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WITH SUSTAINABILITY ENGINEERING TO SUSTAINABILITY EFFICIENCY

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Abstract. This paper is an attempt to perceive the universal sustainability, when it comes to a discrete country or region, where actually the religious, political, social-demographic, economic, environmental, creative, technological and investment subsystems are revealed not only through the vitality of spiritual and material existence medium, but maybe through the signs of the development of these subsystems as self-assembled units of through the erosion of their interaction. In the article the possibilities of sustainability subsystems' portfolio, as contemporary systemic analysis means are used. With the help of the expert methods and techniques of portfolio methodology, the problem of optimal allocation of investment resources among the separate sustainability's subsystems is being solved, which will enable to achieve the enshrined universal sustainability standards. As the universal sustainability index for the country, the particular index composition of that country's sustainability subsystems' indices was chosen. The index in the dynamics is perceived as a random process. While projecting its state and evaluating its power, i.e. the impact of subsystem efficiency in a particular moment, this power is measured by the level of the index and the reliability or guarantee of the respective level. To solve the problem of investment resources allocation the idea of Markowitz Random Field was invoked in order to reach the maximum power of sustainability index, and for the technical solution the system of simulation models and decisions "GoldSim" was applied.

Keywords: sustainability concept, sustainability intelligence, universal sustainability, sustainability engineering.

Jel classification: O16, Q01, Q56, R11

1. Introduction

Sustainability, as orientation of activity towards the today's needs satisfying, leaving for future generations the possibility to satisfy their needs as well, is the main concept of science capable of finding the solution for the mentioned problem (Clark, Dickson 2003; Blackburn 2007; Sinclair 2011). The concept should match its prototype in every subsystem of sustainability. Today the category of sustainability is highly demanding the adequate appreciation and engagement in science, as well as in practice (Omer 2008; Munitlak Ivanovic *et al*. 2009; Hannon, Callaghan 2011; Yildiz, Yercan 2011). There is a need for sustainability analysis and manamement in protozoa germination, as well as in the evolution of universe.

The concept and methodology of sustainable development, which has brought us a new viewpoint towards the cognition of genetic code and creative application of physical, biological, technological and socio-economical system's evolution, forming the strategies of the mentioned system's development, obtained the desired appreciation and application almost in every area of human life: from the state of mind to the projects of saving life on the Earth; from individual activity to global behaviour of the world (Streimikiene *et al.* 2009; Bartkus, Grunda 2011; Bojnec, Papler 2011; Kersys 2011; Manteaw 2011; Shen *et al.* 2011).

Sustainable development retained the knowledge of management and economic science, which has endured the experiments of the reality, and revealed the created credo of thought and activity – *to sustain ability for that which leads us to the future*. The concept of sustainability dominates in the management of scientific cognition and universal knowledge formation.

The objective of the research is to propose the solution for optimal allocation of investment resources among the separate sustainability's subsystems.

The research methods are: comparative literature analysis, Markowitz Random Field (MRF), adequate portfolio technique, expert valuation, imitative technologies, multicriteria stochastic optimization.

2. The principal scheme of country (region) development sustainability analysis and management

In this paper we will use the universal concept of sustainability, which was proposed by the authors for the 1st World Sustainability Forum (Rutkauskas *et al.* 2011), intended to investigate the development sustainability. Fig. 1 presents a slightly modified scheme, disclosing the content of the mentioned concept.

INVESTMENT DEVELOPMENT SUSTANABILITY						
SOCIAL-DEMOGRAPHIC SUSTAINABILITY	ECOLOGICAL SUSTAINABILITY	ECONOMIC SUSTAINABILITY	RELIGIOUS SUSTAINABILITY	POLITICAL SUSTAINABILITY	CREATIVE SUSTAINABILITY	TECHNOLOGICAL SUSTAINABILITY
SUSTAINABLE COUNTRY (REGION) DEVELOPMENT						

Fig.1. The scheme of country (region) development sustainability analysis

According to Fig. 1, the cognition of universal sustainability is oriented towards self-sufficient enough combination of functional components or subsystems.

Four of the earlier mentioned subsystems – subsystem of ecological sustainability, subsystem of social-demographic sustainability, subsystem of economic sustainability and subsystem of political sustainability – are practically included into every detailed enough case of development sustainability. The subsystems of technological and creative sustainability are quite rarely analysed as subsystems of independent development. The subsystem of religious development sustainability hasn't found its official recognition during quite a long time period, but the experience of the last decades states that this is especially important component of development sustainability.

A subsystem of investment development sustainability, which is actually very rarely mentioned, requires a distinct presentation. Inevitably there should be noticed that this is the core subsystem searching for efficient sustainable development strategies. Its mission – to develop an investment structure, investment science and investment means measured up with country today's opportunities and future needs, which would guarantee the return on today invested capital, forming a base for the development of all functional sustainability subsystems and the guarantee for universal sustainability of development.

2.1. Universal sustainability as a halo of sustainability subsystems

Speaking about the problems of evaluation and management of sustainability, usually a set of sustainabilities or a structure of universal (from the Lat. *universalis*) sustainability is chosen, revealing the possibilities to formulate and solve the specific sustainability problems. As it was already mentioned, usually the social, economic, ecological and political sustainability subsystems are distinguished, often – technological and religious sustainability subsystems and rarely – investment sustainability subsystems.

In turn, for each subsystem specific characters and objectives are raised:

– *Religious sustainability* is the possibility for humankind to face up its temporariness of existence on the Earth and forever existence in the other world, to recognize spiritual values of each other, to avoid a contraposition of religious gospel, to focus exceptional attention of everybody on weaklings and unfortunates.

– *Political sustainability* is the possibilities of citizens to ensure democratic regeneration of country's political institutions, what would guarantee public representation of all citizens' interests and also represent country's interests in international institutions.

– *Social sustainability* is the possibility to combine harmoniously the interests of all social groups, ensuring proper conditions of human existence on the ground level of hierarchy and, what is most important – the ability to develop society evolution under science-revealed consistent patterns.

– *Technological sustainability* is the ability to ensure the renewal of technologies used to make products and services with the help of the most efficient innovations.

– *Creative sustainability* is the ability to respond independently to the matured necessity to train business intelligence, development of creative industries, and admit the dominance of creativity and knowledge economy.

– *Economic sustainability* is the ability to satisfy the needs of country maximally using the disposed resources together invoking international communication and support opportunities.

– *Investment sustainability* is the ability to generate such investment strategies that would mobilize the country business, public sector and the broad society, along with that proposing the ways and methods for the capital invested in the past to help ensuring the possibilities for future generations to reach their objectives.

The main objective of each universal sustainability subsystem in a more simplified way could be understood as a subsystem's ability to maintain with the high level of guarantee the certain core system parameter’s level above the critical threshold, while dropping below the threshold the subsystem starts to lose its ability to rebuild itself as a system. However, undoubtedly the main question is rising – what kind of ability the universal sustainability should foster, i.e. the resultant of all sustainability subsystems. Searching for the answer to this question unambiguously the idea is coming that this feature conceptually should be understood as preservation of the subsystems’ ability to interact. Actually, the necessity of such feature is being searched by analyzing the environmental sustainability individually, as well as other sustainability subsystems. However, for individual subsystems the interaction of their elements or subsystems is conceptually more perceivable and unfolding for management. In the case of universal sustainability there is a need for formation of the perfect concept of interaction, as well as for preparation of engineering foundations of interaction.

The key tasks here are to understand the content, methods and consequences of the universal sustainability and be able to simulate adequately those processes in order to create the assumptions for the specialists of various subsystems to discuss on the basis of quantitative information.

Considerations about the universal sustainability apprehension and fostering are not abundant and one-directional, and even more – practically constructive. Actually, in 1999-2005 the ESI (Environmental Sustainability Index) was published. However, it was rather measurements of environmental state’s parameters or estimates, which are more suitable to compare environmental states of different countries. Later, it was substituted with the EPI (Environmental Performance Index), and as the name asserts it pretends to become the instrument of sustainability’s anatomy research.

2.2. Investment as a constructive discussion with the future

Investment subsystem, which gained an exceptional position on the mentioned scheme, also assumes an exceptional function – to mobilize resources necessary to maintain the main functions of the mentioned subsystems and strengthen their interaction. Here the exceptionality shouldn’t be identified with importance, however, inopportune attention to the saving of sustainability powers renders an account for expenses, which can become crippling for the mankind.

Investment can and must be perceived as a discussion of the present with the future, when past and present leaves the created assets, as well as inevitably growing liabilities for the future. Moreover, investment scope and structure is concurrent to the evaluation of powers accumulated in the past and to the amount of liabilities included into country or region development balance.

The condition of investment sustainability subsystem is related to the condition of all development subsystems. Along with that, the nurturance of every sustainability subsystem is based on the ability of investment subsystem to raise the power of today invested capital in every sustainability subsystem distinguished. Also, it is worth noticing that investment subsystem reveals the essence of the sustainability concept in the most natural way.

Is the capital invested today capable of giving the required return in the future, will we be able to bear the growing burden of liabilities?

The deeper analysis of financial and economic crises, including today’s processes, shows that investment is losing its ability to efficiently use the accumulated and natural resources.

Indeed, what balance of liabilities and assets we have today and what will be left for the future? What should be done in order to retain the power of invested capital and make it grow in every sustainability subsystem? It is almost clear that even global investment strategies and policies increasingly approach the inability to settle the assumed liabilities. This trend concerns virtually every subsystem. The elementary accounting allows us to make a conclusion that insolvency, and, in turn, bankruptcy is approaching.

There is no need for an exceptional wisdom in order to understand that the constructive dialogue with the future, or a rational investment strategy, is an essential condition to assure the development sustainability for every country or region.

3. The essence, nature and anatomy of sustainability concept

Losing the sustainability power in any universal sustainability subsystem threatens the catastrophic losses for the country or region, however, the possibility or even realization is not the full source of information about how sustainability power should be fostered.

In order to use the adequate methodology to formulate the decisions of system analysis and management, the following steps should be taken:

– to understand the essence, nature and anatomy of sustainability concept;

– to be able to quantitatively measure the power of sustainability;

– to be able to relate the positive changes of sustainability power with the required resources volume and structure;

– to be able to understand the link of universal sustainability power with sustainability subsystems' powers and the possibilities of interaction of these subsystems;

– to be able to disclose the optimal resource allocation among separate subsystems in order to reach the maximum power of universal sustainability.

It is quite a risky activity to analyse these questions, because literature assigns them a lot of attention and the number of unanswered or even unanswerable questions is not decreasing. However, in order to take the five mentioned steps it is necessary to answer these principal questions.

3.1. Theoretical background for sustainability development research

First of all the principal question arises: is sustainability a category of evolution or development – i.e., is there objectively existing characteristics of naturally composed processes and systems, including social, and consistent patterns displayed in the evolution of processes and systems, or it is the personal attitude that it should be like this? Of course, the conclusion can be such that sustainability category has brought the evolution of thinking for the mankind, and then sustainability category should be accepted as a development category.

Second, is sustainability an attribute of power, i.e., does higher degree of sustainability stipulate higher productivity? Thus, this characteristic can disappear as a consequence of the system or process development or evolution. Still it is especially important to perceive if sustainability is only the informational characteristic, which informs environment about its presence, or it is the feature of power, the degree of which informs about the usefulness of the system or process. This information is important when sustainability is attempted to measure.

The theoretical conclusions of thinking, stating that: „sustainability assessment has recently emerged as policy tool, whose fundamental purpose is to direct planning and decision making towards sustainability", along with practical selection of sustainability index models ensures that for sustainability, as a characteristic of state, the feature of power is also assigned.

However, when the past or the present moment is considered, the power, as well as other features, can be measured with a certain adequate determined indicator. But when it comes to future, then the indicator of the real power should be supplemented by the probability of its achievement, or simply it should be expressed as probability distribution of sustainability power possibilities' indicator.

In the researches of populations' evolution and survival to analyse the situation, analogical to our formulated problem, the logics of the so-called survival function is applied, which organically combines the magnitude of power and probability of that magnitude. For every population, its quantity is a natural characteristic of population's vitality, along with the biology and environment, where the existing population generates critical for the population quantity k. If population quantity decreases below this value, the population would lose its ability to reproduce.

If the mentioned universal sustainability subsystem possesses the indicator of its efficiency power S^i, and it drops to the level S_k^i, critical for the subsystem, the subsystem loses its main characteristic – ability to remain renewable. This means that the logics of population's evolution sustainability fostering could be shifted to the universal sustainability subsystems management.

If the critical level of indicator, describing the power of subsystem, equals S_k^i, and if we assume that the possibilities of indicator in the future can be perceived as the realization of a random process, then our aim can be understood as actions guaranteeing that:

$$P\left\{\xi^i \geq S_k^i\right\} = \beta_k^i, \tag{1}$$

where:

ξ^i – current quantity of population members,

S_k^i – critical index value.

This means that the guarantee of the event that subsystem's sustainability index will not drop below the critical threshold, is of desired level. Geometrically (Fig. 3 section a) this logics is fully disclosed by graphical view of the so-called survival function. Here in the abscissa the possible sustainability index values S^i are depicted, and in the ordinate axis – the values of probabilities $P\left\{\xi^i \geq S_k^i\right\}$, where S_k^i is the critical index value.

The geometrical view of the survival function provokes for further contemplation. Let sustainability index level influence the efficiency of the subsystem, and reaching the desired guarantee demand certain expenses. Then naturally the problem arises – what level of sustainability index is the most useful for the subsystem? And, in general – what universal level of sustainability index in the most useful for the whole sustainability system?

The problems of profitability, reliability and risk management can be coherently investigated using the concept and technique of the adequate portfolio (Rutkauskas 2006; Rutkauskas, Stasytytė 2011; Rutkauskas *et al.* 2011). This will be described in the next chapter.

3.2. Uncertainty as permanent state of systems and processes

Uncertainty is natural state of many systems and processes. However, often such expressions as optimal decisions with regard to uncertainty or stochastic optimization, etc. need additional explanation and stipulation.

First of all, it is the matching of the determined state of present and the past with uncertainty of the future. It seems that while switching to the perspective we simply wade into the reality of uncertainty. Let's say, if we know that today a roll costs 1 LTL and feeling the tendencies of price increase, we do not decide and we would not succeed to evaluate unambiguously the price of the roll after 1 year.

Probably the most popular, but not the unique method for constructive analysis of the future price possibilities after one year is the probability theory, when we analyse the possibilities of the forecasted prices through the evaluation of their happening (realization) probabilities.

These assumptions seems to be elementary with regard to the reality, however, they raise the need for completely new thinking. In effect, when we have a preconceived assumption that we are interested in a possibility of particular value, then the objective, and often even the means of its attainment, becomes clear – there is a need to minimize riskness possibility. Almost the same way of problem solving is in case when we are already limited by the level of risk, then we clearly choose the biggest possibility not exceeding the particular riskness level.

But if we have to consider the selection of the pair of best possibility and its riskness, there is a need for completely new assumptions. There is no doubt that rationality of choice depends on the subject performing selection. However, often in taking decisions or formulating decision-making strategies riskness is identified with risk, and abilities of the subject to respond to risk are not taken into account.

In many cases at least partly related to investment portfolio management we face the situation depicted in Fig. 2.

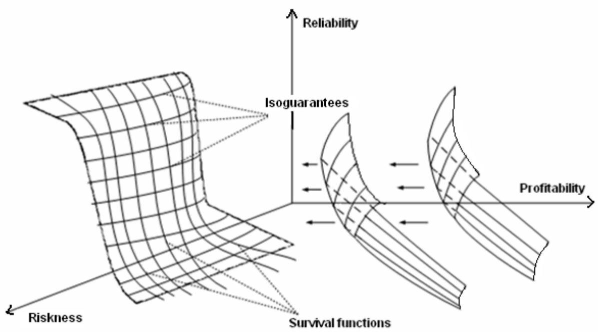
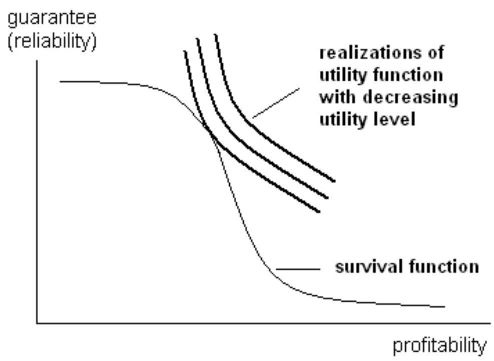
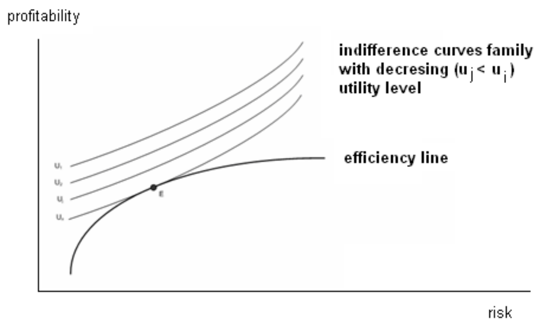


Fig.2. The general view of three-dimensional efficient surface and respective utility functions (Rutkauskas 2006)



a) selection of optimal ratio between profitability and reliability



b) selection of optimal ratio between profitability and riskness

Fig.3. The main moments of optimization on the efficient surface (Rutkauskas, Stasytytė 2010)

On this three-dimensional surface we can analyze all existing dependencies among profitability, guarantee and riskness or risk, when survival functions react to investor's possibilities to respond to risk.

The exceptional dependencies are the selection of optimal ratio between profitability and reliability (Fig. 3 section a) and determination of optimal ratio between profitability and riskness (Fig. 3 section b).

On spatial utility function (Fig. 2) these moments are integrated and optimization is performed according three criteria: profitability, reliability (guarantee) and riskness (risk). Recalling that portfolio actually is a multifactor function, Fig. 3 presents the multicriteria optimization case of multifactor stochastic function.

4. The problems of universal sustainability assessment

Interaction or the ability to interact – is there a difference? Often such question arises, when we analyse the development of separate sustainability subsystems' interaction. In previous chapters of the paper we were trying to perceive if the content of universal sustainability and interaction of sustainability subsystems are the encoded principles of evolution, or it is a subjective desire that it should be so. Till the recent years the content of sustainability definition was illustrated by consequences which accompanied the results of human activity. The humankind, meeting its needs growing as a result of the population growth and irrational satisfaction of needs, send a signal about possible catastrophic results in the future. However, it mostly happens because the conservators of the content of sustainability category were not claiming to turn it into scientific category. As noted in recent years (Jerneck *et al.* 2011; Schoolman *et al.* 2012), an area that has come to be called sustainability science has emerged. Though sustainability is not yet an autonomous in its perception field or knowledge extention discipline of its own, but has tended to be perceived problem-driven and seem as a network of aims, oriented towards guiding decision-making. There is a hope and necessity that knowledge about the interaction of sustainability's subsystems will become the first and most important problem of this science.

Measuring, analysis and management of subsystems, and especially sustainability powers is not limited to the mechanical changing of indicators. Let's say, if country volume of National Product (NP) per capita does not decrease – this does not mean that country social sustainability power does not change, if in that period ten percent of the most qualified workforce left the country.

The sources of the subsystems' sustainability powers mainly lie in their interaction. Thus, assessing resources needed for subsystems', for example for natural environment sustainability power maintenance, they often must be taken from other, for example economic subsystems. May be because of this even having detailed enough and functionally adequate description of country economic, social, political, religious, ecological and investment processes, one should apply experts or even expert systems, which can form additional feeling for complex sustainability problems raising and solving moments. Also, often the speculation on the expert evaluation results can take place.

The authors of this paper, probably like many others analysing country or its certain structures' development sustainability problems, do not want to leave the ambition that this is especially important scientific problem. Of course, this is a complex problem, but discussing the question if this is a classic scientific problem, it is also worth recalling other reality cognition means, which are applied for complex systems' analysis, – namely, the engineering. The delicate comparison of these two systems can result in a saying that science investigates the reality as it is, while engineering – as we want it to be. Probably the authors ready to analyse the possibilities of country or its certain structures' development sustainability will not chagrin if it appears to be the object of engineering research. Along with that it is worth noticing that this is not engineering in the sense of competences of a particular engineer profession, but it is engineering in the sense of the application of science to the optimum conversion of the resources of nature to the uses of humankind.

4.1. Universal assessment of sustainability index

Facing up the assumption that in cognition of sustainability there is a place for engineering philosophy and methods, let us suppose that for sustainability of religious, political, social, economical, ecological and investment subsystems as for natural purposes of these systems' management, integrating public EU support and business funds, the particular fund is formed, which can be disposed by the country distributing it among the mentioned subsystems and thus reaching the desired changes in universal sustainability index. With the help of specific measurements got from lower level subsystems and based on expert evaluation, we can assess how the usage of the marginal financial unit impacts every sustainability subsystem's index changes. This impact is estimated as a stochastic variable in the indexes of subsystems. The index of universal sustainability is embraced as a production of all subsystems' sustainability indexes, what recalls the presumption that universal sustainability accumulates changes of all systems.

Note 1. In this case the coefficient c is the bearer of changes, by which the existing index value is multiplied.

$$C = D(a_{si}, \sigma_{si})^{w_i}, \quad (2)$$

where:

D – is the form of probability distribution adequate to the index marginal change in the i-th subsystem under the description of state s;

σ_{si} – the standard deviation of the mentioned distribution;

m_{si} – the mean value of the mentioned distribution;

s – the state where the marginal change is analysed;

i – the number of subsystem.

The expert valuations allowed to determine such values of coefficients:

D (0.99; 0.13) – for social-demographic subsystem;

D (1.02; 0.04) – for ecological subsystem;

D (0.96; 0.12) – for economic subsystem;

D (0.93; 0.11) – for political subsystem;

D (0.9; 0.1) – for creative subsystem;

D (1.05; 0.5) – for technological subsystem.

Note 2. It was set that for initial situation, i.e. for the mentioned situation s, the indexes of subsystems equal 1. Also, for religious sustainability experts did not match their opinion, thus it is omitted here.

The possibilities of universal index are characterized by the index change extent, as well as by the reliability of the change and by the riskness. It is obvious that we have to know the way how to select the possibility which guarantees the maximum increase of index powers. The power of index is calculated with the help of utility function analog:

$$U = u(e, p, r) = \frac{ep_e}{r_e}, \quad (3)$$

where:

e – the value of index change possibility;

p – the guarantee of the possibility;

r – riskiness of possibilities' set.

5. Engineering as suitable instrument for sustainability promotion

Recalling the discussion commenced earlier, questioning if sustainability is the main attribute of development, or it is a subjective conviction of development agents, it is worth to evolve the idea of Theodore Van Karman (American… 1970) that „Scientists study the world as it is; engineers the world that has never been“. May be, this idea could be corrected in the same time not offending nor Theodore Van Karman, nor the engineers in such a manner: "Science studies the world as it is, while engineers – the world that they can create".

Vincent Walter (1993) in its work states that the world of engineering researches differs from scientific researches. First, engineering usually considers situations where basic knowledge of physics or chemistry are well-perceived, but problems are too much complicated for accurate decision finding.

Theodore Van Karman says that there exist overlap between the sciences and engineering practices; in engineering one apply science. Both areas of endeavor relay on accurate observations of materials and phenomena, both uses mathematics and classification criteria to analyze and commensurate observations.

By it's nature engineering is bound up with society and human behavior. Engineering is a subject that ranges from large collaboration to small individual project. Almost all engineering project are beholden to same sort of financing agency: a company, a set of investors or a government. The few types of engineering that are minimally constrained by such issues are pro bono engineering and open design engineering.

To resume what is said above, there should be noticed, that engineering is the discipline, art, skill and profession of acquiring and applying scientific, mathematical, economic, social and practical knowledge in order to design and build structures, machines, systems, materials, devices and processes that safely realize the improvements to the lives of people.

Sustainability is the state of systems and processes that could serve for safety and efficiency and should be gained with the help of engineering.

5.1. Is the problem of sustainability management already solved?

Keith Campbell (2009) in his paper "Sustainability – Engineering for the rest of us" resumes, that sustainability is about the same things that engineering is about – achieving outcomes in responsible ways. A capital project is about achieving a specified objective in a way that produces maximum return on investment. This requires minimizing the consumption of resources, basically matter and energy, over the lifetime of the product or process. This is what engineers are trained to do, and it is why many of them are having a difficult time warming up to the concept of sustainability – to them, it's nothing new.

Further he supposes that engineers are natively trained to execute in a sustainable way. Their education is steeped in an understanding of conservation laws and equations involving matter and energy. Differential calculus is about evaluating and finding minimums. Give engineers a challenge to find solutions that utilize minimum resources, and they will jump right on it. But sometimes they find their efforts thwarted.

To point out the oneness of engineering thinking Keith Campbell says that “During my career in project engineering, we were encouraged or expected to take courses with titles such as "Marketing for non-Marketers" or "Finance for the non-Financial". I don't ever remember a course on "Engineering for the non-Engineer". Perhaps if such courses were required, sustainability would be easier for many to embrace. Is sustainability really about engineering for all of us? Maybe sustainability gives us all a chance to dabble a bit in engineering principles without looking nerdy.”

Of course because sustainability is the way of existence i.e. system or process state category and engineering is the way of action these ways ought to go side by side. Though both of them needs additional attention.

The state of universal sustainability requires its full-rate subsystem interaction recognition, engineering practically does not exploit the formation of concerns and their usage in pursuance of management strategy preparation of desired system or process.

5.2. Step by step to sustainability management

In the previous chapter the preparation of principles for system’s sustainability power management was commenced, assuming that the index is a real indicator of subsystem sustainability power, but its projection for the future can be accepted as a preparation for the random process management. For every universal sustainability subsystem out of the six influencing the power of universal sustainability, the concept and application principles of survival function were formed with regard to fostering sustainability powers of subsystem.

How should the selection of sequence of steps for universal sustainability power fostering start? Probably, the first step should be the assigning of universal sustainability index S_u to a certain function of universal sustainability – the index of subsystem. Further the universal sustainability index S_u will be treated as a product of subsystem’s sustainability indexes:

$$S_u = \prod_{r=1}^{6} S_i^{ai}, \qquad (4)$$

where:

$$\sum_{i=1}^{6} a_i = 1$$

Actually this is quite a reasoned step, because the index $S_{u,}$ as well as the index S_i is treated here as probability distributions of index possibilities. Then the product serves as a certification that S_u is the result of S_i, i = 1,2,…,6 subsystems’ combined operation.

Further, following the example of stochastic optimization for investment portfolio formation and application, we will construct an efficient surface and respective utility functions in the three-dimensional space for our case.

However, if in the case of investment portfolio efficient surface is composed out of profitability possibilities, measured with the magnitude, reliability and riskness of this possibility, in the analysed case the surface is composed of the sustainability subsystems’ portfolio or, simply, universal sustainability index changes, which are raised by additional marginal unit of expenses for sustainability index maintenance.

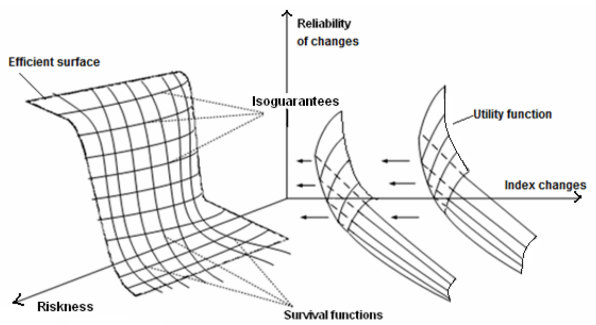


Fig.4. The idealized view (scheme) of efficient surface and utility functions of universal sustainability index changes

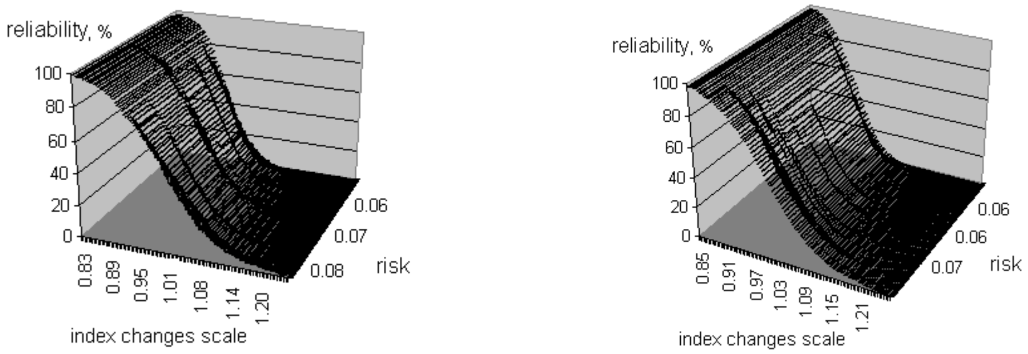
Thus the projecting of these changes is performed according the same three measurements as in the case of investment portfolio profitability.

5.3. Case study

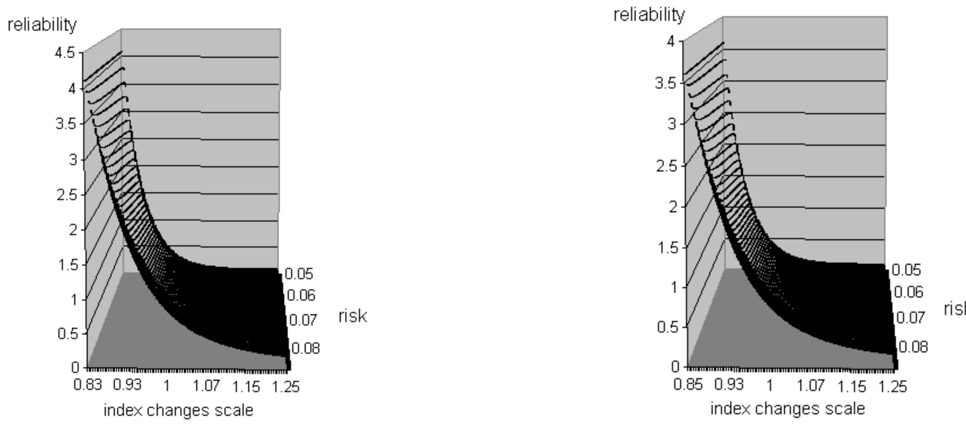
Further we will come back to the analysis of the particular data, which was presented in subchapter 4.1. Using this data, we will present the efficient surface (Fig. 5 section a), utility functions (Fig. 5 section b), the general view of utility functions and efficient surface (Fig. 5 section c), and, finally, the finding of the intersection of efficient surface with utility function, i.e. the optimal decision (Fig. 5 section d). On the left side the graphs are presented when the coefficients set by experts in subchapter 4.1 conform to the Normal probability distribution of possibilities, and on the right side – when these coefficients conform to the Logormal probability distribution of possibilities. In both cases the mean value and standard deviation of possibility are the same values. This allows to see how the decisions taken are sensitive to the nature of the probability distribution of possibilities.

Fig. 5 section e shows the moment of optimal decision finding for both analysed cases when the the risk coefficient in the utility function is set 2.

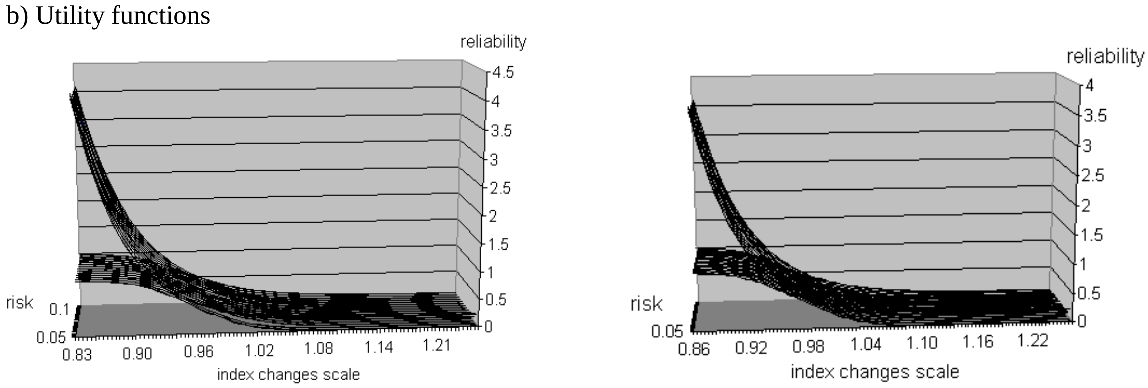
According to their analytical form, random efficient surfaces and utility functions are convex surfaces with regard to each other. Since for the existence of a decision and its finding this is the principal moment, we admit that the situation presented in Fig. 6 can also be an alternative to the surfaces convex with regard to each other.



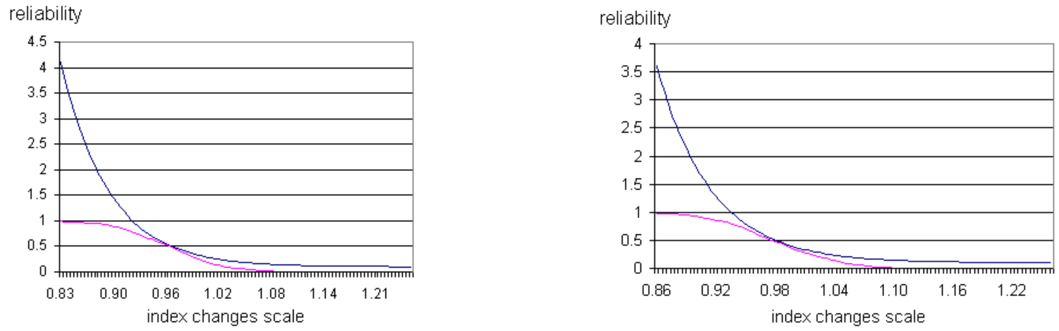
a) Efficent surface



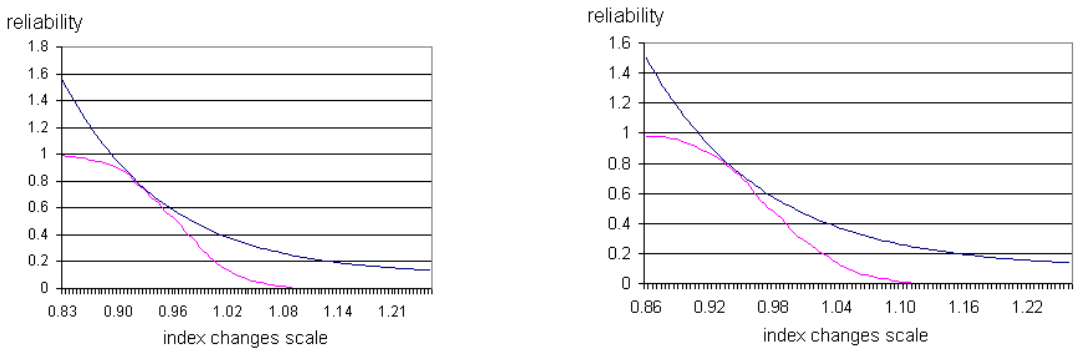
b) Utility functions



c) The intersection of possibilities' and utility set



d) The finding of intersection points



e) The finding of intersection points in Normal and Lognormal case including the risk coefficient 2 in the utility function

Fig.5. Section a – efficient surfaces, b – dimensional view of utility functions, c – the intersection moments of possibilities' set and utility functions, d – particular points of intersection, e – intersection points in Normal and Lognormal case including the risk coefficient 2 in the utility function. Note: on the left side – Normal probability distribution, on the right side – Lognormal probability distribution

From Fig. 5 we can see that coordinates of optimal decision in the case when risk is identified with riskness differs only slightly and in completely explicit direction, according Fig. 3 section a.

Further we present the values of the main parameters of every case out of four intersection points analysed (Table 1). It is clear that increasing the impact of riskness in utility function, the maximum utility value decreases.

Table 1. The values of parameters of the intersection points (optimal decisions) of possibilities' set and utility function

Parameter	**Normal prob. distribution**	**Lognormal prob. distribution**
Usual impact of risk		
Index value	0.96	0.98
Riskness	0.056	0.056
Reliability	0.48	0.47
Impact of risk, multiplied by 2		
Index value	0.91	0.93
Riskness	0.056	0.056
Reliability	0.85	0.83

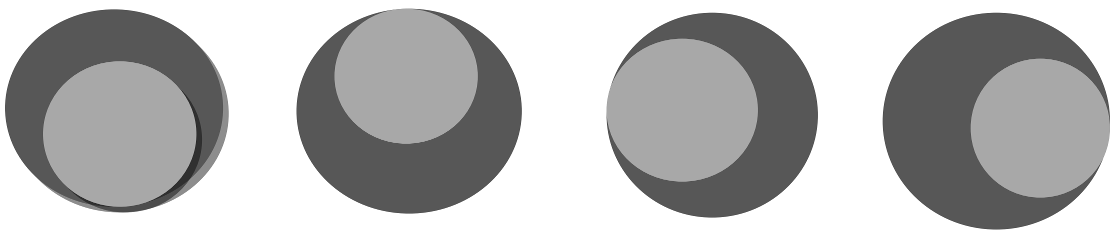


Fig.6. Non-typical geometric view of mutually convex surfaces

However, to assume that the argument of utility function becomes a function of riskness (in the analysed case it is assumed that risk equals riskness multiplied by 2), allows to see significant changes in the situation of coordinates of optimal point on the efficient surface. We see that the value of utility function decreased in Normal and Lognormal distribution case.

In fact, the intersection of possibilities‘ set (surface) with utility surface is not perceived apparently. There are possible cases when possibilities‘ surface – the external ring, and the utility surface – the internal ring, and their intersection resembles the situation depicted in Fig. 6. Anyway, it is seen that even in this case the intersection of these surfaces results in a unique possible solution.

6. Conclusions

The concept of sustainability, which brings the credo “*to sustain ability for that which leads us to the future”*, fosters the formation of scientific knowledge field, named the development sustainability.

The universal scheme of country (region) development sustainability invokes the following subsystems: social-demographic, economic, ecological, political, technological, religious and creative sustainability, the synergized operation of which allows to retain and improve general sustainability power.

Sustainability can be explained as the state of systems and processes that could serve for safety and efficiency and should be gained with the help of engineering philosophy and methodology.

Expert systems and simulation technologies are capable means for solving the tasks of optimal allocation of resources, particularly – for determining the coefficients and parameters of the probability distribution of sustainability effect and their function.

To solve the problem of financial resources allocation among different sustainability subsystems the idea, concept and technique of adequate portfolio was invoked in order to reach the maximum power of sustainability index.

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