Role of Technology in Product Innovation

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Abstract - Creating a new product is a creative process and should be treated as such. Requirements for a more innovative society include a competence base, entrepreneurs willing to take risks and develop new activities, and rules that support innovation. Change does not happen by itself; someone has to take the initiative. However, the context sets the parameters of what is possible and can provide more or less powerful incentives for change. This paper analyses role of technology in product innovation and management.

Keywords: Technology, Product Innovation, Management, Entrepreneurs

I. INTRODUCTION

Technology is the collection of techniques, skills, methods and processes used in the production of goods or services or in the accomplishment of objectives, such as scientific investigation. Technology can be the knowledge of techniques, processes, etc. or it can be embedded in machines, computers, devices and factories, which can be operated by individuals without detailed knowledge of the workings of such things.

Another definition was put forth by J. Paap, as quoted by Michael Bigwood in *Research-Technology Management.* Paap defined technology as "the use of science-based knowledge to meet a need." Bigwood suggests this definition "perfectly describes the concept of technology as a bridge between science and new products." Technology draws heavily on scientific advances and the understanding gained through research and development. It then leverages this information to improve both the performance and overall usefulness of products, systems, and services.

In the context of a business, technology has a wide range of potential effects on management:

- Reduced costs of operations. For example, Dell Computer Corporation used technology to lower manufacturing and administrative costs, enabling the company to sell computers cheaper than most other vendors.
- New product and new market creation. For example, Sony Corporation pioneered the technology of miniaturisation to create a whole new class of portable consumer electronics (such as radios, cassette tape recorders, and CD players).
- Adaptation to changes in scale and format. In the early part of the twenty-first century, companies addressed how small devices such as cell phones, personal digital assistants (PDAs), and MP3 players could practically become, as well as how each product could support various features and functions. For example, cell phones began to support email, web browsing, text messaging, and even picture taking as well as phone calls.
- Improved customer service. The sophisticated package-tracking system developed by Federal Express enables that company to locate a shipment while in transit and report its status to the customer. With the development of the World Wide Web, customers can find the location of their shipments without even talking to a Federal Express employee.
- Reorganised administrative operations. For example, the banking industry has reduced the cost of serving its customers by using technologies such as automated teller machines, toll-free call centres, and the Web. As of early 2005, the cost of a bank transaction conducted by a human teller was approximately $2, compared to $1 for a telephone banking transaction, $.50-1.00 for an ATM transaction, and about ten cents for banking over the Internet. Automated Clearing House (ACH) or "check less" check processing costs were $.25-.50 per transaction. This reduction in cost could be attributed primarily to reduction the amount of labor involved, which had a profound effect on employment and labor-management relations in banking.

II. TECHNOLOGY MANAGEMENT

Since technology is such a vital force, the field of technology management has emerged to address the particular ways in which companies should approach the use of technology in business strategies and operations. Technology is inherently difficult to manage because it is constantly changing, often in ways that cannot be predicted. Technology management is the set of policies and practices that leverage technologies to build, maintain, and enhance the competitive advantage of the firm on the basis of proprietary knowledge and know-how.

The U.S. National Research Council in Washington, D.C., defined management of technology (MOT) as linking

"engineering, science, and management disciplines to plan, develop, and implement technological capabilities to shape and accomplish the strategic and operational objectives of an organisation" (National Research Council, 1987). While technology management techniques are themselves important to firm competitiveness, they are most effective when they complement the overall strategic posture adopted by the firm. The strategic management of technology tries to create competitive by incorporating technological opportunities into the corporate strategy.

Technology management needs to be separated from research and development (R&D) management. R&D management refers to the process by which a company runs its research laboratories and other operations for the creation of new technologies. Technology management focuses on the intersection of technology and business, encompassing not only technology creation but also its application, dissemination, and impact. Michael Bigwood suggests that New Technology Exploitation (NTE) lies somewhere between R&D and New Product Development, with characteristics of the cyclical learning process of scientific discovery and the more defined and linear process of product development.

Given these trends, a new profession, known as the technology manager, emerged. Defined as a generalist with many technology-based specialisations and who possessed new managerial skills, techniques, and ways of thinking, technology managers knew company strategy and how technology could be used most effectively to support firm goals and objectives.

Educational programs supporting this career grew as well. Formal Technology Management programs became available in the 1980s and these were largely affiliated with engineering or business schools. Coursework was limited, and the field was just finding its own unique focus. During the 1990s, the increasing integration of technology into overall business function and strategy helped to align technology management more closely with business programs. Most graduate programs in the 2000s were offered through business schools, either as separate MBA tracks or as MBA concentrations. Coursework in these programs shifted emphasis from technology to management, centring around innovation management and technology strategy, while touching on other areas such as operations, new product development, project management, and organisational behaviour, among others. There was still little specialisation in any particular industry.

During the early 2000s, another shift took place. Global distribution, outsourcing, and large-scale collaboration impacted the nature of technology management (TM) and preparatory educational programs. At least two MBA programs were shifting their technology management focus to "innovation and leadership," with particular emphasis on real-world problem solving in partnership with large corporations.

III. TECHNOLOGY AND INNOVATION

Technological change is a combination of two activities invention and innovation. Invention is the development of a new idea that has useful applications. Innovation is a more complex term, referring to how an invention is brought into commercial usage. The distinction between the two is very important. As an example, Henry Ford did not invent the automobile; companies in Europe such as Daimler were producing cars well before Ford founded his company. Henry Ford instead focused on the innovation of automobiles, creating a method (mass production) by which cars could be manufactured and distributed cheaply to a large number of customers.

The practice of technology management and the development of technology strategy require an understanding of the different forms of innovation and the features of each form.

- Incremental innovations exploit the potential of established designs, and often reinforce the dominance of established firms. They improve the existing functional capabilities of a technology by means of small-scale improvements in the technology's value, adding attributes such as performance, safety, quality, and cost.
- Generational or next-generation technology innovations are incremental innovations that lead to the creation of a new but not radically different system.
- Radical innovations introduce new concepts that depart significantly from past practices and help create products or processes based on a different set of engineering or scientific principles and often open up entirely new markets and potential applications. They provide new functional capabilities unavailable in previous versions of the product or service. More specifically related to business, radical innovation has been defined as "the commercialisation of new products and technologies that have strong impact on the market, in terms of offering wholly new benefits, and the firm, in terms of its ability to create new businesses." (O'Connor and Ayers)
- Architectural innovations serve to extend the radical-incremental classification of innovation and introduce the notion of changes in the way in which the components of a product or system are linked together.

IV. INNOVATION MANAGEMENT

Invention is an activity often identified with a single engineer or scientist working alone in a laboratory until he or she happens upon an idea that will change the world, like the light bulb. In reality, industrial invention, at least since the time of Edison, has involved many people working together in a collaborative setting to create

new technology. Innovation requires an even broader set of people, including manufacturing engineers, marketing and sales managers, investors and financial managers, and business strategists. The methods for organising this set of people to bring a new idea from the laboratory to the marketplace form the basis of the discipline of innovation management.

Innovation traditionally has been viewed as a linear process, which involves several stages in sequence: research, development, manufacturing, marketing, and ultimately, reaching the customer.

In each step, a group of employees take the idea as it is passed to them from the previous stage, modify it to accomplish a specific function, and pass it on to the next stage. Each team involved in the process has a clear function. Researchers are responsible for creating a working demonstration of the technology, developers and engineers turn it into something that can be produced, manufacturing engineers actually turn out the product, and marketers sell it to customers.

This linear model of innovation has proven to be a misconception of the process, however. For example, problems during the manufacturing process may require researchers to go back and change the technology to facilitate production. The technology may reach the marketing stage, only to turn out to be something no one wants to buy. Technology cannot be handed off between stages like a baton in a relay race. In any case, managing innovation in a sequential process would take a very long time, especially if each stage needs to perfect the technology before it can move on to the next stage. Some models simply add on to the linear stage-gate development approach, adding R&D discovery or planning phases to the front end of the process.

An alternative to the linear model of innovation was offered by the expanded, *chain-linked* model of innovation. This model captures the interactions between the different stages of innovation in a more complete fashion. Some of the important aspects of innovation highlighted by this model are:

- Technologies can move both forwards and backwards in the process, for example going back to the lab if further development is needed.
- Downstream stages (such as marketing) can be consulted for input at earlier stages (such as design and test).
- Scientific research and engineering knowledge contributes to every stage in the innovation process.
- Most firms create technology platforms, which are generic architectures that become the basis for a variety of technology-based products and services.
- The knowledge and skills needed for innovation are developed by communities of practitioners, not by individuals, and many of those communities exist outside of a particular firm (for example, in universities).
- Users of technology can be an important source of ideas for improvements or even new innovations with substantial market potential.

While the chain-linked model of innovation is more difficult to comprehend and analyse than the linear model, it is ultimately more rewarding as it tracks more closely to the way that innovations actually progress on their way from the laboratory to the marketplace.

V. INTERNAL FORCES AFFECTING INNOVATION

While users and other external organisations are important sources of ideas for innovations, the internal organisation of a company has the greatest impact on its capability for creating innovation. The ideal work environment for innovation does not exist. Instead, innovation is facilitated through the tension and balance between various conflicting but necessary forces:

- Creativity and discipline. Creative employees are needed who challenge existing assumptions and develop new and radical approaches to solving key problems. That creativity must be tempered by the discipline to capture the ideas generated by creative employees and by systematically determining which ideas can be turned into innovations, and how.
- Individuality and teamwork. Creativity is considered an individual trait, with some people being more naturally creative than others. But innovation is clearly a team effort, often involving hundreds or thousands of people. While companies should allow employees to express their individuality as a way to facilitate creative thought, that freedom must be placed in the context of the firm as a collaborative environment, where even the most brilliant individual has to work well with others for the company to succeed.
- Exploration and focus. New ideas can come from a wide variety of sources, and it is hard to predict which paths of investigation will lead to the next breakthrough technology. Still, no firm has the resources to conduct research in every conceivable field at all times. The freedom to explore new domains of knowledge needs to be balanced by corporate decisions on what areas of investigation have the greatest promise of paying off, and focusing research in those areas.
- Long-term and short-term. Radical innovations often take years to progress from concept to tangible product. For example, the digital computer invented in the 1950s had its roots in research conducted in the mid-1800s on logic and mathematics. Unfortunately, most firms cannot spend money on research that will only begin generating revenues in ten or twenty years. Most innovative activity in firms by necessity is focused on short-term improvements and technologies. Still, firms should not lose sight of long-term innovations, as those are the technologies that can undermine existing market dominance.

The Technology Perspective

	Market Pull	*Market Push*
Technology Pull	*Market Satisfying*	*Technology Satisfying*
Technology Push	*Technology Satisfying*	*Market Seeding*

During the early 2000s, companies were still seeking ways to build radical innovation competencies into their own organisation. O'Connor and Ayers reported on a three-year study of twelve large firms (such as GE, Corning, IBM, and Shell Chemicals, among others) who worked to develop this competency, and identified three key competencies that were critical to success:

- Discovery—creation, recognition, elaboration, and articulation of opportunities
- Incubation—experimentation, technical, as well as for market learning, market creation, and matching the innovation with company strategy
- Acceleration—exploiting the technology, investing to build new business and infrastructure, responding to market opportunities

Finally, O'Connor and Ayers concluded that no one model works for all companies. Of the twelve companies studies, four had very distinct but different approaches, each influenced by that company's corporate culture. But nearly all participants in the study acknowledged a need for cultural change within the organisation before radical innovation could take place.

VI. EXTERNAL FORCES AFFECTING INNOVATION

Various forces outside the direct control of the firm can also affect the innovation process. One set of forces relates to the tension between the demands of the market and the capabilities of the technology under development.

A conventional way of analysing technology development is to contrast the influence of *technology push* with that of *market pull.* The primary difference between a push or pull scenario is between solving a problem and accommodating a solution. Technology push is the process of solving a problem by providing a technical answer to a market need (which can be either anticipated or existing). Market pull involves solving a problem to provide a market answer to a technical need, or accommodating a technical solution by finding market uses. The dynamic balancing act between technology push and market pull drives the speed and acceleration of technological change, and in the process creates significant windows of market opportunity as well as competitive threats to the established technologies.

The terms push and pull can be expanded to encompass either a technology or market point of view:

- Technology push has been historically defined by an innovation-cycle-driven culture focused on marketing/technology management analysis. In this context, a firm's R&D division brings an idea from the invention stage to its fruition in commercial markets.
- The not-so-traditional technology pull is best described as the reaction to demand in the market. The desire for more efficient technologies by customers creates incremental improvements in these technologies that may eventually lead to a critical mass of innovations and possibly to radical improvements.
- On the other hand, market pull has been historically defined by marketing. The marketplace dictates the products that are to be supplied by a firm. In order to meet demand, a firm must constantly strive to increase performance and customer satisfaction.
- Market push is a term that addresses the creation of markets through marketing-driven efforts that, along with technology pull, can lead to the creation of technological standards that define and enable the emergence of new markets .

The Market Perspective

	Market Pull	*Market Push*
Technology Pull	*Reacting to Demand*	*Seeding Demand*
Technology Push	*Meeting Demand*	*Anticipating Demand*

The emphasis swings from a reactive stance, through an accommodating one, to a proactive one (from reacting to demand and satisfying markets to seeding and anticipating demand). The relative strength of each of the four forces (technology push or pull and market push or pull) varies during the lifecycle of the technology.

Technologies, as they develop, often follow a pattern known as the technology S-curve. In the first phase of development, tremendous investment in the technology yields relatively little improvement in performance, since the investment is devoted to researching various aspects of the technology, many of which do not have useful results. At some point, the technology takes off when a key breakthrough is made. At this critical moment, called an inflection point, the performance of the technology improves rapidly. During this second, or growth, phase, additional investment is focused on the technological breakthrough, with rapid results. As that breakthrough technology is more fully understood and exploited, the rate of improvement begins to slow and the technology enters its third phase, maturity. Finally, the technology reaches a point where additional research yields little new knowledge and few results. At this point, the technology begins the final stage, decline, and

often becomes obsolete as better technologies are developed and introduced to the market.

VII. CONCLUSION

There are two important steps required to properly manage corporate innovation. First is to correctly identify a project as a new product vs. a technological innovation, so a proper development process can be used (the first may be a more traditional stage-gate process; the second should be more cyclical and iterative). Second, managers need to identify what category an innovation falls under, since each type of innovation has its own challenges.

Technology and innovation management constitute a discipline of management that continues to gain importance, impact, and attention. As technology is a pervasive force in business and in society, management of technology helps to ensure that the development of new technology and its applications are aimed at useful purposes, and that the benefits of new technology outweigh the disruptions and difficulties that accompany innovation. While it is possible to specialise in technology management, this discipline also constitutes a set of skills that all managers should possess in the modern technology-intensive and technology-driven world of business.

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