ELEMENTS OF NEW TECHNOLOGY DEVELOPMENT

Leticia Pekk[1], Andras Hary[2]

[1]Technology Center Zalaegerszeg, H-8900 Dr. Michelberger P. u. 3, Zalaegerszeg, Hungary

[2]ZalaZONE Industrial & Science Park, H-8900 Dr. Michelberger P. u. 3, Zalaegerszeg, Hungary

Abstract

Research on new technologies have been closely linked to significant technological developments in the 20th century. Technology as an object and concept has thus been known and researched for a long time, so this paper starts from the side of a classical conceptual approach in order to place the topic. Our comprehensive research addresses the effects of new technologies on value creation. As part of this research program, the aim of the present research is to explore state-of-the-art research areas of new technologies, building on the identification of the most researched areas. The technological approach of some of the leading industrial reports is also highlighted. The current paper approaches the process of introducing technologies from this side, as defining the elements built around the most researched topics. As a conclusion of the publication, an application-based technology research map is defined, and a three-level approach is generalized.

Keywords: *new technologies, research areas, technology trends, technology introduction*

1. INTRODUCTION

The word „technology" has a complex meaning in general usage, not just as a narrow manufacturing process. According to a definition (Pataki, 1994), „A system of expertise and tools that enables technology to meet needs." To do this, it is important to distinguish that is called everyday knowledge: the basic level of real knowledge with which we orient ourselves in the world. This knowledge can be acquired through learning in and out of education. In addition, professional knowledge, expertise is already a higher level of real knowledge, which can be acquired within the framework of organized education and learning. At the same time, we apply expertise in addition to everyday knowledge, but thus, everyday knowledge is not part of technology. Technology is a system whose elements are compatible with each other. Technology typically relies on science, but it can also be part of experiential knowledge for which we do not know the scientific explanation, but is still used because it purely works.

The field of technology and its theory is described in Pataki's book in a comprehensive way. Technologies can be divided into two groups based on their professional content (Steele 1989):

- product technology,
- process technology or manufacturing technology.

Product technology includes product planning, product engineering, application and commissioning, and service planning. At physical products, process technology is also called manufacturing technology, however, due to the proliferation of service, the term process technology is used, thus referring to both service and manufacturing.

In the case of a connection to the essence of a product (physical product or service), technologies can be grouped as follows (Trott, 1998):

- core technologies,
- complementary technologies,
- peripheral technologies.

By using core technologies, the essence of a product is created that cannot not exist without that technology. The R&D activities of most companies typically focus on these core technologies.

Complementary technologies are also needed for products, but they are needed to create value-added features that complement core functions. The product functions created by the use of peripheral technologies are not necessary for the product or service, but their application may further increase the market value of the product.

In terms of market competitiveness, technologies can be divided into three groups (Little, 1998):

- base technologies,
- key technologies,
- pacing technology.

Base technologies are the basis of activity in a given field. They are not critical to the success for the competition, as almost all competitors have them or can easily access them. However, key technologies have the greatest impact on competitiveness. Those who have it can benefit, but those who do not can easily be disadvantaged. Pacing technology is a technology that is at the beginning of the development phase but has the potential to have a positive effect on the outcome of competition in the future. The name comes from the fact that they dictate the pace of competition with their formation.

Each technology can be classified into the above mentioned technology categories as the most typical point of view for them (Figure 1).

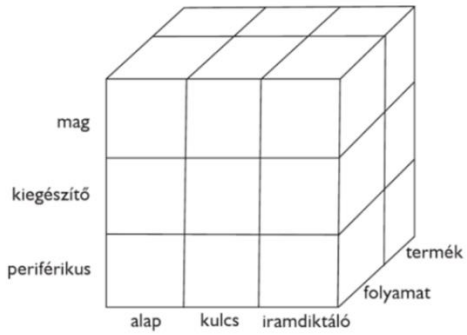


Fig. 1. Classification of technologies

Source: Pataki, B., "A technológia menedzselése" Book (1994), p. 32

2. RESEARCH AREA AND METHOD

2.1. Mind-map of the research

The research topic is the study of the effects of technological trends by exploring the professional focuses of research in the world. The topic was reviewed using the mind-map technique, which summarizes the relevant subtopics of technological development. In the present research, the technological research elements are examined with view on their appearance primarily from technical perspective.

Based on the mind-map, seven areas to be examined can be highlighted, which are arranged in order according to the chronology of technological development process:

1. Technology trends
2. Technology forecasting
3. Newest technologies
4. Future market
5. Technology capabilities

6. Technology change management

7. Technology services

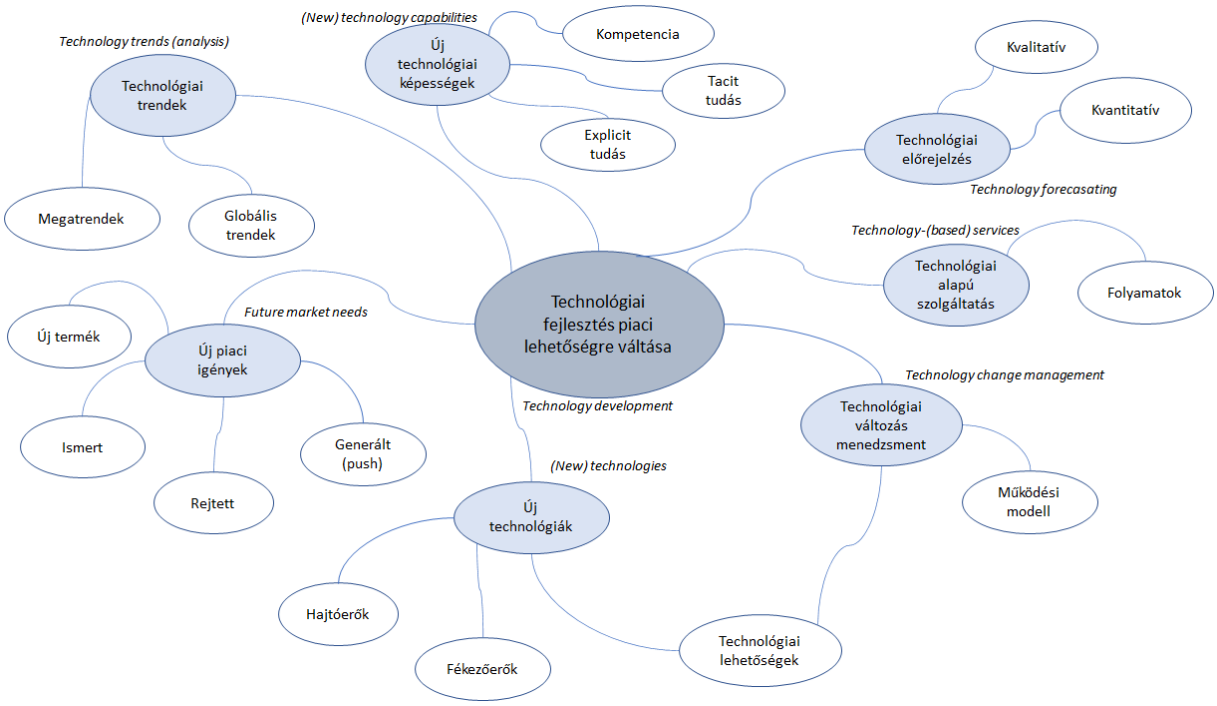


Fig. 2. Mind-map of technology development research field

2.2. Literature research

The words of the seven areas were taken as research keywords, and then the research intensity observed through the keywords was examined based on bibliographic data. To do this, scientific articles were searched about Microsoft Academic between 2011-2021 using the Publish or Perish software. In each case, 1000 articles were saved per search keyword. The resulting bibliographic data were processed using VOSviewer. The program searches the input bibliographic database for keywords based on a specified minimum number of occurrences, which in the ccurrent case was 10. The keywords were searched in the title and abstract of the article. The program displayed the minimum occurrence of keywords and formed clusters of them. The more important keywords were highlighted with a larger font size and circle. In addition, it illustrates the strength of the relationship network of different keywords, indicated by the lines of relationships between them, and by the distance from each other.

All the seven keywords were examined through this way, but the current paper takes only an example due to limitations of the paper. As an example, Figure 3 shows the keyword “Technology forecasting” test result displayed using the VOSviewer. It can be seen the categorization of the mostly relevant related keywords into clusters using different colors. Within clusters, the most significant keywords represent the most common keywords in the study, appearing in larger font sizes and larger circles. The distance and proximity of these keyword circles to each other, and possibly their density are also an observation on focus around the specific research field.

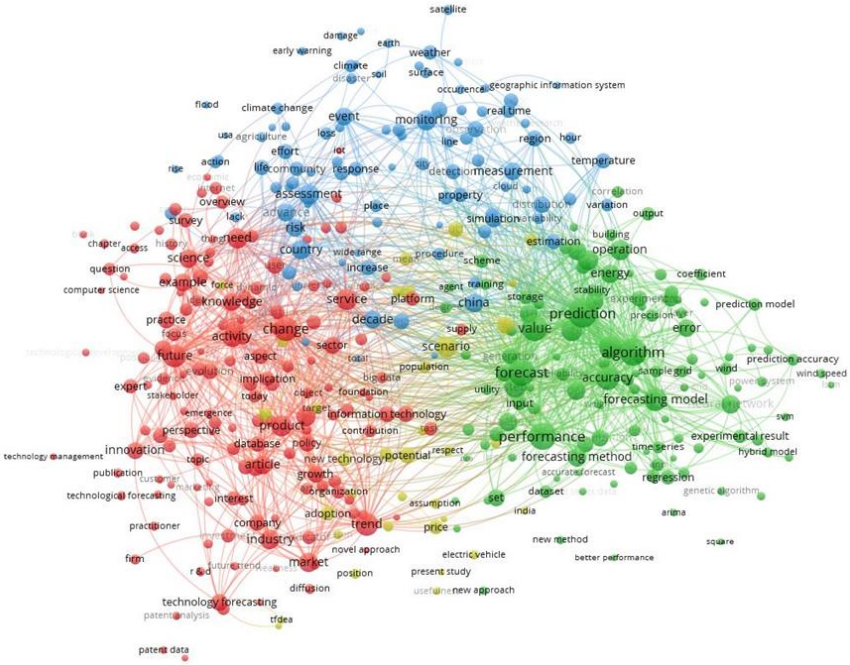


Fig. 3. Keyword search of "Technology forecasting"

2.3. Example of keyword research

Based on the analysis shown in Figure 3, the following key keywords can be highlighted:

- algorithm, prediction, forecast, performance - which infers cluster group methodologies,
- change, future, trend, innovation - this cluster group appears as an area of change effect,
- monitoring, assessment, measurement - cluster of assessment examples,
- scenario, potential, price, adoption - a smaller cluster that plays a bridging role for the previous three.

Overall, the study concludes that the methodology of forecasting and the impact of change play a major role in the field of "Technology forecasting". Forecasting technological trends is an important research area, as its introduction and application involve unclear steps. Both qualitative and quantitative methods can be used for forecasting methods, but areas of impact are less identifiable. Thus, the specific territorial application of the given technological trend is also a challenge (e.g. digitization, e-mobility, etc.). In the course of the analysis, a "toolbox frame" was concluded that may be needed to complement trend forecasting methods.

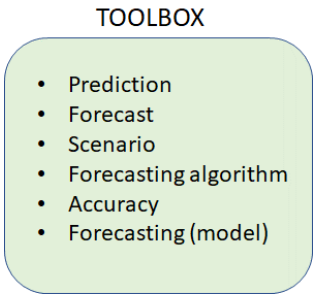


Fig. 4. Keyword analysis conclusion: toolbox elements for technology forecasting methods

2.4. Industrial technology trend reports

Term „megatrend" is used to describe changes at the global level. Researchers analyze highlight different aspects of these trends, but they usually agree in putting the main societal challenges at the forefront.

Retief et al. (2016) identified the main megatrends as follows.

- Megatrend 1: rapidly changing demographics,
- Megatrend 2: rapid urbanization,
- Megatrend 3: accelerating technological innovation,
- Megatrend 4: power shifts,
- Megatrend 5: resource scarcity,
- Megatrend 6: climate change.

The development of a new technology should desirably contribute to tackling an unresolved social problem. At the same time, technological development directions do not usually appear at the megatrend level, but as their supporting elements. Industry and sectoral professionals analyze along these lead to the proposed directions of intervention and the prospects for each technology.

2.4.1. Example of experts

Figures 5 and 6 show some examples, with models from the Future Today Institute (2021) and Roland Berger (2017) studies.

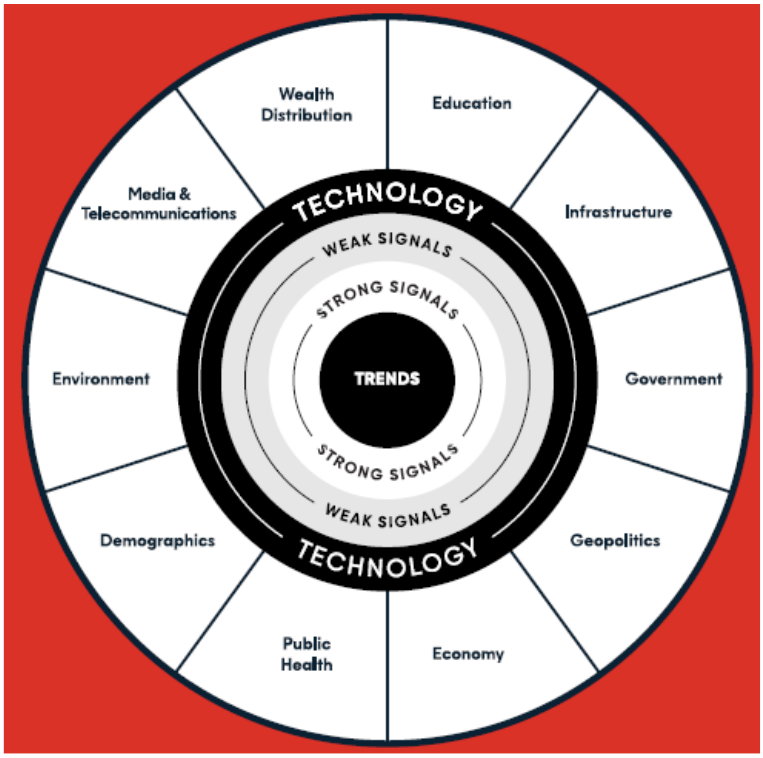


Fig. 5. Technology challenges defined by Future Today Institute

Source: Future Today Institute, Tech Trends Report (2021), p. 09

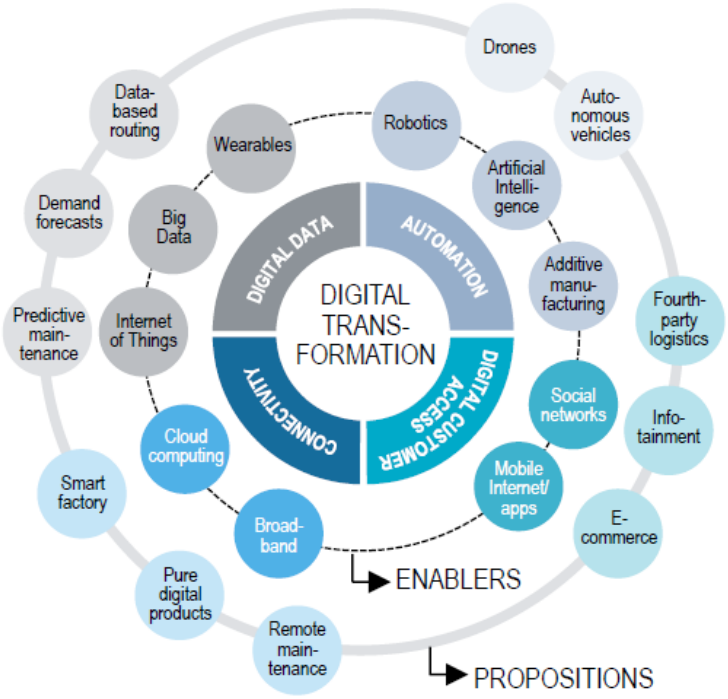


Fig. 6. Technology challenges defined by Roland Berger

Source: Roland Berger, Trend Compendium 2030 (2017), pp.23

2.4.2. Examples of professional association

The range of research on the process of technological change and transformation is also very wide, often not only scientific but also sectoral organizations publish relevant results. It is not the purpose of this paper to elaborate on this topic. For review, reference is made to two figures published by the IEEE (Institute of Electrical and Electronics Engineers) depicting the main drivers of technologies and the main disturbers (Figures 7 and 8) as a result of a specific study (IEEE, 2014).

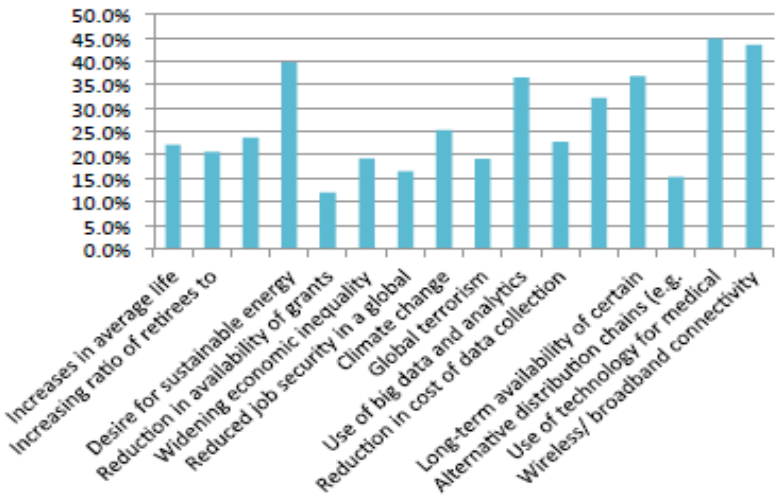


Fig. 7. Major drivers of technology changes by IEEE

Source: IEEE, CS 2022 Report, (2014), p. 113-114

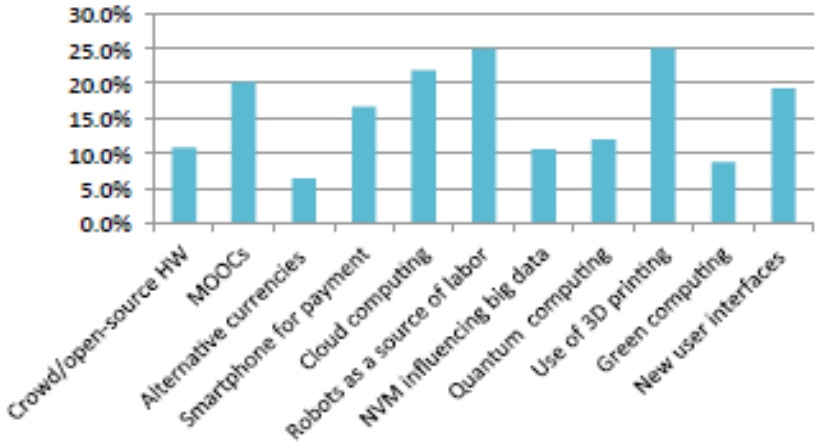


Fig. 8. Major technology disruptors by IEEE

Source: IEEE, CS 2022 Report, (2014), p. 113-114

2.4.3. Example of industrial sector

At the level of a specific sector, the individual technological trends can already be well interpreted, to which specific technological responses can be attached. For example, the automotive industry is known to be one of the most technology-intensive areas facing with a major technological transformation today. An available analysis from Mckinsey & Company (2021) illustrates well the main areas of transformation (Figure 9).

Within each technology trend definition (such as Industry 4.0 or IoT), it is common to talk about specific technologies in relation to which management issues can be interpreted. An example is robotic support, or 3D printing, or in the field of ICT, the range of 5G or wireless solutions.

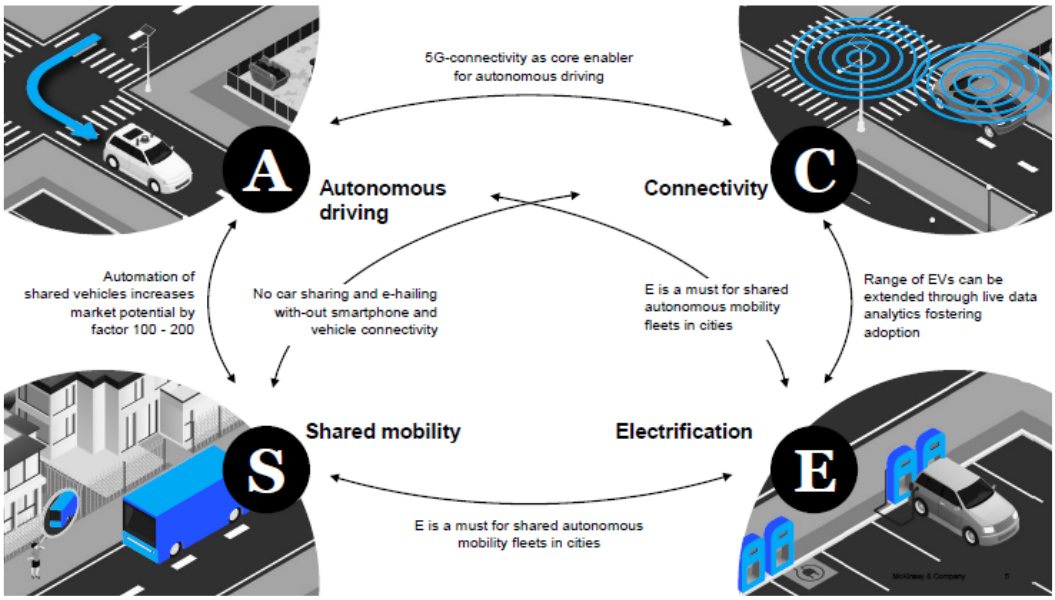


Fig. 9. New technology trends in automotive industry by McKinsey & Company

Source: Key trends in the automotive industry (2021), p. 5

3. RESULTS – ASPECTS OF NEW TECHNOLOGY DEVELOPMENT

In connection with technology forecasts, specific elements of technological development can be formulated. Aspects of introduction are discussed from the emergence of new technologies to market introduction. This process-oriented approach to innovation and development processes has been discussed by many authors (e.g., Deák, 2013, and many others), and is therefore forms the base for the present paper. The essence of the different approaches all points from the exploration of a new technological possibility to the practical implementation. Dias (1999) provides an overview of the topic from the side of technological integration as a catalysator.

The following parts of the paper summarizes the concluded elements derived based ont he keyword analysis made based ont he mind-map structure shown in Figure 2. The methodology used as described at Figure 3 analysis have been used for each of the seven addressed keyword areas. The point of the current paper is to outline the typical research cluster focuses as elements of new technology researches.

3.1.1. Technology trends research area

First of all, at most researched cases, the new technologies have certain connection to the market needs and potential. This relationship can act as a "pull" from the market side, so some demand emerges in the market that requires some technological innovation. On the other hand, on the science side, new development directions are emerging that act as a "push" on the market side, thus generating new market demands. (Figure 10).

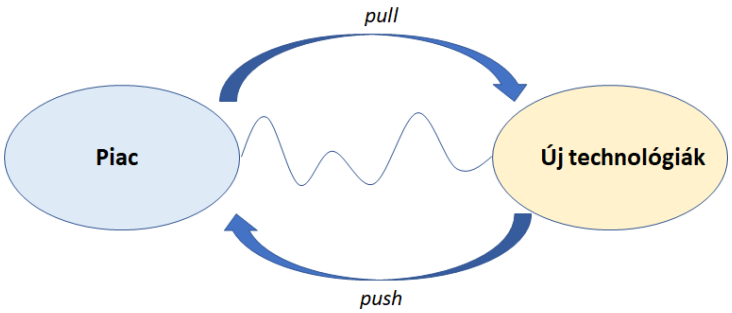


Fig. 10. Push-pull relationship of the market and new technologies

3.1.2. Technology forecast research area

In addition to the relationship between new technologies and the market, additional findings were made separately during the keyword analysis. Thus, it can be said that the field of new technologies can be divided into three major clusters, such as „professional directions" (method, measurement), „social aspects" and „focuses". These areas are closely related, and as a new technological emergence can prevail primarily in focused areas, then influences many professional directions and, last but not least, also impacts on social aspects. During the previous literature search, it was proved that in almost all cases the emergence of a new technology appears to solve some social problem or need. (Figure 11)

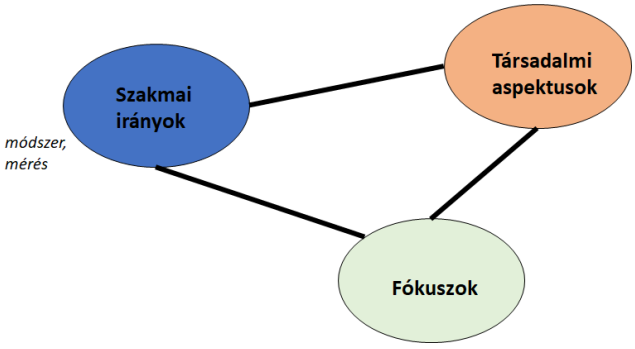


Fig. 11. Beyond new technologies research field

3.1.3. Future market research area

Behind the field of studying market needs, the field of social aspects re-appears, thus re-affirming the claim that social needs generate technological development emerging as market demand. In addition, the connection re-appears with technology application and thus gaining market advantage, as illustrated in Figure 12. These two areas are closely interlinked, as the application of a new technology can lead to market benefits. At the same time, the market competition also affects the economic situation. Next to the economy, a method appears that supports the re-measurement of the change in the economy so that we can be sure of the direction of the effect. Thus, these five territorial elements emerged during the "Future market" study.

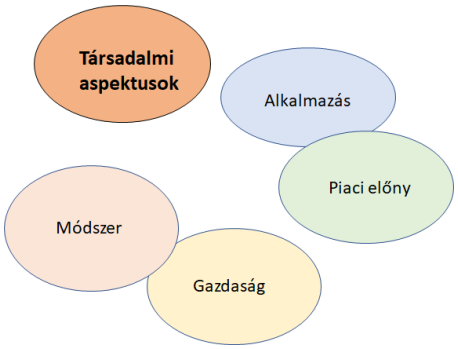


Fig. 12. Elements of technology developments market integration by keyword analysis

3.1.4. Newest technologies research area

Overall, the market validation of the technology can be established, consisting of the territorial elements of the professional-technical, economic and social aspects. A given technology must be supported by an appropriate professional (technical) background, in addition to which the economic effects must be examined and, last but not least, social needs must be assessed, all of which together allow the market validation of the given technology. (Figure 13)

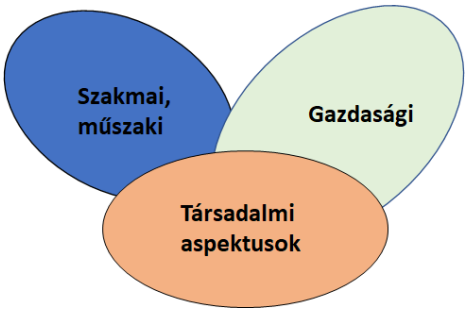


Fig. 13. Fields of market validation and introduction

3.1.5. Technology capabilities research area

In addition to market validation, technological capability, technology management and implementation, appears as key for a marketable new service. This trio together represents the company-related tasks related to a new technology. An essential element for adapting technology is the technological capability itself. As a result of the research, in addition to the technological capability, there is a need for infrastructure, the specific definition of the capability, and a combination of human and technical skills.

Perhaps one of the most important segment within technological ability is human factor and the related practical abilities, referring to the concept of technology definition described in the introduction. The present research also argues that the introduction of a new technological and the provision of a marketable new service are essential for the human side. (Figure 14)

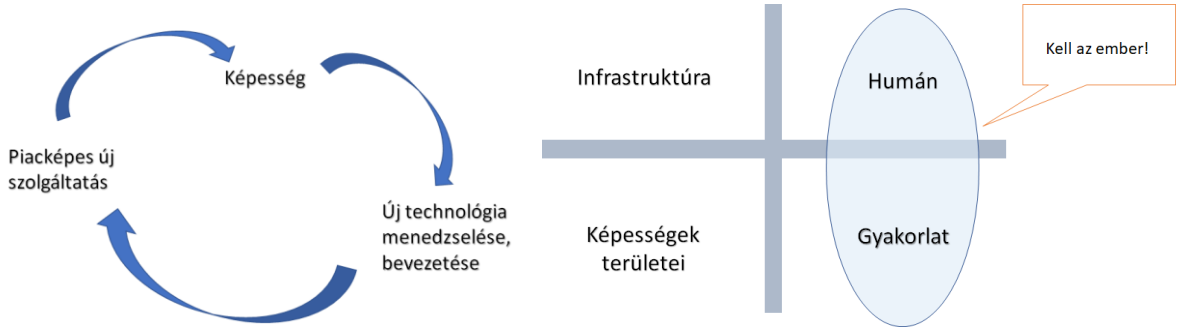


Fig. 14. Human factor for a new technology introduction

3.1.6. Technology change management research area

„Technology change management" is an area that helps managing new technologies, including the human side. Three areas can be highlighted based on the keyword relationship researches: ecosystem environment, practice introduction, and specific areas-social problems. In other words, in the case of identifying specific areas or social problems (e.g. climate change), what technological practices need to be introduced, and then the ecosystem where they need to be mobilized must be identified. (Figure 15)

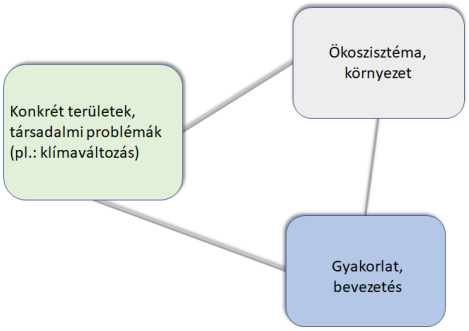


Fig. 15. Relevant areas related to implementation of new technologies

3.1.7. Technology service research area

Finally, in the „Technology service" analysis, the market introduction of the new service was examined. When bringing a new technology into market, it is necessary to know the specific goals, what to achieve. From the past, practical solutions might be available to help to open up a market. However, with a brand-new new technology, previous solutions may not be suitable. First, a theoretical background must be provided, like various factors must be analyzed and learned, and then their consequences must be taken into account. Finally, specific service mode and service structure need to be formulated. However, a key challenge is to be able to delimit the scope of application properly and thus compile the specific architecture. (Figure 16)

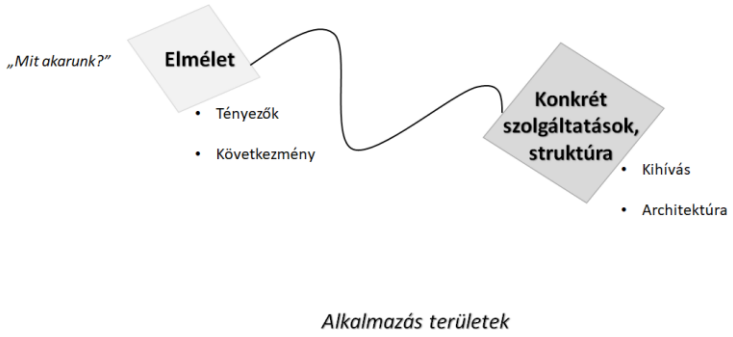


Fig. 16. Main research topic of new technology-related services

4. DISCUSSION

In summary, the seven study areas outlined using mind-mapping are closely related. In the field of technological forecasting and technological trends research, we defined additional parameters to be examined, such as the evaluation of the forecasting method, the examination of the required competence, etc. Even before the new trend appears, it is possible to gradually prepare for and attempt to adapt it, but for these it is important to evaluate the issues we have articulated, as it is not known the impact on the future (both for the company and society). In the life of a company, the development of a technology occurs when the given technological trend is adapted. This includes specific adaptation solutions and technology-related infrastructure, human resource and market demand assessment. We also set up this points as an evaluation of application method and technology. In the following steps, the defined area is application identification and market introduction, where we also formulated research input. These elements cover the examination of social, economic, market and technological impact. Continuing along this line, it can be said that a company can successfully adapt the technology to introduce it to the market. An illustrative summary is shown in Figure 17.

However, an additional level has emerged that our research has not covered, is the question of how to care for a technology.

It can be said that even if a new technology is successfully applied, technology forecasts should continue to be monitored, as it can easily turn out to be better than the current one. In addition, it is important to monitor the feedback of continuous social and market needs, and to map the development opportunities of the technology itself, even in combination with other technologies that can open up new directions.

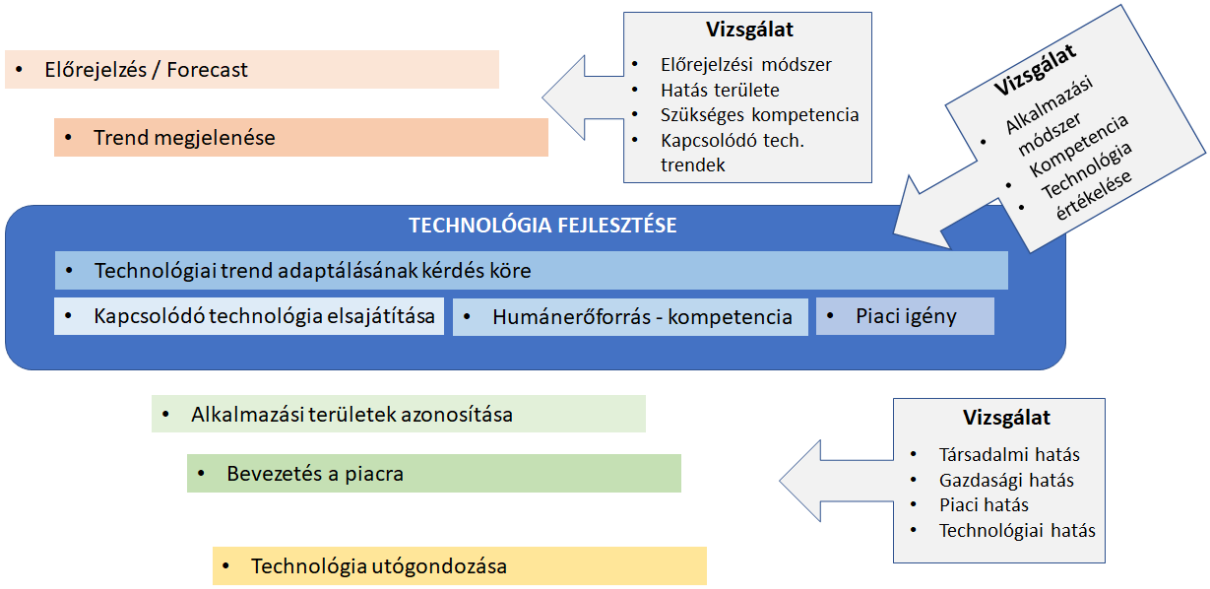


Fig. 17. Summary of the keyword researches – Application-Based Technology Research Map

5. CONCLUSIONS

Based on the presented point of view, the methodological issues and research of technology forecasting form a bridge between megatrends and the related comprehensive or sectoral technological trends and specific technological applications.

An important finding of this summary is that social aspects are important and indispensable elements of research on new technologies. In addition, it is the balance and integrated mechanism of actions of scientific and industry responses that drives the diffusion and widespread adoption of new technologies. Finally, the specific technology solutions are those within which operational technology management issues can be interpreted.

The triple division of the conclusion is illustrated in Figure 18.

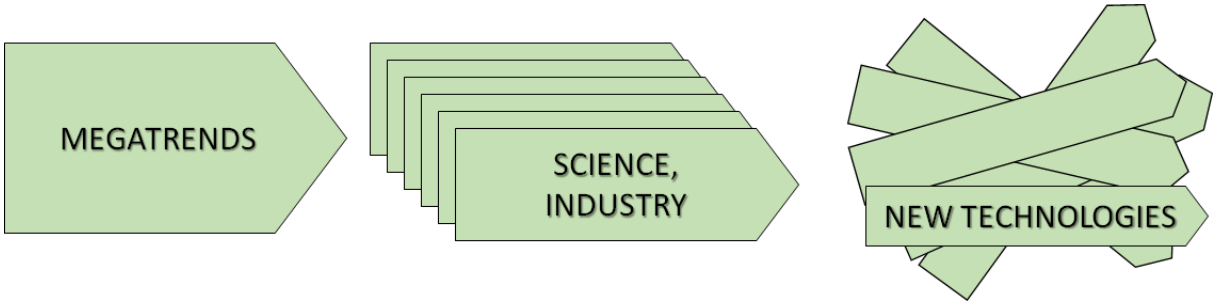


Fig. 18. The three-level approach of new technology solutions

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