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Universal Sustainability Code of Country Development as an Intelligent Stochastic Net

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Abstract: The paper analyses the following problem: how to create a stochastic net of intelligent solutions for compliancy of existing interests, possibilities and disposable resources' allocations while developing the strategy for nurturing universal sustainability of a middle-size country that does not possess abundant natural resources and, as a result, can use mainly intellectual resources while nurturing its own development.

Why the universal sustainability category is used? Firstly, the UN, EU and a number of other global organizations and forums began to actively use the concept of universal sustainability in the analysis and projection of perspective. Secondly, the scientists and practitioners also resolutely search for adequate categories to distinguish the modern development processes, as well for valid theoretical solutions based on advanced development experience and scientifically-based development possibilities, as well as on adequate objectives and development models.

Globalization has revealed a set of indispensable features of perspective and at the same time has emphasized the fact that orientation of the past and future towards certain development values and models could be inadequate to the well-being of civilization quality and longevity.

The system of scientific knowledge, innovation and technologies as a tool of intelligence and means of showing where and how the civilization should develop vaguely undertakes the solutions for many recent political, social, humanitarian, ecological and other problems influencing the quality of civilization. Moreover, the optimization of value structure of training the powers of integral cluster of knowledge, innovation and technologies demands greater attention. Otherwise inexhaustible guarantee of civilization nurturing will become economically inaccessible with regard to many aspects of civilization preservation.

The paper aims at thorough analysis of theoretical viewpoint towards small countries' universal sustainability development, inventorying the best practice of the separate development subsystems' universal sustainability. On this basis a stochastic network model of country development universal sustainability code should be formed, matching development interests, possibilities and disposable resources' allocation, and it should possess all the characteristics of complex adaptive systems.

Keywords: universal sustainability; development code; integral cluster of scientific knowledge, innovation and technologies; stochastic net of intelligent solutions.

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1. Introduction

The necessity of adequate use of value concept and selection of quantitative measurement for value, along with development of value creation management scheme is perfectly disclosed through the creation and implementation of development strategies for complex adaptive systems. However, in order to prepare the viable and adaptive complex development strategies, one encounters a necessity to solve a set of conceptual and pragmatical issues related with implementation of these strategies. The most important issues are as follows:

- Development of viable system of interests intended for implementation of the project of development strategies;
- To foresee the volume and structure of the real existing resources that is required to create factors and means of strategy implementation;
- Creation of the intelligent strategy development monitoring, paying exceptional attention to the management of risk generated by uncertainty and globalization;
- Preparation of operational strategy management models and adequate system of computer programs.

A distinct attention in the paper is paid to the management of value added chain creation (according M.Porter's model) optimizing the allocation of development resources among the activities ensuring the creation of value added. Such optimization considers the efficiency and reliability of the possibilities created by the value added. It appears to be a case of stochastic optimization.

Analysing projection of country development, systemic thinking that is based on quantitatively measured value indexes would probably encounter a set of unsolved problems. This is why a concept of universally sustainable development along with sustainability index is invoked, that are indicators of condition and dynamics pertaining to a system. This makes it possible to form a system of interest for strategy implementation under the case broader than classic "triple bottom". In such a case an integral sustainability index of country development is considered as an adequate composition of sustainability indexes pertaining to separate activities. Also, sustainability is to be measured by the adequate function of efficiency and reliability of development possibilities. Determination of sustainability indexes in subsystems, as well as selection of integral sustainability index for the whole system that is expressed as adequate composition of sustainability indexes pertaining to subsystems, still lacks an unambiguous perception from different parties, but has a long-term application practise in various national and international reports.

The paper presents in details the integral model of stochastic networks, processes and fields proposed by the author. The model turns to be a means of operational decisions optimizing the allocation of development resources among the separate activities with regard to possible impact of uncertainty on the solutions taken today.

The structure of universally sustainable development model has been formed and expert valuations have been performed on the example of EU Member State – the Republic of Lithuania. The model itself has been presented in former MDPI forums and publications.

2. Stochastic Networks as Adequate Means to Manage the Value Chain

While projecting rational allocation of investment or other development resources in order to achieve the optimum of the value created by business, it is required to use the logics of stochastic optimization. The key instruments here are theoretically grounded and practically approved possibilities to adequately describe the stochastic networks, stochastic processes and fields as complex processes.

The objective of the paper is to apply the models of stochastic networks for the adequate description of the value being formed and propose the formation idea and particular decision methods of optimal value creation and resource allocation problem. This will be done by constructing a stochastic network of possibilities of the value being formed, along with proposing a network of possibilities' utility for various subjects. It will allow us to obtain the highest-utility realization of value creation for the subject.

Along with analytical possibilities, the stochastic network can be used as a visualization mean for problem formulation and decision search. Also, the adequacy of the proposed methodology and algorithms will be disclosed by presenting the results of applying them to investments in financial markets.

3. Integral model of stochastic networks processes and fields (IMSNPF) to improve the value creation chain efficiency

The management of value creation chain is a complex problem even in common situations. Business value creation process will be treated, as usually more commonly perceived, - value supply chain, that is understood as a system of subjects, their activities, the information and other resources being used and influencing the supply of the produced product of service to the user (Esper et al. 2010; Closs et al. 2011; Grönroos 2011; Hou et al. 2014).

The value added creation process on a macro-level will be analysed using statistical data about the financial activity of country economy sectors and the investment resources consumed to perform the mentioned activity.

Logical and quantitative analysis of the value supply chain will be performed using the integral model of stochastic networks processes and fields (IMSNPF), as well as the search scheme of the created value dynamics sustainability. The particular stochastic optimization algorithms and computer programs along with original quantitative criterion of dynamics sustainability will be applied in order to insure the value supply chain sustainability, while optimally allocating the possessed resources among the value generating subjects.

3.1. Description of the main concepts used in the research

The key concepts used in the previous part of the text – stochastic networks, stochastic processes, stochastic fields, as well as the concept of development sustainability or the perception of sustainability measurement have been first found in the fields of research where they had been formed (Klibi et al. 2010; Sarkar et al. 2011; Marin et al. 2012; Ghasemi et al. 2014; Wang et al. 2014). However, going far away from the fields of research that are perfectly structured with regard to these concepts, their ambiguity is being shown up along with different interpretation of the obtained results (Adner, Kapoor 2010; Pietrobell, Rabelotti 2011; Bechmann, Stine 2013; Bilge et al. 2014).

It is worth admitting that in our field of research – the value supply chain – the perception and application of sustainability has not been made up to an unambiguous approach, thus there are no clear evaluation of the consequences of decisions. That is why, probably, it is recommended to discuss in our area of research the contents and essence of the research concepts or instruments being used in order to adequately perceive the perfectness of the obtained solutions and consistency of the practical consequences.

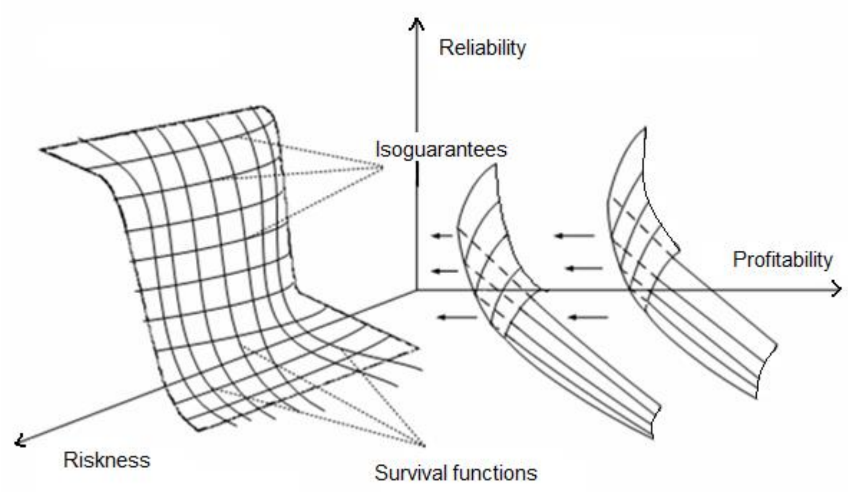
In the paper while analysing the problem of development sustainability we will not oppose the plenty of almost adequate and fulfilling each other or discussing perceptions of sustainability. Let us just remind that while projecting an intelligent – that is nurturing the development sustainability – investment strategy, the phenomena of uncertainty will be put in the spotlight. Discussing the dynamics of development possibilities, we will evaluate its efficiency and reliability by a maximum of the function U, adequate for the positivity of development and selected as a criteria of development sustainability assessment:

$$U - \max u(\text{efficiency, reliability}) \quad (1)$$

Let us recall that almost all the criteria of development sustainability discussed in literature require the aspects of effectiveness and sustainability to be taken into account, even if often the description of their priority or interaction is avoided. Thus one of four concepts that will be used in the analysis of development sustainability will be the maximum of function (1). As a result, stochastic optimization will become the key instrument to disclose the possibilities of sustainable development.

To describe the stochastic optimization problem we will use the concepts of stochastic fields and stochastic processes in the most general form of perception. Let us remind that stochastic field is a set of random values with a certain common characteristic for all random values being a leading indicator (Lee et al. 2012; Hiraishi 2014). Stochastic process is a set of random values with a certain external parameter, ex. field, being a leading indicator.

Figure 1. The general scheme of decision search (Rutkauskas, 2006)



Stochastic network will be understood as an analogue of the deterministic network in a multidimensional space. One of three-dimensional sub-spaces of that space will be a three-dimensional space with abscissa being the efficiency coordinate, ordinate being the reliability coordinate and applicate being the riskness coordinate. Such perception of the stochastic network indicates that it is intended to analyse the stochastic events' values and processes, as well as fields and their functions. Also, it serves as a means of visualization of arguments, substantiations and discussions (Fig. 1).

3.2. The application scheme of IMSNPF and the criterion of the created value dynamics sustainability for disclosure of possibilities of value dynamics sustainability

Fig. 1 presents the graphical view of value added creation possibilities of the marginal unit of resources intended for value creation. The value added is expressed by a family of probability distributions of possibilities, the identity of distributions' origin being determined by the condition that different probability distributions have been obtained by allocating in different proportions the marginal investment unit among the value creation factors. The edges of the right-lower corner network have been formed by the intersections of survival functions with isoguarantees of the family of distributions. Quantitatively the edges of the network are expressed by the three elements determined by the family of distributions: e – effect (the magnitude of the created value) is placed on abscissa, r – risk level (measured by the standard deviation of probability distribution) is placed on the ordinate and p – reliability level, measured by the survival function F(x) - P{$\sum \geq$ X} and its value placed on the applicate axis.

In turn, the upper-right corner of the figure presents the network of utility functions' values U=u(ex, px, rx), which is a constructive instrument for determining the edges of possibilities‘ network that would lead to the highest results of value growth, i.e. the edge of the possibilities‘ curves should determine the way of marginal investment unit allocation among the value creating factors. Such edges can be found by determining the touch point of two surfaces convex with regard to each other. It is worth noticing that with continuously increasing number of possibilities of created value in the survival functions, we observe the approximation of the network of possibilities' set and the network of utility values' set to the state of continuity.

Along with that it is worth noticing that stochastic network of utility possibilities, which is formed likewise the network of a set of survival functions and the network of isoguarantees' intersections with utility functions' value network, is a code of dynamic sustainability transformation of the value creation chain, the analysis of which is presented in the next chapter.

The composition of IMSNPF and the criteria of value dynamics sustainability criterion will be perceived as value creation chain sustainability code.

4. Markowitz Random Field as Interface between Optimal Portfolio Selection and Stochastic Optimization

It is the understanding of the author the efficient investment portfolio frontier disclosed by H. Markowitz may be fairly justifiably perceived as a random field in which the underlying parameter is the riskiness of the possible investment portfolios composed from a selected set of assets measured by a standard deviation of a portfolio as a random value, and the field value or the index is equalized to the respective probability distribution of a portfolio as a random value (Lefebvre 2011; Maine et al. 2012; Weaven et al. 2014). H. Markowitz offered a mean value as a resultant of the probability distribution. The developing field of theoretical and pragmatic research was named the mean-variation optimization method that became one of the key instruments in search for efficient investment opportunities in practice. And specifically important is the fact that the research became a "meeting point" for the problem probably the most relevant for the sustainability of the development of civilization – the qualified investment into the future of the civilization and the stochastic optimization – the most adequate field of science addressing the problem under the conditions of uncertainty and globalization.

The current chapter represents an attempt to contribute to addressing of the issue – the possible methods of building up of investment solutions today to preserve and increase the invested value in the future. The method chosen to achieve the objective is the specification of the Markowitz field – adequate development of the investment portfolio and its complement. Further to the conceptual answer to the formulated problem the present article discloses the practical approaches to addressing the problem.

4.1. Assumptions of stochastic optimization

Randomness or stochasticity, a random event or a value, a random process or field – all are the categories that cover an increasing number of phenomena, processes and systems the possibilities of whose comprehension by means of deterministic approaches would cause no doubts (Vissarion, Kokkinos 2013). Probably one of the most intriguing situation is an attempt to interpret the past recorded by dates and facts as a transformation of stochastics which demonstrates the regular development of stochastic nature. The cognition of such regularities is a key to adequate choices under the conditions of uncertainty.

The material object for the survey presented in the present paper is the investment return, also its management and the generation of the information required for efficient decisions; therefore in the foreword will specifically focus on the concept of a random field which naturally encompasses a range of investment portfolio management modes. However, adhering to the principle of consistency in cognition it is appropriate to recall the contents of a random event, random value and the random process concepts. This will facilitate a more efficient use of the random field concept in managing investment decisions.

The analysis of uncertainty has become an object for cognition of a number of theories, such as the probability theory, the fuzzy sets theory or mathematical statistics. The examination of the uncertainty of investment return in the present paper will be limited to the probability theory concepts.

Hence a simple random event which as a result of a random observation or a random experiment may be realized under a probability P, or remain not realized by under a probability 1-P. Complex random events are understood as different compositions of elementary random events.

A random value is often perceived as a specific function of a random event. An inseparable attachment to a random value is ordinarily a probability distribution of the values of the function. In practice, there is a profusion of possibilities probability distributions that as a rule adequately describe related sets of random values.

The understanding of a random process is best formalized by means of a determined process, however, the determined process conditions that may be spread in time or arranged at any other scale are in this case replaced by random values. The cognition of a random value is a multi-aspect process, first, needs to be determined whether the random values constituting the process are characterized by correlation, etc.

Not much dissociated from the concept of a random process is the category of a random field. The underlying parameter of a random field is normally not time, but rather one of the field content parameters, while the object of the field content is represented by the multi-dimensional functions of random values.

4.2. Optimization under the conditions of uncertainty is a typical environment for taking investment decisions

Optimization under uncertainty – typical environment for investment decision making

Optimization is selection of the best possibility for the existence of a system according to a certain criterion. The possibilities of existence may be examined according to different indicators determining the viability of the system.

In mathematics which requires the presence of a qualitative functional relation between the elements of the system, optimization is perceived as minimization or maximization of the function f(x) in respect of all x belonging to a specific set X.

Optimization as a search for the best opportunity is simply a method of a natural projection of behavior, since humans are searching not for a path to go, but rather for a path to reach the destination. The observation is equally valid for projection of social and economic behavior of an individual, or a group of individuals, and of economic activity or the presentation of a research area, etc.

Deterministic mathematics has defined a range of criteria according to various naturally emerged or scientifically sophisticated principles, as well as a sufficient number of solution methods, or even computerized algorithms on reaching a condition defined by a specific criterion. The search procedure itself is referred to as mathematical programming or simply, programming.

The diversity of optimization criteria, abundance of search methods for attaining the condition defined by criteria, as well as the adequacy of programming methods bring about optimism as long as we perceive ourselves in an idealized deterministic environment. Nevertheless, the transition to an actual environment to a larger or smaller extent dominated by uncertainty, does not by itself mean that we are less prepared for solving the previously formulated problems.

Still, retaining of sustainability of an individual, an entity or even a State, or the implementation of their development opportunities is fairly susceptible to the uncertainty phenomena of a certain level. Suppose, the State has projected specific budget expenditures for a specific year, but actually managed to generate only 75 % of the funds required to cover the expenditure. The State will undoubtedly survive the unsuccessful year, most likely the Government will also remain in place. Still, such enhanced and longer-lasting uncertainty causes erosions in the sustainability of existence and development.

Therefore it is of utmost importance to be able to reconcile the two naturally emerging requirements – the inevitability of uncertainty and optimization, or simply to understand optimization under the conditions of uncertainty. As noted by V. Shanidis (2006), in the second half of the XX c. a general understanding emerged that in nearly all systems, such as social, economic, technological, natural or nature we are being effected by uncertainty, which causes an increase in the number of papers on optimization under uncertainty or stochastic optimization.

Further we will discuss these questions in details:

1. Optimization under uncertainty
2. Utility functions under uncertainty
3. Optimization of the investment portfolio

4.3. Optimization under uncertainty

Optimization under uncertainty or simply stochastic optimization may be comprehended analogically to the comprehension of deterministic optimization, i.e., that optimization under uncertainty is a selection of the best possibility for the existence of the system under a certain criterion. The visual difference becomes evident from the fact that in this case the stochastic even logics is used for the description of the condition of the system, establishment of the criteria to be used, as well as the expression of the used limitations. However, the analytical problems arising from such differences are fairly complex. First, certain primary (basis) comparisons of values or processes as $a > b$, also all expressions of comparisons or reconciliation containing such elements in this case disappear. However, the most complex task also in essentially every situation requiring an original solution is to select the criteria for the optimal condition of the system, and establish an efficient quantitative measure for the realization of the selection.

Apparently, the concept of the utility function and the method for the practical application are the most appropriate set of instruments to implement the function, especially that the utility function concept seemingly retains certain continuity in view of the transition of the situation from the deterministic to the stochastic case, including when looking for an optimal solution.

However, there is huge range of methods and solution algorithms for addressing stochastic optimization problems, while emphasizing the important characteristics of random variables, dependencies, limitations, etc., such as mean, minimum, maximum, mode, or a standard deviation, and while defeminizing stochastic tasks on the basis of such characteristics. Not infrequently this substitute fully meets the needs of the customer, as well as those of the necessary analysis of the problem.

However, a more comprehensive analysis of the transformation of the utility function concept under uncertainly and of the possibilities of its usage technique makes it easy to notice that the solution of certain problems has been lasting for centuries, involving in the discussions a good dozen of Nobel prize laureates. This only testifies to the significance of the problem and the complexity of it solution.

In social and economic sciences utility is defined as an ability of an object to meet the needs or wishes of a subject (Polese 2012). The fact that ability of the object far from always acquires a monetary form, and that the ability of the object is related to the needs or wishes of different subjects, and that the need or the wish of the subject is fully met by abilities of different objects is part of the reason for the time consuming nature of the solution formation.

4.4. Utility function under uncertainty

Any attempt to produce a universal utility function model would encounter the circumstances as referred to above. Therefore, a typical situation, notionally referred to as investment may be presumed, when the object is an investment market existing under uncertainty conditions generates certain return to the investor. It might be assumed that the investment market is perfect, and no individual investor may influence the market; therefore, such investor may manage his benefit by appropriately selecting the structure of the invested capital.

The optimal outcome of a one-off investment for a certain period is the maximizing of the return per unit of the invested capital. But how this can be achieved? Both in the deterministic case and under the uncertainly conditions the most comprehensively examined instrument was the utility functions whose analytical characteristics in the first, and in the second case are fairly similar.

However, the use of the utility function in the case of uncertainty brings about several new aspects as compared to the deterministic case. One of them being the problem of double measurement. The possibilities of investment return are measured both in terms of monetary or percentage effect, or the probability of the transition of effect, i.e., p:

$$0 \leq p \leq 1 \tag{2}$$

Among the most extensively examined utility functions having regard to the uncertainty are the expected utility function whose logics is directly related to the characteristics of the expected values of a random value (Porter, Kramer 2011).

A search for the solution of the problem – a selection of a utility function having regard to the uncertainty started back in the early stages of the development of the fundamentals of the probability theory, while searching for a form of the utility function enabling to disclose the possibilities probability distributions that are most beneficial for the needs of the subject.

At the same time the pragmatic search for the apparent and adequate analytical expression of the utility function. In this relation it is worthwhile recalling that the utility function

$$U = e_1 p_1 + e_2 p_2 + ... + e_n p_n \tag{3}$$

where e_i – the return of investment into asset *i*;

$$\sum_{i=1}^{n} P_i = 1$$

p_i part of the investment unit assigned to asset *i*,

may become a satisfactory instrument in search for an optimal investment capital distribution between the investment assets at the disposal of the investor.

It is understandable that the possibilities probability distribution within asset i may have its original and e_i fairly complex analytical forms. In its own turn the correlation matrix may be in each C(e_i, c_j) different. An adequate evaluation of the two aspects is an indispensable condition for an objective assessment. Not infrequently in the process of the search for an optimal distribution equation (2) is replaced by an identification of the maximum mean value of utility. The latter case in research papers is often referred to as the use of the expected utility function. Such optimization of the distribution of investment capital among the investment assets may be meaningful in certain situations; however, the issue of the optimal distribution of the investment capital among the different assets will be addressed in the following sections of the present paper.

4.5. Investment portfolio as a universal instrument for investing optimization under uncertainty

The unique knowledge and the accumulated expertise in examining the possibilities of the use of investment portfolios in practice agitates for replacing the conventional concept of an investment portfolio as any composition of investment assets by a more complex concept, however, better representing the possibilities of an investment portfolio (London et al. 2010; Leena, Jaakola 2012). This understanding of the concept could resemble the perception of a portfolio as a stochastically adaptive optimizational complex system devoted to the appreciation of the value of the investment of a subject.

Quite a number of different criteria have been offered that are supposed to lead to the fulfillment of the principal function of a portfolio – to increase the value of the invested assets, in addition to a diversity of methods and means to implement the criteria (Pietrobelli, Rabellotti 2011; Hurmelinna-Laukkanen, Heiman 2012; Schrödl, Turowski 2014).

A detailed analysis of the criteria or methods of a portfolio is beyond the scope of the present paper, therefore further the paper will focus on the different types of portfolios and the different theories on portfolios that discloses the different qualities of a portfolio as a stochastically adaptive optimizational complex system.

Since further the paper will be limited to stochastic systems only, it is of utmost importance to understand the methodological principles that led to the inclusion of uncertainty in the process of decision-making under uncertainty. The easiest way to respond to the question would be to refer to the fairly robustly established investment decision management system – the modern portfolio theory or simply the modern investment portfolio.

Here the investment return in the future is seen as a set of possibilities, or simply as a distribution of the probability of possibilities, where the probability theory is selected as analytical instrument set. A modern investment portfolio may be viewed as a system which by adequately responding to the possibilities of the interaction of investment assets and riskiness, seeks to build up the structure of the investment assets that it seeks a maximization of the return of the investment capital at a certain specific moment of the existence of the portfolio, or preservation of a maximum return possibility at a certain period in the future.

With a view to ensuring such possibilities the modern portfolio has been on a regular basis developed and improved. The most impressive result of the disclosure of the interaction of the scientific uncertainty and efficiency is the efficiency frontier and its use while formulating investment decision. Efficient frontiers exist not only with respect to the ratio between standard deviation-mean, but also with respect to the ration standard deviation-quintile. Furthermore, analogues of efficient frontiers are active not only in respect of standard deviations, but also in respect of a huge number of indicators measuring uncertainty and risk.

This projected into the construction of the Markowitz random field produces a powerful system for the analysis of investment risk and efficiency and search of efficient solutions. This may be achieved by a relatively simple and easily understandable simulation of the interaction between the efficient surface and the efficient three-dimensional utility functions.

It needs to be recognized that an exceptional role in the process is devoted to the adequacy of the utility function which reflects the natural efficiency indicators, and the indicators reflecting uncertainty.

An adequate understanding of utility and a selection of an adequate utility function are the core issues when passing decisions both in relation to the entire economy or a group of economic entities, as well as with respect to an individual.

An while in respect of an enhancement of the value of investment assets where the ultimate effect is measured by a universally understandable measure of value – money, the situation seemingly becomes simpler, the issue of reliability of possibilities remains and even becomes more enhanced in the sense that the benefit acquired is projected for a specific moment in the future.

Since in terms of its return investment is a forward looking activity, it is essential to understand how many perspectives may reduce the success effect, and increase the failure effect.

5. Possibilities of application of the adequate portfolio and the necessity of its further development

Starting with the first ever presentation at the international function in Dublin („Macromodels 99“) the adequate portfolio was presented together with the possibilities of its application for a rational distribution (most often optimal) of resources (most often investment) among development actions in view of uncertainty and risk possibilities in the situations being examined.

The application of the adequate investment portfolio with respect to one of the key problems in the science and practice of economics – rational (optimal) utilisation of development resources under sufficiently different conditions and in view of the diversified manifestations of risk realisation – required building up of original models and creation of their solution methods.

Further an attempt will be taken to highlight one more case of the use of the adequate portfolio in seeking the highest possibilities of the objective with lowest costs. In addition it should be reminded that the objective is the guarantee for the achieving of the target results.

Specifically should be examined the issue of determining the minimal amount of investment required for the implementation of a specific objective with a preferred level of guarantee. Suppose projecting possibilities for the enhancing of possibilities of the sustainability of the science of the integrated sustainability of the State and seeking to establish the minimum investment scopes providing a required guarantee for increasing of the sustainability index requires a projection of specific values.

Here it is worthwhile reminding that the situation hereby examined is conditioned by uncertainty, and that in relation to projecting the transition of a possibility necessarily account must be taken of the guarantee of the transition.

The logic of the construction of an efficient possibility surface (see x) suggests that the efficient surface may be transformed (see x) into its complement which remains to represent the network of iso-guarantees and distribution functions.

Having regard to the simplicity of the formation of the efficient surface complement where its survival function

$$P_x = P\{\zeta \geq x\} \tag{4}$$

was only replaced by the distribution function

$$\hat{P}_x = P\{\zeta < x\} \tag{5}$$

we understand the simplicity of the usage of such possibilities.

However, a selection of utility functions in the efficient surface complement remains a challenge. Logical thinking would suggest that in this case the utility function should be similar to the following phenomenon:

$$U = u\left(\frac{\hat{P}_x}{x\hat{r}_x}\right) \tag{6}$$

where

$$\hat{P}_x = 1 - P_x \tag{7}$$

and $\hat{r}_x$ is the riskiness level of the distribution function in which actually the investment scope value itself is located. However, choosing an adequate analytical expression (1) of the function of the three factors remains a fairly subtle issue. In a case of an adequate analytical investment portfolio the utility function of the type

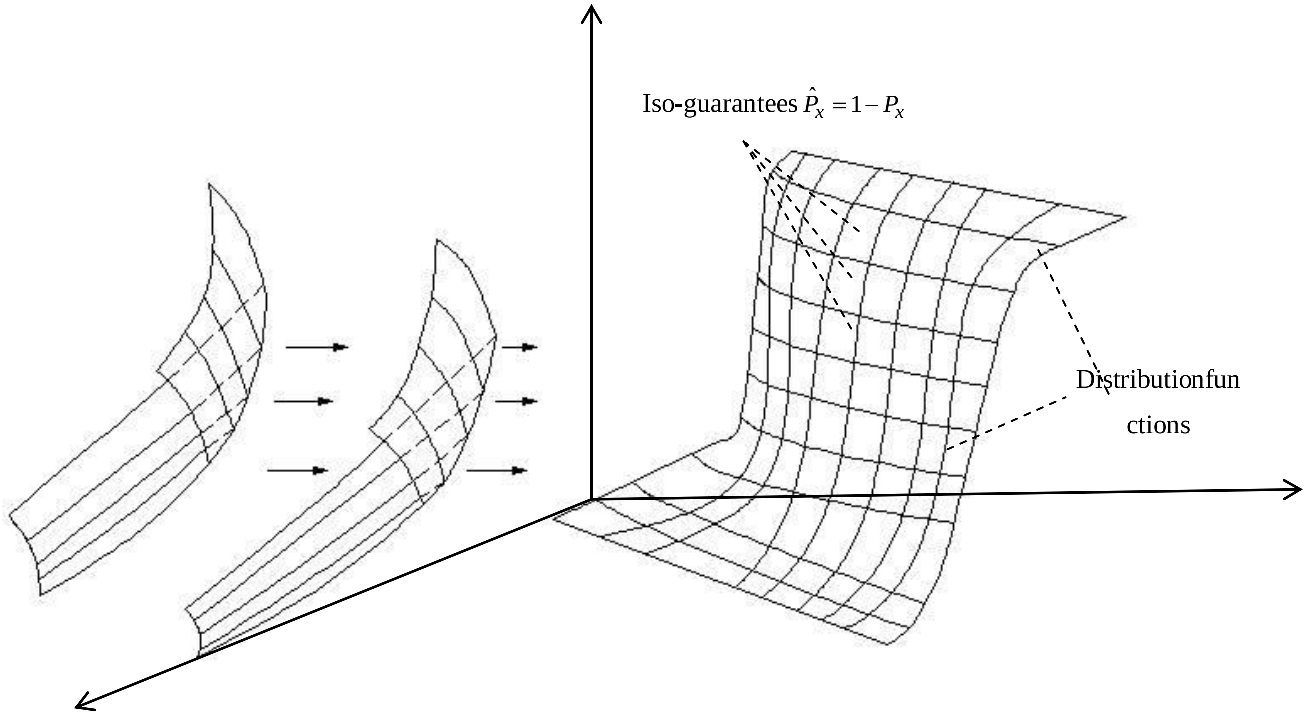
$$U = u\left(\frac{x \times P_x}{r_x}\right) \tag{8}$$

would disclose itself as viable and used even in its simplest interpreted form

$$U = \frac{x \times P_x}{r_x} \tag{9}$$

However, when comparing the complement to the efficient surface (see Fig. 9) with the efficient surface itself it becomes evident that in this case the role of the iso-guarantee is taken by the distribution function. The role of the survival functions is performed by the distribution functions, and the complement of the efficient surface becomes the network of the iso-guarantees $\hat{P}_x$ and the distribution functions.

Figure 2. The overall view of the efficient surface



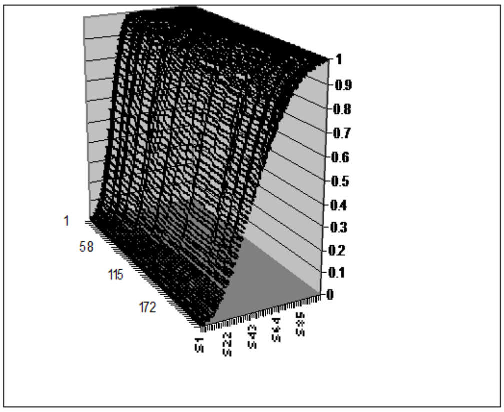
It is evident that each intersection point generates information that for the purpose of the attaining of the objective with the preferred guarantee a certain volume of investment is required which further depends on the level of the risk inherent to the portfolio. Thus the efficient surface complement actually enables us to determine the minimum investment volume that enables attaining of the objective with a selected guarantee.

Although the final stage of the solution seems not complicated and geometrically obvious, the structuring of the search for the solution of the task requires the efforts going beyond the formation of the efficient surface.

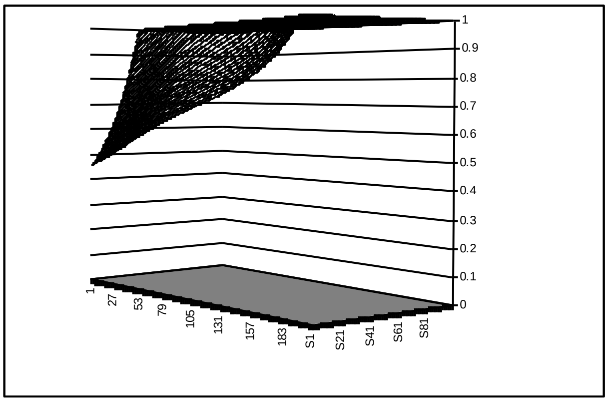
Therefore further are presented the fragments of the demonstration stand of the adequate investment portfolio at the decision making moment, i.e., at the time when the surface of the three-dimensional utility function intersects with the efficient surface (see Fig. 3).

Figure 3. The fragments of the adequate investment portfolio formation

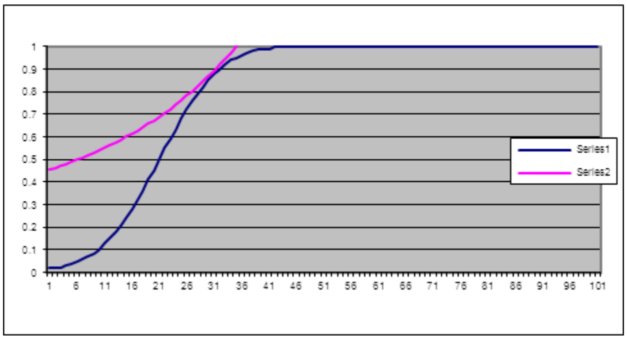
a. efficient surface of the complement possibilities



b. three-dimensional utility function



c. the establishment of the intersection point between the efficient surface and the utility function



d) determination of the investment funds use structure

1	0.08
2	0.12
3	0.62
4	0.18

e) fragment of the determination of the solution: possibilities of the investment possibilities being searched – in the first line and the respective guarantees $P\{\zeta < x\}$in columns depending on the increase of the risk

1.213	1.214	1.215
0.88	0.9	0.92
0.88	0.9	0.92
0.88	0.9	0.92
0.83	0.86	0.89
0.79	0.82	0.84
0.79	0.82	0.84
0.79	0.82	0.84
0.79	0.82	0.84
0.79	0.82	0.84
0.79	0.82	0.84

f) Optimal point coordinates: $x = 1{,}114$, $\hat{P}_x = 0{,}9$, $\hat{r}_x$ = 0,0834; and the theoretical evaluation of the distribution function $N(a, \delta)$.

X=1.214
P_x=0.9
r_x=0.0834

Having regard to the possibilities of complementing the adequate portfolio a task could be formed which might become an object of the usage of the method. Evidently a perfect object in this respect could be (Rutkauskas et al. 2011) a proposed project of the universally sustainable development of the country; the project is to be used to relate the condition of the integral sustainability index with the specific required investment volumes, with an exceptional focus upon the ensuring the guarantee of the objective to be attained with the smallest investment costs.

In the project referred to above the sustainability of the development of a small country is related to the twelve activities the efficiency of which robustly targets the implementation of the sustainability of the development. In their own turn the activities naturally fall into four sub-systems acquiring an image of the four sustainability whales (Rutkauskas, Račinskaja 2013): social-demographic, economic and ecological sub-system (EES), educological, creative and religious subsystem (ECR), financial, innovative and integral (FII), political, managerial and integral (PMI). Further, an attempt is taken to structure the problem by operating only the sustainability indices of the four aggregated development sub-systems: the task is to identify the minimum investment volumes that would enable, in the margin (last) year, to ensure an increase of the integral development sustainability index by 10 percent with a 99 percent guarantee, i.e., $\hat{P}_x = 0.99$.

The practical experience shows that the development of the integral sustainability index may be equalized to the changes in the weighted means of the indices of individual sub-systems, especially in the cases when the gains of the sub-system indices were not more significant than a certain share of the gain of the integral index.

In this relation it is expedient to remind that in this case the system to be used is the stochastically informative expert evaluation system, which would facilitate the selection of stochastic estimates for the determination of the need for investment resources in order to achieve the specific changes in the sustainability indices of the development sub-systems. At the same time it needs to be remembered that the investment need to a large extent depends on the inter-correlation of individual sustainability indices.

Finally, the problem selected for solution needs to be formulated in an analytically completed manner.

Suppose, there are four stochastically informative estimates:

$$R_1^{\omega}(\alpha_1,\delta_1);\ R_2^{\omega}(\alpha_2,\delta_2);\ R_3^{\omega}(\alpha_3,\delta_3);\ R_4^{\omega}(\alpha_4,\delta_4) \tag{10}$$

on the distribution of the probability of the investment need in individual development sub-systems with a view to achieving the desired status of the sustainability indices.

Also is available the matrix of correlational dependencies

$$M = \left(C_{ij}^{\omega}\right), i, j = \overline{1,4} \tag{11}$$

which defines the correlational dependencies among the sustainability indicators of the development sub-systems.

It should be noted that such estimates most often result from statistical observations that are recorded and processed in a specifically complex manner, or they may be formulated by professional experts.

The task here is to establish the proportions at which the investment resources need to be allocated between individual components of development in order to ensure that the integral sustainability index, evaluated according to an officially adopted and scientifically innovative method, would achieve the required level with the desired guarantee.

6. Practical application situations of the composition of IMSNPF and the development criterion

6.1. Practical realization of IMSNPF and value chain dynamics sustainability scheme composition

In order to solve this problem it is recommended to consider our earlier employed definitions of random process and random field.

A random process is a certain set of random values that can be numerated in a case of discrete process as follows:

$$\xi_1, \xi_2, \xi_3, ..., \xi_n, ... \tag{12}$$

Here a set of natural numbers can be time: hours, days, years, etc.

However, a random field in a discrete case can be understood as the following set of random values:

$$\xi_{11}, \xi_{12}, ..., \xi_{1m};\ \xi_{21}, \xi_{22}, ..., \xi_{2m};\ ...;\ \xi_{n1}, \xi_{n2}, ..., \xi_{nm}; \tag{13}$$

where uniquely formed set of natural numbers represents certain characteristics of the random field, etc. standard deviation values.

A scheme of random process management can de expressed as a certain composition of a random process (12) and random field:

$$\xi_1, \xi_{11}, \xi_{12} ..., \xi_{1m};\ \xi_2, \xi_{21}, \xi_{22} ..., \xi_{2m};\ ...;\ \xi_n, \xi_{n1}, \xi_{n2} ..., \xi_{nm}; \tag{14}$$

The presented expression allows us to recall the rule of our research, stating that we go out of the state ξ_1 by forming a resource allocation on the basis of random field and sustainability criteria. The formed state ξ_2 and while repeating the action, also the states $\xi_3, \xi_4, ..., \xi_n$ indicate the sustainability of the value chain dynamics.

In expression (14) presented stochastic Markowitz field can be viewed as an intelligent step of random process from the state ξ_1 to state ξ_2 and in general from the state ξ_{t-1} to state ξ_t where t = 1, 2, ..., n+1.

In the previous chapter it was shown that this can be done with the help of adequate portfolio possibilities.

The search of possibilities pertaining to the sustainability of value creation chain dynamics by optimally allocating investment resources among the value creating factors further can be practically illustrated by:

a) an example of M.Porter value creation (supply) chain;

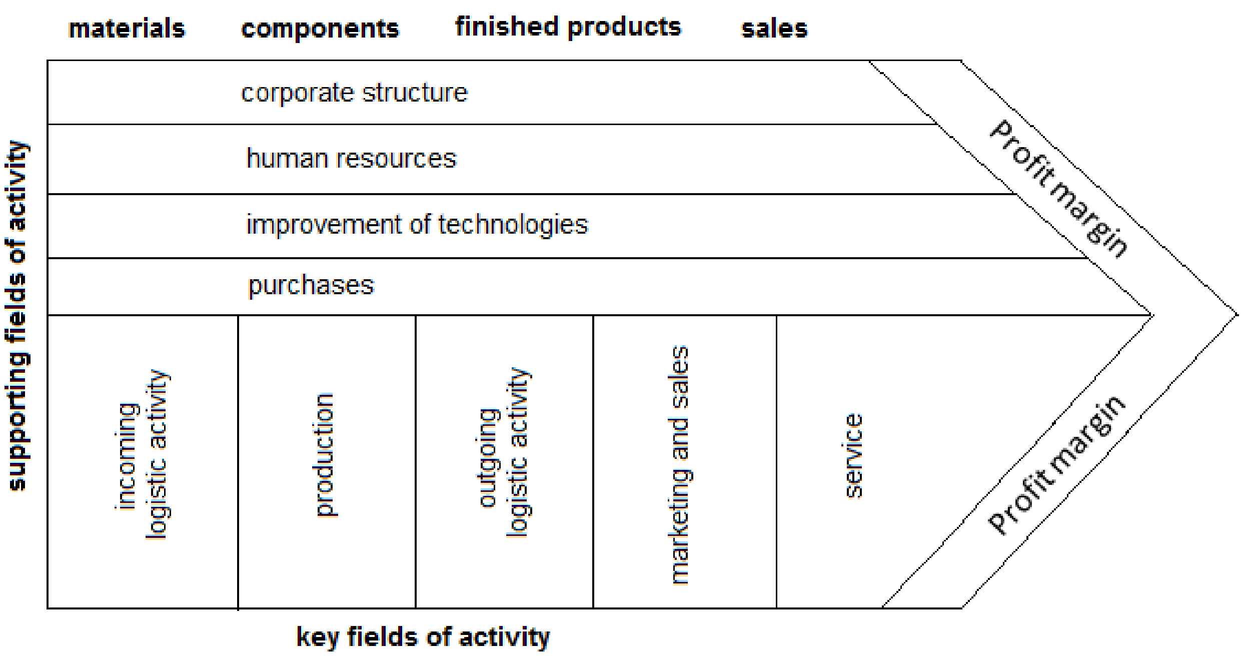
b) an example of country universally sustainable development integral sustainability index.

Both cases will be illustrated using utility function and the logics of minimum resource volume search.

6.2. The value chain

The value chain developed by Michael Porter is one of the first important attempts in the field of strategy to analyze the structures of the customers‘ needs. In 1985 Porter presented the value chain in his published book „Competitive advantage“. According to Porter, value is understood as something that customers want to buy for the things obtained from suppliers. Value is measured in net income, which is a function of a price of a company product being sold and a number of production units that company can sell. A company is profitable if its generated value exceeds costs incurred while creating the value. Thus the competitive state should not be based on expenses, but particularly on value. Porter presents value chain of a corporation in a bigger flow of fields of activities, which is called a value system.

Figure 4. The system of value



Professor Michael porter composed the diagram in Fig. 4 in order to present the value added chain, which describes the value added to the product that is obtained from buying the materials and the final product. While analyzing this process, it is possible to determine chains where we are competitive or vulnerable. All the types of activity generating value can be divided into two classes: key fields of activity and supporting fields of activity.

Key fields of activity in Fig. 4 are shown at the bottom of the arrow. These are the types of activity intended for physical creation and selling of a product, for delivering it to customer and for servicing the sales market:

- **Logistic activity made by the company**. This is the takeover of goods or materials, storing, sorting, transportation, storing the amount of stock, managing stock, transportation and return.

- **Production**. These are all types of activity which transform the incoming production flow into the finished products, for example, machine processing, packaging, assembling, maintenance and servicing of mechanisms, testing the finished products.
- **Outgoing logistic activity**. This is activity of products‘ sending, storing and physical distribution to customers, which also covers the processing of orders, formation of delivery schedules, delivery, transportation, etc.

According to Porter, the competitive advantage of a company cannot be understood only by studying the company in general. Competitive advantage arises from multimedia activity that is performed by the company through projection, production, marketing, delivery and support functions. Every out of mentioned types of activity can add to the relative position of costs of the company and create the base for differentiation. However, there is a need to mention the two key functions:

- **Marketing and sales**. These are all types of activity intended for persuading the customer to accept the product and pay the asked price for it. This activity covers advertising, sales promotion, individual selling, creation of price proposals, selection of distribution channels and pricing activity.
- **Service**. These are all activities intended for retaining and strengthening the value of products delivered to customers. This activity covers product installation, repair, training, spare parts delivery and product modification.

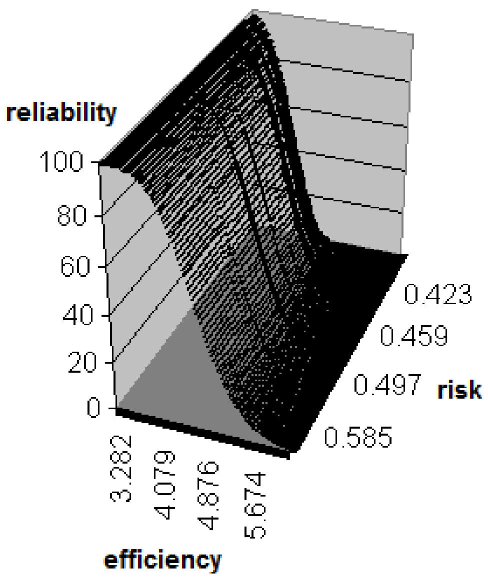
The supporting fields of activity in Fig. 4 are presented in four upper lines. These are:

- **Corporate structure** covers several types of activity: management, planning, finances, accounting, legal issues, publicity and quality management.
- **Human resource management** – hiring employees of all categories, their training, improving their qualification and rewarding them.
- **Improvement of technologies**. New technologies influence any value generating type of activity in the fields of knowledge, experience, procedures and processes.
- **Purchases**. This is activity related to obtaining the materials, i.e. not with logistical flow of materials, but with actual function of supply of purchases.

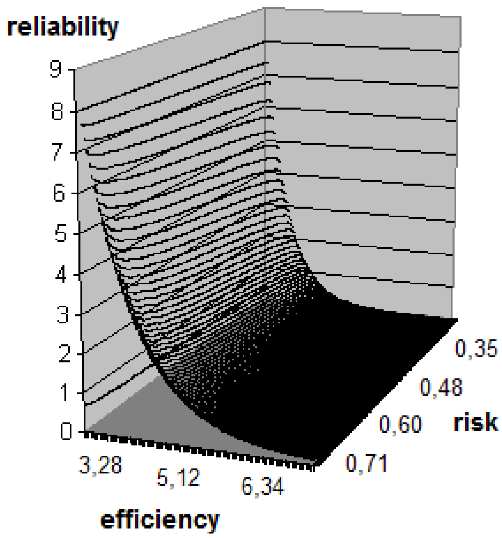
Fig. 12 shows the results of problem solution – the portfolio structure of investment allocation among nine value chain activities, as well as the following optimal solution parameters: efficiency, reliability, risk and utility.

Figure 5. Moments of optimal solution search

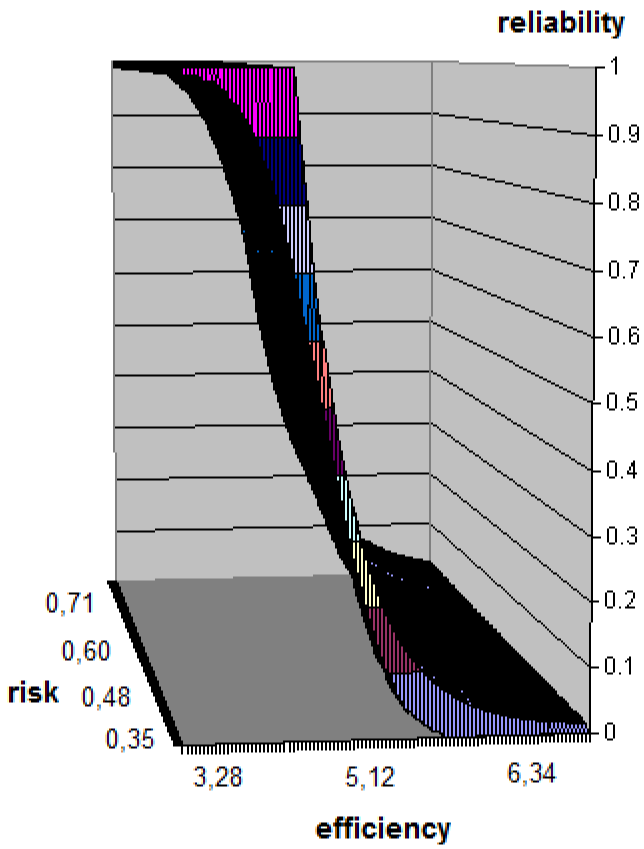
a) efficient surface



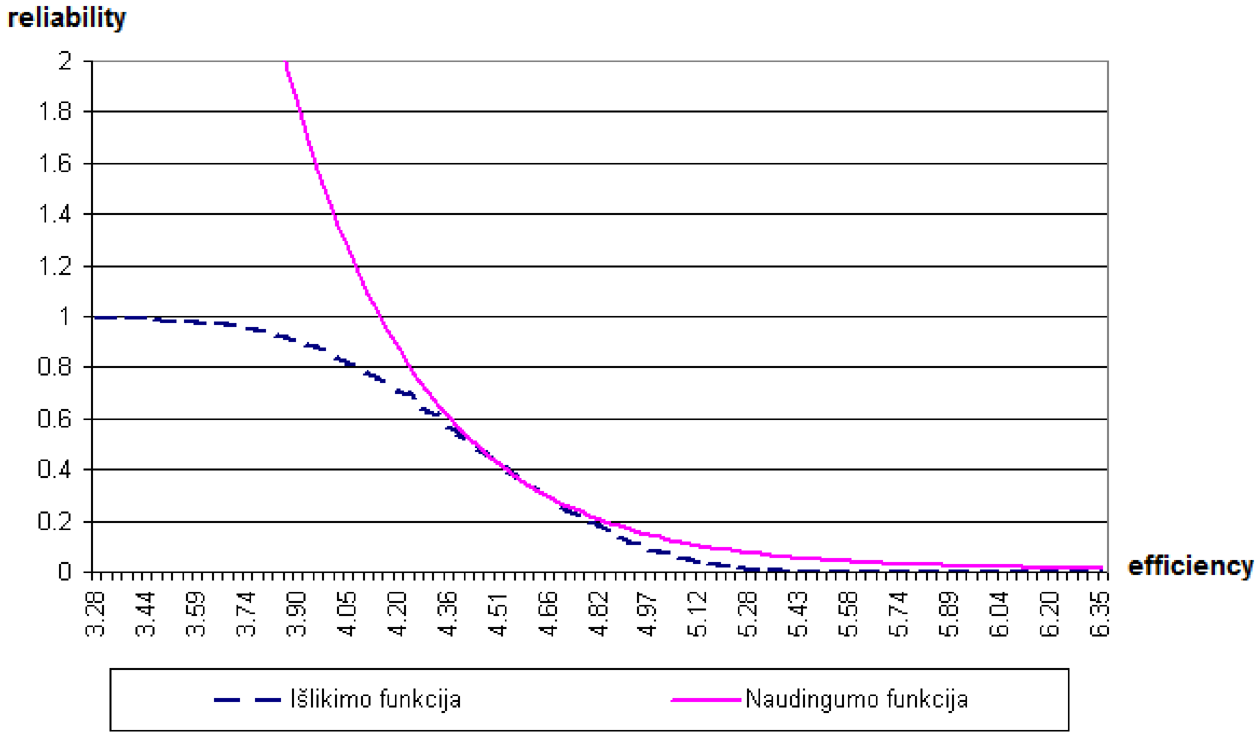
b) utility function



c) touch point of the efficient surface and utility function (three-dimensional view)



d) touch point of the efficient surface and utility function (two-dimensional view)



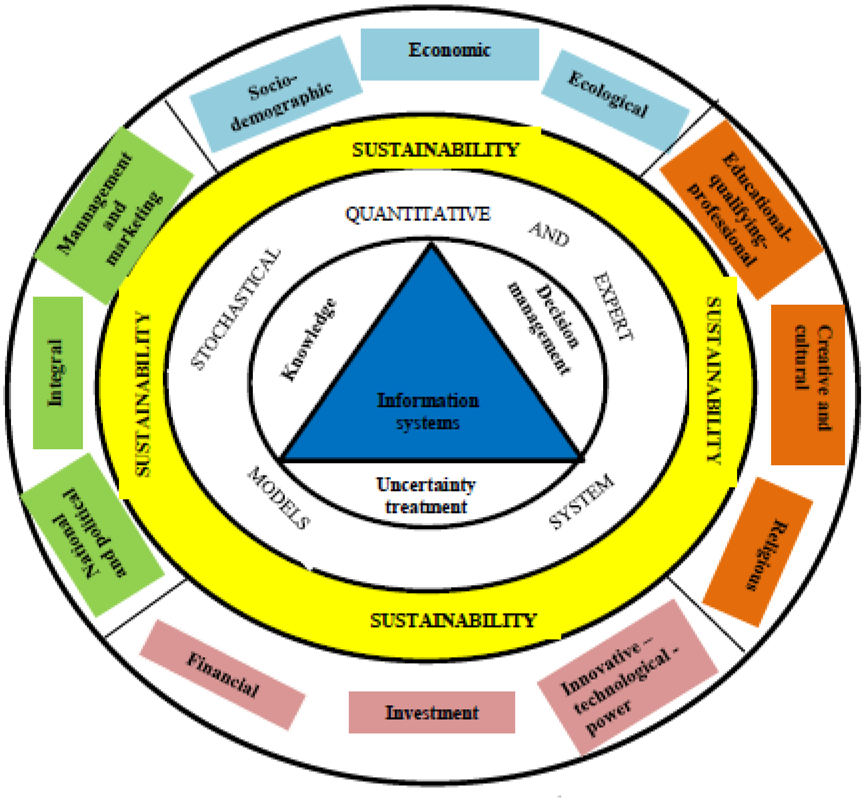
e) structure and parameters of solution

Structure								
w1	w2	w3	w4	w5	w6	w7	w8	w9
0,1033	0,1033	0,2066	0,0579	0,0579	0,1033	0,0579	0,2066	0,1033
Parameters								
Efficiency 4,662259		Risk 0,426345		Reliability 0,364132		Utility 0,44		

6.3. Integral sustainability of country universally sustainable development

In Fig. 6 the conception of interaction among subsystems' and the whole of instruments for decision formulation and search is presented: the information systems of knowledge, decisions management, uncertainty evaluation, as well as stochastic models of quantitative decisions and expert evaluation. However, the evaluation of separate problems should be recognized here as the exceptional moment, when with the help of the gathered and generated information a search for the compatibility of different aspects of development is performed.

Figure 6. The idea of the round table: the formation of components delivering the development sustainability and preparation of the means of knowledge and expert valuations pursuing the possibilities of development sustainability management (Rutkauskas, Račinskaja 2013).



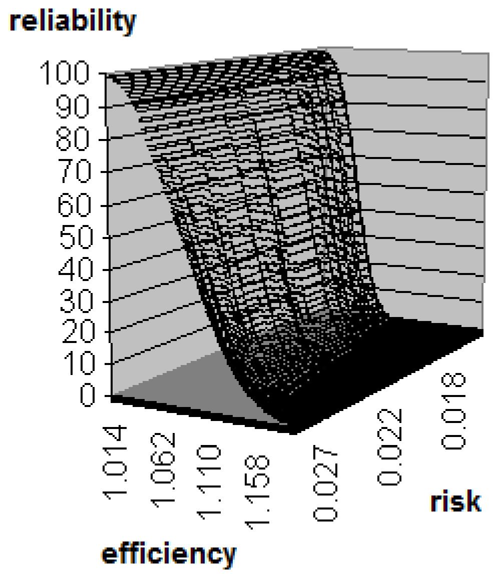
As a separate challenge while analysing the sustainable development problems in the context of systems' methodology a question arises on the unification of measurement dimensions of separate subsystems and the effectiveness of the whole system. First of all, let us remind that sustainability measurement is related with two-dimensional measures – effectiveness and reliability. Reliability has an undimensional way of measurement, but while measuring the effectiveness one cannot get along without the indicators expressing the content of existence of subsystems or the whole system, such as created product, grown harvest, etc.

Also, in complex systems it is accepted that in the reality serving as the object of their cognition the possibilities exist that the state of one subsystem can be a factor of the other subsystem's state, that ultimate indicator of the state of the whole system or its generated effect can be a complex function of separate subsystems' indicators. But the most difficult problems arise when it is necessary to solve the key economic problem – how to allocate rationally the possessed scarce resources with the objective to orient the system's movement to the optimal state or trajectory.

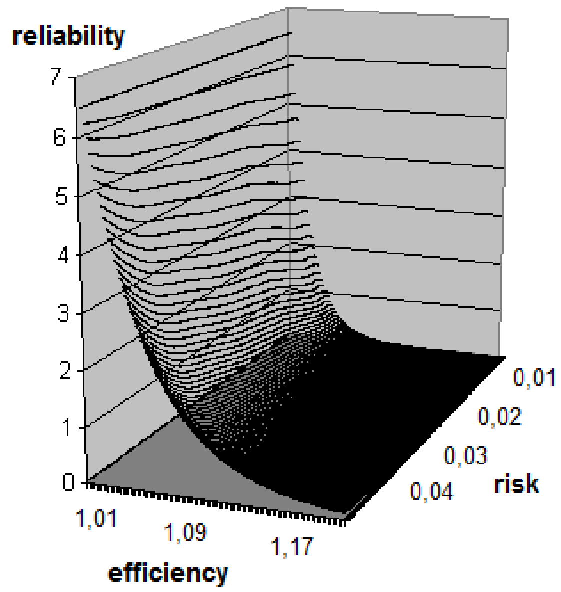
Further temporarily simplifying the situation let us suppose that the state of every subsystem can be measured with undimensional indicator and that using the stochastically informed expert valuation one can determine the effectiveness of marginal investment unit, if it is used for the training of subsystem i functioning. Then we can form a task – how one should search for the optimal allocation of resources among the subsystems under the conditions of uncertainty. Fig. 7 shows the results of problem solution – the portfolio structure of investment allocation among four subsystems, as well as the following optimal solution parameters: efficiency, reliability, risk and utility.

Figure 7. Moments of optimal solution search

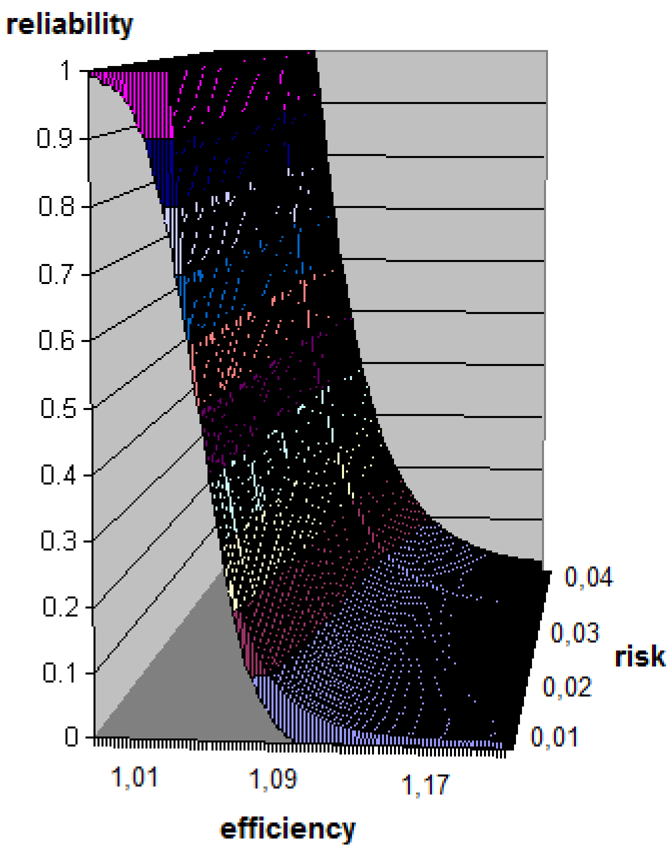
a) efficient surface



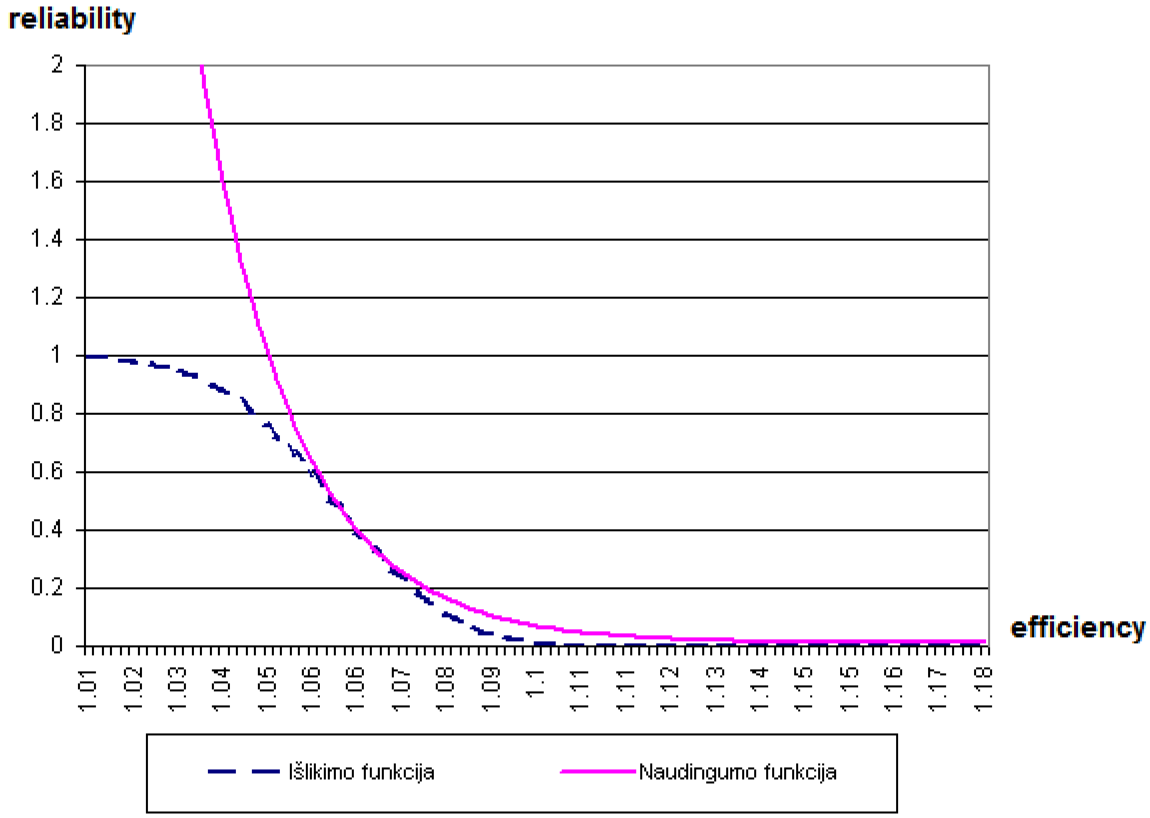
b) utility function



c) touch point of the efficient surface and utility function (three-dimensional view)



d) touch point of the efficient surface and utility function (two-dimensional view)



e) structure and parameters of solution

Structure			
w1 = 0,1351	w2 = 0,1802	w3 = 0,4324	w4 = 0,2523
Parameters			
Efficiency 1,06548	Risk 0,017626	Reliability 0,364132	Utility 0,37

7. Conclusions

The optimal use of natural and human capital, that is already created and possessed, when providing utility-generating products or providing respective services remains an indicator of economic activity, while the amount of value created during a certain period informs about the economic efficiency pertaining to a system.

Globalization processes create their world order and often strongly correct the civilization development objectives that have set up in regions, as well as consistent patterns and management ideology. In order to perceive this and form innovative management knowledge and technologies, it is necessary to understand that clusters of scientific knowledge, innovation and technologies are oriented towards the formation of universally sustainable development strategies for separate countries, and that they should become economically efficient and productive.

Uncertainty that covers country development strategic goals, as well as formed consistent patterns and interactions, requires to train management skills to formulate problems and solutions of algorithms, quantitatively considering uncertainty and its generated risk.

The experience of universally sustainable development strategies preparation and implementation states that “triple bottom line”, i.e. the whole of three subsystems – economic, ecological and social progress – is not sufficient base for the full-fledged commensuration of development objectives and possibilities, as well as for revelation and balancing of development tasks and resources.

While projecting country universally sustainable development strategies it is necessary to determine the development sustainability code – i.e. a system of assessments based on universally sustainable development canons, which reveals the functioning possibilities of sustainable development with required efficiency and reliability indicators in the long-term perspectives.

The paper analyses an experimental research of possibilities of small country (on the example of the Republic of Lithuania) to design a universally sustainable development implementation strategy. It has shown a necessity to use a strong computer model system allowing quantitatively analyse interactions among objectives of development subjects, development possibilities, disposed resources and revealing the most expected risk generated by uncertainty.

The integral model of stochastic nets, processes and fields proposed in the paper has revealed its possibilities to become a means to identify the strategies and generate decisions of value added chain that is created by the business and universally sustainable development pertaining to a country.

Conflict of Interest

The authors declare no conflict of interest.

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