APPLICATION OF TECHNOLOGY FORESIGHT STRATEGY IN INNOVATION ACTIVITY

Nataliya Pankratova

Abstract: The methodological tool of the technology foresight strategy in innovation activity which is based on the new expert estimation principles and software for processing the results of the foresight under the real conditions are proposed. Obviously, this strategy should determine the main development directions of strategically important industries, the prospects of competitiveness products, the sensible use of natural, human, industrial, and scientific resources, and the technological potential of the country, and the strategy should consider the needs of the world market of high technologies and hi-tech products take into account the processes of sustainable development.The real projects were realised on the basis of proposed methodological instrument and created software.

Keywords: foresight system strategy, new principles, innovation activity, mathematical tool, software

ACM Classification Keywords: H.4.2. Decision Support

Conference: The paper is selected from XVth International Conference "Knowledge-Dialogue-Solution" KDS 2009, Varna, Bulgaria, June-July 2009

Introduction

The modern stage of the world's development is characterized by high globalization rates of economical, social, ecological, and other processes. Global processes have created the new development effect, which M. Godet – the French economist – has completely and precisely characterized by a short phrase: «The future ceased to look like the past» [1]. In our opinion, the essence of this effect is based on the fact that the typical approaches and methods to prognosis targeted on investigation of the evolutional gradual development cannot detect and foresee the changes in the process that are quick in time and discontinuous. At the same time, such processes characterize the modern global dynamics of the world system. Such dynamic characteristics given by the continuous influence of the semistructured, multilevel, hierarchical, practically unlimited set of continuously changing positive and negative correlations, interdependencies, and interactions between different processes, factors, and situations. The dynamic results started to reveal themselves as «the unforeseen and unpleasant consequences» [2]. Under the existing conditions of the world dynamics, the innovation activity becomes the defining tendency of the economical and social progress.

Practical necessity in new, system coordinated principles, approaches, methods of revelation of possibilities and measurement of prospects and tendency of civilization and international economy development and prospects of innovative development of specific country as well have appeared. In some countries and international organizations the new apparatus of qualitative and quantitative foresight of different dynamic processes, which in general calls science and technology or technology foresight, begins to develop intensively.

Goal of this paper is to present methodological tool for scenario analysis information platform creation in real conditions of innovation activity [2]. It is necessary to note, that when deciding practical foresight problems on the basis of the scenario analysis platform, expert estimations are received, as a rule, via Internet in on-line mode. One of the most important aspects of scenario analysis information platform is development of expert estimation procedure conception, methodology and software.

1. Peculiarities of innovative activity management

The complexity of dynamics and uncertainty of properties in intercommunications, interdependencies, interactions between different processes and factors require prior investigations on the basis of the models which define existing interconnections between the processes and practically required interconnections between the innovation activity subjects. The structural model is proposed on Fig. 1, which defines the structure and goals of systemic relations between the main organizational innovation activity subjects (industry, science, education) themselves and between them and the market of intellectual products [3].

We should note that the innovation activity strategy of the country is totally different from the development program of the country under the planned economy conditions. It is so not only due to the underlying differences between the market economy and the planned economy, but it is also due to the peculiarities of innovation activities under the modern conditions of high dynamism and globalization of international processes. The main difference is the conceptual uncertainty; unlike the informational uncertainty, such an uncertainty is conceptual in a sense of understanding it as the uniform system of uncertainty, ambiguity, and inconsistency of interrelated and interdependent elements of the set of uncertainties of various types. This set contains the uncertainty of goals of development and perspectives of innovation product competitiveness; the dynamics of the demand and distribution markets of competitive products, active competitors' opposition; the situation risk uncertainty in the dynamics of developing, producing, distributing, and using the innovation products.

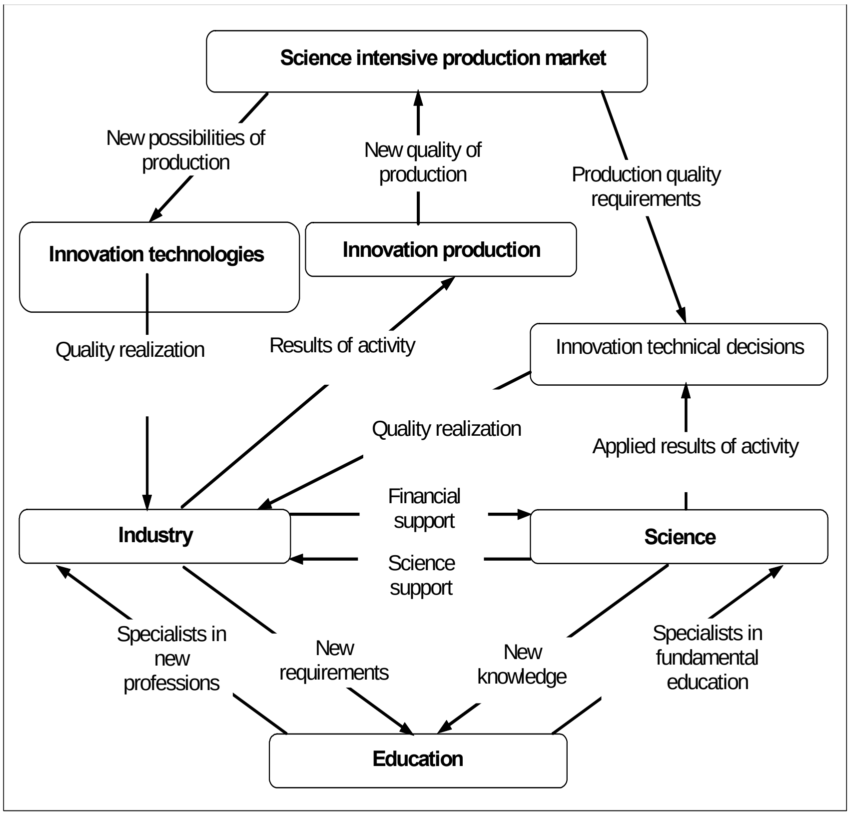

Fig. 1. System subject correlation structure of innovation activity

2. Scenario analysis as a basic foresight methodology

Formally by the term foresight we shall understand a complex system with a human factor that may be presented by a company, an enterprise, an industry, or a country as a whole, uniting certain parts of society (humans or any social groups) with technological, ecological, economic, and other components that are characteristic of such systems. First of all, these systems may be subjected to various external influences and restrictions: legislative, political, economic, etc. Systems with a human factor consist of various subsystems with complex interconnections between them, of both quantitative and qualitative character. They function according to various purposes that, in most cases, clash among themselves. For complex systems with a human factor considerable uncertainties of data and information are characteristic, and risks of various sorts are inherent in their behavior. Expert judgments concerning their qualitative character always have a subjective character. Thus, taking into account all peculiarities of such systems, regarding their behavior in the future quite definite decisions should be taken in the form of scenarios and strategies of their development. Qualitative and quantitative methods are used to solve such problems in a complicated human–machine procedure. It is important to note that the influence of the human factor on foresight results determines the major level of subjectivity of the given procedure. It is connected with a combination of objective knowledge and subjective human attitudes to the object under investigation.

Every expert taking part in the foresight process expresses his or her personal opinion in the form of subjective estimation; however, at the same time, he or she should be maximally guided by objective knowledge. At the same time, such a glance into the future requires hypotheses and assumptions. The convergence of objective knowledge and creative assumptions in an interactive human-machine procedure allows one to increase the accuracy of the development scenarios for processes, phenomena, and events under investigation. Such scenarios can be constructed with the help of the universal set of means and approaches called scenario analysis methodology [2], which is a complex of mathematical, software, logical, and organizational means and tools for determining the sequence of method application, their interconnections, and the formation of the foresight process in general In the first stage one should study the problem and the object of foresight using qualitative and quantitative analysis. After that qualitative and quantitative information is reduced to a unique platform. Then the consequences of the methods will be defined and the interconnection between them will be established. This makes it possible to form a complete foresight process and to develop a group of scenarios of the future behavior of the foresight object (complex system with a human factor).

Analyzing characteristics and peculiarities of each of the developed scenarios the group of strategic decision makers chooses scenarios that interest them, develops a plan of action according to the foresight object, and ensures implementation of this plan.(Fig.2). Comprehensive analysis of these scenarios is carried out in accordance with the following procedure: determine the reality and feasibility level for each scenario; estimate event probability based on scenarios; estimate risks connected with each of the scenarios; construct simulation models; select most acceptable scenarios based on above indicated criteria. The realness and realizability level of each scenario (confidence level) is determined on the basis of searching for each event of the scenario “contrary instance” or “antievent,” which excludes the possibility of realization of the examined event. If such antievents are found, the confidence level for the investigated scenario decreases. The procedure is based on the application of methods of combinatorial mathematics of variants of enumeration of combinations.

3. Development of principles of technology foresight strategy

The formulated requirements raise a number of completely new problems related to the strategy of technology foresight; among these problems, first of all, we should underline those related to the development of new expert estimation principles in technology foresight. A technology foresight strategy should not only satisfy the new requirements, but also correspond to new conditions in innovation activities and correct itself in synchrony with the changing market for the corresponding product type. Adjustments of one’s strategy should be adapted to dynamic market changes while preserving the strategic goals in the national manufacturing. In turn, strategic goals should be coordinated with the long-term development trends of the world market and the development dynamics of the corresponding national industry.

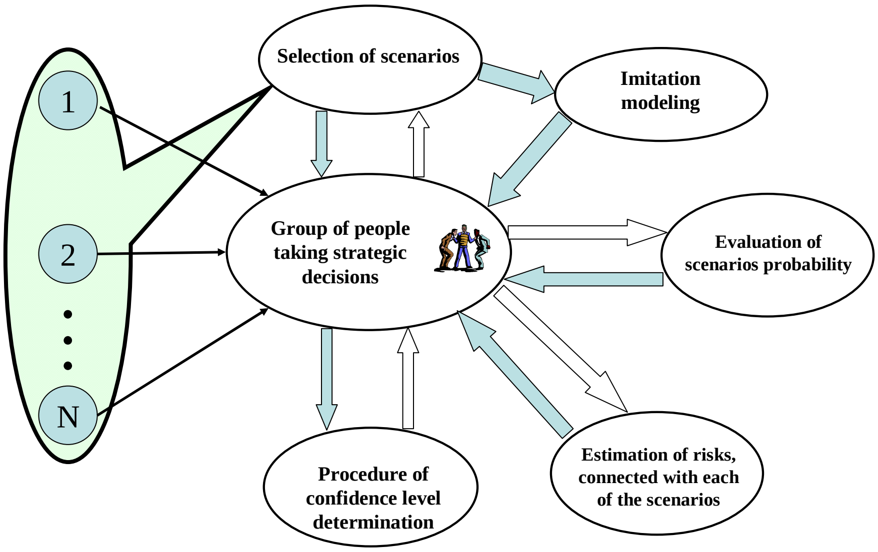

Fig.2. Submission of scenarios to the group of people taking strategic decisions, their analysis and selection

The necessity of developing new principles of expert procedures is dictated not only by the listed earlier factors and peculiarities of innovation activities, but also by the essential differences between technology foresight conditions and typical conditions of expert estimations. Typical expert procedures are oriented toward intuitive execution of the logical analysis of objects or processes of reality on the basis of comparing, ranking, systematizing, grouping, uncorrected proof measuring, classifying, and other procedures. In particular, the classification may be performed as the ranking of objects by increasing (or decreasing) values of a given parameter the quantitative (or qualitative) value of which is known for every object, and may be measured or calculated. Other expert procedures are implemented in the same way. Essentially, the ability to obtain initial information with the required completeness level means that an expert (each expert individually or the expert group as a whole) knows a priori that the given expert evaluation procedure can certainly be performed. Moreover, when information is provided with the use of expert evaluation results, it is possible to make a valid statement about the feasibility of implementing the given technologies, products, or other products, processes, and actions under investigation. Such conditions are satisfied in practice for a wide range of problems. From the theoretical viewpoint, this approach corresponds to the *potential realization principle*, which is accepted in intuitive logic [4]. The main point is that an expert knows a priori, proves, or postulates that the procedure is potentially realizable, and that is why he can ignore limitations in space and time resources. Furthermore, in the case of implementing the potential realization principle, the conditions are satisfied for the invariance principle of intuitive logic.

The main point of the invariance principle is the following: if the validity of any statement, opinion, or conclusion is determined or proved, it will holds in the future too [4]. Note that the conditions and principles mentioned earlier allow us not only to simplify the solutions to many important theoretical and practical problems, but it also allows us to create various automatic systems for classifying, comparing, measuring, and rejecting various products, making it possible to exclude human participation in expert procedures. However, fundamentally different conditions are typical for technology foresight expert procedures. The high competition dynamism of innovation products in the world market place has created fundamentally different conditions of innovation activities, which are characterized not only by the conceptual uncertainty of market dynamics, but also by the multifactorial risk of overdue realization and quick obsolescence of an innovation product proposed in any project, and also due to the absence of technological possibilities for product realization. In particular, information incompleteness and uncertainty of many properties and peculiarities of attitudes toward the innovation product in the market are typical for an innovation project, for example, the information on how potential buyers and competitors feel about this product. Thus, the technical foresight expert procedures cannot be implemented for a typical expert estimation, which requires complete and valid information about the object under investigation. Therefore, technology foresight expert evaluation procedures should not only conform to the fundamentally new requirements, but it should also contain the fundamentally new characteristics and principles of organization and realization of expert procedures.

Expert procedures in technology foresight should be organized and realized on the basis of technologies that allow the insufficiency and uncertainty of the initial information about the investigated innovation object to be supplemented and compensated with knowledge, experience, intuition, and human foresight. In this case, the expert estimation results become dependent on many new risk factors that, in the group strategy of a typical expert estimation, are practically excluded. We need to emphasize that, among these factors, the expert estimation results depend on the peculiarities, knowledge, experience, and ability of a customer to determine the expert estimation goals and problems, a manager to choose the expert estimation strategy and form experts' groups, and, what is most important, the results depend on the abilities, knowledge, experience, intuition, and foresight of each expert. Note that, under conditions of uncertainty, the dependence arises on external factors and time, on the amount and level of research in scientific areas that have a direct or indirect effect on the innovation object under investigation. The essence of such dependence is the fundamental possibility to change estimations of an innovation object during a comparatively short period of time. If something is not known today, that does not mean that it will be impossible to realize an innovation object in the future. It may become known, possible to realize, and very useful and needed tomorrow. The most impressive example is a personal computer. But it is not excluded that tomorrow someone proves that a given innovative technological solution or a product is unquestionably impossible to realize.

Therefore, conditions and factors that exclude a priori postulation of potential realization of an innovation project or product take place in innovation activities. And, as a result, the possibility is excluded of realizing the invariance principle in time for the correctness of an expert statement, opinion, or conclusion. It follows that other principles that take into account its conceptual uncertainty must work for innovation activities; therefore, they differ completely in their properties from the principles of intuitive logic that are the potential realization principle and invariance principle [4].

Based on the expert procedure analysis of innovation activities, the following principles can be proposed. Instead of the potential realization principle, *the possible realization principle* is suggested [5]. This principle postulates that for certain innovation objects (scientific ideas or technical solutions, or projects of industrial products, or manufacturing technologies), the initial expert estimation results cannot guarantee their practical feasibility or prove the impossibility of being realized. This principle postulates that for the listed innovation objects, based on the expert estimation results of the presented information, a reliable estimation cannot be obtained a priori that would allow one, for the object under investigation, being grounded and valid, to exclude the possibility of being unrealizable. The estimation for an innovation project retains the uncertainty of the conclusion about the possibility of realization, until, theoretically or exuncorrected proof perimentally, the possibility of technical or technological realization is proved for the product.

Instead of the *truth invariance principle*, which postulates the invariability of the theoretical or technical statement, judgement, conclusion, or opinion about the object for a comparatively long time, a completely different principle is needed. Such a necessity is brought about by the previous principle and the innovation activity practice, as expert estimations under conditions of conceptual uncertainty cannot stay the same for a long time. In scientific research and experimental design processes, not only new knowledge about a product under development is accumulated, but the conception about the product's characteristics, use, and application areas may change; new inventions, technical solutions, and other know-how may emerge. Thus, the new principle must reflect the probabilistic characteristics of invariance in time of the initial estimation results of an innovation object, and that is why we shall call it the *probabilistic invariance principle*. This principle postulates that initial expert estimation results certain innovative ideas or technical solutions, industrial products, or manufacturing technologies are probabilistic and do not guarantee that they will be saved in time. Initial expert estimation results obtained under conditions of conceptual uncertainty as positive or negative findings, proposals, or recommendations are not invariant and may substantially change, be confirmed, or be disproved as time passes. Therefore, we do not exclude in a certain time frame both safekeeping of truth expert statements, opinions, or findings, and the possibility of disproving them.

4. Technology foresight expert estimation procedure requirements

Assertions given earlier prove that it is possible for innovative objects that do not have analogies and prototypes of objects that are actually produced to be producible or nonproducible. Therefore, there is a series of certain practically important requirements for technology foresight expert estimation procedures.

First, while performing these procedures, one must not only estimate the properties, advantages, and disadvantages of innovative objects, but also estimate the probabilities of them being realized in practice. Then, it is advisable, taking into consideration the subjectivity of expert estimations, to introduce an additional index that should determine the expert's confidence in the estimation. The introduction of such indices opens the possibility to substantially improve the reliability of the total object estimation, because the group of experts is formed by taking into account the known a priori uncorrected proof level of each expert's competence and the possibility of taking this level into account while processing the expert estimation results.

Second, while doing the expert estimation of innovation objects in the technology foresight process, it is advisable to introduce latent indices of project quality estimation and innovation objects proposed in this process. In particular, such indices characterize the practical necessity, technology possibility, and economy expediency of an investigated object [5]. In order to obtain the coordinated qualitative and quantitative estimations of these indices, it is necessary to provide each expert with a simple understanding of the content and the sense of estimated characteristics of expert estimation objects.

The main feature of the latent indices of innovation projects and products is their mutually exclusive dependence. It expresses itself in such a mutual systemic coordination of conditions for realizing characteristics that an absence of any of them excludes the necessity of realizing other characteristics. For example, an absence of market demand for innovation production excludes the necessity and expediency of its industrial production. The next main feature is the discrepancy of requirements for the internal and external characteristics of innovation products. This follows from the contrast of technical and economic interests of producers, which are expressed by internal characteristics (prime cost, technical and economic effectiveness, convenience, etc.), and the social and market interests of its potential customers, which are presented by external characteristics (price, aesthetics, quality, usage convenience etc.).

Other features are the impossibility of direct qualitative estimation of combined characteristics, as they depend not only on qualitative and quantitative indices of innovation products, but also on sets of different factors. We cannot always control and forecast the structure and level of their influence. Among uncontrolled factors the most important are the various risk factors in the dynamics of the sequence of stages in the product's life cycle. We need to emphasize the importance of risks in the production cycle and the risks of market demand for new products. Their impact may substantially lessen the technical and economic effectiveness of production or even make the production unprofitable.

Modeling top-priority problems of Kiev city on basis of analytic hierarchy process (AHP) is shown on fig.3. AHP was developed by T. Saaty [6, 7] and is based on the description with multiplecriteria of a problem and allows to turn the analysis even of very complex problems into a sequence of pair-wise comparisons of their individual components. During the problem stating stage, the group of experts performs decomposition of a complex problem – represents it as a hierarchical sequence of interconnected and interdependent systems and subsystems; determines its elements and relations between them. Then, the hierarchy is built which is the systematic model of reality. The top of the hierarchy is the general goal, sub-goals lie lower, then forces that influence these sub-goals, people, goals of people, policies, strategies, and, at the end, the outcomes that are the results of strategies. At the next stage of solving, the individual components of hierarchy are compared to each other. As a result, the relative degree of interaction intensity between elements in the hierarchy can be determined. Then, these judgments are expressed numerically. At end of the problem analysis, AHP includes procedures for the multiple judgments synthesis, determination of the priority of criteria and alternative solutions. Having completed the processes of decomposition and formalization of the considered problem, we apply the Analytic Hierarchy Process to the formalized problem with the consecutive account of its comprising procedures such as the usage of the fundamental integer scale, calculation of the matrix of paired comparisons, coincidence of matrices, local priorities, and carrying out the synthesis of priorities.

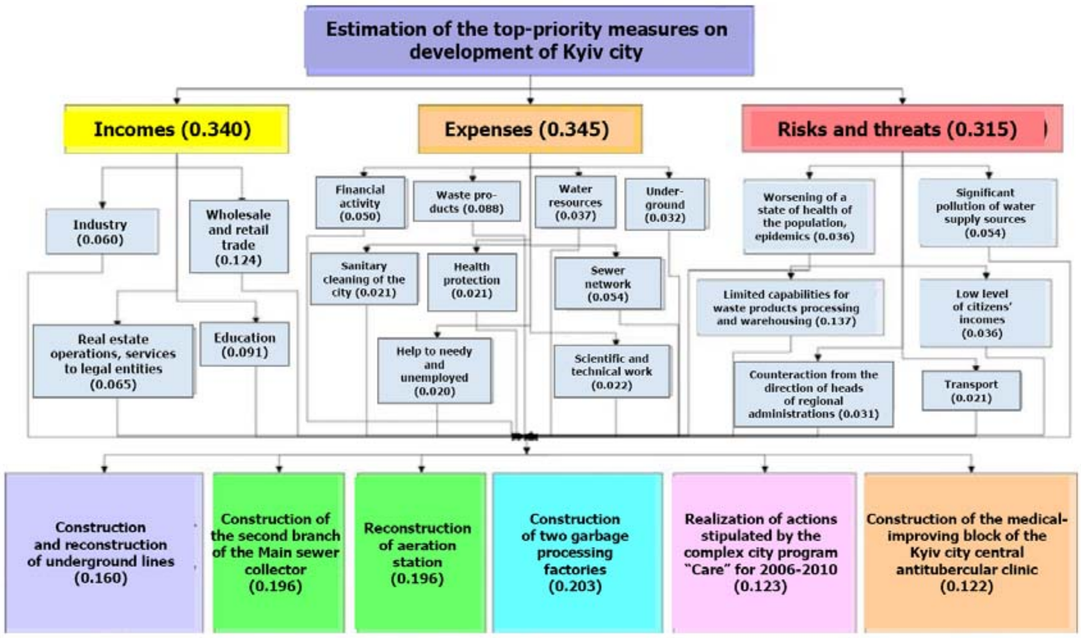

Fig.3. Estimations of top-priority problems of Kiev city

Having calculated the global priorities for every variant, we obtained (fig.3), that construction in Kiev of two garbage processing factories with priority 0.203; reconstruction of aeration station and construction of the second branch of the main sewer collector with priority 0.196 are more preferable than stipulated by the complex city program "Care" for 2006-2010 (0.123); construction of the medical-improving block of the Kyiv city central antitubercular clinic (0.122) and construction and reconstruction of underground lines (0.160)

Conclusion

The realization of the expert estimation procedure of an innovation activity is carried out according to stages of expertise realization with the help of the developed software focused on automation of the expert estimation procedure.

Because the expert estimation needs to involve experts who are on different continents, in different time zones, with different levels of computer knowledge, the system is implemented in the form of a web-site and works in an on-line mode. It is possible also to explain this choice by the chosen strategy of expertise organization – implementing the independent estimation in which the information about the structure and size of the expert group is anonymous. Besides, the program allows saving the results of the analysis of the quality of an expert estimation in files.

The software was created using the programming language Python with the elements of Z-object publishing environment. The core of the system is the database constructed on the basis of MySQL 3.23.21, which allows storing the large volume of information on expertise results and ensuring the independence between the developed program and the area under research.

The real projects were realised on the basis of proposed methodological instrument and created software.

Acknowledgement

The paper is partially financed by the project ITHEA XXI of the Institute of Information Theories and Applications FOI ITHEA and the Consortium FOI Bulgaria (www.ithea.org, www.foibg.com).

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Authors' Information

Nataliya Pankratova – Depute director of Institute for applied system analysis, National Technical University of Ukraine "KPI", Av. Pobedy 37, Kiev 03056, Ukraine; e-mail: natalidmp@gmail.com