreover, it becomes clear that any slackening of attention makes the quality levels slip. Quality is not really under control. On top of that, the quality gap with the new competitors has not narrowed.
3. Slowly but surely, it dawns upon the Efficient Firms that quality should be seen as a powerful means of improving competitive strength. The quality threat turns into the quality challenge, to be met by everyone in the organization.

The Quality Firm: More Value for Money

At the third stage, a top-down quality approach, often known as Total Quality Control or Company-Wide Quality Improvement, ultimately leads to a metamorphosis of the Efficient Firm, fusing it into the Quality Firm (see Figures 1 and 2). The successful firm in the 1970s was the Quality Firm, with a hierarchical organization and competent management (i.e., acting more businesslike than political).

The Quality firm is strongly customer-oriented. Negative sanctions have largely given way to positive ones, getting people to really put their hearts into their work. There is a spirit of cooperation, in which people are assessed on results and much attention is paid to horizontal and vertical communication. All efforts of the Quality Firm are directed toward the pursuit of quality as well as realizing the still-necessary efficiency improvements. The message to the customers is: "We are better."

It is essential to recognize that the importance of efficiency as a factor in market success has in no way diminished with the appearance of quality. Companies now have to compete on price and quality at the same time. Efficiency (i.e., the ability to master mass production) is a precondition for quality, and quality, in its turn, supports and enhances efficiency.

R&D in the Quality Firm

As leading companies have demonstrated, the quality approach is characterized by long-term, continuous improvement in all parts of the organization, including R&D. The already-mentioned change from a sellers' to a buyers' market leads to the rise of considerable market pull, forcing much closer cooperation between R&D and Marketing. Although the assortment of products is still modest, much attention is paid to ensuring that products are received well by the market.

Managing R&D includes evaluating results by comparing targets with actual results obtained during the manufacturing stage. Realizing that the quality delivered by Manufacturing can never exceed the inherent quality of the product design leads to much closer attention to design aspects such as producibility and serviceability.

New design analyses like DfA lead to a more integrated view of products and processes; the same holds true for the use of multidisciplinary project teams. Reliability engineering techniques (e.g., FMEA), are used by companies leading in quality (1). The Quality Firm has a long-lasting relationship with its main suppliers. Sometimes these suppliers act as co-designers during the development stage. Also, the intensified cooperation with Sales and Marketing means that considerable information about external markets and competitors is available to the R&D departments concerned.

In short, the change from an Efficient Firm to a Quality Firm has two main effects on the functioning of R&D. First, much more attention is paid to producibility and serviceability. Second, the product-out approach is replaced by market-in, calling for much closer cooperation between Sales, Marketing and R&D. Most of these changes take place in the development stage and leave the research stage of the innovation chain relatively unaltered.

Transition To Flexibility

At the end of the 1970s, the competitive struggle changed for the second time. More and more industrial sectors suffered from overcapacity, depressing profits. A wide array of new technologies not only led to the introduction of new products such as videorecorders, compact disc players and personal computers, but also offered new opportunities for renewing and improving existing products. Japan, in particular, started to modernize its product lines more often, putting new models onto the market at ever-shorter intervals (2). Customers, confronted with a broad, often bewildering, assortment of products, reacted by becoming even more fashion-conscious. Brand

loyalty for many products all but disappeared and in addition to price and quality, choice from a wide product line with up-to-date designs became a major factor in market success.

Internally, this translated into increasing time pressure: Turning out new products faster means shortening development process time, as well as the time needed for engineering and pilot production runs.

The reaction of the Quality Firms again passed through the three stages:

1. At first, the new market demand is denied: "We don't need this variety; all that customers want are low-priced quality products. So give them less choice, but pay even more attention to quality and price." Instead of widening their assortment, companies strive for (high quality) global products. But profit margins scarcely increase, as the global, and thus standard, products get bogged down in a price war by lack of distinction from competitors' products.
2. More and more analyses show that lack of flexibility in the primary processes is a problem. Long manufacturing lead times, for instance, with the associated high inventories, seriously hinder the necessary quality improvements and prove to be very costly. Measures are taken to improve speed and flexibility of the primary process in order to meet market demands for speed and reliability of deliveries (minimizing resetting times of machines, setting up continuous flow production, CAD/CAM etc.)
3. At last, it is recognized that a top-down approach is needed to capitalize upon flexibility, including intercompany networks, customer-supplier relationships and the choice of make-or-buy. Such an approach opens the way to making flexibility profitable as the company becomes a market leader (3). In hotly contested markets, with products having short commercial life cycles, there is little future for market followers, with the possible exception of those in low-wage countries. A broad, up-to-date product line, and being first in introducing new generations of products, are now used as a competitive weapon; with correspondingly short delivery times and the ability to cater to the specific requirements of large customers. The Quality Firm is changing into the Flexible Firm.

More Choice for Fragmented Markets

Success in the 1980s belonged to the Flexible Firm, having a hierarchical, but flat and externally oriented organization. In the Flexible Firm, organizational design is based upon simplification and the creation of fast feedback loops, enabling processes to react quickly to changes while retaining their reliability. The functional organization of the former Efficiency and Quality Firms has largely given way to product-oriented organizations, consisting of relatively autonomous product-market combinations--business units--in which all primary and directly supporting functions are present. Communication lines are therefore short, the number of hierarchical levels limited and central staff groups kept to a minimum.

Most manual work is carried out in groups, employing multi-skilled employees, responsible for day-to-day operations. The inflexible mechanization of the past is replaced by flexible, often computer-aided, automation. In addition to cost reduction and quality improvement, the efforts of the Flexible Firm are directed at increasing speed in order to minimize the time from "ore to customer store."

This also holds true for developing and introducing new products. The message to the customers is: "We offer more choice and faster delivery." Broad product lines and fast deliveries now become an important factor for market success, in addition to price and quality. Consequently, companies are under pressure to simultaneously improve efficiency, quality and flexibility.

Again, it is worthwhile to note the relations between these performance criteria. Flexibility, the ability to quickly renew product lines, offer a wide choice of products and meet high delivery demands, can only be achieved (at reasonable cost) if processes are controlled, if coordinated actions are taken, and if components and semi-finished goods are of excellent quality with no rejects; in short, if and when efficiency, and in particular, quality, are properly under control.

Moreover, in the long term, flexibility supports and enhances efficiency and quality (4). Flexibility is profitable because it leads to smaller inventories, less space needed and simpler logistics. Flexibility improves quality through faster feedback loops, less inventory and improved overview of products and processes. Last but not least, flexibility is profitable because it enables companies to be first in introducing new technologies, thereby beating competitors in bringing superior products to the market.

R&D in the Flexible Firm

Speed characterizes the Flexible Firm, enabling it to quickly develop new products and introduce them to the market. R&D management strongly believes, as do all managers in the Flexible Firm, that time and not cost is the overriding success factor. As such, even overshooting an R&D budget is accepted if that ensures finishing a project on time.

Various means are used to compress development time, including concurrent engineering, project management, one-room approaches and, last but not least, group sessions to arrive at "solid" marketing specifications early in

the development stage. Simplification of designs and optimal use of proven technologies also shorten lead times. So do standardization of components and the use of CAD-CAM technologies.

Manufacturability becomes all-important for the fast upscaling necessary when taking new designs into production. Consequently, it is no longer the case that Manufacturing simply produces whatever R&D designs. R&D now has the responsibility to design in such a way that products can be produced efficiently and with high levels of process control, using existing manufacturing capabilities. Job rotation between R&D and Manufacturing, as well as multidisciplinary project teams, are means to arrive at that goal. Not only is information present regarding markets and competitors, but extensive analyses are also made of the actual user demands.

Senior R&D staff have a broad knowledge of the total product creation and realization chain, enabling them to manage bottlenecks so as to meet the general goal: "Always deliver on time." Close cooperation and communication exist across the entire spectrum from components to assembled products. In many instances, time pressure, together with high CAD investments, leads to prolonged laboratory operating times. Flexibility of work is, therefore, not unknown in the R&D departments of the Flexible Firm.

Engineering, Manufacturing, Marketing, and Sales are involved from the very beginning of R&D projects. The already-mentioned co-designship relations with main suppliers increasingly lead to farming out (parts of) development projects. This calls for precise and clear specifications, as well as frequent contacts by R&D with buyers and suppliers. The R&D staff not only act as innovators, but also as technical buyers. Farming out makes it possible for R&D to focus its activities on the truly strategic technologies of the Flexible Firm.

Time pressure changes the functioning of the R&D departments. The notion of the creative R&D process, outside of any planning system, is radically changed. Formal planning and decision systems are introduced, most "open" R&D activities are replaced by contract R&D with specific targets concerning output, investments required and, above all, date of completion. Such contracts are generally made by direct contacts between R&D and the semiautonomous business units.

The gap in functioning and style of management between R&D and operational activities like Engineering and Manufacturing is closing rapidly as both sides change. Manufacturing, confronted with greater demand for flexibility, changes from a static organization that often resists change into a flexible organization that still meets set targets. At the same time, R&D learns to cope with formal planning systems and the demands placed upon the organization by the environment. Last but not least, the difference between Research and Development, so prominent in the Efficient Firm, vanishes to a large degree as a result of time pressure.

Transition To Innovativeness

As described, the evolution of large-scale industry has led to the situation today, in which companies have to simultaneously meet increasing demands for efficiency, quality and flexibility. Recent research shows that successful firms cut costs, increase quality levels and improve flexibility at the same time (5).

There are indications, however, that competition is changing for the third time. As could have been expected, the changes are initiated by industry leaders who have already mastered quality and flexibility. As a consequence, they are searching for a new way to distinguish themselves in the market. These companies try to stay ahead of competition by putting more innovation into their products.

New technologies play a key role in these changes. The past decade has taught us the amazing possibilities new technologies offer for improving the performance of existing products and for supplying completely new ones. Fiber-optic cables, micro-electronics, industrial ceramics and micro-lasers are just a few examples. The use of new technologies in products accounts for much of the recent productivity increase. Other productivity improvements stem from advances in process technologies, such as flexible manufacturing systems, or automation equipment for placing surface mounted devices.

This evolution gives rise to a new market demand: uniqueness. The internal performance criterion associated with uniqueness is innovativeness or innovative ability. Success in the market will increasingly depend on innovativeness, in addition to efficiency, quality and flexibility. This capability for renewal under time pressure will give innovativeness a completely new character.

Analogous to the developments described above, it is to be expected that the reaction of the Flexible Firm to this new market demand will again pass through three stages.

- 1. At first, the new market demand is denied by saying: "We don't need all this renewal. The constant stream of new products bewilders customers." Companies attempt to play for time with new products, or to reach agreements on the time of introduction. Some companies stress that a leading role in innovation is improper: It costs too much, giving you a weak financial position when the market starts to grow. In addition, the speed of innovation of competitors is said to be so fast that you can hardly take advantage of any lead you might have. "Innovation simply doesn't pay" is the attitude.
- 2. The Flexible Firm recognizes it has a problem, because it loses market share to more innovative companies. It turns out that fast innovation is the key to achieving high productivity improvements and better market positions. Recognizing the problem, innovation is promoted bottom-up by means of

innovation teams and parallel development, without changing the organization's structure and culture. However, companies discover that the timely capitalization of innovative ideas is not merely a question of technological ability. Internal entrepreneurship, open communication and the courage to put existing procedures, conventions and strategies up for discussion are also needed.

- 3. At last, it is recognized that the new market demand encompasses a challenge and opportunity. To exploit innovation as a competitive weapon, the firm starts to develop a top-down approach, involving accelerating processes of renewal, creating an innovative climate, and learning to manage creativity better. Mastering these processes changes the company into the Innovative Firm.

Note again the relation between efficiency, quality, flexibility, and innovativeness. Innovation always involves renewal. And renewal always includes change. Flexibility means the ability to change quickly, whereas innovativeness depends on the ability to renew quickly, which is more than change. It is possible to be flexible without being innovative, but the reverse is not true; you cannot be innovative without being flexible. As before, the new requirement reinforces the old ones: Innovativeness reinforces efficiency, quality and flexibility. It improves efficiency through better product price/performance ratios, increases overall productivity (especially of white collar workers), leads to improved quality, and enhances flexibility by being able to more quickly capitalize upon new ideas.

Unique Products for Customized Markets

The successful firm of the 1990s will be the Innovative Firm having very typical characteristics: Cost reduction, quality improvement and increasing flexibility are embedded in a continuous search for breakthroughs in all areas involved, with the ultimate goal of delivering outstanding products in terms of price, quality and performance. As such, this company of the 1990s not only produces a wide and varied product range but it is also known for its unique products.

The Innovative Firm is characterized by its ability to coordinate technological developments, applicable in separate business units. This means that strategic management of technology, as it is called, is an important activity. Outwitting competitors by changing the game is an important part of the company's success. Considerable use is made of multidisciplinary ad-hoc teams, generally manned by experts from all over the company. Lines of command to the various teams change with time, depending upon the state of the activities concerned. Integrating managers direct and coordinate the various activities, both horizontally--a, from Research through Development and Engineering to Production--as well as vertically along the product axis from components to end products. The traditional line-staff distinction has lost most of its significance as teamwork is the name of the game. A system of group assessment is applied. The company firmly believes that--as the technological abilities of companies throughout the world equalize--innovative capacity becomes the key success factor.

Thus, the basic premise is the inseparable link between technological innovation and social renewal. An innovative climate is created and maintained by such measures as the employment of mavericks, the use of an open-door policy, including the possibilities of hierarchical bypasses and the promotion of diagonal communication, supplementing the horizontal and vertical communication of the Flexible Firm. The innovative organization is a "learning" organization.

As innovation is not restricted to new technologies, the results of creativity are not limited to the introduction of new products. They also lead to novel approaches in opening up new markets, setting up new organizations, designing new factories and offices, updating industrial relations, and formulating new missions.

Coming up with alternatives--a necessary ingredient for an innovative organization--is encouraged through an open, informal atmosphere. Strong cohesion between all members of the organization and much attention to superordinate goals and the mission of the company make for the concerted, aggressive approach that makes the company such a formidable competitor. More often than not, successful innovations can be applied in various parts of the organization; hence, much time and energy is spent spreading the word.

This does not mean that the entire company is in a state of flux. On the contrary, the Innovative Firm has to strike the right balance between renewal and stability; the same holds true for the balance between entrepreneurship and the tight, hands-on management of innovation. Therefore, within the company, various organizational forms exist alongside one another, depending upon the requirements of the specific activities.

Just as not all of the organization is in a process of innovation, not all of the company's products are unique. It simply puts more innovation into more products, apart from producing a wide variety of products, than its competitors. This keeps it one step ahead of the competition.

R&D in the Innovative Firm

Time-driven, market-oriented renewal is the name of the game in the Innovative Firm. Unique products demand the latest, state-of-the-art technologies and call for novel approaches, such as multidisciplinary ad-hoc teams and skunk-works, often organized outside the existing hierarchical structure. Far-reaching delegation of power to

these teams, together with the use of so-called integrating managers, promote fast, results-driven teamwork. Team results are closely scrutinized for possible learning effects.

Members of the team have contact with practically, all layers of the organization, up to and including top management, which clearly stimulates the innovative climate. This climate is also fostered by the existence of hierarchical by-passes and an open-door management style. True creativity is rewarded, even when accomplished with a critical, non-conformistic attitude. This is also made possible by a dual-ladder career system, enabling staff to pursue a technical career in parallel with the managerial career line. Human resource management, focused upon getting and keeping top specialists as well as promoting teamwork, forms the most essential task of top management.

Characteristic of the Innovative Firm is the effective dissemination of know-how from Research to Applied Development and Engineering. Often, technology gate-keepers judge new ideas and keep a keen eye on outside developments. The traditional barriers in the entire chain from concept to product have largely vanished (6). Most drawing boards have been replaced by CAD workstations, coupled to worldwide data networks. Using centrally developed technologies in products designed to maximally satisfy local tastes couples global technological competition onto local market responsiveness. One of the main corporate tasks--in which R&D plays a key role--is strategic management of technology, aimed at capitalizing on technological synergy between the various divisions and business units of the company.

Entrepreneurship not only applies to marketing and commerce, but also thrives in R&D. Taking the initiative together with the risks involved shows how far R&D of the Innovative Firm is removed from the classical "green pastures" environment of the Efficient Firm.

Challenge for R&D Management

Changed customer demands, the increasing pace of technological development but, above all, the intensified international competition--made possible by liberalization of international trade--have brought about profound changes in the nature of international competition and, consequently, in the structure and functioning of large industrial organizations. In hindsight, these developments can be described as a series of steps, changing the Efficient Firm into the Quality Firm, then into the Flexible Firm with the next change to the Innovative Firm to be expected (7). Each step draws R&D further into the competitive battle. Starting with the appearance of quality pressure--initiated by Japanese industry--sellers' markets change to buyers' markets and R&D must now cope with customer wishes, forcing closer cooperation between R&D and commerce. The change also means more attention to manufacturability and serviceability in the design stage. But, by and large, changes for R&D due to quality pressure are mainly restricted to the development phase.

The necessity of competing under time pressure radically changes R&D. Firm limits on the completion of R&D projects, together with very specific demands on the products to be delivered, forces R&D management to manage R&D as if it were an "innovation factory." R&D people become part of business-unit teams, feeling the heat of competition. This calls for R&D managers to keep a tight rope between the short-term demands of business-unit leaders while, at the same time, leaving enough room to work on long-term research. Time pressure also forces R&D to analyze what its real strengths are; in other words, to make "make-or-buy" choices, similar to those made in Manufacturing. The ensuing growth of strategic alliances, or outright buying of know-how, will mean an increase of external managerial tasks, illustrative of the open character of the Innovative Firm.

In short, large industrial companies will, to an increasing degree, compete on the basis of innovative ability. This calls for close cooperation at all levels of R&D with the other major functions of the organization, such as Sales, Marketing and Production. The differences that used to exist between these functions will all but disappear. R&D, by becoming essential to the success of large industrial organizations, will experience more pressure to perform according to measurable targets, with all the consequences thereof. On other hand, the chances for entrepreneurship in R&D, and the pivotal role of R&D as a strategic issue for top management, pose a real challenge for R&D management.

GRAPH: Figure 1.--Evolution of market requirements and performance criteria for large manufacturing industry means that companies today are under pressure to improve efficiency, quality, flexibility, and innovativeness simultaneously.

DIAGRAM: Figure 2.--The industrial evolution is a process of learning in which skipping phases is impossible; strengths developed in each phase are not only retained during the evolutionary process, but newly acquired capabilities contain and reinforce the previous ones.

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