MANAGEMENT OF TECHNOLOGY

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Summary

Management of technology is a set of concepts, skills, techniques and practices resulting in decision-making and implementation in relation to the development and use of technology by firms and ultimately aimed at succeeding in innovation and increasing firm's competitiveness. This article describes the co-evolution of this multidisciplinary activity and the process of technological innovation as well as its understanding through economic and management models. The first approaches to manage innovation were consequently linear, technology-push approaches focused on research and development activities within the firm. The rapid changes in the business environments and the patterns of competition have yielded new integrated approaches to what can now be called 'technology-based management of technology'.

1. Introduction: Recent Changes in Business and Technological Paradigms

Today, there is general agreement regarding the importance of technological innovation for the growth and competitiveness of firms and for the improvement of national economic performance. Indeed, for the past three decades diverse areas of research have paid special attention to two essential aspects of these phenomena. The first concerns the formulation and revision of diverse models in an effort to identify and explain the constitutive elements as well as the dynamics of technological change. The second concerns the identification and analysis of the macro- and micro-level factors influencing and conditioning the innovative performance of firms.

Thus, new proposals on the epistemology of innovation as well as economic and management studies on this phenomenon have shown that the competitiveness of organizations depends increasingly less on fundamental discoveries, and more on knowing how to combine different types of technologies with efficient manufacturing processes and high quality products. This has implied, on the one hand, the gradual, continuous improvement in aspects of function, cost and quality and, on the other, the conversion of firms into intelligent organizations.

During the last decade, many specialists have been pointing out several changes in the basic pattern of technological innovation. Mainly attributed to the emergence of high technology, various and important modifications have been occurring in the whole framework of science, technology and innovation. According to Fumio Kodama, these changes are significant enough to merit the label: 'paradigm shift'. The traditional arguments that have hitherto been common sense in the management of business and technology are thus becoming obsolete.

These changes affect those agents that make technology available, the way in which it is generated, and what it is utilized for. They impact manufacturing companies as well as their main business and in general, they affect all the economic actors involved in bringing technology into the marketplace. Naturally, research and development (R&D) activities and the technology development process are affected too, modifying innovation patterns and the diffusion of technology. In sum, this shift has impacted all the intellectual activities involved in the generation of technology and the societal processes through which it is realized.

1. A fundamental redefinition of the manufacturing company is taking place. This is perceived by the fact that R&D investments have begun to surpass capital investments in many companies; thus, it could be said that the corporation is shifting from its traditional function of being a place for production to being a place for thinking.
2. The pattern of business is changing, since the progress of technological diversification makes it hard to distinguish a firm's principal activity from its secondary business. Corporate diversification seems to be mostly the result of mergers and acquisitions, but these cannot explain all the situations. More precisely, many high technology firms have entered the stage where they survive by adapting to the environment, relying on consistent R&D activities.
3. Innovation patterns are also changing. Recent innovations in high technology fields seem to be better described as the results of the fusion of different types of technical breakthroughs rather than as single technical breakthroughs.
4. Major changes are occurring in the area of research investment decision making in industry. The pattern of competition reflects at least two important modifications. First, companies are being forced to introduce new products into the market before the learning process regarding the preceding innovations is complete. Thus, corporate investment decisions are no longer made on the conventional basis of rates of return. Instead, companies have no choice but to invest to ride the wave of innovation to avoid being left behind by its competitors. In addition new competitors can emerge now from different industrial sectors.

5. In the new technology development process, the key issue now, is not how to break through technological bottlenecks, but how to put existing technology to the best possible use. This demand articulation process, i.e. the process of search and selection among technical options, has generated a new type of pre-competitive research, one in which the goal is to create an engineering infrastructure or technological platforms as the basis of competition.
6. Finally, technology diffusion is shifting from technical change to institutional inertia; i.e. the widespread generalization of a new radical technology is possible only after a period of change and adaptation of many social institutions to the potential of the new technology.

In the following sections, the co-evolution of the notions of innovation and management of technology will be described to show the way in which theoretical approaches have attempted to explain the dynamics of the economic phenomenon of innovation. At the same time, and inspired in these approaches and in the analysis of the business environment, practitioners and academics in the field of management have devised methods and techniques to enhance the utilization of firm's resources to cope with the changes in the business dynamics.

2. Management of Technology and its Role in the Process of Innovation

During the last 40 or 50 years, the attention to technological phenomena has been constantly increasing, especially since the 1980s, due to the rapid changes in the business, political and social environment of firms. Consequently, the emerging discipline of management of technology (MoT) has received widespread attention from practitioners of management, academics and even from governments and international organizations. In general terms, management of technology comprises the set of concepts, skills, techniques and practices resulting in decision-making and implementation in relation to the development and use of technology by firms. More specifically, MoT is ultimately aimed at succeeding in innovation and increasing firm's competitiveness. Spanning the interface of science, engineering, economics and management, MoT requires a synergy of decisions and their realization at diverse levels of government, institutions and enterprises.

From the MoT perspective, it is assumed that a firm is a system composed of diverse integrated processes coordinated by a management team whose purpose is to reach certain business objectives. From this point of view, any firm must fulfill a series of minimum requirements with regards to skills and knowledge in order to satisfy an adequate cost/effectiveness relationship in its processes and maintain the standard level determined by the market and the environment in which it operates. These requirements correspond to broad functions that in turn imply the accomplishment of a series of specific activities.

Diverse management of technology approaches consider that firm's success depends on the appropriate use of certain methods in the administration of the critical or strategic activities, thus allowing the company not only to maintain itself within the cost/effectiveness standard but also to systematically surpass it. Under this perspective, the key characteristic seems to be the ability to adapt itself to its area of business, its

environment and the necessities of its clients. Thus, the general performance of a firm depends ultimately: First, on its ability to relate to the environment (extra-organizational aspects), and second, on its capacity to translate the outside stimuli into a series of technological and business strategies (intra-organizational aspects).

Within the MoT framework, management methods should thus consider the firm as a complex system, a blending of varied and complementary skills at least in the following areas:

1. Entrepreneurial and business aspects to establish the strategic planning process of the company, and the ways in which the basic supporting activities are handled and aligned in the firm.

    - Competitive strategy and planning, including all the activities concerned with the selection of the future of the firm and the way to accomplish it by means of the definition of a general framework that integrates the company's decisions.
    - Organizational management to provide an appropriate organizational structure according to the firm's specific needs.
    - Competitive technological intelligence and knowledge management activities aimed at providing early warning of external developments that represent potential threats and opportunities, and communicating this information to all the relevant actors in the corporation, e.g. new innovations, collaboration prospects, and shifts in science and technology.
    - Human resources management to establish the policies and methods for hiring, training and evaluating personnel, as well as the reward system of the company. It also includes the methods to foster creativity within the firm.

2. Technological aspects to establish the firm's technology strategy and its alignment with the firm's general competitive strategy.

    - Engineering, design and R&D including those activities associated with defining the firm's plan to develop technological resources according to its competitive goals.
    - Technology transfer and procurement policies, ranging from the transfer of knowledge within the firm and between the firm and external organizations, to acquiring the various inputs needed for production. It also includes the intellectual property strategies adopted by the company.
    - Operations and manufacturing management including all the activities concerning logistics and production, from receiving and disseminating inputs to transforming them into the final product.
    - Quality management to assess and implant the methods and systems needed to guarantee the final product characteristics and specifications.

3. Marketing aspects to establish the competitive strategy of the firm, involving those activities associated with benchmarking and monitoring competitors. The evaluation of products' performance and the establishment of customers' relationships are included too.

4. Financial aspects, including the management of financial resources and the investment policies of the firm. These activities concern the definition and achievement of financial goals within the firm's general competitive strategy.

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Biographical Sketch

Roberto Lopez-Martinez is currently researcher at the Institute of Engineering of the National University of Mexico and visiting lecturer of science and technology policy at the Metropolitan University of Mexico City. He is an Industrial Designer from the Universidad Iberoamericana and obtained an M.Sc. on Technical Change and Industrial Strategy at the University of Manchester. From 1979 to 1985 he founded and directed a multidisciplinary master degree program of Product Development at the Metropolitan University. He has been Vice-Principal of the Centre for Technological Innovation and Executive Liaison Officer of the Institute of Engineering, both at the National University of Mexico. He has published several articles and contributions for books on management of technology and science and technology policy. He has carried out diverse consulting activities for universities, as well as public and private organizations in Mexico and Latin America.