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Phenomenon of Uncertainty in the Process of Holistic Anticipation of Non-deterministic Reality

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Abstract

Uncertainty is one of the most important features of many areas of social and economic life, especially in the forward-looking context. In order to significantly reduce the uncertainty in the current decision-making (by ordering the knowledge of the present tense), an entity can centre their actions on the future through the foresight actions. This article attempts to answer the following research question: "What factors and methods of foresight methodology enable the identification, analysis and minimization of the effects of uncertainty in the process of holistic inquiry of the future?" The study uses the results of analysis methods and criticism of literature as main research methods.

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Keywords: uncertainty; foresight; future; system; unexpected events

1. Introduction

In turbulent XX and XXI century, there are no easy methods to predict deterministic reality, which was characteristic for scientific analysis before the beginning of the quantum era. Thanks to the "quantum revolution" deterministic phenomenon in the science was to be overcome, in the beginning, in the area of physics. Then it had incontestable connotations in other sciences, such as philosophy, economics and management science [2]. In addition, more typically it transformed into so called progressive changes, which unlike the usual changes, do not run regularly, i.e. they are discontinuous and irregular and have not an equivalent in the past. The result of these phenomena is the growing area of uncertainty, both about the current decision-making as well as the future state of the examined systems [18].

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The uncertainty of the modern era is also the result of the complex interaction of forces of many kinds: technological, social, political, economic and environmental [17].

Uncertainty next to the complexity of the investigated phenomena, systems, creates a space in which one can determine limits of computability (Fig. 1). Alive systems, the climate, the economy will be still field of experiments and statements to the necessary but not entirely certain prove [4].

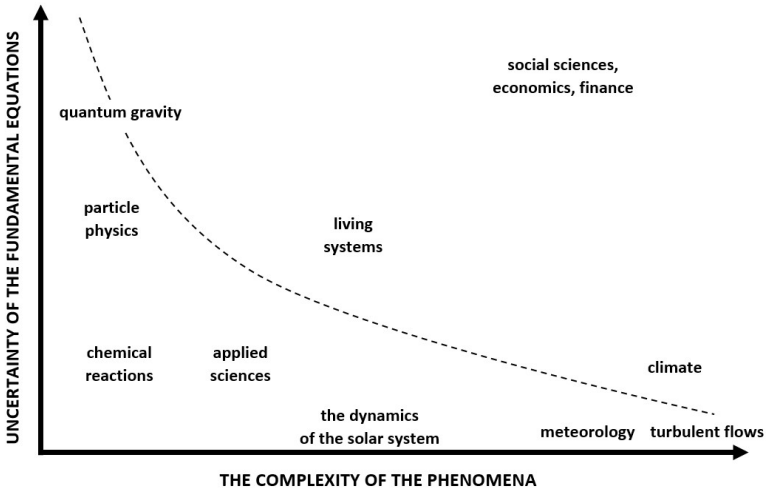

Fig. 1. The uncertainty and complexity as the boundaries of our knowledge.
Source: Author elaboration on the basis [4].

Interesting proposals for overcoming deterrministic thinking, especially in the context of anticipation of complex socio-economic-scientific-technological systems, in a holistic view, presents the methodology of foresight. Despite several decades of presence in the field of science foresight still requires unambiguous formulation, especially in terms of methodical knowledge. One of the important areas of research regarding foresight is the phenomenon of uncertainty. In foresight literature this aspect often is cited, but it seems to be the background on future research and not main subject. It takes the form of "action for the future under conditions of uncertainty".

The research problem in this paper is to identify, in a complex non-deterministic environment, sources of uncertainty by future research, in particular foresight research. This article attempts to answer the following research question: "What factors and methods of foresight methodology enables the identification, analysis and minimize the effects of uncertainty in the process of holistic inquiry of the future?"

In the article was used the results of the methods of analysis and criticism of literature as the main research method. On this basis, author conducted deductive reasoning.

2. The phenomenon of uncertainty in the context of study of the future

Predicting the future regardless of time horizon is always associated with some degree of uncertainty. It is the greater if examined areas of reality are longer and more complex [19].

Till now we have many definition of "uncertainty". Analyzing this phenomenon in the future context of the complex reality, we can say that the uncertainty lies in the fact that the observer tested the system in a given place and time, can not define with complete certainty the further functioning of it (the system), [20]. For further horizons uncertainty continues to expand and deepen. This is due among other things, the complexity of the features, structures and behaviours studied systems which usually extend beyond the area observed and verified by available knowledge, especially for individuals [2].

On the occurrence of uncertainty in the context of future analysis of the development of complex systems which performance is not based on the deterrministic phenomena affect following factors [2]:

- Multitude of possible system structures with high complexity and variability in time
- The number and strength of connections inside the system
- Numerous and insufficiently known links of system with the environment, and insufficient knowledge of this environment
- The scope of structural changes
- Behaviour of individuals and institutions managing system in the context of the potential going beyond the known rules and regulations
- Ignorance of potential new rules and principles and their scope
- Increasing number of possible combinations of events occurring in the studied systems
- The length of considered time horizon
- Lack of sufficiently complete data.

In a future study often is used "combined" method of construction models. It consists of defining the main, relatively stable and simple model combined by relationship with optional variants [1]. Help in the search for appropriate structures of model regarding the uncertainty study can be the classification of the models and their application based on the knowledge (Fig. 2), [13].

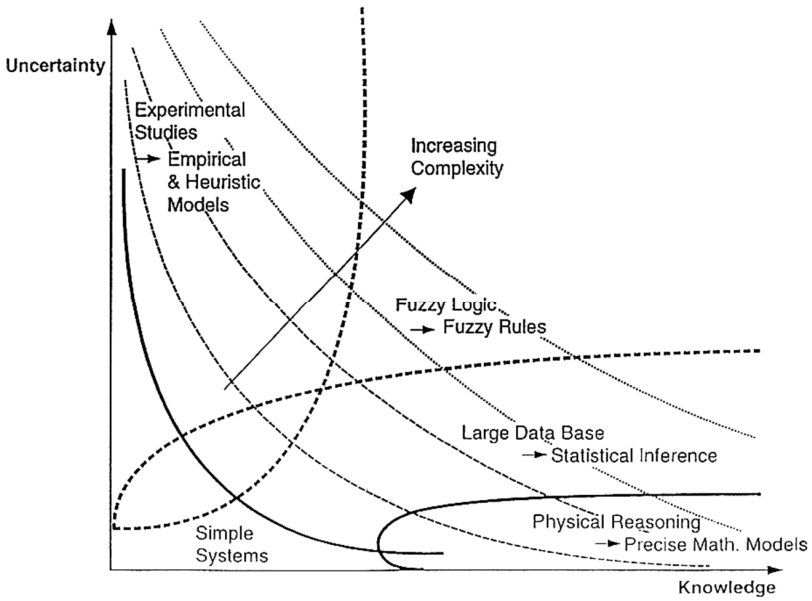

Fig. 2. Model types in relation of knowledge to uncertainty.
Source: Author elaboration on the basis [3].

In the process of inquiry the future, there are two types of conditions on the anticipation and decision-making. Referring to the A.H. Willett these conditions are objective (mathematically quantifiable) risks and subjective – interpreted uncertainty [12].

In the process of inquiry the future, uncertainty can be regarded as a barrier to achieving one hundred percent reliability of the predictions. Beyond the boundaries of risk conditions (Fig. 3), the uncertainty of predictions accumulates, because it concerns two related categories: identification of individual strategies and the likelihood of their occurrence [13].

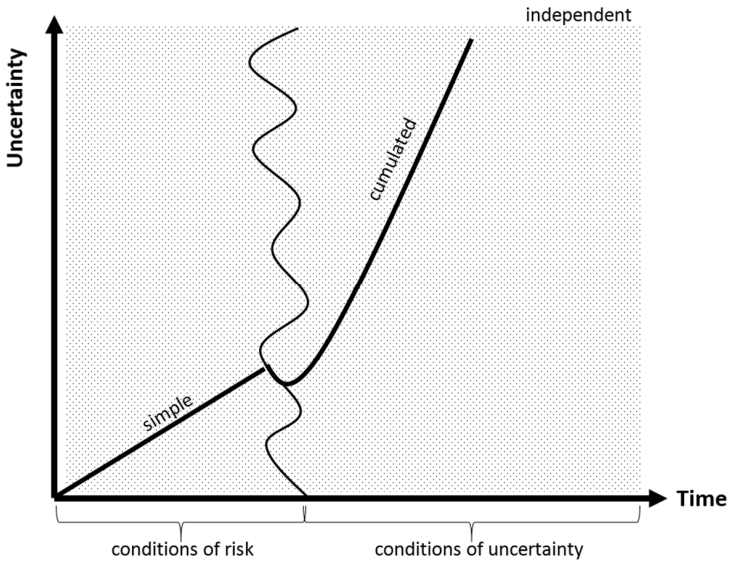

Fig. 3. The ratio of risk to uncertainty.
Source: Author elaboration on the basis [13].

On the basis of the foregoing, E. Jańczuk distinguishes three types of uncertainty: simple uncertainty (which is the difference between certainty and reliability in terms of risk), accumulated (in the strict sense) and independent (unprecedented). Uncertainty independent refers to abnormalities that represent a total surprise to the observer. These phenomena appear simultaneously with the occurrence of are knowledge [13].

3. Factors of the holistic foresight methodology affecting to study the uncertainty phenomenon

In order to determine the vision of the development of phenomena in time significantly exceeding the maximum horizon of typical mathematical projections (based on a deterministic approach), you can use expert (intuitive) approaches research. One of these tools to identify, interpret and minimalize the phenomenon of uncertainty and the conditions of its occurrence may be the foresight methodology [5–10]. Foresight is a branch of the collective (based on a group of expert opinions) anticipation of complex phenomena which causes the individual expert opinions burdened with an element of subjectivity in the event of their total analysis increases the likelihood of obtaining results with a high level of objectivity.

The integration of predictive knowledge can contribute to reducing uncertainty about the correctness of the expected future understood as the convergence of the created expertise with the objective probability [13]. Because in the predictive considerations, the aim is to minimize any uncertainties associated with predictions, the question is "what factors or its combination affect the identification, analysis and minimalization the phenomenon of uncertainty with the foresight methodology?"

According to R. Slaughter, using any method in foresight studies you must always be reinforced with in-depth knowledge of the foresight process, which course affects a lot of factors [20].

Literature and direct observation allowed the author to identify a list of factors related to the process of foresight which must be taken into account under designing research methodology of foresight. Based on the author's experience of foresight and literature data factors were synthetically grouped. It was evaluated factors of foresight methodology to study the phenomenon of uncertainty in 3 areas: identification, analysis and minimalization. It was made in terms of the degree of influence of each group (Table 1).

Table 1. The degree of the impact of main foresight factors to study the phenomenon of uncertainty.

IMPACT ON UNCERTAINTY STUDY →	I	A	M	IMPACT ON UNCERTAINTY STUDY →	I	A	M
STARTING POINT				**HUMAN RESOURCES**			
Institutions realizing foresight	✸✸	✸	✸	Methodological and organizational competence	✸✸✸	✸✸✸	✸✸✸
Partners of consortium	✸	✸	✸	Stakeholders	✸✸	✸✸	✸
Cooperating institutions	✸	✸	✸	The scale of participation	✸✸✸	✸✸✸	✸✸✸
Institutional Architecture	✸	✸	✸	The involvement of social participants	✸✸✸	✸✸✸	✸✸✸
The information and material infrastructure	✸✸	✸✸	✸	**ASPECT OF TIME**			
Way of process management	✸	✸	✸	Time for study	✸✸	✸✸	✸✸✸
Access to quantitative and qualitative data	✸✸✸	✸✸✸	✸✸✸	Horizon of foresight	✸✸✸	✸✸✸	✸✸✸
RESEARCH AND GEOGRAPHIC CONTEXT				**FINANCIAL ASPECT**			
Territorial scope	✸✸✸	✸✸✸	✸✸✸	Budget of project	✸✸	✸✸	✸✸
Type of foresight	✸✸	✸✸	✸✸	Sources of funding	✸	✸	✸
The needs of the project	✸✸✸	✸✸✸	✸✸✸	**METHODOLOGICAL BACKGROUND**			
Subject of study	✸✸	✸✸	✸	Key attributes of methods	✸✸✸	✸✸✸	✸✸✸
Objectives	✸✸✸	✸✸✸	✸✸✸	Legitimacy combination with other methods	✸✸✸	✸✸✸	✸✸✸
Expected result	✸✸✸	✸✸✸	✸✸✸	Cognitive Nature	✸✸✸	✸✸✸	✸✸✸

The degree of the impact of main foresight factors to study the phenomenon of uncertainty

✸ (low) ✸✸ (medium), ✸✸✸ (high)

I – Identification; **A** – Analysis; **M** – Minimalization

Source: Author elaboration on the basis [11, 16].

A very high degree of influence on the foresight research methodology shows 12 factors, including the entire range methodological context. Six factors: institutions realizing foresight, partners of consortium, cooperating institutions, institutional architecture, way of process management, sources of funding, has an average degree of influence. The lowest impact on the study of uncertainty phenomenon shows 6 factors. These are: the information and material infrastructure, type of foresight, subject of study, stakeholders, time for study, and budget of project.

The big advantage of foresight methodology is a large collection of usable methods (Table 2), which can be used in very different contexts and configurations [14].

Table 2. Classification of foresight research methods.

The name of classes	Methods belonging to each class
Consultative	Voting, Polling, Survey, Interviews, Expert Panels, Essays, Conferences, Workshops, Citizen Panels, Brainstorming
Creative	Wild Cards, Weak Signals, Mindmapping, Lateral Thinking, Futures Wheel, Role Play, Business Wargaming, Synectics, Speculative Writing, Visualization, Metaphors, Assumption Reversal
Prescriptive	Relevance Trees, Morphological Analysis, Rich Pictures, Divergence Mapping, Coates and Jarratt, Future Mapping, Backcasting, SRI Matrix, Science Fiction Analysis, Incasting, Genius Forecasting, Futures Biographies, TRIZ, Future History, Alternative History
Multicriterial	Key Technologies, Source Data Analysis, Migration Anal., Shift-Share Anal., DEA, Factor Anal., Correspondence Anal., Cluster Anal., Sensitivity Analysis, AHP, Input-Output Anal., Priorization, SMART, PRIME, MCDM
Radar	Scientometrics, Webometrics, Patent Analysis, Bibliometrics, Technological Substitution, S-Curve Analysis Technology Mapping, Analogies
Simulation	Probability Trees, Trend Extrapolation, Long Wave Anal., Indicators, Stochastic Forecast, Classification Trees, Modeling and Simulation, System Dynamics, Agent Modeling
Diagnostic	Object Simulation, Force Field Anal., Word Diamond, SWOT, STEEPVL, Institutional Anal., DEGEST, Trial&Error, Requirement Anal., Theory of Constraint, Issue Management, ANKOT

The name of classes	Methods belonging to each class
Analytical	SOFI, Stakeholder Anal., Cross-Impact Anal., Trend Impact Anal., Structural Anal., Megatrend Anal., Critical Influence Anal., Tech. Barometer, Cost-Benefit Anal., Technology Scouting, Technology Watch, Sustainability Anal., Environmental Scanning, Content Analysis, FMEA, Risk Analysis, Benchmarking
Survey	Web Research, Desk Research, Tech. Assessment, Social Network Anal., Literature Review, Retrospective Analysis, Macrohistory, Back-View Mirror Analysis
Strategic	Technology Roadmapping, Tech. Positioning, Delphi, Scenarios, Social Impact Assessment, RPM, Technological Scanning, Multiple Perspectives Assessment, Causal Layered Analysis, MANOA, Action Learning

Source: Author elaboration on the basis [15].

Similarly, because the study of factors in foresight methodology has been made, in the 3-point scale, classes of methods were evaluated in the context to three research functions in the uncertainty phenomenon. The summary results (Table 3) were obtained in relation to research, characterized in the papers [14]. These results referred to the analysis of the features of the all research methods of foresight.

Table 3. Linking classes of foresight methods with the research areas of uncertainty: the identification, analysis, and minimization.

RESEARCH OF UNCERTAINTY →		IDENTYFICATION	ANALYSIS	MINIMALIZATION
CLASSES OF FORESIGHT METHODS	Consultative	✱✱✱	✱✱✱	✱✱
	Creative	✱✱	✱✱✱	✱✱✱
	Prescriptive	✱✱	✱	✱✱✱
	Multicriterial	✱✱✱	✱✱✱	✱✱
	Radar	✱✱✱	✱✱	✱
	Simulation	✱	✱✱✱	✱✱
	Diagnostic	✱✱	✱✱✱	✱✱
	Analytical	✱✱	✱✱✱	✱✱
	Survey	✱✱✱	✱✱	✱
	Strategic	✱	✱✱	✱

The first class is a group of consultative methods based on the study of expert opinion. This is particularly important in the case of complex issues where there is a high uncertainty regarding the interpretation of the data, or in the case of the creation of future events that may result from specialized and difficult issues. Thanks to the methods of this class, it is possible to collect tacit knowledge, inaccessible in traditional sources of information for which there is a good connotation to testing uncertainties. People involved in the study should represent the different environments: scientific, economic, media, social, and should be professionally associated with the various fields of research.

The second class has a strong connection with research of uncertainty. It brings together creative methods, which are a useful tool for planning or construction of the development vision of the audited entity, but also in solving the current problems. These methods allow synthetic unconventional presentation of many issues with a single shot (in the form of diagrams, maps, drawings). They facilitate discovery (using simulations, analogies) seemingly unrelated relationship (interaction) between the various aspects influencing the formation of entirely new ideas. The end result of applied research approaches is the image of a future reality, often breaking tested schemes

The starting points in prescriptive class are the needs and objectives from the perspective of the desired future (established based on meeting specific individual or group ideas/vision of the research participants). Using the methods of this group it is possible to make identification, indexing and counting solutions to the problem from the present and future point of view, activities, and events, in different contexts, mostly in systemic or holistic terms. In the context of uncertainty it is a group of methods, which closely relates to the effect of minimization uncertainty.

The fourth class of multicriterial methods uses the quantity and quality data for complex research problems. Methods of this group, using the expert opinions, allow measuring the relationship regarding the current state between a large group of variables and criteria used for the test subjects. These methods help in the classification and selection

of alternatives of action, with a large number of decision-making criteria. They are used to determine the optimal priority issues. Therefore, methods of this group have a strong potential to identify and analyze chosen areas of uncertainty.

Most methods of radar class refers to the analysis of the current state as well as the past, so the methods of this group very well may be checked in the process of identifying various aspects of uncertainty. These methods focus on monitoring, categorization, typology, classification, identification networks, analyzing influences, analyzing bibliographic sources, online, patent-related technology as well as on other aspects in order to detect important signals regarding the latest research discoveries, technological potential of innovation and all opportunities and threats.

Simulation class focuses on hard (quantitative) methods of mathematical perspective. The most characteristic features of this cluster is analyticity, the graphic nature, using secondary data, generate codified results. Methods of this class facilitate the simulation and analysis of the development in many possible variants of a complex system in the form of interactive and combinational links. The end result of simulation methods are usually based on analysis of trends, statistics, and probability (forecast) investigated the occurrence of events. Thanks to the methods of this group, it is possible to measure numerical level of uncertainty, in extreme cases, taking the form of risk.

Methods of diagnostic class are based on expertise, in a systemic way recognize, analyze and assess the current state of the object characterizing all kinds of factors and trends, and stimulating inhibitory effect on the (object) development. Apart from purely diagnostic character another important aspect of these methods is to identify and evaluate potential directions of development of the study area. The purpose of the methods belonging to this class is also a quality strategic identification, assess and manage potential problems, constraints and the associated uncertainty, using among other solutions from other systems and objects.

The analytical methods identify and analyze, often in a heuristic way, drivers of change, and the factors that influence these changes. Analysing the mutual influences on different aspects it is takin into account the direction of these effects and their intensity. Analytical methods allow you to define a long-term assessment of developments in selected areas, indicating the intensity and level. Methods from this group allow identifying breakthrough phenomenon (e.g. technology) products, potential strategies related to the examined areas, as well as solutions to specific problems. In the context of uncertainty analytical methods are characterized by similar characteristics as the diagnostic methods.

Survey methods, in the context of uncertainty research have a similar interpretation to the radar methods. They assist in the evaluation of available secondary data, such as publications, reports, newsletters, databases, directories, statistics, publications, Internet portals and other sources. Survey class has a logical, reflective approach, based on the analysis of the current state of knowledge regarding the study area (both in the strictly scientific way, as well as based on simple observations). In particular methods form survey group relate to the present time but also help in the spatio-temporal analysis covering the history of the analyzed issue (for example, social systems) contributing to the assessment of the reasonableness of past actions, experiences and verification of the validity of taken decisions.

Methods of the strategic class are helpful in strategic planning, scenario building, solving the complex problems of decision-making and management of changes, strongly taking into account the conditions of uncertainty. They assist in the formulation of the final results of the final projects while process of discovering key factors and trends of development in the context of science, innovation, technology.

Referring to the above analysis, it is noted that the classes show the strongest correlation with the areas of the identification and analysis of uncertainty. The strongest relationship to minimizing the phenomenon of uncertainty relates to the creative, prescriptive and strategic classes.

4. Conclusion

In the post Second World War era the challenges facing decision makers in both the public and the private sectors mounted in complexity and uncertainty. The future is always uncertain. But it seems at the moment as though the uncertainties facing us are more likely and more potentially disruptive than at other times [17].

Uncertainty is the absolute correctness within the reality known to man. The degree of uncertainty is related objectively to a mechanism (being) a phenomenon that is always random. From the human or the system point of view uncertainty is compounded by imperfection of factors perception, proper specificity of perception of the human

being (subjectivity of perception), [20]. Subjective estimation is based on currently available bases of data in this reference work [19]. Wherever is possible, this collection should include data on the currently present uncertainty regarding the study area. Such data can be unambiguously described by means of objectively understood probability. It is desirable that in the process of long-range prediction of the subjective assessment of the likelihood are verified as updating the resource information. Ideally, systematically corrected data currently present uncertainties affect the long-term predictions [13].

Some areas of uncertainty are the fields of challenges for searchers of symptoms phenomena that are only seemingly undetectable. Such phenomena can be predicted, if we know what to observe and how.

Implementation of the jointly developed accepted and systematically verified in the process of foresight results should reduce the uncertainty associated with the future and increase the chances of making choices that give good results [13].

By C. Cempel in the process of inquiry the future, it is important to take into account the uncertainty and associated unexpected events [3]. Referring to the results presented in this article group of foresight methods by which you can make such an analysis is the class of creative methods.

According to the author it was achieved the goal established in the article. Factors and a wide range of methods have been identified. Thanks to them it is possible to identify, analyze and minimize the phenomenon of uncertainty in the context of holistic future investigations. In addition, it was demonstrated the rationality of the need to systematically anticipate in order to make appropriate practical decisions, assuming the phenomenon of uncertainty, the behaviour of systems at the same time accepting non-deterministic perception and understanding of reality.

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