

Technology and Strategy: Towards Strategic Techno-Management

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SUMMARY

Although technology is as old as humanity and technological issues can be traced in several disciplines and their development, the strategic level of managing technology is a relatively new area. The ever-accelerating changes in science, economy, and society require adaptive competencies. A company must gain gradually knowledge from systematically monitoring and developing its technology. The aim is to give an overview of the key concepts of exploiting the strategic opportunities of techno-management. There is conceptual diversity in the literature, and information and communication technology dominate recent publications; strategic techno-management deserves a general approach.

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INTRODUCTION

Technology has an imprint on any age. New technologies in agriculture and later in the textile industry expanded life chances. The assembly line created by József Galamb offered an explosive development of mass production, first in the automotive industry. Chemical engineering technologies have changed the world since the 1920s. Computers offered mass data processing and automation from the 1950s. Information and communication technologies are now embedded in our lives. Although it has not often been highlighted in history, managing technologies has an important role; technologies must be considered an enabler supporting efforts to meet the customers' needs.

Nowadays, technology is often used as a buzzword for plans or actions, and information technology is presumed when the term is used. However, technology has a broader meaning that allows a systemic approach to matching challenges and solutions. The even more agile business and social environment of the 21st century requires rethinking management tools. Industry factors and the external environment can cause significant pressure on industries to change technology (Onufrey & Bergek, 2021). Among others, achieving success requires managing technology and human aspects

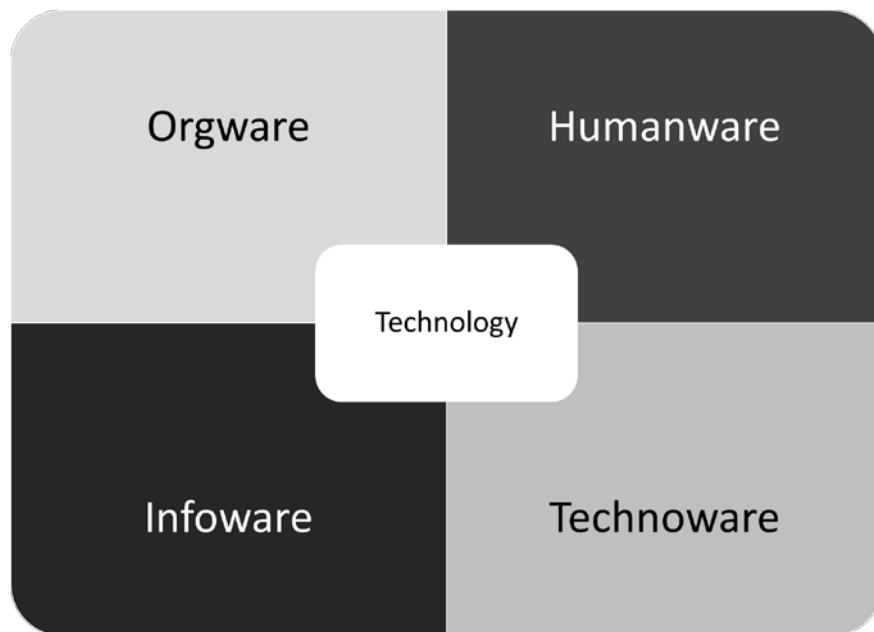
together (Kollman & Dobrovič, 2022). We believe that the emergence of strategic management has established a framework for business thinking. The resource-based strategic theories emphasize capabilities, which can be interpreted as a focus on technologies, and the appreciation of dynamic capabilities justifies the applicability in the agile environment. However, incorporating technological aspects into strategies and their exploitation to gain or maintain a competitive advantage requires re-learning strategic capabilities and breaking organizational barriers. According to the technology-intensive Industry 4.0 implementations, failures in achieving strategic goals and improving competitiveness usually can be traced back to internal causes (Ramadan et al., 2022). Among appropriate conditions, strategic technology management can be expected to offer a potential solution for managing ambiguity, complexity, and business dynamics caused by technology (Sahlman, 2010). The study aims to give a comprehensive overview of how techno-management can serve corporate competitiveness through strategic applications. The results are based on a literature review.

TECHNOLOGY

The Greek word „τεχνη” (techne) means the practical ability to create something. „λογος” (logos) refers to human knowledge and causality. Together, these mean the sum of skills, the ability to do things, and the knowledge that underpins them (Szakály, 2002). Sikander (2011) defines technology as types and patterns of activity, equipment and material, and knowledge or experience to perform tasks. Porter (1998) notes that every value activity embodies technology in the form of know-how, procedures, or technology embodied in process equipment. Steele (1989) distinguished product and process (manufacturing) technologies based on the professional content and purpose of the technology. Pataki (2005) focused on the substantive content of technologies, delimiting:

- core technologies: that are an essential element or component of products and services;
- additional technologies: to increase the utility and functional value of products and services;
- peripheral technologies: that add value to the products or services for the target market segment.

The THIO model (Figure 1) offers a general approach that describes technology as a synergic system of four components: technoware, humanware, inforeware and orgware (Pataki, 1999; Szakály, 2002). THIO can demonstrate the contribution of existing technologies in a company (Siregar et al., 2016). Depending on the purpose, the different definitions of technology emphasize one or more THIO elements.



Source: based on Deutsch et al., 2019

Figure 1. THIO model

Technoware is the tangible form of technology. It includes the machines, equipment, tools, factories, and other items that are necessary for the transformation processes of companies. Accordingly, technology can be understood as hardware, as tangible tools, as man-made things that both enhance people’s existing capabilities and enable them to perform tasks that they would not be able to perform – qualitatively or quantitatively – without them (van Wyk, 1999).

Orgware (or organware) is essential to the transformation processes of companies, embodying technology in an institutionalized form. It includes processes, systems, networks, allocations, etc. They are

needed because the hardware needs to be invented, designed, developed, manufactured and enabled for use. In other words, this is the soft side (software), i.e., the knowledge, know-how, skills, practices, and other non-physical means needed to produce and use the hardware properly (Schön, 1967; Ayres, 1994; Lowe, 1995; Rogers, 1995).

Infoware refers to the information supply and support of the transformation process, including the elements of the technology in the form of documentation, such as specifications, plans, blueprints, diagrammes and descriptions.

Humanware covers the people-related elements of technology, encompassing all the skills, abilities and competencies that drive the transformation processes of enterprises.

TECHNO-MANAGEMENT

There are several approaches to the relationship between technology and management (Nagy-Borsy, 2018). ‘Technology management’, in the narrowest interpretation, refers to methods and practices that support the development and use of technology within an organization (Zuckerman, 2002; Pelser, 2014). Based on the innovation-centred approach of Friedman et al. (2008) and Shane (2009), technology management refers to the embedding and use of innovation within an organization, and technology management is characterized by the relationship of the company’s activities to innovation.

According to Szakály (2002), technology management links the professional, scientific and management domains, while Pataki (2005) defines it as cross-functional activity of putting technology at the service of the effective and efficient operation of the organization.

The concept ‘Management of Technology’ means managing technology-intensive business activities (Braun, 1998; Pilkington et al., 2006). It assumes that the need for managing technologies is common in all companies, just the company-level focus is unique, and a flexible and resilient understanding of the concept is

suggested. The main characteristics of technology management can be summarized as follows:

- In the narrow sense, technology management refers to the methods that can be used to improve available technologies or to acquire and integrate technologies that are not available.
- In the broader sense, technology management is understood as a cross-functional activity within the enterprise, an integrated framework of activities designed to enable the organization to use and exploit available technology effectively and to facilitate technological improvements.
- As a functional area, technology management is linked to the innovation activities of companies and has a strategic orientation, supporting and defining the formulation and implementation of corporate and business strategies.
- In the case of technology-intensive developments and projects, technology management supports the management of the project portfolio (from a technology perspective) and the efficient implementation of projects.

A review of techno-management functions allows a more practical interpretation of the content. Table 1 summarizes major models in the field. Most of the models follow a similar logic. Jemala (2012) presented company-level tasks with three main functions: identification, implementation, and commercialization. The model is a simplified version of Gregory’s (1995) approach. An exception is a model by Cleland and Bursic (1991), which links the functions to the phases of the strategic technology management system life cycle, with a focus on technology integration.

Table 1
The function of techno-management and strategic techno-management

Gregory (1995)	Rush et al. (2007)	Arasti & Karamipour (2003)	Cleland & Bursic (1991)	Kropsu-Vehkaperä et al. (2009)	Pelser (2014)	Jemala (2012)
Identification	Awareness	Identification	Creation	Technology strategy	Technology awareness	Identification
Selection	Search	Selection	Monitoring	Technology development and utilization	Technology acquisition	Implementation
Acquisition	Core competence	Acquisition	Assessment	Information and knowledge management	Technology and product planning	Commercialization
Exploitation	Strategy	Exploitation	Transfer	Technology acquisition and transfer	R&D organization and management	
Protection	Assess/selection		Acceptance	Technology forecasting	R&D investment	
	Acquire		Utilization	Product development	Manufacturing and	

					process technology	
	Implementation		Maturity	Life cycle management		
	Learning		Decline	Commercialization		
	Linkages			Production process management		

Source: based on Deutsch et al., 2019

The need to take a comprehensive approach to techno-management can be served by the identification of key activities along the functions. Based on Cetindamar et al. (2016), the key activities are as follows:

- Technology identification: identifying technological opportunities involves the process and means of monitoring external and internal environmental changes that support the acquisition and maintenance of competitive advantage.
- Technology selection: addresses strategic issues at the enterprise level and their relationship to technology strategy, which also requires strategic objectives and priorities at the business unit level.
- Technology acquisition: the determination of how a company or business acquires technologies of value to it, i.e., whether the organization develops them itself, develops them jointly with other organizations, or purchases technologies to gain and maintain a competitive advantage.
- Technology exploitation: involves the effective transfer, deployment, absorption, operation within the organization, and ultimately, commercialization of technology. Exploitation processes naturally include incremental improvements, process adjustments and marketing activities.
- Technology protection: covers the formal processes and tools that ensure the protection of a company's intellectual property, including the knowledge and expertise embedded in its products and processes.
- Learning: the knowledge gained from the implementation of a company's or enterprise's technological activities and projects and from feedback from the external environment to improve those activities.

STRATEGY AND TECHNOLOGY STRATEGY

The term strategy covers the long-term goals set by the company and the possible ways and means to achieve them, with the intention of environmental adaptation (Bartek-Lesi et al., 2007; Balaton & Tari, 2014). In each era, the strategy has been the proper response to market and other environmental challenges with the right tools and approach. As the environment has become more

complex (the development of the information society, advances in computing and ICT, the environment, and the growing importance of social responsibility), the range of strategic approaches and tools has expanded.

Strategic planning and strategic management have a broad literature tracing its evolution from financial and long-term planning to strategic issues (Barakonyi, 2000). Porter (1996) defined strategy as a competitive position, "deliberately choosing a different set of activities to deliver a unique mix of value". Mintzberg et al. (1998) summarized five approaches; the strategy can be interpreted as follows:

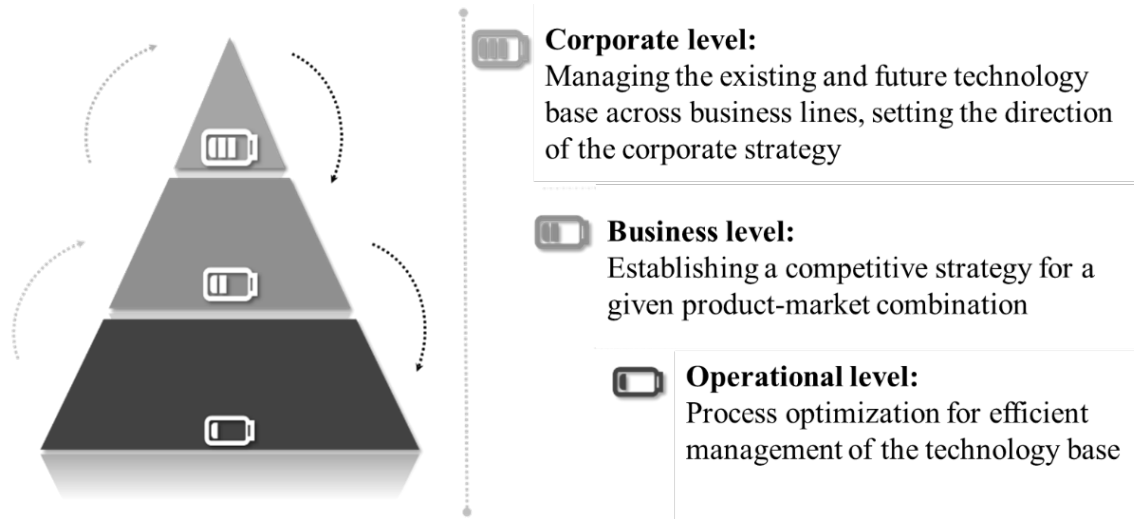
- Plan: direction, a guide or course of action into the future;
- Pattern: consistency in behaviour over time;
- Perspective: the fundamental way of doing things;
- Position: locating particular products in particular markets;
- Ploy: a specific manoeuvre intended to outwit an opponent or competitor.

Three interacting levels of strategy have been distinguished (Mészáros, 2005; Chikán, 2021):

- Corporate strategy: the company's vision, mission, objectives, and the series of strategic actions needed to achieve them. Its main task is to determine the areas and markets in which the company should operate and the means to move in these strategic directions.
- Business (unit) strategy: the business strategy sets out the position to be achieved in the sector or market in question, in line with the corporate strategy, and the specific competitive strategies required to achieve these objectives in the relevant product-market configurations. If the company is present in only one business sector, the corporate strategy is the same as the business strategy.
- Functional strategy: these define the objectives and the means of achieving them in each functional area (finance, marketing, R&D, production, etc.) in line with the corporate and business strategies. The purpose of functional strategies is to ensure the efficient use of resources (optimal operation of the function), continuous innovation, and the development of capabilities that support the company's competitive advantage.

Sukri and Yusoff (2021) approach technology strategy as a long-term plan that leads companies to utilize the committed resources toward technology in order to provide manufacturing companies with a competitive edge. It seems obvious to handle techno-strategy as functional, but this would be an oversimplification. Techno-management and techno-

strategy must be managed on each level of strategy (Figure 2). The role of technology is presented as a key factor in Porter's (1998) concept. A chapter deals with technological change and technological strategy, in which it is highlighted that technology impacts the conditions of industrial competition and creates the corporate basis for competitive strategies, as well as rethinking the value chain.



Source: based on Deutsch et al., 2019

Figure 2. Levels of techno-strategy

The primary goals of corporate-level technology strategy are as follows (see also Arasti et al., 2017):

- Ensure the development of company-wide principles and policies for strategic technology management and the company-wide coherence of technology strategy implementation;
- Support the company's growth by developing and sharing core technology capabilities and selecting tools;
- Ensure consistency between technology strategy objectives in various time horizons;
- Align the company's business and technology portfolio;
- Ensure company-wide protection of intellectual property rights;
- Enforce the way and principles of technology sharing within the company;
- Define the priorities and methods for resource allocation within the company to implement the technology strategy;
- Provide support activities relevant to each function of strategic technology management.

In contrast, strategic business unit-level technology strategy provides answers to the following questions (Skilbeck & Cruickshank, 1997; Jemala, 2012):

- How can the firm or company gain or maintain a competitive advantage in each product-market combination through technology?
- How can the technological base of the firm or company support the competitive strategy it is pursuing or intends to pursue?
- How can strategic technological goals and objectives be pursued for a business unit?
- What technological changes can be expected in the given product-market combination?

Of course, technology strategy has a functional role as well. It deals with operational tasks, namely:

- Translating strategic technological decisions into concrete projects and actions;
- Supporting the technology base for business processes;
- Allocation and use of technological resources;
- Optimizing internal processes and systems;
- Operating monitoring and control processes for technology management (Skilbeck & Cruickshank, 1997; Jemala, 2012).

TOWARDS STRATEGIC TECHNO-MANAGEMENT

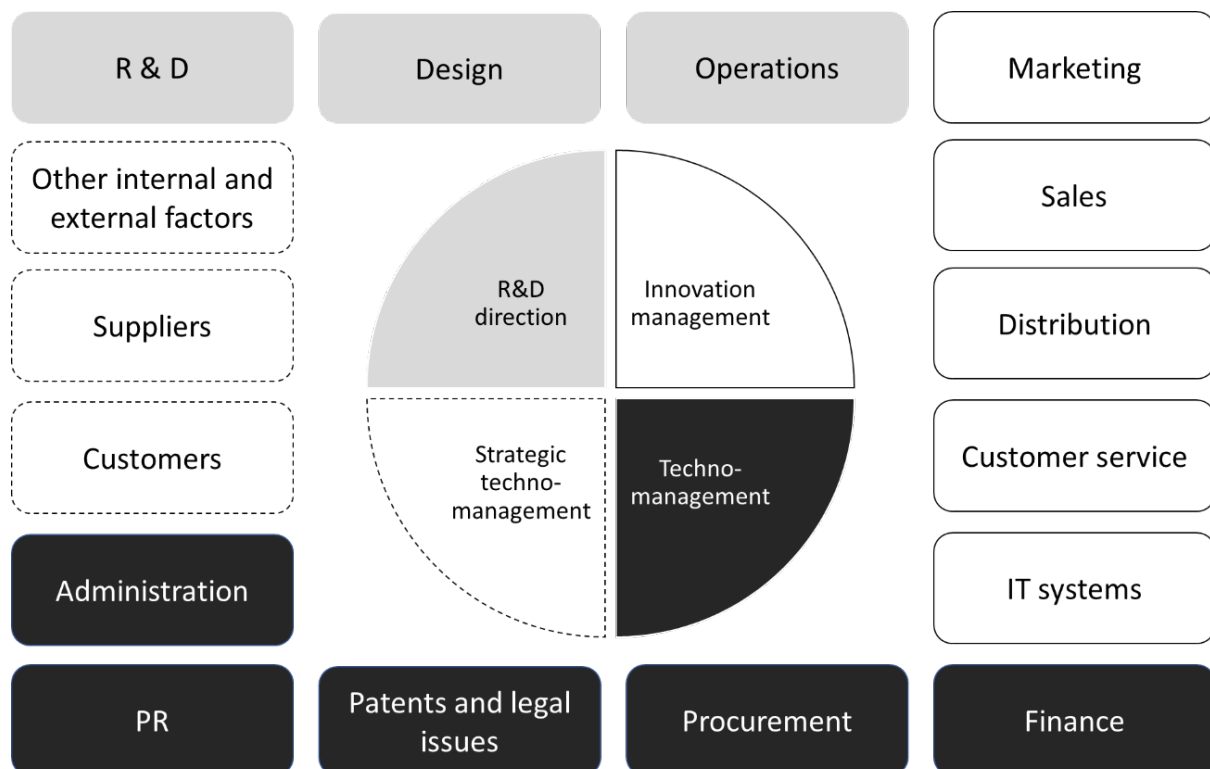
Similar to the understanding of techno-management, there are competing approaches and definitions of the strategic aspects of tech management in the literature. ‘Technology strategy’ and ‘Strategic technology management’ or ‘Strategic management of technology’ may be referred to as synonymous by some authors, while others make serious differentiations. Moreover, technology strategy can be part of corporate strategy or the related competencies in the field. Szakály (2008) gives a synthesis, as techno-strategy is the corporate activity of creating, searching for, disseminating, and adopting technologies with a strategic orientation.

Although techno-management and techno-strategy are about technology, it is to note that these are different concepts. Technology management focuses on developing and managing technological resources and capabilities within the company and integrates them according to the operational objectives. Techno-strategy manages technologies and innovations within the company and those to be sourced from outside,

according to the corporate strategy, with a strong external orientation.

Sahlman (2010) and Sikander (2011) give a broad interpretation of strategic technology management. Strategic management of technology is “planning, organizing, leading and controlling of technological activities, interacting with company’s skills to apply knowledge, structures, resources, and socio-economic environment. The goal is contributing to formulation and execution of the company’s basic, long-term goals and objectives, and adoption of courses of action and the allocation of resources necessary for those goals” (Sahlman, 2010, p. 45). According to Sikander (2011), strategic technology management means developing a company’s technology strategies and then evolving methods to implement and manage them, including implementation and management tasks. Technology policy is mentioned as the integration of technology strategy and technology management. Strategic technology management is therefore concerned with how to integrate technology strategy and its management into the strategic thinking, high-level planning, and management processes of the company.

The options and areas involved in managing technology are illustrated by Gaynor (1996) with an overview of the phases (Figure 3).



Source: based on Gaynor, 1995; Deutsch et al., 2019

Figure 3. Stages in the evolution of technology management in practice

TOWARDS PRACTICAL IMPLICATIONS: COMPETITIVE STRATEGIES AND TECHNOLOGY

Porter's generic strategies describe the basis on which a company can gain a competitive advantage over its competitors by "outperforming" them (Balaton & Tari, 2014). The source of the advantage may be lower cost (cost-leadership) or the development of characteristics that are distinct from others (differentiation). The target within an industry may be broad or concentrated on a specific customer segment (focused). The related tasks of product and process technology are summarized in Table 2.

TECHNO-STRATEGIC OPTIONS

It may seem that the benefits of a techno-strategy are only available to a narrow group of companies, the market, and technology leaders. Indeed, such companies are at the forefront of developing and deploying new products and processes. Their results are spectacular and dictate the future, but they are not exclusively the economy. The competitive advantage of follower companies can come from lower product prices, learning from the experience of the frontrunners, and lower research and development costs. In a differentiated competitive strategy, benefits and savings can be achieved by focusing on product variations. Buzás (2002) provides an overview based on Mytelka (1999) of the characteristics of leaders, early and late followers (Table 3), which can be used as a map for interested companies

Table 2
Product and process technology and the generic strategies

	Product technological change	Process technological change
Cost leadership	Product development to reduce product cost by lowering material content, facilitating ease of manufacture, simplify logistical requirements, etc.	Learning curve process improvement to reduce material usage or lower labour input Process development to enhance economies of scale
Differentiation	Product development to enhance product quality, features, deliverability or switching costs	Process development to support high tolerances, greater quality control, more reliable scheduling, faster response time to orders, and other dimensions that raise buyer value
Cost focus	Product development to design in only enough performance for the target segment's needs	Process development to tune the value chain to a segment's needs in order to lower the cost of serving the segment
Differentiation focus	Product design to meet the needs of a particular segment better than broadly-targeted competitors	Process development to tune the value chain to segment needs in order to raise buyer value

Source: Porter, 1998, p. 178

Table 3
Innovation strategies (Mytelka, 1999:20)

	Front runners	Quick followers	Latecomers
Innovation strategy	Get ahead	Keep-up	Catch-up
Capabilities	New combinations of generic technologies Pushing back the frontiers of knowledge	Introduction of variety Improvement in quality Reduction in costs incremental change	Problem-solving innovation (attention to “know-why”, learning to learn) Improvements in productivity and machinery maintenance Imitation Adaptation
Critical Knowledge Inputs	Scientific research and scaling up of laboratory models. Linking of R&D and marketing within the firm.	Engineering, testing, design, and marketing; linking design and production within the firm.	Engineering and management capabilities: feedback from the production process, product scanning, and adaptation capabilities.
Policy Objectives	In-house research, technology development R&D networking	Technology development R&D networking	Technology transfer, diffusion, demonstration, training
Useful Partnership Linkages	Windowing through a broad array of long-term R&D collaborative projects with research institutions, users & materials suppliers	To university engineering faculties, consultancy firms, design centres, technology institutes, users	To apprenticeship programs, productivity centres, clients, equipment suppliers, and intermediaries

Source: Mytelka, 1999, p. 20

CONCLUDING REMARKS

Technology and techno-management is not a novel invention; it belongs to the normal functioning of a company or organization. Evidence of this is that technology appears regularly in the literature. However, based on the screening of the recent sources, it can be concluded that direct attention to technology management and strategic relations has been less focused in the 2020s than earlier. Industry 4.0 relations, supply chain extensions, and information and communication tools applications receive prominent attention. A recent book by Cowan (2023) is entitled *Introduction to Technology Management*, but digitalization relations are discussed. We believe that managing technology requires a more general approach that allows the adjustment of strategies and actions to the changing environment regardless of the issues of digitalization.

Challenges can be derived from the features of the environment, especially the dynamics of its change. A turbulent and agile business and social environment leads to appreciating the value of dealing with

technology. The exploitation of the possibilities requires special competencies. Several models are available; competitive advantages depend on an appropriate combination and redesigning of them. This paper has offered a comprehensive overview of the terminology and the related models, offering an industry-independent map for future adopters.

Two issues must be noted when dealing with technology at a managerial level. First, it is a broad and fundamental area that needs attention in every company. Second, the conceptual diversity of the subject makes it difficult to get to grips with. A company must gain knowledge gradually from systematically monitoring and developing its technology. The necessary steps and tools should be chosen by factors such as the maturity of the company, the information needs of its managers and the specificities of the industry.

Techno-management and techno-strategy can be best captured by their functions, since these allow a practical approach and a link to the processes. Putting together technology management functions and tools is a corporate-level task. Literature supports this with grouping and tool orchestration but cannot replace individual implementation.

Author's contribution

Conceived and designed the study: Nikolett Deutsch 50%, László Berényi 50%; collected the data: Nikolett Deutsch 60%, László Berényi 40%; performed the analysis: Nikolett Deutsch 50%, László Berényi 50%; wrote the paper: Nikolett Deutsch 40%, László Berényi 60%

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