Technology, Wealth and Modern Management of Technology

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In the paper, we propose somewhat different conceptualizations of technology, of a fundamental relationship between technology and wealth in a society, of technological capability, and of management of technology. We based our proposed conceptualizations on the current general and relevant technological practice. In order to infer these conceptualizations, we studied today's largest companies worldwide in different production and technology sectors as well as some general reporting on technology from technology-oriented media. These fundamental conceptualizations may be of interest to all those who are practically or theoretically concerned with technology, wealth, technological capability and management of technology, and who want to comprehend the essence of technology and its relations to phenomena, such as wealth and management ('to get the big picture'). At the end, we explain why there is a need in modern companies to manage technologies and what a new paradigm of management of technology is, i. e. what new challenges and trends a modern management of technology has to face.

Key Words: technology, wealth, technological capability, management of technology, technology trends
JEL *Classification:* I31, J30, M10, O3

Introduction

The paper is about the fundamental relationship between technology, wealth, technological capability and management.

Technology is a phenomenon that most people intuitively regard as rather important for their lives and purposes. 'Technology has a profound impact on our lives. On the one hand it is the source of many benefits and most of our wealth. On the other it is disturbingly disruptive. To harness it effectively calls for pervasive understanding, managerial skill

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and good luck' (Van Wyk 2004, 10). Yet despite this, it seems that people generally do not have a clear idea (concept) of what technology really is and how it is connected to our lives and purposes. Van Wyk points out that there is a growing need in our society for a better understanding of technology: 'We need a simple, comprehensive grasp of technology. We need to understand at the macro level how technology is composed, how it evolves and how it interacts with other systems' (p. 6). Despite the deciding impacts of technology on our lives, 'our understanding of technology is poorly structured. Technological knowledge has not undergone that profound simplification that marks the development of most fields of knowledge as they grow to maturity' (p. 10). From a scientific point of view, it is therefore our first task, quite strangely, to convincingly determine and explain what technology is, before we can actually go any further in analyzing and understanding technology in its connection to other related phenomena, such as wealth and management. If we consider some of the most relevant and acknowledged literature on technology and management of technology, we find that relevant and acknowledged authors (e. g. Burgelman et al., 1998; Khalil, 2000; Van Wyk, 2004; Zeleny 1986) define technology somewhat differently and that there is no generally accepted definition of technology among these authors (also in general, there are numerous and quite diverse definitions and conceptions of technology). In the past few years, a few scholars have searched for a fundamental theoretical structure that underpins all technology – and there is a growing need for this structure. 'This search could possibly yield one of the most significant conceptual foundations for the 21st century. Such a fundamental structure would materially improve our understanding of technology, enhance our ability to manage it better, and increase our effectiveness in formulating public policy in this area' (Van Wyk 2004, 13).

In the practice of technology management, there is also evidence of the need for better theoretical structure. 'Most corporate managers will admit to being blindsided by new technology. Rare indeed is the chief executive officer who systematically maps the global technological landscape and who knows where to expect definitive developments [...] In the world of investments, monies flow in and out of technology-based companies more on the basis of fashion than on the basis of rational technology analysis' (Van Wyk 2004, 14).

According to the International Association for the Management of Technology (IAMOT), technology is a large and growing part of every

manager's daily experience – managers develop technology, use technology, buy technology and sell technology. Fusfeld (1978) pointed out that in general, key management decision makers have inadequate background and ability to make judgments and forecasts in the area of technology. And without that ability, their options in utilizing technology in corporate strategy are severely limited. Many executives, venture capitalists, and entrepreneurs know of corporate success in which technology had played a dominant role. Many dream of technology being turned into a profit and these dreams are motivated by real-life successes. Fusfeld stresses that, despite the obvious role of technology in very successful enterprises, technological issues are only occasionally explicitly included in typical corporate strategy reviews, and only rarely are they among the regular inputs to corporate planning and development. Technology is addressed in strategic plans only implicitly, except in the case of special endeavors which are outside the main lines of production – new and joint business ventures, licensing, and acquisitions. Tesar et al. (2003, 5–10) stress that managers have to understand the technological side of the business just as well as the marketing side and they need to properly coordinate technical and marketing competencies in firms. Burgelman et al. (1998, 1) pointed out that 'strategic management of technology and innovation is a young field and the domains of different, partly overlapping concepts are still somewhat in flux.'

The main purpose of the paper is thus to provide a general understanding of what technology is (and how it is connected to wealth in a society), what is a technological capability, what is management of technology and what are the main challenges of the modern practice of managing technologies. In each of these fundamental elements, we first present what relevant authors have said about these elements, and then we propose, based on our research and analysis of the current general and relevant technological practice, our own conceptualizations of these elements. These fundamental conceptualizations may be of interest to all those who are practically or theoretically concerned with technology, wealth, technological capability and management of technology.

How to Conceptualize Technology

Our review of literature on the theory of technology and management of technology shows (as is generally the case in modern social sciences) that there is no single definite, clear, convincing and generally accepted definition or conception of what technology actually is. Leading academic

authors in management of technology propose the following conceptualizations of technology.

Khalil (2000, 1–2), for example, says that 'technology can be defined as all the knowledge, products, processes, tools, methods, and systems employed in the creation of goods or in providing services [...] it is common to think of technology in terms of hardware, such as machines, computers, or highly advanced electronic gadgets. However, technology embraces a lot more than just machines. There are several technological entities besides hardware, including software and human skills.' Zeleny (in Khalil 2000, 2) proposed a conception that any technology consists of three interdependent, codetermining, and equally important components:

- *Hardware:* The physical structure and logical layout of the equipment or machinery that is to be used to carry out the required tasks.
- *Software:* The knowledge of how to use the hardware in order to carry out the required tasks.
- *Brainware:* The reasons for using the technology in a particular way. This may also be referred to as the know-why.

Khalil also stresses that in addition to the above three components, a fourth one must be considered independently, for it encompasses all levels of technological achievements, and that is know-how: 'The learned or acquired knowledge of or technical skill regarding how to do things well. Know how may be a result of experience, transfer of knowledge, or hands-on practice. People acquire technical know-how by education or training or by working closely with an expert in a certain field.' Khalil concludes that it is 'only when knowledge is practically implemented to create new things, operate a system, or provide a service that we enter the realm of technology.'

Van Wyk (2004, 23), for example, suggests that 'technology is competence, created by people, and expressed in devices, procedures and human skills [...] devices, procedures and human skills reflect the three constituent elements that combine to form a unit of technology – a technology entity.' Van Wyk links technology to developed capability, i. e. ways and means for taking action. However, technology is not concerned with the ultimate ends of the action. Van Wyk emphasizes the artificial nature of technology; technology is man-made, meaning that it does not occur spontaneously in nature.

Burgelman et al. (1998, 2), on the other hand, say that 'technology

refers to the theoretical and practical knowledge, skills, and artifacts that can be used to develop products and services as well as their production and delivery systems. Technology can be embodied in people, materials, cognitive and physical processes, plant, equipment, and tools.'

A Proposed New Conceptualization of Technology

If we study the above cited definitions and conceptions of technology, we can conclude that these definitions and conceptions are basically different from one another, yet they have certain similarities and common themes (knowledge, skills, artifacts, processes, methods). Since these definitions and conceptions are a result of theoretical work, the most important theoretical question in this respect is whether these conceptions adequately and correctly conceptualize current technological practice, i. e. our current practical experience with technology. In order to answer this question properly, it is necessary to study where (in which organizations/institutions) the term technology is most commonly used, where technology is regarded as very important or even decisive for achieving purposes of organizations, and how the term technology is used (what do people mean when they speak of technology) in these organizations.

Our experience with technology shows that it is in companies that produce commodities where the term technology is most commonly used, where it is regarded as very important or even decisive for achieving purposes of these companies. Our experience with technology also shows that technology is being invented, developed and used predominantly (but not exclusively) in companies that produce commodities. It is therefore necessary to be acquainted with how the term technology is being used in these companies, and what is meant by technology when this term is used by these companies.

For the purpose of becoming acquainted with how the term technology is being used in modern companies, we used companies' annual reports and technology related documents available on companies' web pages. In the first round, we studied some of the largest companies in the following technologically most advanced manufacturing sectors: energy, nanotechnology, biotechnology, information technology, electronics, robotics and aerospace. Our study shows that in these companies, technology refers to:

- methods, techniques, procedures, processes, activities of production (see for example ExxonMobil 2009, 2008; iRobot 2009; Nanophase 2010; AMGEN 2010),

- machines and devices by means of which processes of production are carried out (see for example ExxonMobil 2009, 2008; AMGEN 2010),
- devices (systems) and their processes that are included as components in final products (see for example iRobot 2009; Boeing 2009; Microsoft 2009; Sony 2010).

Examples of methods of production are cogeneration, directional drilling (ExxonMobil 2009), molecular fingerprinting (ExxonMobil 2008), surface treatment and coating processes, physical vapor synthesis, nanoarc synthesis (Nanophase 2010), genetic engineering utilizing restriction enzymes, polymerase chain reaction, cell culture, gel electrophoresis, protein electrophoresis, mass spectrometry, DNA sequencing and computerized imaging, X-ray crystallography (AMGEN 2010).

Examples of machines and devices by means of which processes of production are carried out are: land-based drilling rig, microscope (ExxonMobil 2009), thermocycler, DNA microarrays (AMGEN 2010), middleware platforms (Microsoft 2009).

Examples of devices (systems) and their processes that are included as components in final products are: lithium-ion battery separator film (ExxonMobil 2008), code bases, modules, signal processing, laser scanners, cameras, optical sensors, payloads, interfaces, controllers, platforms, manipulators, algorithms (iRobot 2009), remote vision systems, refueling pods, hose drum units, digital cockpits (Boeing 2009), cloud computing ecosystems, natural user interfaces, file formats, programming interfaces, protocols, automated reasoning, adaptation, human-computer interaction (Microsoft 2009), lenses, close-proximity wireless transfer, image processing engine (Sony 2010).

In the second round, we then studied:

- world largest companies in 2010 (Fortune 2010b),
- world largest financial companies in 2010 (Fortune 2010b), and
- US largest service companies in 2010 (Fortune 2010a),
- general public reporting on technology and its development (Technology Review (2011) and New Scientist – Technology).

Our study shows that in these companies and in this general public reporting, technology refers to:

- machines and devices that are used in manufacturing (processing), storing and delivering of material products, energy and information,

- processes (with the use of machinery and devices) of manufacturing (processing), storing and delivering material products, energy and information,
- devices and their processes that are included as components in final products,
- advanced functional materials,
- most generally, devices that people and organizations use in their activities.

This is our proposed conceptualization of technology that is derived from our study of current general and relevant technological practice, and not from past uses of the term 'technology' (etymological conceptualization) or from a recombination of numerous diverse definitions and conceptualizations of technology at present.

Our conceptualization of technology is similar to the above cited definitions and conceptualizations of technology by different academic authors. What is most specific in our conceptualization is the third element of technology: devices (systems) and their processes that are included as components in final products. This element is not explicitly present in the above cited conceptualizations; however, it might be implicitly included.

All the above cited conceptualizations by different academic authors stress knowledge and skills as necessary elements of technology. Our study of both the world's largest as well as the technologically most advanced companies shows that these companies do not immediately refer to technology as knowledge or skills, but they rather speak of technological or technical expertise, technical knowledge, technical skills when they refer to knowledge and skills. Also, when companies explain how their technologies work, they provide knowledge on these technologies. However, machines, devices and processes of production (manufacturing, storage and delivery) would not function as such if the knowledge and skills to use them rationally, purposefully, effectively, productively were lacking. Knowledge and skills are fundamental to consistently use machines, devices and processes of production rationally and effectively. Knowledge and skills to rationally and effectively use technology are a necessary presupposition of technology. Without knowledge and skills, machines, devices and processes of production would be just some unknown, unuseful, arbitrary and coincidental processes and pieces of material.

According to our conceptualization, technology does not refer to tools or accessories as such, but only to one part of tools or accessories – i. e. machines and devices. Machines and devices not only enable and make our work easier (like tools in general), but they perform some work (execute functions) themselves (thus replacing or complementing human labor), and this distinguishes them from tools or accessories that do not perform any work by themselves (e. g. a simple knife, a pencil, a hammer). Technology also does not equal equipment for production as such, because technology is only one part of this equipment – again machines, devices and their processes, and not buildings or furniture.

According to our conceptualization, technology also does not refer to processes or procedures of activity or work as such, but only to processes of one part of our activity or work – i. e. manufacturing (processing), storing and delivering material products, energy and information, whereby machines and devices are being used.

Technology and Wealth in a Society

Khalil (2000, xix) states that technology has always been intertwined with society's progress and it has been linked to improvements in standards of living: 'The human aspiration for a better life increasingly depends upon technology and its effects on all aspects of life' (Khalil 2000, xix). Today's pace and scope of technological change are having profound effects on every human institution. Technology has enabled humans to achieve unprecedented change in their way of life.

We propose to say that a *principal* relationship between technology and wealth is that by inventing, developing technologies, by using them and by advancing, improving them, we can:

- produce existing goods more efficiently,
- produce more goods,
- produce better goods,
- produce new goods,
- save labor (though development, maintenance and advancement of technology requires labor) and increase leisure/spare time,
- make labor easier,
- improve goods,
- make activities easier,
- enable new activities.

This is the *essential possibility* of technology in relation to wealth. We *can* do all of the above with technology. Development, use and advancement of technology/-ies *can* mean our greater dominance and power over nature; it *can* mean our greater dominance and control of our material life conditions. Technological advancement *can* be decisive for the better quality of our lives. Technology *can* empower people.

However, whether this *essential possibility* of technology is realized and to what extent it is realized, depends on the availability of material resources, people's will and their ingenuity, skills and capabilities to develop, use and advance technology. Also, if technology is developed, used and advanced in a particular society, then whether this *essential possibility* of technology is realized and to what extent it is realized depends on the principles of the socio-economic order in that society in which technology is developed, used and advanced.

For example, in capitalism (the present predominating global socio-economic order), technology is being constantly invented and existing technology constantly advanced.[1] In capitalism, by inventing, developing, designing technologies, by using them and by advancing, improving them, existing commodities are produced more efficiently, more commodities are produced, better commodities are produced (though not all commodities tend to be better, because there are necessarily different levels of purchasing power – those with the highest purchasing power tend to get the best quality commodities), new commodities are produced, commodities are improved (by including technology as a component in final products), activities are made easier and new activities are enabled.

However, in capitalism, the essential possibility of technology in saving labor and increasing leisure/spare time or in making labor easier is not realized. In capitalism, technology is not invented, used and advanced in order to save labor as such and to increase leisure/spare time as such, but to save paid labor and thereby to decrease labor costs. A necessary consequence of constant technological invention and advancement in capitalism is increasing unemployment (saving paid labor in producing commodities, less and less workers are needed to produce the same amount of commodities) and employing new workers at the same time, because new technologies create new production processes (and new markets) where new workers are needed (technological change is the chief source of new profitable areas). In capitalism, these two opposite tendencies in the technology-labor relation are in force all the time, not just in times of (increasing) profits, but also in times of crises.

Also, in capitalism, essential possibilities of technology and therefore its contribution to wealth are only in part realized. Rubinstein (1931) explained this in the following manner:

> Capitalism, in developing machine production, pursues the purpose not of developing the means of production, but of increasing the profits. Therefore, capitalism introduces a new machine only when the difference between the price of this machine and the cost of labor that it replaces is sufficiently large to secure an average profit and successful competition in the market. Already at the commencement of capitalist development we find a number of cases when inventions or improvements in machinery were either entirely held in abeyance or they were utilized not in the country where they were originated, because labor in that country happened to be so cheap that the adoption of the machine was unprofitable and undesirable to the capitalists [...] Unemployment, under capitalism, is the inevitable consequence of technical progress, and in its turn, it checks the further development of technical progress, the introduction of new machines, and the application of new scientific methods in industrial practice [...] These tendencies to check and obstruct technical, and consequently also scientific development, become particularly pronounced in the final monopoly stage of capitalism [...] Under capitalism, the adoption of technical achievements is always considerably below the extent possible under a given level of scientific and technical development [...] real application of technical discoveries lags far behind the already possible development of the forces of production [...] To begin with, these tendencies of monopoly capitalism, by hindering the growth of the forces of production, clip the wings of scientific creative activity, technical initiative, and inventiveness. A huge portion of scientific work, the labour of many years, is practically wasted finding no application in industry, in life, in reality. [...] Already the present state of science and technique secures such a gigantic growth of the forces of production as modern capitalism is unable to realize.

The German scientific group GegenStandpunkt (1983) also explained that technology in capitalism is not developed and used in production of commodities in order to make labor easier, but in order to make production more cost-effective for entrepreneurs. By using new technologies (machines and devices) and thus by new divisions of labor, the same

commodities can be produced cheaper, as long as additional expenditures for 'technical progress' are compensated by saved wages. By means of rationalization of his company, a capitalist increases the productivity of labor and at the same time takes care for dismissing or not employing a part of the workers.

In capitalism, substitution of labor through technology thus has the advantage of increasing productivity of labor. But this substitution also has disadvantages. By means of introducing machines and automatization into the labor process, a man becomes more and more dependent on technical apparatus. This dependence then manifests itself in substantial shifts in the cost-structure of a company; by means of substituting labor through technology, a share of proportional costs (wages) inside the company's total costs decreases, while fixed costs of growing installations substantially increase. Thereby, a company becomes more inflexible – the lower price-limit is very high due to increased and high fixed costs. A company can therefore get into troubles if its sales decrease (even in a slight manner) for a longer period of time – in that case, a company cannot cover its fixed costs any more.

To sum up, how and to what extent a technology contributes to wealth in a society depends on the principles of the socio-economic order in that society, in which technology is developed, used and advanced. These socio-economic principles determine the contribution of technology to wealth in each particular society. And since each socio-economic order is governed by different socio-economic laws, technology then differently and to a different extent contributes to wealth in each particular (past, present, or any possible future) socio-economic order.

Technological Capability

In 1987, the National Research council stated the following: 'Management of technology links 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, 9). Technological capability is one of the central elements in the practice of technology management. Theory in management of technology should therefore pay sufficient attention to this phenomenon and provide some satisfying results. Based upon convincing conceptualization of technology, the most important concept in management of technology has to be developed, i. e. technological capability.

In the literature on management of technology, the concept of technological capability is often used in different contexts. However, as with the case of general conceptualization of technology, the concept of technological capability also lacks one definite, clear, convincing and generally accepted conceptualization. Zedtwitz and Jin (2004) point out that the definition of technological capability is varied in perspective, depending on the aims of the researchers. Lall, for example, defined technological capability broadly as 'the entire complex of human skills (entrepreneurial, managerial and technical) needed to set up and operate industries efficiently over time' (Lall in Zedtwitz and Jin 2004, 2). He defined technological capability in the narrow sense as the capability to execute all the technical functions entailed in operating, improving and modernizing the firm's productive facilities. It is categorized to the investment TC, the production TC, and linkages TC according to the functions (Lall in Zedtwitz and Jin 2004, 2). Kim pointed out that in the developing countries 'technological capability' could be used interchangeably with 'absorptive capacity' (Kim in Zedtwitz and Jin 2004, 2): absorbing existing knowledge, assimilating it, and in turn generating new knowledge. Zedtwitz and Jin (2004, 2–3) themselves define technological capability as the capability to make effective use of the technical knowledge and skills, not only in the effort to improve and develop the products and processes, but also to improve the existing technology and to generate new knowledge and skills, in response to the competitive business environment.

Our Proposed Conceptualization of Technological Capability

Based upon our conceptualization of technology (see above), we propose the following conceptualization of technological capability: technological capability refers to our capability (capacity) to use technologies (as well as knowledge and skills necessary for their proper use) in a way that contributes to effective and successful achievement of our purposes.

Technology can be either a purpose itself or some of our means by which we achieve some other purposes, or both. Our experience with technological practice shows that usually, technology is not a purpose by itself, but is invented, developed, used and advanced in order to achieve some other purposes (e. g. making work easier, increasing productivity, producing or consuming new products, improving services). And only in this respect (using technology as a means to achieve some purpose), does it make sense to speak of our technological capability, i. e. our compe-

tence/capacity to purposefully use technology. However, if we were not to use technology to achieve some purpose, then it would not make much sense to speak of our technological capability in this respect, but rather of how successful we are at achieving this purpose by using some other means (non-technological).

Technological capability is not the same as technology or as knowledge and skills of how to use a technology in order to produce a desired product. Technological capability is our competence/capacity to *purposefully* use technology and the necessary knowledge and skills.

Technological capability refers both to individuals and organizations/institutions – an individual as well as an organization/institution can have a technological capability. According to the National Research Council (1987), it is the technological capability of organizations that is relevant to management of technology. In the following, we will thus focus on the technological capability of organizations.

The technological capability of an organization refers to managing technologies (and technological knowledge and skills) in a way that guarantees effective and successful achievement of the purposes of an organization, where technology plays an important role. And since our experience with technology shows that technology is being invented, developed, used and advanced predominantly (but not exclusively) in companies, technological capability usually (but not exclusively) refers to successful management of technologies in companies. The technological capability of companies refers to the competence/capacity of companies to use technologies (as well as the knowledge and skills necessary for their proper use) in a way that consequentially guarantees value maximization and profits for investors. Janeš and Dolinšek (2007, 1411) stated that 'the technological capability of the company is the ability to effectively and successfully exploit the management of technology knowledge.' And since management of technology is a rather broad managerial practice (it covers many activities, functions and tasks in a modern corporation), then technological capability must also be a rather broad concept. Technological capability is much more than technology itself or technical knowledge on how to use certain machines, devices and processes to produce a desired product. According to our conceptualization, technological capability does not refer to machines or devices, in the sense that these would have technological capabilities (machines and devices have functions and different levels of performance), but it refers to organizations, especially to companies (and also to states) in the present economy.

They have and they develop technological capabilities. The technological capability of an organization is thus a managerial and organizational category – and not a mathematical, physical, biological, psychological or any other category.

In the following, we present a particular theoretical case, where technological capability is conceptualized in a much more narrowed, technical sense than ours. Gallon et al. (1995), namely, explain technological capabilities as 'technical capabilities providing direct support to the (creation of) product or service portfolio with unique value to customers.' These capabilities are then divided into:

- applied science capabilities (fundamental know-how derived from basic research),
- design and development capabilities (disciplines employed in converting a product idea into an operational reality),
- manufacturing capabilities (capabilities employed in, or directly supporting, established manufacturing or operations).

Gallon et al. (1995) stress that 'in modern organizations, the large majority of the capabilities that are critical to organizations are either technological or market interface capabilities. Most core competencies rely on technological and market interface capabilities. Technical competencies are especially important because they are more frequently able to cross market boundaries and can provide the basis for significant product superiority. In most organizations, only few areas of technical expertise have the right attributes to be worthy of the term core technical competency and even fewer have been developed by these companies to the level of excellence that is necessary to give them broad strategic value.'

Managing Technology

According to Khalil (2000, 51), technology is very important in interactions between the individual, society, and nature. Technological advances have major effects on each of these entities and are, in turn, influenced by them. Management of technology (hereafter, MOT) involves developing and understanding these relationships and dealing with them in a rational and effective manner. In 1987, the National Research council stated the following: 'Management of technology links 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, 9). Khalil

(2000, 7) also says that management of technology is 'an interdisciplinary field that integrates science, engineering, and management knowledge and practice [...] Managing technology implies managing the systems that enable the creation, acquisition and exploitation of technology. It involves assuming responsibility for creating, acquiring, and spinning out technology to aid human endeavors and satisfy customers' needs.'

Based on the above conceptualizations of technology and technological capability, we propose the following conceptualization of management of technology: management of technology is organizing, coordinating and leading the use/handling of technology (and technological knowledge and skills) in an organization. Management of technology involves the following basic activities:

- planning of the use of technology,
- identification, selection and acquisition of technology,
- preparation and introduction of the use of technology,
- implementation, installation and control of the use of technology,
- motivating and maintaining the use of technology.

If an organization uses technology to achieve its purposes and goals, there is a need for effective management of technology in such an organization. An individual human itself does not manage technology and does not have the need to manage technology – it only uses (effectively or ineffectively) technology to achieve some purpose or goal. Technology is managed only in organizations where technology is being used, and management of technology is only one part of the general management of an organization. However, organizations in different socio-economic orders have different purposes/goals and management of technology in organizations depends on these particular purposes/goals, and also on the principles of each particular socio-economic order in which organizations are operative.

Management of technology is management of an effective and purposeful use of technology in an organization. Based on our conceptualization of technological capability (see above), management of technology is thus also developing and advancing the technological capabilities of organizations. For example, Janeš and Dolinšek (2007, 1411) stated that 'technological capability of the company is the ability to effectively and successfully exploit the management of technology knowledge.'

Some of the possible activities in the practice of MOT are also:

- technology auditing,

- scanning the technological environment and analyzing technology trends,
- technology forecasting and technology foresight,
- formulation of technology strategy,
- technology transfer,
- technology development.

The Need for Managing Technology Today: A New Paradigm

According to Khalil (2000, 54), the efficient utilization of technological resources is a critical aspect of today's management of corporations. In the modern way of life based on technology, the rational and productive use of available technology, materials, skilled workers, information, intellectual assets, and financial resources is crucial in providing a competitive posture for corporations.

Burgelman et al. (1998, vii) simply state that technology and innovation must be managed, since this is generally agreed upon by management scholars and managers. 'One key task of the general manager is to acquire, develop, and allocate an organization's resources. Technology is a resource of paramount importance to many organizations in today's competitive environment; managing this resource for competitive advantage entails integrating it with the firm's strategy' (p. 1). Management of technology must be a part of a firm's overall business strategy.

Our study of major companies in different material production sectors (e. g. energy, information technology, robotics) shows that innovative, advanced, leading-edge (possibly proprietary) technologies are today regarded as a decisive source of competitive advantage and consequentially value maximization and profits (see for example ExxonMobil 2008, 2009; iRobot 2009, Microsoft 2009). Technology is regarded as an element underpinning success across all sectors of these companies.

According to the International Association for the Management of Technology (IAMOT), technology is a large and growing part of every manager's daily experience – managers develop technology, use technology, buy technology and sell technology (Van Wyk 2004, 84). Technologies today are an integral factor that exerts influence upon all managerial disciplines (finance, accounting, human resource management, marketing, operations management).

The essence of today's MOT is in combining business management with science and engineering: a primary focus is on technologies in the

whole business process – from strategic planning concerning investment and development of new technologies to operative questions concerning development of products and technologies as well as their commercialization. A framework (model) of the technology management activities consists of identification, selection, acquisition, the exploitation and protection of technologies (Janeš and Dolinšek 2007, 1411).

MOT is very important today due to unprecedented and fast technological development. Managers daily face technological challenges, upon which they have to quickly and appropriately respond, and this requires new knowledge and brings new tasks. Research and development as well as inventions are important elements for advancing technological development, yet still more important is exploitation and commercialization of existing technologies.

Khalil (2000, 54) states that 'drastic changes in the business environment in the third millennium are expected. There is a search for new paradigms that are suitable for this new environment. New paradigms in management of technology are interdisciplinary – they draw upon knowledge from existing fields such as engineering, management, accounting, finance, economics, production, and political science.' There are today very dynamic conditions for manufacturing and service organizations, conditions dictated by changes in technology and by the global business environment. Major technological changes in the world's economy now include: rapid technological change and diffusion, increasing technological complexity, new computer-based service technologies, and globalization of technology-competition and markets. These require changes of the dominant paradigm by which the productive enterprise is managed. 'Management of technology focuses upon how technological change can be managed to improve the competitiveness of the business enterprise. This focus is resulting in some major alterations in the management paradigm by which competitive enterprises should be managed' (p. 66).

The modern practice of management of technology should take the following trends into account:

- production economies of scope are equally important with economies of scale, and production automation should be appropriately balanced between hard and soft automation (depending upon product volumes and product lifetimes),
- multi-core-technology product lines will have shorter product life-

times and should be planned as generations of products (paced by the most rapidly changing critical technology), and the organization must be flexibly organized for rapid and correct response,

- world markets and technology are now global, and enterprises should be globally based to 'think globally and act locally' (Khalil 2000, 68–70).

Based on conclusions of the National Science Foundation workshop on management of technology, Khalil (2000, 73) stresses that rapid change in technology will very likely intensify in the 21st century. The following changes are expected to occur:

- technological complexity is expected to increase,
- technology fusion will be more pronounced. Technologies from one discipline will cross-fertilize technologies of other disciplines, thus enhancing the level of performance of technology,
- a diffusion of information and communication technology will continue into the future. Mergers and acquisitions of information- and communication technology firms are expected to increase,
- the emerging technologies, particularly molecular biology and computer information technology, will have a major impact on industry and on all walks of life. Applications of genetic engineering, biotechnology and nanotechnology are expected to change existing industries and create new markets. These emerging technologies are expected to find many applications in the health industry, in agriculture, and in human and animal genetics,
- technology life cycles for high-tech industries are becoming much shorter. This trend will continue in the future, enabling closer linkage and better harmonization of business and technology strategies.

Conclusions and Discussion

In the paper, we provided our conception of technology that is very similar to other predominating conceptions of technology in the (management of technology) literature. However, some minor elements are present in our conception, which are not explicitly presented in other conceptions. We also clearly stated what our empirical base was, upon which we conceptualized technology. A question to be further investigated is whether our empirical criterion is whether we sufficient or should add some other relevant empirical material and accordingly modify our conception.

In the paper, we explained a general and principal relationship between technology and wealth in a society. While there is a lot of literature on the relationship between technology and economic growth, there is not so much literature on the fundamental relationship between technology and capitalism (and its forms of wealth) or technology and real-socialism (and its forms of wealth) or between technology and another past or possible future socio-economic order (and its forms of wealth). Economic growth is by itself a very abstract and dubious determination (organisms grow, while economic orders do not grow, but are instituted, executed, enforced, implemented), and in different socio-economic orders so called 'economic growth' means very different things.

Regarding our conception of technological capability, it should be stressed that this is only a proposed conception and that it is based on our previous conception of technology itself. Other researchers should examine our conception of technological capability and verify if this conception convincingly grasps technological practice and technological capability in modern companies. In their practice, companies and other organizations and institutions do not speak so much of technological capability (as they do of technology), so an organization's technological capability is more of a theoretical concept in the MOT academic field, albeit a fundamental one.

We live in a society of increasingly fast and various technological changes and advancements, so the challenges for modern MOT practice are thus also constantly changing. In the paper, we have presented some general and most notable challenges. However, this list could go on and on and could include more and more specific trends and challenges. One of the constant MOT tasks is to scan, analyze and foresee such challenges.

Notes

1 Facts about rapid technological advancements in the last decades are startling. To name only a few; there has been more information produced since 1960 than during the previous 5,000 years and information supply available to us doubles every 5 years (Pritchett in Khalil 2000, 2–3). Gordon Moore, a cofounder of Intel Corporation, has predicted that microchips will double in power and halve in price every 18 months (Isaacson in Khalil 2000, 3). Subsequently, Intel succeeded in fulfilling this prediction.

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