

MANAGEMENT OF TECHNOLOGY IN THE PROCESS OF BUILDING COMPETITIVE ADVANTAGE OF THE FIRM

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1. Introduction

Technologies and advanced technologies in particular are becoming more important factors that shape competitiveness, effectiveness and efficiency of private and public enterprises, government institutions and economy in general. Successful development and implementation of advanced technologies require careful consideration not only to scientific and engineering advances and resulting capabilities, but also to human resources, raw materials, financial feasibility, and a competitive environment. Appropriate consideration of each of these factors requires conscious choices and actions. Achieving an appropriate balance among these factors is an increasingly important problem for modern managers, it is a issue of technology management that address this issue. The common understanding is that there is a substantial room for improvement for the techniques and expertise in the field of technology management, that are being utilised by business units and public institutions.

Competences in the field of technology do not come by itself, nor can it be simply bought as goods out of the stock, acquired through a new business, or a prominent scientist or a skilled engineer. This unique knowhow and expertise is acquired through tedious process of information gathering that takes place over time, accompanied by successes as well as mistakes and wandering in blind alleys. And knowledge acquired with such difficulty must be collected and systematized so that it can also be used by other employees in the enterprise – in the form of procedures, patents, databases, etc. (Pavitt, 1991).

The concept of technology management, by all means, should not be limited to research and development activities regardless the level of economy (public or private), it embraces the coherent set of activities starting from understanding the technological challenge and ending with appropriate implementation of the particular technology.

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The main purpose of this paper, alongside bringing up the issue of technology management, is to identify various aspects of the technology management process and identification of the drivers for the increasing importance of technology management in the modern world associated with the development of technologies and elements of artificial intelligence.

2. Management of technology, definition and identification of key elements

The term management of technology comprises the process of technology development, implementation, and diffusion in various types of organisations. 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 organization” (National Research Council, 1987). The crucial element of successful MOT is related to the optimum decisions making and their implementation in various types of public and private institutions. Technology management process is vitally important to firm competitiveness. MOT process in order to be most effective and efficient ought to complement the overall strategic framework adopted by the firm. The strategic management of technology aims to create competitive advantage by merging technological opportunities with the general business strategy. Management of technology is also defined as 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.

The proper understanding of technology management function requires adequate distinction between MOT and research and development function of the firm and management of R&D in particular. Management of research and development activities is, in the first place, concerned with organization of company’s research facilities and with the process of new technology creation. Management of technology is more related to the connection of technology and business, it embraces technology creation together with technology acquisition, application and the overall impact of the new technology on the firm. Michael Bigwood suggests that New Technology Exploitation (NTE), conceptually rather close to MOT paradigm, is located somewhere between R&D and New Product Development, with emphasis on the cyclical learning process of scientific discovery and the more defined and linear process of product development (Bigwood, 2004).

It is recognized that further to the constitution of technology management concept, a new profession, known as the technology manager, emerged. A person who combines unique skills in technology and management, technology manager is well familiar with company strategy and how technology should be used to achieved company goals.

2.1. The phases of technology management process

The technology management process consists of several successive phases. The relatively comprehensive concept of management of technology comprises several mutually interconnected set of activities, that include (UNIDO&ICS, 2002):

- Sensing and understanding signals to change. The essence of this stage is about understanding the upcoming changes in the marketplace and technological challenges that are taking place in the environment. The key element of this stage include: the necessity of innovation, understanding the change, problems related to technology, building and utilising appropriate set of tools
- Development of technology strategy. That focuses on how to develop the appropriate technology strategy thought proper strategic analysis and strategic choices and planning in relation to technology. The key elements of technology strategy include analysis and understanding of signals and potential threats and opportunities related to the technological change, the knowledge and expertise on how to choose between deferent potentially available options, how to plan, acquire and implement selected technologies.
- Acquisition of technology. This stage tackles and emphasises the identification and assessment of deferent routes of technology acquisition in association with is need for the implementation of technology strategy. The important element of technology acquisition is related to identification of benefits and potential traps and problems related to deferent technological options. The key elements include identification and selection of appropriate option of technology acquisition (internal, external and mixed) in conjunction with proper understanding of company potential, its development plans, key cost and profit issues. On top of this risk factors are also important at this stage.
- Implementation of technology. This module stresses the difference between technology acquisition and implementation. Technology acquisition is related to formal transfer of ownership rights whereas its implementation is concerned with proper utilisation and profits (benefits) generation on the basis of the given technology. The key elements of this module include: design and concept of technology implementation, identification

of problems and obstacles related to implementation process, proper utilisation and management of work force and team work, parallel implementation, management of change and project launching. The technology implementation is, in contrast to previous phases, relatively less theoretical and more practically oriented on the technology initiation process.

- Learning how to improve management of technology is mainly devoted to a review of the ways of acquiring knowledge about the technology management process. Learning how to enrich knowledge and capacity in this area is twofold: (1) increasing and improving technological potential, (2) developing more effective management of the process of technological change. This module concentrates on three main learning topics: (1) general learning process and the need to shape and develop a comprehensive learning cycle, (2) specific tools and techniques to facilitate learning based on technology management projects, (3) mechanisms enabling the realization of the project.

Successful implementation of technology management process within a company requires careful appreciation and understanding of managerial and technological function from the point of view of firm's main strategic objectives. Process and product innovations comprehended within the MOT function of a company should result with its increased competitiveness in the market place.

The term management of technology is closely related to two concepts, that is the issue of management and technology. The understanding and definition of the term technology varies from more science oriented, to more intangible and socially oriented aspects. Technology is often interpreted as the purposeful application of information in the design, production, and utilization of goods and services, and in the organization of human activities. Technology might also be defined as „a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome”. Technology embraces tangible products, such as the computer, and knowledge about processes and methods, such as the technology of mass production (Rogers, 1995). According to another definition that was put forward by J. Paap, technology as „the use of science-based knowledge to meet a need”, M.P. Bigwood proposes the definition of technology as „a bridge between science and new products" (M.P. Bigwood 2004). 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.

The basic understanding of the term management is the organization and coordination of the activities of a business in order to achieve defined objectives.

In the more sophisticated way management is defined as “a vulnerable force, under pressure to achieve results and endowed with the triple power of constraint, imitation and imagination, operating on subjective, interpersonal, institutional and environmental levels” (Deslandes, 2014).

The term technology is often closely related to the issue of competition and competitiveness. Michael Porter is one of business analysts who argues that technology is one of the most significant factors influencing business competition and competitiveness. M. Porter argues that technology has the potential to change the structure of existing industries and to create new industries. Technology often changes the rules of game, questioning the competitive advantages of market leaders and enabling new companies to take leadership away from existing firms (Porter, 1985).

The growing importance and changing notion of technology is closely related to growing pace of technological change. The changing paradigm in the field of technology is often referred to as industrial revolution. Technological revolution might be defined as a „dramatic change brought about relatively quickly by the introduction of some new technology” (Bostrom, 2007). It is an era of an accelerated technological progress characterized not only by new innovations but also their application and diffusion. In the process of social and economic development humanity have experienced four industrial revolutions so far.

First Industrial Revolution was mainly about changing mostly agrarian, rural societies became industrial and urban. It took place between 18th and 19th century mainly in Europe and North America. The most critical technologies that played its role during the first industrial include the development of steam engine, mechanical production of equipment, textile industry.

Second Industrial Revolution, also referred to as the technological revolution, started 1870 and lasted until the beginning if the World War the Ist (1914). It was concerned with the process of rapid industrialisation, the establishment of machine tool industry and the development of methods for manufacturing interchangeable parts. Tan acknowledgment of important element of the second industrial revolution is the Bessemer process, the first inexpensive industrial process for the mass-production of steel. Development of new production technologies streamlined the adoption of already existing innovations, including electricity and electric lighting, telegraph and railroad networks, gas and water supply, and sewage systems.

Third Industrial Revolution also known as digital revolution started in the early 1980's and continues today. The key technologies related to the third industrial revolution include wide spread application of digital systems and interest in renewable energy. The digitisation of manufacturing transformed the way goods are made. The digital revolution affect not only how things are made,

but also where. As the effect of digital revolution factories are being moved to low-wage countries to lower labour costs.

Fourth Industrial Revolution is strongly related to cyber-physical systems. The Fourth Industrial Revolution builds on the digital revolution, representing new ways in which technology becomes embedded within societies and even the human body. The Fourth Industrial Revolution is defined by emerging technology breakthroughs in a number of fields, including robotics, artificial intelligence, nanotechnology, biotechnology, the internet of things, 3D printing and autonomous vehicles. „The fourth industrial revolution is about bringing together digital, physical and biological systems. The unique future of fourth industrial revolution is that it doesn't change what and how individuals are doing things but it actually changes these individuals, that means us. Within the concept of fourth industrial revolution the importance of economic growth per se is going to be less important than the improvement of the quality of life of individuals” (Schwab, 2016).

3. Technology, innovation and competitiveness

Innovations should be considered broadly as improved products, processes and business or organizational models. Technology and innovation development strategists should not only focus on R&D and the creation of new knowledge, but also take under consideration the specific details of acquisition, adaptation, dissemination, and use of technology in diversified local environments. Innovation in relation to the less developed countries is not so much a matter of shifting to the right the production frontier of available knowledge base, but more the challenge of facilitating the first commercial use of new technology in the domestic context. Therefore, in many cases, it is more related to small incremental changes in the field of manufactured products or utilised processes, that the case of radical innovations that to the large extent change the techno-economic paradigm.

In the past, issue of competitiveness used to be based on other premises, it was mainly relayed to greater extent to static comparative advantage. The elements of which included relative and rather stable manufacturing cost factors and specific technological advantage. The changing notion of competitiveness is to gradually greater extent related to continuous improvement, including continuous improvement in the field of technology and innovation, continuous learning and development of skills, efficient communication and transport infrastructure and environment supporting business activities. The key elements of the changing competitiveness paradigm include (Dahlman, 2007):

Innovation is becoming a crucial element of company competitiveness. Dynamic development and proliferation of knowledge sets a constant innovation challenge. Not all business units have to be radical innovators and be involved in

the process of shifting technological frontier forward, only the limited number of firms represent that kind of technological and innovative excellence. Firms in general, in order to stay in the market, have to be efficient adopters and imitators and be capable of using, upgrading existing and improving new technologies. Firm's innovative activity manifests itself not only in the field of new product and process development but also in the development and implementation of new organisation and management technique and improved business models.

Technology, Globalization and International Competitiveness requires companies to increase their efforts to follow new technologies and new professional knowledge related to organisation and management. In order to keep up with these challenges companies ought to invest in search and adoption of related new advanced knowledge. This challenge is of special importance for dedicated innovators that are operating in close proximity to the technological frontier and those business units that are trying to push this frontier forward.

Education and skills as fundamental enablers. Technological progress requires constantly more educated work force. New skills and capabilities of the work force to growing extent define the level international competitiveness and help to attract foreign direct investment. In international terms one can notice significant increase in average level of obtained education, educational attainment and increased number of persons representing higher level of education. Since multinational corporations make their investment to significant extent on the basis the level of education of the work force, education has become important element determining the level of foreign investment and the general development of the local economy.

Logistics, transportation and distribution becoming more important. Intensifying globalisation processes combined with the accelerating technical change result with the need to quickly and efficiently shift goods often from over long distances. This results with growing importance of IT coordinated logistics and transport infrastructure. The growing importance of, broadly speaking, distribution infrastructure put less developed countries in relatively weaker competitive position in globalised economy. Establishment of direct links with key global markets is vitally important for keeping under control transportation and inventory costs of goods in transit.

Efficient IT becoming new critical infrastructure for contemporary market challenges. Information and communication technologies enable flexible business communication and coordination of often globally integrated supply chains and production networks. ICT facilitates and speeds up internal (i.e. inter-department) and external (i.e. buyer-seller) relations. The real time communication between consumer and manufacturer, the new important element of contemporary

global economy, vastly improves competitiveness and marketing function of the firm via enabling quicker response to changing market needs.

As far as the implications for the less developed countries are concerned, one can identify various implications of changing competitiveness paradigm in relation to innovation. At the national level the modern and low cost communication systems, as well appropriate training ought to be provided. The fast development of ICT systems and e-business requires implementation of adequate legal and regulatory framework, including e-signature and safe digital communication and payment systems. At the firm's level, adequate investments in training, hardware and restructuring business processes are also necessary in order to take advantage of these new ICT and e-business technologies. So called enabling environment is a critical issue, it consists of the government regulations and institutions that support and facilitate the operation of business and the economy (Dahlman, 2007).

4. Conclusion

In the contemporary world we are facing the problem of growing importance and dependence on various forms of technology (technology is gradually becoming more and more comprehensively integrated with humans) and constantly more complicated patterns and factors that determine competitiveness related to technological change. Management of technology is important and relatively new function of the company. MOT in essence is about increasing firm's competitiveness as the result of efficient innovation. Successful MOT depends on proper utilisation of knowledge, expertise and beneficial synergy in the field of science, engineering, economics and management. The growing importance of the management of technologies in the contemporary world depends, among others, on the following main elements, the growing pace of technological progress, the changing notion of competitiveness and unique characteristics related to the, already started, fourth industrial revolution. Technology is becoming not only more advanced and complicated and sometimes hard to comprehend (i.e. artificial intelligence), but as the result of the fourth industrial revolution, technology is becoming more integrated with society and even with individuals. Contemporary management of technology should take under consideration the increasing pace of technological change and the changing notion of competitiveness represented mainly by transition from static to dynamic competitiveness. Management of technology in relation to transition and less developed economies should reflect the specific factors determining innovation and technological in relation to this type of economies.

It seems to be inevitable, that gradually more advanced technologies and more sophisticated technology oriented environment will become part of our daily

routine, therefore the proper understanding and implementation of technology management is becoming gradually more important, both from the point of view of private and professional perspective.

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