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THE USE OF SCENARIO METHODS TO PREPARE TECHNOLOGY DEVELOPMENT SCENARIOS: THEORETICAL AND PRACTICAL ASPECTS

Key word

Scenarios, scenario methods, technology, technology development scenarios.

Abstract

Scenario methods enjoy strong popularity, especially in a situation of
changes with discontinuous characteristics. Thanks to their application, we can
identify factors of the environment that can have a significant impact on the
functioning of companies and regions. The use of scenarios for the analysis of
technology development is an expression of openness to changes taking place in
the environment. Thanks to them, it is possible to track changes, redefine
strategic assumptions, and consider decisions made. This paper presents
assumptions of scenario methods and practically uses the environment status
scenario method to formulate development scenarios of Intelligent Systems
technology in Małopolska.

Introduction

The meaning of technology for enterprises, regions, and consumers keeps growing. As a result of, among others, the development of IT systems, they have become the cause for revolutionary and evolutionary changes. At present, technologies determine the earned economic benefits of enterprises or the regions' innovativeness. Owing to discontinuity of changes, the specification of technological development directions is a difficult task. It increases in the situation of future uncertainty, excessive amounts of information, the shortening of the life cycle of products, and the time between the occurrences of ideas and the launching of the product on the market.

However, the prediction of technology development directions has a fundamental meaning not only for formulating strategy of enterprises but also for the proper shaping of economic policy. Managers keep looking for better and more precise methods of their prediction. Scenario methods and scenario building are still valid tools, enjoying strong popularity. The purpose of this publication is the presentation of theoretical assumptions of scenario methods and their practical application for the identification of the development of intelligent systems technology in the region of Małopolska.

1. Notion of scenario methods

The literature presents a wide range of various and sometimes contradictory definitions, characteristics, principles, and methodological ideas concerning scenarios. Additionally, as H. Kosow and R. Gaßner (2008) have written, a scenario can be defined as a description of a possible future situation, including the path of development leading to that situation. Scenarios are not intended to represent a full description of the future, but rather to highlight central elements of a possible future and to draw attention to the key factors that will drive future developments.

We may notice that the period of the development of scenario methods is long, and it was shaped by numerous factors, while their popularity is of a sinusoid character and currently they are experiencing their renaissance. It seems that the most probable reason is the global economic situation and the economic crisis as well as the continuous need to conduct systematic research in the organization's future. The notion of scenarios and scenario planning methods evolved throughout the centuries. However, it seems that certain ideas, notions, and events were so significant that they strongly influenced the contemporary shape and the character of scenario planning.

When conducting a critical analysis of the subject matter, we notice that the literature presents a wide range of various and sometimes contradictory definitions, characteristics, principles, and methodological ideas concerning

scenarios[1]. It results in, e.g., the diversity of opinions, methodological approaches, or definitions in this respect [24]. Numerous authors, including, e.g., M. Godet and F. Roubelat [6, 14, 21, 22, 29, 32], A. Khakee [14], D.H. Mason [22], D.G. Simpson [29], A. Martelli [21], A. Wright [37] believe that the notion of scenarios and methods of scenario planning is abused, and it cannot be defined.

The author who used the notion scenario for the first time was H. Kahn, according to whom scenarios are potential sequences of events prepared in order to expose accidental processes and the related decision-making problems [12].

The definitions of scenarios proposed by W.R. Huss [9], H.S. Becker [1, 2] and P.J.H. Schoemaker [25, 26] refer to events in the future and are a credible and consistent description of future conditions for the operation of an enterprise.

On the other hand, R. Kreibich [16], L. Fahey, and R.M. Randall [5] claims that a scenario is a projection of the potential future. It is a special combination of possible events and assumptions regarding future events. However, scenarios are not forecasts of future events, but a certain kind of view into the future that is formed based on specific information and a set of logical assumptions. P. Schwartz [28] is also of a similar opinion. He believes that scenario methods are not used for forecasting, but for increasing the level of strategic decisions.

H. Kosow and R. Gaßner [15] claims that, in the context of futurology, however, scenarios can also represent far more complex products which include the interactions of a plethora of variables [4]. Here too, however, "scenarios" may refer on the one hand to texts (with different degrees of comprehensiveness and detail) [cf. 30]; while, on the other hand, the term "scenario" may also refer to modulations of a quantitative model [cf. 30].

We will adopt the definitions of scenarios by H. Khan [12], according to whom "the scenarios are hypothetical sequences of events constructed for the purpose of focusing attention on causal processes and decision points". Scenarios will be a description of a possible future situation including paths of its development.

Scenarios in enterprise management are a source of information used in current decision-making, which enable a better understanding of the dynamics of changes, indicate ground breaking future moments, and make it possible to consider significant consequences of future changes for the enterprise. Scenarios are a good way to question the future and can be defined as a description of a possible future situation.

The future is shaped by technology like never before. Technologies play an increasingly important role not only in enterprises but also in the economy. It is very likely that the importance of technology will still increase in the future. We

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[1] More details concerning scenarios method, see E. Bielińska-Dusza 2013, Concepts of scenario methods in improvement of an enterprise, Business, Management and Education, Vilnius Gediminas Technical University, Volume 11, Number 1.

notice that technology is very often the cause of radical changes as well as their main driving force, and technological progress is a certain phenomenon.

However, considering the fact that technological changes are often revolutionary, the prediction of development directions and the effect on humanity, the company, or the economy is extremely difficult. Thinking in categories of the future is a challenge in itself, especially in the situation of the growing complexity of the world and the discontinuity of technological changes, which prevent future forecasting based on the past. In connection with the above, there will be increasingly use of the method of scenario in technology planning, forecasting, strategic analysis, and foresight studies.

Scenario writing proposes different conceptions of future technology. Each conception of the characteristics of the future technology is based on a well-defined set of assumptions. A scenario represents alternative characteristics of the future technology, with each alternative being based on certain assumptions and conditions. The results of this evaluation are used to determine the scenario most likely to occur [13].

The author considers that, in view of the above, we may make an assumption and suggest an original approach to treating scenario methods as a super-method. This means that it may be supplemented with other detailed methods and techniques. For example, the following groups of methods may be specified: heuristic methods, PEST, SPACE, ASTRA methods, and techniques of environment analysis, techniques of forced associations, and information methods.

It seems that the advantage of using the scenarios method supplemented with other detailed methods and techniques in improving enterprise is the reduction in the uncertainty level that accompanies almost all activities carried out in the contemporary world.

2. Scenarios of environment conditions for the intelligent systems technology in Małopolska

Analysis of technology problems clearly indicates that technology development becomes one of the key determinants for competitive advantage and can provide constant business development. Thanks to scenario methods application, we can identify factors of the environment that can have a significant impact on the development of technology. We can track changes, redefine strategic assumptions, and consider decisions made. The present part of the paper will present the results[2] from the use of the scenario method to

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[2]   The results are an effect of the works implemented under the Innovation Broker project as a tool for effective development of modern economy system of Małopolska Province, implemented by the Centre of Technological Forecasts of the Krakow Technology Park. Krakow 2013. Experts in the scope of the intelligent systems technology included: Nominated Professor PhD hab. A. Ligęza, PhD Eng., J. Bułka, PhD Eng., J. Jedliński, PhD, Eng.

formulate technology development scenarios of Intelligent Systems in Małopolska[3].

In the initial part of the publication, we have noticed that scenario methods are applied to the analysis of relationships between the phenomena present in the environment, the impact of these phenomena on the subject or object of our concern, and predicting their changes in the future. As emphasize by A. Kononiuk and J. Nazarko, scenario methods are the most common methods in regional foresight projects [18].

Attention should be paid that scenario methods, and the procedure is widely described in the literature of the subject, especially strategic management.

The author, for the purpose of building the development scenarios of technology IS, also suggests using other methods such as PEST, Delphy methods, the matrix of relations between factors, and substantive discussion between the members of the (experts) research team.

The method subsequently includes the following consecutive steps:

1. The determination of the impact of each of the factors on the development of technology and the identification of weight with the use of the following range of grades:
   – strength of impact 1 – small, poor, 2 – medium, 3 – high 4 – very high;
   – determination of weights 1 – little important, 2 – important, 3 – very important.
2. Indication of factors which may be important in the period of the next few years; and,
3. Identification of relations between the development of technology and macro-environment.

The procedure of implementing Item 3 comes down to performing the following activities:

1. Writing down very important factors (weight of which has been determined on Level 3) to a non-directional matrix of relations;
2. The identification of relations of i-th factor to other factors, at the same time, determining the character of this linkage. (It may consits in the impact of i-th factor on j-th factor, then we determine such relation with sign (+), or conditioning i-th factor upon j-th factor, we assign sign (–) to such relation);

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[3] The notion of intelligent systems (IS) is defined as systems that, in order to achieve the goal desired by the user, apply the obtained information and process it on the basis of their own self-learning mechanisms or built-in processing logic, permitting autonomous adaptation of their action to the changing working conditions; intelligent systems should have the following characteristics: internal representation of knowledge, embedded methods and algorithms for processing knowledge, modules and methods of acquisition and update of knowledge, executive devices (in the case of control systems), modules and methods of communication with the user.

3. The determination of impact force for all earlier specified relations, by indicating one grade from the following range of grades: (full – 5; very high – 4; high – 3; average – 2; weak – 1; not present – 0); and
4. Filling the matrix of relations between factors.

The earlier identified factors are subject to additional analysis. Not only their effect on the other elements of the environment is examined, but also the effects are determined that they can have of IS technology. This enables the definition of the importance of particular spheres of the macro-environment and not only for the present condition, but also for the future.

Later, the procedure of implementing the scenario methods includes the following stages [20]:
1. Identification of factors in particular spheres of the macro-environment having an effect on technology;
2. Assessment of identified factors in the environment:
   – The strength of impact of a given factor on technology: negative (very high: –5, high: –4, average: –3, small: –2, very small: –1) or positive (very low:+1, low: +2, average +3, high: +4, very high: +5);
   – The probability of changes of a given factor according to trend variants: growth, stagnation, regress (0.0–1.0).
3. Ordering trends according to scenarios: optimistic, pessimistic, most likely, and surprise;
4. Determination of the average factors' impact force in particular spheres of the macro-environment; and,
5. Reasoning.

Identified factors were the subject of further analysis. The selection of factors under different segments of the environment may affect and have a very high and high strength of impact of a given factor on technology and growth probability of changes of a factor.

It should be noted that, due to the limited number of publications and the vastness of workshop materials, Table 1 and Figure 1 present technology development scenarios of IS in Małopolska.

To prepare scenarios, four spheres have been adopted: political-legal, economic, socio-cultural, and technological. These spheres constitute a consequence of previously selected areas in the PEST method and the Delphi method.

In particular spheres, experts selected 7 factors, whose occurrence will be significant in the future for the development of IS technology in Małopolska (Tab. 1). The basis of the selection factors presented in table 1 was to use methods of PEST, the Delphi method, and substantive discussion between the members of the (experts) research team.

It should be noted that the experts, during the assessment, have taken into account the passage of time and technological progress and the new economic

conditions of widespread crisis, which has reduced the financing of research and development [19].

Table 1. Factors affecting the development of the IS technology in different spheres of the environment

| **Political and legal environment**	**Socio-cultural environment**
1. Quality and effectiveness of intellectual property law; 2. State policy towards innovations; 3. The occurrence and availability of fast paths for direct promotion of particularly innovative and competitive solutions; 4. The quality, consistency and stability of political conditions at the state level and region; 5. The elimination of restrictions related to the formal and legal aspect of business (bureaucratic barriers and restrictions on access to external markets); 6. The effectiveness of institutions and state agencies in supporting the development and innovation; and, 7. Quality administrative support R & D sector and public funds.	1. The popularity of engineering, sciences and natural science study majors; 2. The ability to undertake integrated activities in regional R&D environment; 3. The quality of education in the region; 4. The level of social awareness; 5. Shaping requirements concerning the labour market/the graduate's profile by employing companies; 6. Unfavourable demographic and labour market structure; and, 7. Emigration of the most creative, ambitious and intelligent individuals.
Technological environment	**Economic environment**
1. The efficiency of the environment sector research and development (institutions supporting the development of the sector); 2. Technological infrastructure; 3. Scientific and research and development infrastructure; 4. IT infrastructure; 5. Financial infrastructure; and, 6. Transport infrastructure.	1. The height and structure of capital for innovation; 2. Macroeconomic indicators; 3. Business costs; 4. Maintaining exchange rate stability 5. cost of access to information about the market, competition and certificates; 6. The level of development-oriented investments; and, 7. Labour market structure.
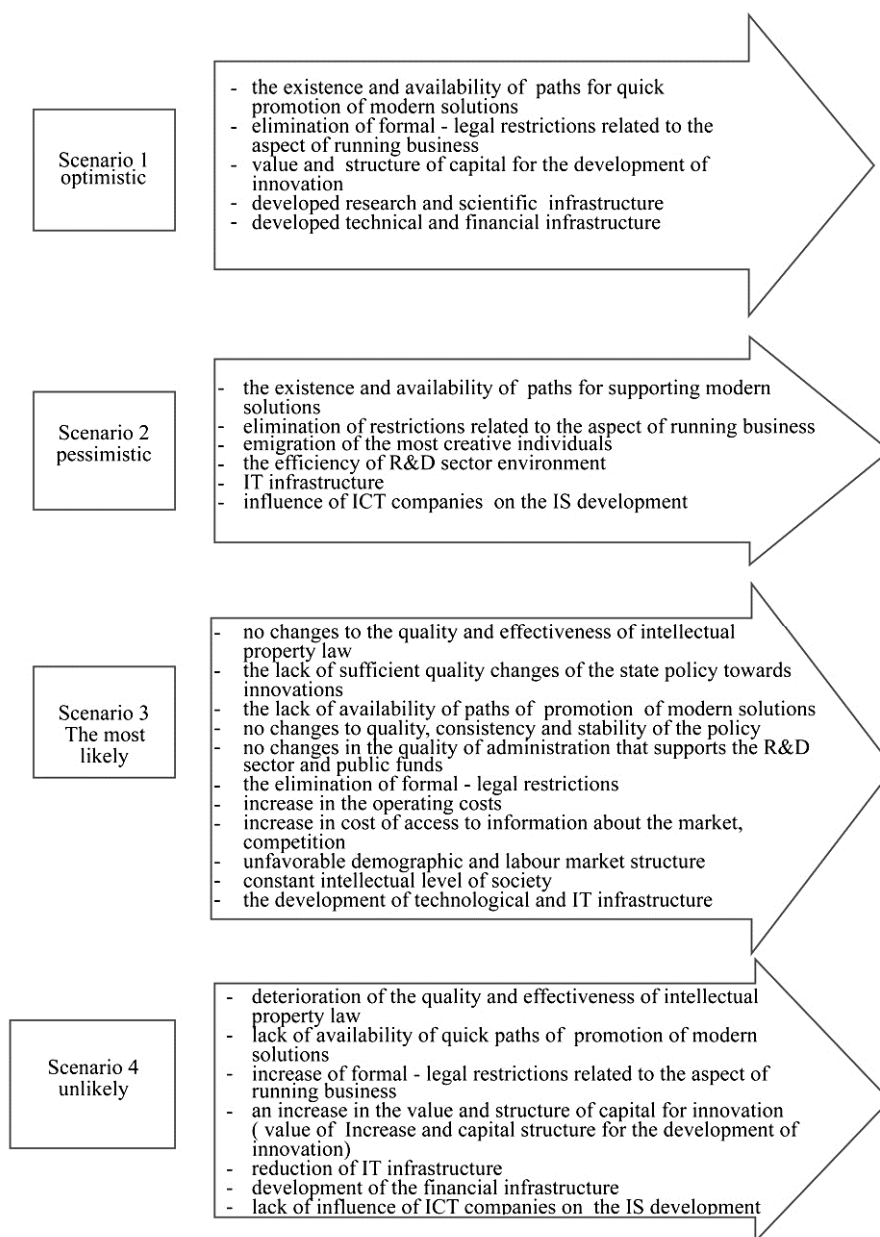
Fig. 1. Technology development scenarios of Intelligent Systems in Małopolska

Source: Prepared by the author based on the works of experts' workshop.

It is also important to note important areas of applications of intelligent systems, where there is funding and the possibilities of profitable export:

military applications, supporting public safety, health protection, medicine, prophylaxis, and public transport.

With regard to future constraints and methods of formulating the strategies relating to IS technology, the following guidelines have been determined.

IS technologies are strongly dependent upon the technological and the political-legal sphere. These spheres are characterized by great instability/variability, which means the necessity for their continuous monitoring.

The socio-cultural and technological spheres are heterogeneous and poorly structuralized, which requires further in-depth research.

The socio-cultural sphere and the technological sphere are dominated by opportunities. In relation to the IS technology, it is necessary to specify actions targeted at their use.

The political-legal and economic spheres are dominated by threats. It is required to determine projects aiming at their neutralization.

Factors favourable for IS development in Małopolska

- The educational and scientific potential of Małopolska;
- The concentration of IT industry in the region;
- Low capital outlays on product development and business itself so dynamic and innovative that only undertakings with short time of return on invested capital are reasonable;
- No patent blockades, which favours creative use of algorithms, ideas and models;
- A constant inflow of new companies from the IT industry, producing growing competition; and,
- The innovation of young people; formation of new companies, support for start-ups.

Factors hindering IS development in Małopolska

- Strong competition on the part of foreign knowledge centres in the context of the lack of system solutions and measures enabling funding high-risk projects;
- A low level of household wealth results in the fact that the local target market for niche, luxurious, and innovative products is too narrow;
- Adverse economic law;
- Excessive tax burdens;
- Poorly developed infrastructure – especially transport;
- Problems with the law in the scope of intellectual property and its protection; and,
- Ineffective system patent.

In relation to leading processes (that may have a very strong positive/negative impact on technologies), consideration should be given to their possible effects for the IS technology. In the strategy formulation process for IS technology and the effectiveness of its implementation, adaptation to opportunities and threats generated by these trends must constitute one of the basic elements of strategy creation and implementation.

Conclusions

The development of both enterprises and the economy is determined not only by the possessed potential but also depends on proper recognition and use of opportunities with simultaneous reduction in the existing threats. For this reason, the identification of factors and trends affecting technology development, support for the development of advanced technologies, and the identification of the level of progress of technology may contribute to obtaining sustainable development of both enterprises and regions over time.

In recent years, more scenario projects relating to the development of technology (technology forecasting) have been published in scientific journals than ever before. The scenario method has been classified as most helpful for strategic issues by several authors. However, there is no "one" scenario method. There is a wide spectrum of strategic aims covered by heterogeneous variants of the scenario method.

We can use a number of methods for forecasting technology as indicated by the following authors: T.J. Gordon [8], A.T. Roper, S.W. Cunningham, A.L. Porter, T.W. Mason, F.A. Rossinni, J. Banks [23], D. Turgul, O. Terry, and K. Jisun [31].

It can be assumed that the method should lead to the achievement of the objectives of the reaserch, having a degree of detail that is sufficient for the current state of evaluation of the test process. In addition, the use of appropriate methods and techniques in forecasting technology enables one to achieve satisfactory results.

In this case, it was decided for the construction of scenarios to use the scenario methods and other methods like PEST, Delphy methods, and the matrix of relations between factors with substantive discussion between the members of the (experts) research team.

H. Kosow and R. Gaßner [15] pay attention to one more important aspect, which is that scenarios are not intended to represent a full description of the future, but rather to highlight central elements of a possible future and to draw attention to the key factors that will drive future developments. Many scenario analysts underline that scenarios are hypothetical constructs and do not claim that the scenarios they create represent reality.

This statement also applies to the development of IS technology in Małopolska. These scenarios of development are hint to aid decision makers in

formulating goals, providing a tool for examining the potential effectiveness of strategies and to draw attention to specific issues that will be significant in the future for the development of IS technology.

In the analysed case, the experts identified 7 factors and 4 scenarios whose occurrence will be significant in the future for development of IS technology in Małopolska. It should be noted that generated scenarios are the framework and should be used to develop more developed descriptions of the future. Moreover, the concept presented is the result of a collaboration of experts from different scientific centres.

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Wykorzystanie metod scenariuszowych do opracowania scenariuszy rozwoju technologii. Aspekt teoretyczno-praktyczny

Słowa kluczowe

Scenariusze, metody scenariuszowe, technologia, scenariusze rozwoju technologii.

Streszczenie

Metody scenariuszowe cieszą się niesłabnącą popularnością, zwłaszcza w sytuacji zmian o charakterze cech nieciągłych. Dzięki ich zastosowaniu możemy dokonać identyfikacji czynników otoczenia, które mogą mieć istotny wpływ na funkcjonowanie przedsiębiorstw, regionów. Wykorzystywanie scenariuszy do analizy rozwoju technologii jest wyrazem otwartości na zmiany zachodzące w otoczeniu. Dzięki nim możliwe jest śledzenie zmian, redefiniowanie założeń strategicznych i podejmowanych decyzji. W niniejszym artykule zaprezentowano założenia metod scenariuszowych oraz praktycznie wykorzystano metodę scenariuszy stanów otoczenia do formułowania scenariuszy rozwoju technologii systemy inteligentne w Małopolsce.