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Hevristični model razvoja proizvodnih zmogljivosti

A Heuristic Model for the Development of Production Capabilities

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Menedžerji v proizvodnih okoljih se pri odločanju srečujejo z visoko stopnjo nezanesljivosti, zaradi hitrih in velikih sprememb, ki opredeljujejo okolja, v katerih delujejo njihove organizacije. Ta pomeni, da menedžerji pri odločanju nimajo popolnih informacij o prihodnjih dogodkih, ne poznajo vseh mogočih alternativ in ne poznajo posledic vseh mogočih odločitev.

Spoprijeti se z negotovostjo pomeni razvijati hevristična orodja, ki lahko ponudijo zadovoljive rešitve, ne pa tudi optimalne. Metode simulacij, ki temeljijo na ekstrapoliranju merljivih podatkov iz preteklosti, niso ustrezne kot pomoč pri odločitvah v okoliščinah negotovosti. V zadnjem času se kot prevladujoča hevristika za reševanje odločitvenih problemov pri visoki stopnji negotovosti pojavlja teorija stvarnih možnosti. Zato se postopki stvarnih možnosti danes uporabljajo za vrednotenje investicij v raziskave in razvoj, v razvoj novih izdelkov, v proizvodno tehnologijo in preostale proizvodne vire. Na inženirskem področju smo priča intenzivnemu razvoju metod, orodij in tehnik, ki sicer po svojem poreklu spadajo na področje uporabne matematike, informacijskih znanosti, operacijskih raziskav in ekonomske teorije (genetski algoritmi, evolucijsko programiranje, genetsko programiranje, mehka logika, nevronske mreže, teorija stvarnih možnosti itn.), se pa zelo uspešno uporabljajo pri reševanju različnih tehničnih optimizacijskih problemov. Teorija stvarnih možnosti se uporablja tudi pri obravnavanju tehnologije, razvoja in raziskav ter proizvodnje. Razmišljanja o uporabnosti teorije stvarnih možnosti so se razširila tudi na področje strateškega menedžmenta.

(Ključne besede: sistemi proizvodni, upravljanje tveganja, teorija stvarnih možnosti, modeliranje negotovosti, mehka logika)

Managers in production environments face a high level of uncertainty in their decision making due to the major, rapidly developing changes defining the environments in which their organisations operate. This means that managers do not possess complete information about future events, do not know all the possible alternatives or the consequences of all their possible decisions.

Overcoming this uncertainty requires the development of heuristic tools, which can offer satisfactory, if not optimal, solutions. Simulation methods based on the extrapolation of available data from the past are unsuitable for help in decision-making processes in uncertain conditions. Lately, the dominant heuristics used for solving decision-making problems during a high level of uncertainty is the theory of real options. For this reason the real-options approach is currently used for an evaluation of the investments in research and development, the development of new products, production technologies and other production sources. As regards engineering, we are witnessing the intensive development of new methods, tools and techniques, which by their origin belong to the field of applied mathematics, information sciences, operational research and economic theory (genetic algorithms, evolution programming, genetic programming, soft logic, neuron networks, the theory of real options, etc.), and are very successfully applied in the solving of various technical optimisation problems. The theory of real options is also used in issues related to technology, research and development, and production. The thoughts on the use of the theory of real options have also spread to the area of strategic management.

(Keywords: production systems, risk management, real option theory, uncertainty modelling, fuzzy logic)

0 UVOD

Odločanje v okoliščinah velike negotovosti postaja eden najbolj raziskovanih pojavov na področjih strateškega menedžmenta, organizacijske teorije, industrijskega inženiringa in menedžmenta razvoja in raziskav. Negotovost je definirana kot značilnost pojava, ki se upira merljivosti in ga je zaradi tega nemogoče učinkovito omejiti na pripadajoče stopnje verjetnosti. V nasprotju z nezanesljivostjo je tveganje merljivo s stopnjami verjetnosti in ga je mogoče upravljati. Nobelovec Arrow [2] predlaga definicijo nezanesljivosti, po kateri ta pomeni, da nikoli nimamo popolnega opisa sveta ali stanja, za katerega verjamemo, da je resničen. Ta definicija pomeni, da verjetnosti, da se kot posledica dejavnosti zgodi dogodek, ni mogoče objektivno določiti, ampak je zgolj rezultat subjektivnih domnev. Neobvladljivost negotovosti še povečujejo človekove spoznavne omejitve. Spoznavna baza človeka sestoji iz predvidevanj o prihodnosti, poznavanja mogočih alternativ in znanja, ki omogoča poznavanje posledic odločitev. Ta spoznavna baza je izrazito omejena in jo opisuje pojav omejene racionalnosti [6].

Ta izhaja iz teorije finančnih možnosti, katere temelje sta postavila nobelovca Black in Scholes [3]. Naključnostna diferencialna enačba, ki sta jo razvila, omogoča vrednotenje finančnih možnosti v okoliščinah negotovosti. Logika finančnih možnosti se je hitro razširila na stvarne možnosti, ki jih obravnava zajeten kup znanstvene literature ([1], [5] in [10]). Finančna možnost predstavlja možnost za nakup ali prodajo finančnega premoženja, ki že obstaja in se prodaja na finančnih trgih v obliki delnic in obveznic. V nasprotju z njo pomeni stvarna možnost možnost za spremembo stvarnega premoženja, virov ali intelektualnih dejavnosti, na primer: postaviti novo tovarno, osvojiti nov trg, razviti novo tehnologijo ali izdelek.

Teorija stvarnih možnosti se je uveljavila kot vodilna hevristika za obravnavanje pojavov, povezanih z negotovostjo. Na prej naštetih znanstvenih področjih se potreba po obvladovanju nezanesljivosti kaže pri razvojno-raziskovalnih projektih, razvoju novih proizvodnih tehnologij, projektih razvoja novega izdelka, investicijah v napredno proizvodno tehnologijo, odločitvah o selitvi proizvodnje in razvoju proizvodnih zmogljivosti, kakor so prilagodljivost v proizvodnji ter obvladovanje kakovosti.

0 INTRODUCTION

Decision-making in high-risk conditions is becoming a common area for research within strategic management organizational theory, research and development management, and industrial engineering. Risk is measurable with probability levels and can thus be managed; however, this cannot be applied to uncertainty. The Nobel Prize winner Arrow [2] proposed an uncertainty theory that suggests that there can never be a perfect definition of the world or conditions for which we believe are real. This definition can be interpreted as such: the probability that an event will occur as a result of our activity cannot be defined objectively, but can only be an outcome of our subjective assumptions. The inability to master uncertainty only enhances human cognitive limitations. The human cognitive base comprises future predictions, potential alternative options and the ability to foresee the consequences of a decision. This cognitive base is very limited and can be described by the phenomenon called Bounded Rationality [6]. It outlines that in decision-making, managers do not have complete data on future-event occurrences and therefore cannot predict all the possible alternatives or forecast all the consequences of their decisions.

It is derived from the Financial Options Theory, which was developed by the Nobel Prize winners [3] Black and Scholes. The stochastic differential equation they developed enables the assessment of financial options in uncertain conditions. Financial Options logic rapidly developed into Real Options, which is outlined in a sizable amount of scientific literature ([1], [5] and [10]). The Financial Option presents a purchase or a sales option for financial assets, which already exist and are being sold in financial markets in the form of stock and bonds. The Real Option, on the other hand, represents an option for real asset change, source and intellectual activity change, for example, building a new factory, conquering new markets and developing new products or technologies.

The Real Options theory has become the leading heuristic for dealing with uncertainty phenomena. The need to manage uncertainty in the above-mentioned scientific fields is most apparent with research and development projects, new production technology development, new product development projects, advanced production technology investments, production migration decisions and production capabilities development, such as production flexibility and quality management.

1 TEORETIČNO OZADJE

Pomembna literatura obravnava problematiko odločanja v pogojih negotovosti le delno. Trenutno potekajo najbolj izrazite raziskave na področju večkriterijskega odločanja, podprtega z izvedenskimi sistemi. Ne glede na pomemben razvoj so problemi, povezani z izbiro ustreznih metod za zapletene in mehko strukturirane odločitvene probleme, z merskimi lestvicami, statistično interpretacijo, sistemsko optimizacijo ter ciljnimi funkcijami pri večkriterijskih problemih nezadostno obravnavani in hkrati ne rešeni.

Različni avtorji ([4], [11], [12] in [15]) trdijo, da pomeni teorija stvarnih možnosti pravšnjo hevristiko za upravljanje postopka razvoja zmogljivosti. Zmogljivost je definirana kot organizacijsko znanje podjetja, ki omogoča izvajaje poslovnih postopkov [8]. Strateška šola dinamičnih zmogljivosti trdi, da zmogljivosti zaradi svojih značilnosti, kakor so sistemska zapletenost in zgodovinska odvisnost, pomenijo temelje za doseganje trajnih konkurenčnih prednosti ([7], [9], [13] in [16]). Iste značilnosti, ki delajo zmogljivosti težko posnemljive in težko prenosljive in zato strateško vredne, omejujejo možnosti uspešnega upravljanja postopka razvoja zmogljivosti. Ta je opredeljen z visoko stopnjo negotovosti in zato se teorija stvarnih možnosti pojavlja kot hevristika, s potencialom pomagati menedžerjem pri upravljanju postopka razvoja zmogljivosti.

1.1 Opredelitev termina negotovost

O gotovosti v organizacijskem sistemu govorimo, kadar usposobljen posameznik sprejema odločitve, povezane z delovanjem organizacijskega sistema, pri čemer ima popolno znanje o mogočih stanjih v prihodnosti in so ta stanja popolnoma neodvisna od dejavnosti, ki jih tak sistem izvaja. Takšen organizacijski sistem je popolnoma prilagodljiv, saj se je mogoče pripraviti na vsa možna stanja.

Osnutek tveganja v organizacijskem sistemu pomeni, da je možno objektivno določiti stopnje verjetnosti nekega stanja ali dogodka. Pomeni, da usposobljen posameznik pozna vsa mogoča stanja v prihodnosti in verjetnosti, da se ta stanja uresničijo.

Stvarnost v organizacijskem sistemu je običajno težko opisati z osnutkoma gotovosti in tveganja. Avtor Kylaheiko [12] navaja podroben

1 THEORETICAL BACKGROUND

The problem of decision-making in uncertain conditions is only partially presented in the relevant literature. Intensive research in the area of multi-level decision-making, supported by expert systems, is currently under way. Despite the immense importance of development, problems associated with choosing the appropriate methods for complex and soft-structured decision-making problems, measuring scales, statistical interpretation, systems optimization and multifaceted problems are inadequately handled and consequently not solved.

Various authors ([4], [11], [12] and [15]) claim that the Real Options theory presents the right heuristic approach to capability-development process management. Capability is defined as the organizational know-how that enables business-process implementation [8]. The strategic school of dynamic capabilities claims that due to their characteristics, such as complexity and historical dependency, capabilities are the foundation for achieving a sustainable competitive advantage ([7], [9], [13] and [16]). The very characteristics that make it difficult to imitate and transfer capabilities, consequently adding to their strategic value, also limit the possibility of successful capability-development process management. This process is also defined by a high level of uncertainty, which makes the Real Options theory only appear as a heuristic, potentially helping managers handle the capability-development process.

1.1 Definition of the uncertainty term

The term certainty in an organizational system is used when a competent individual makes decisions associated with organizational system operations based on perfect knowledge of all possible future situations, and these situations are completely independent of the activities performed by such a system. Such an organizational system is totally adaptable, as one can prepare for any possible future situations.

The concept of risk in an organizational system means that an objective assessment of probability levels for an event or a situation to occur is possible. This means that a competent individual is aware of all possible future situations and of the probability that these situations will actually occur.

Reality in an organizational system is difficult to describe with the concepts of certainty and pregled različnih tipov negotovosti. Osnutek negotovosti je dosti bolj primeren za opisovanje stanja v organizacijskih sistemih:

- *Parametrična negotovost* predstavlja tip negotovosti, ki ga je še mogoče matematično obvladovati. Negotovost se tiče samo subjektivnih parametrov verjetnosti.
- *Strukturna negotovost* pomeni, da ima oseba, ki odloča, nepopolno znanje o strukturi problema. Za strukturno negotovost je značilno, da je nemogoče imeti znanje o vseh mogočih posledicah. Pomembno je poudariti, da strukturna negotovost pomeni, da stanja v prihodnosti niso neodvisna od dejavnosti.

1.2 Izzivi proučevanja negotovosti

Tip strukturne negotovosti je najmanj raziskan v znanstveni literaturi [14]. Nenapovedljiva negotovost pomeni nezmožnost prepoznati ustrezne vplivne veličine in njihove funkcijske povezave.

Tsoukas [18] govori o *radikalni negotovosti*, ko poudarja, da je v organizacijskih sistemih nemogoče vnaprej vedeti, katero znanje se bo razvilo in katere kombinacije razpršenega znanja bodo pomembne za določene okoliščine.

Obsežne zamiselne razprave in izkustvene raziskave dokazujejo, da je razumevanje osnutka negotovosti ključno za razumevanje delovanja organizacijskega sistema. Kljub zavedanju o pomembnosti upravljanja organizacijskih sistemov v razmerah negotovosti, je na voljo presenetljivo malo sistemskih postopkov in hevristik, ki bi podpirale postopek sprejemanja odločitev v negotovih okoliščinah.

V zadnjem času se je kot vodilna hevristika za obvladovanje postopka odločanja v okoliščinah negotovosti uveljavila teorija stvarnih možnosti. Stvarne možnosti so pomembne v različnih situacijah:

- ko je projekt mogoče ustaviti;
- ko je investicija prilagodljiva, npr. ko je mogoče zamenjati proizvodno tehnologijo;
- ko priložnosti v prihodnosti temeljijo na odločitvah, ki so sprejete danes, npr. razvoj in raziskave.

1.3 Stvarne možnosti in razvoj zmogljivosti

Postopek razvoja zmogljivosti je negotov zaradi zapletene strukture zmogljivosti in zaradi njenega dolgotrajnega razvoja. Bowman in Hurry [4]

risk. The uncertainty concept is far more suitable for describing the actual state that an organizational system is in [12]:

- *Parametric uncertainty* is a type of uncertainty that can still be mathematically mastered. Uncertainty can only be related to subjective probability parameters.
- *Structured uncertainty* means that the decision-maker has limited knowledge of the problem structure. In structured uncertainty it is impossible to possess knowledge of all possible consequences. It should be emphasized that structured uncertainty means that future situations are not independent of the activity.

1.2 Uncertainty research challenges

The structured uncertainty type is the least researched theme in scientific literature [14]. U*nforeseeable uncertainty* means the inability to recognize the relevant influence variables and their functional connections.

Tsoukas [18], who talks about *radical uncertainty,* emphasizes that it is impossible to predict which proficiency will be developed and which scattered knowledge combinations will be important for the specific conditions in organizational systems.

Extensive conceptual discussions and empirical research studies prove that in order to comprehend organizational system operations, it is imperative to understand the uncertainty concept. Despite the fact that there is awareness of the importance of organizational systems management in uncertain conditions, there are surprisingly few systematic approaches and heuristics in place that support the process of decision-making in uncertain environments.

Recently, the Real Options theory has become the leading heuristic for decision-making process management in uncertain conditions. Real options are important in different situations:

- When a project can be terminated.
- When the investment is flexible. For example, when it is possible to modify the production technology.
- When future opportunities are based on decisions made today. For example, research and development.

1.3 Real Options and Capability Development

The capability-development process is uncertain due to the complex nature of capabilities and its lengthy development procedure. Bowman and sta ugotavljala, da menedžerji v poslovnih sistemih pravzaprav intuitivno uporabljajo logiko stvarnih možnosti, ko sprejemajo odločitve v zvezi z razvojem zmogljivosti.

Uporabnost stvarnih možnosti ne bodo povečala matematična orodja, ki bodo zapleteno stvarnost omejila v nekaj spremenljivk, ampak razvoj hevristik, ki bodo upoštevale zapletenost stvarnih razmer in obenem omogočale odločitve na podlagi merljivih pokazateljev.

1.4 Sistemski postopek za obravnavanje razvoja zmogljivosti

V analitičnem delu je treba podrobno analizirati vire in zmogljivosti. Ugotoviti je treba, kateri viri in zmogljivosti so že na voljo in v katerih povezavah jih je mogoče uporabiti. Ugotoviti je treba primanjkljaj virov in zmogljivosti. Strokovna literatura ponuja nekaj sistemskih postopkov, ki podpirajo analiziranje virov in zmogljivosti. Preden se izvedenska skupina loti razčlenitve razvoja zmogljivosti na kategorije in dejavnike, je treba opredeliti tipe negotovosti. Milikenova delitev na negotovost stanja, učinka in odziva je koristna, saj poenoti razumevanje pojma med različnimi člani izvedenske skupine.

Razčlenjevanje obravnavanega postopka na kategorije in dejavnike negotovosti pomeni del, ki se vsebinsko razlikuje v različnih sistemskih okoljih. Izvedenska skupina, ki obravnava negotovost seljenja proizvodnje na geografsko oddaljeno lego, bo identificirala drugačne dejavnike in kategorije kakor izvedenska skupina obrambnega sistema, ki obravnava izvajanje mirovnega opravila na geografsko oddaljenem kraju. Razčlenitev na kategorije in dejavnike negotovosti pomeni razstavitev zapletenega problema in omogoča začetek izvajanja postopkovnega dela.

2 METODOLOGIJA

Za pričujoč prispevek je bil uporabljen dvojni metodološki postopek zaradi potrebe po usklajevanju med celostnim obvladovanjem znanstvenega problema in analitično-numerično natančnostjo oblikovanega hevrističnega postopka. Običajno razviti numerični modeli predstavljajo zgolj abstrakten model stvarnega sistema in so razviti brez izkustvenih kakovostnih temeljev, ki določajo zapleteno

Hurry [4] have found that managers, when making capability-development decisions in business systems, actually use the logic of real options intuitively.

The applicability of real options will not be enhanced by mathematical tools, which reduce the complex reality to a few variables, but by the development of heuristics that take into account the complexity of real conditions and simultaneously enable decisions to be based on measurable indicators.

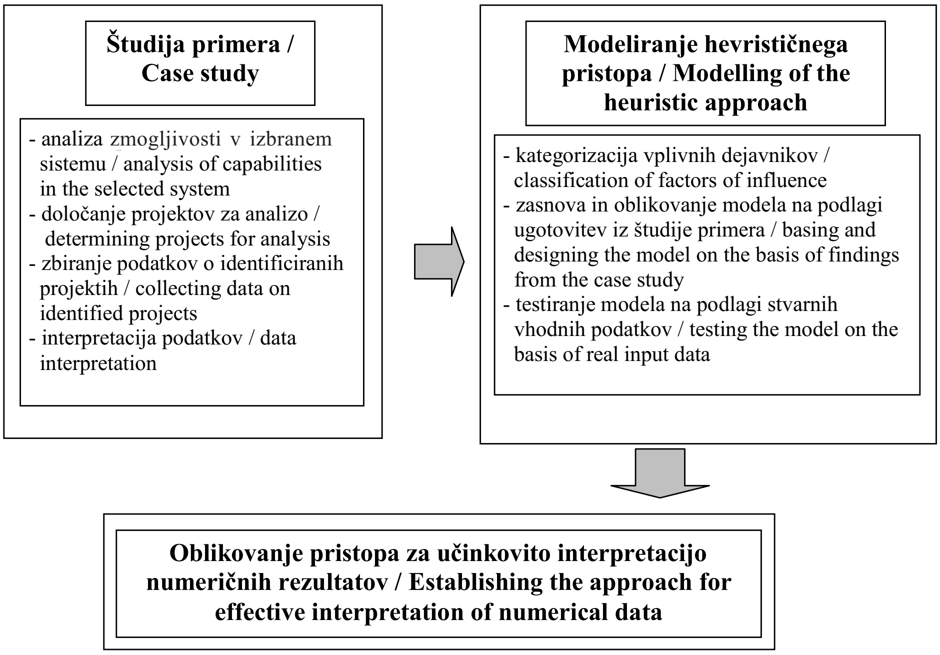
1.4 A systematic approach to handling capability development

In the analytical part of the work, the sources and abilities should be analyzed in detail. It is necessary to find out which sources and abilities have already been at disposal, and in which contextual applications they might be used. It is necessary to find out the deficiency of sources and abilities. Professional literature offers some system approaches, the application of which serves as support for analyzing sources and abilities. Before the expert team starts with ability development, broken down into categories and factors, the types of uncertainty should be defined. Miliken's partition into the situation uncertainty, effect, and response is useful, as it unifies the understanding of the notion between the different members of the expert team.

Breaking down the treated process into categories and uncertainty factors actually represents the part, the contents of which differ in various system environments. The team of experts, treating the uncertainty of production movements to a geographically distant location, will identify other factors and categories than the expert team for the protection system, treating the implementation of peace operation on the geographically distant location. The breakdown to categories and factors of uncertainty represents the decomposition of a complex issue, thus enabling the start of implementing the process work.

2 METHODOLOGY

The double methodological approach was used for the underlying paper due to the need for coordination between the holistic management of a scientific issue and analytical-numerical accuracy of the formed heuristic approach. In most cases, the developed numerical models represent only an abstract model of the real system and are developed without any empirical, qualitative grounds, which



Sl. 1. *Struktura dvojnega metodološkega postopka*
Fig. 1. *The structure of the double methodological approach*

stvarnost sistema. Uporaba dvojnega metodološkega postopka pomeni novost v obravnavanju tovrstne problematike. Dosedanje raziskave so se predvsem naslanjale na monometodološke postopke, ki so bodisi natančno opisovali dejavnike, ki oblikujejo stvarnost organizacijskega sistema, ali pa so natančno modelirale podsisteme obravnavanega sistema in pri tem numerični natančnosti žrtvovali celosten pogled na obravnavani pojav. Na sliki 1 je prikazana struktura uporabljene metodologije.

Raziskava se je začela s podrobno analizo zmogljivosti v livarskem sistemu. Za obravnavanje projekta so bile kot metode zbiranja podatkov uporabljeni dokumentacija in intervjuji z usposobljenimi posamezniki. Interpretacija podatkov je bila izvedena skupaj z nekaterimi člani Laboratorija za načrtovanje proizvodnih sistemov, kar je omogočilo zmanjšanje subjektivnosti raziskovalca.

Poglobljeno kakovostno delo v okviru obravnavanega projekta je pripeljalo do podatkov, na katerih je bilo mogoče oblikovati hevristični sistemski postopek. Razlogi za izbiro tega projekta so naslednji:
- gre za projekt, ki zahteva razvoj strateških zmogljivosti,
- projekt ni povezan zgolj z investicijami v posamične tehnične sisteme,
- obravnava postopke, ki zahtevajo evolucijsko

determine the complex reality of a system. The use of the double methodological approach is a novelty in dealing with such issues. Past studies have mostly relied on mono-methodological approaches, which either included a detailed description of factors shaping the reality of an organisational system or the detailed modelling of subsystems of the underlying system and sacrificed the holistic view of the phenomena in question to numerical accuracy. The structure of the used methodology is presented in Figure 1.

The study started with a detailed analysis of the capabilities in a casting system. The data-collection methods used in the project were documents and interviews with qualified individuals. The data interpretation was carried out in cooperation with certain members of the Production Systems Planning Laboratory, which resulted in a lower level of subjectivity of the researcher.

In-depth, qualitative work within the project in question resulted in data that could be used to form the heuristic systemic approach. The reasons for selecting the project in question were:
- It is a project requiring the development of strategic capabilities;
- The project is not linked solely to investments in individual technological systems;
- It deals with processes requiring evolutionary

učenje,
- projekt je omejen z visoko stopnjo negotovosti,
- negotovost je mogoče dojemati skozi različne vidike,
- matematično modeliranje stvarnih možnosti ne omogoča celovitega obravnavanja problematike.

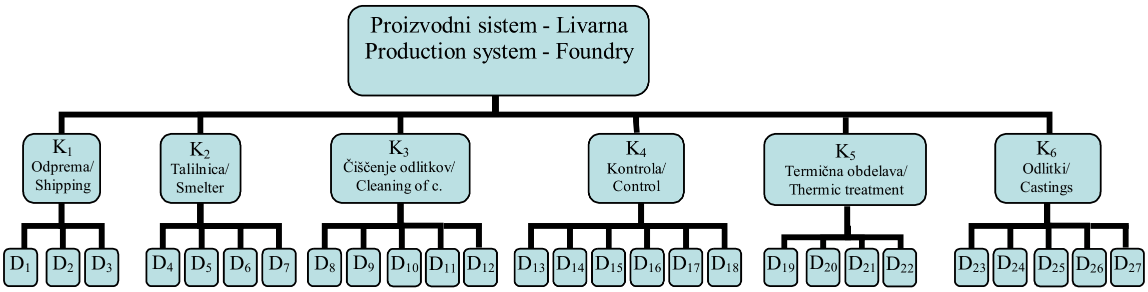
Livarski sistem v okviru proizvodnega sistema je ustrezen sistem za proučevanje.

learning;
- The project has a high level of uncertainty;
- The uncertainty can be perceived through various aspects;
- The mathematical modelling of real options does not enable a holistic dealing with the issue at hand.

The casting system as a part of the production system is a suitable system for studying.

3 UPORABA MODELA NA PRIMERU LIVARNE

3 CASE STUDY ON THE MODEL OF A PRODUCTION SYSTEM – CASTING SYSTEM



Sl. 2. *Primer strukturiranja hevrističnega modela za proizvodnji sistem - livarna*
Fig. 2. *Example of the structuring of the heuristic model for a production system - foundry*

Preglednica 1. *Kategorije K in dejavniki D v livarskem sistemu*
Table 1. *Categories K and Factors D in the foundry system*

K1 Odprema Shipping	D1 - cestni road D2 - železniški railway D3 - letalski air	K4 nadzor control	D13 - mehanske lastnosti mechanical properties D14 - kemijske vsebnosti chemical contents D15 - trdnostna hardness D16 - razsežnostna dimensional D17 - radiografska radiographic D18 - ultrazvočna ultrasound
K2 Talilnica/litje Smelter/casting	D4 - indukcijske peči induction furnace D5 - vakumske peči vacuum furnace D6 - litje v jeklena orodja croning D7 - peskovno litje sand casting	K5 toplotna obdelava thermal treatment	D19 - nitritranje nitrating D20 - vakumska obdelava vacuum treatment D21 - popuščanje yielding D22 - normalizacija normalisation
K3 Čiščenje odlitkov Cleaning of casts	D8 - peskalne komore sand blast chambers D9 - ročni strojčki manual appliances D10 - dobava od zunaj outsourcing D11 - doma home D12 - razmaščevanje fatcleaning	K6 odlitki castings	D23 - majhni small D24 - srednji middle D25 - veliki large D26 - oglična jekla carbon steel D27 - nerjavna jekla stainless steel

3.1 Določitev pomembnosti dejavnikov negotovosti

Razmerja med kategorijami oz. dejavniki so izražena z vprašanjem: "Kolikokrat bolj je kategorija/dejavnik *i* pomemben od kategorije/dejavnika *j* glede na cilj oz. nadrejeno kategorijo?"

S primerjavo dejavnikov in kategorij po dvojicah (po podani ocenitveni lestvici) in rabo trikotno porazdeljenih mehkih števil dobimo mehke matrike na vseh ravneh hierarhije.

Mehke matrike → stopnja zaupanja (α) → stopnja optimističnosti (μ) → preračun uteži
Npr. za K4:

3.1 Definition of the importance of importance factors

The ratios between the categories or factors are expressed with the question: "How many times is the category/factor i more important than category/factor j according to the aim or the superior category?"

With a pair-wise comparison of the factors and categories (according to the provided estimation scale) and the use of triangularly divided fuzzy numbers, we arrive at the following fuzzy matrix on all levels of hierarchy.

Fuzzy matrix → level of trust estimate (α)→ level of optimistic estimates (μ) → weights calculation (where K4):

$$K_4:\ \mathrm{MM}_4 = \begin{array}{c} \\ D_{13} \\ D_{14} \\ D_{15} \\ D_{16} \\ D_{17} \\ D_{18} \end{array} \begin{array}{c} \begin{array}{cccccc} D_{13} & D_{14} & D_{15} & D_{16} & D_{17} & D_{18} \end{array} \\ \begin{bmatrix} 1 & \tilde{2} & \tilde{2}^{-1} & \tilde{2}^{-1} & \tilde{7}^{-1} & \tilde{5}^{-1} \\ \tilde{2}^{-1} & 1 & \tilde{1} & \tilde{2} & \tilde{1} & \tilde{3}^{-1} \\ \tilde{2} & \tilde{1}^{-1} & 1 & \tilde{2}^{-1} & \tilde{5}^{-1} & \tilde{3}^{-1} \\ \tilde{2} & \tilde{2}^{-1} & \tilde{2} & 1 & \tilde{4}^{-1} & \tilde{5}^{-1} \\ \tilde{7} & \tilde{1}^{-1} & \tilde{5} & \tilde{4} & 1 & \tilde{3} \\ \tilde{5} & \tilde{3} & \tilde{3} & \tilde{5} & \tilde{3}^{-1} & 1 \end{bmatrix} \end{array}$$

$$K_4:\ \mathrm{MM}_4^{\alpha=0,5} = \begin{bmatrix} 1 & \frac{17}{8} & \frac{17}{30} & \frac{17}{30} & \frac{7}{48} & \frac{5}{24} \\ \frac{17}{30} & 1 & \frac{4}{3} & \frac{17}{8} & \frac{4}{3} & \frac{3}{8} \\ \frac{17}{8} & 1 & 1 & \frac{17}{30} & \frac{5}{24} & \frac{3}{8} \\ \frac{17}{8} & \frac{17}{30} & \frac{17}{8} & 1 & \frac{4}{15} & \frac{5}{24} \\ 7 & 1 & 5 & 4 & 1 & 3 \\ 5 & 3 & 3 & 5 & \frac{3}{8} & 1 \end{bmatrix}$$

$$K_4:\ \mathrm{MM}_{4_{\mu=0,5}}^{\alpha=0,5} = \begin{bmatrix} 1 & \left[\frac{5}{4},3\right] & \left[\frac{1}{3},\frac{4}{5}\right] & \left[\frac{1}{3},\frac{4}{5}\right] & \left[\frac{1}{8},\frac{1}{6}\right] & \left[\frac{1}{6},\frac{1}{4}\right] \\ \left[\frac{1}{3},\frac{4}{5}\right] & 1 & \left[\frac{2}{3},2\right] & \left[\frac{5}{4},3\right] & \left[\frac{2}{3},2\right] & \left[\frac{1}{4},\frac{1}{2}\right] \\ \left[\frac{5}{4},3\right] & \left[\frac{1}{2},\frac{3}{2}\right] & 1 & \left[\frac{1}{3},\frac{4}{5}\right] & \left[\frac{1}{6},\frac{1}{4}\right] & \left[\frac{1}{4},\frac{1}{2}\right] \\ \left[\frac{5}{4},3\right] & \left[\frac{1}{3},\frac{4}{5}\right] & \left[\frac{5}{4},3\right] & 1 & \left[\frac{1}{5},\frac{1}{3}\right] & \left[\frac{1}{6},\frac{1}{4}\right] \\ [6,8] & \left[\frac{1}{2},\frac{3}{2}\right] & [4,6] & [3,5] & 1 & [2,4] \\ [4,6] & [2,4] & [2,4] & [4,6] & \left[\frac{1}{4},\frac{1}{2}\right] & 1 \end{bmatrix}$$

Numerična rešitev (lastni vektorji matrike → uteži), npr. za K4 (pri $\alpha = 0,5$ in $\mu = 0,5$):

Numerical solution (eigenvector of matrix → weight) where K4 (at $\alpha = 0.5$ and $\mu = 0.5$):

$$\sqrt[6]{1\cdot\frac{17}{8}\cdot\frac{17}{30}\cdot\frac{17}{30}\cdot\frac{7}{48}\cdot\frac{5}{24}} = 0,5241 \qquad \sqrt[6]{\frac{17}{30}\cdot 1\cdot\frac{4}{3}\cdot\frac{17}{8}\cdot\frac{4}{3}\cdot\frac{3}{8}} = 0,9640$$

$$\sqrt[6]{\frac{17}{8}\cdot 1\cdot 1\cdot\frac{17}{30}\cdot\frac{5}{24}\cdot\frac{3}{8}} = 0,6744 \qquad \sqrt[6]{\frac{17}{8}\cdot\frac{17}{30}\cdot\frac{17}{8}\cdot 1\cdot\frac{4}{15}\cdot\frac{5}{24}} = 0,7224$$

$$\sqrt[6]{7\cdot 1\cdot 5\cdot 4\cdot 1\cdot 3} = 2,7366 \qquad \sqrt[6]{5\cdot 3\cdot 3\cdot 5\cdot\frac{3}{8}\cdot 1} = 2,0943$$

$$\sum 7,7158 \;\Rightarrow\; \tilde{x}_4 = \begin{Bmatrix} D_{13} & D_{14} & D_{15} & D_{16} & D_{17} & D_{18} \\ 0,0679, & 0,1249, & 0,0874, & 0,0936, & 0,3547, & 0,2715 \end{Bmatrix}^T$$

$$UD_{13} = 0,3279\cdot 0,0679 = 0,0223 \qquad UD_{14} = 0,3279\cdot 0,1249 = 0,0410$$

$$UD_{15} = 0,3279\cdot 0,0874 = 0,0287 \qquad UD_{16} = 0,3279\cdot 0,0936 = 0,0307$$

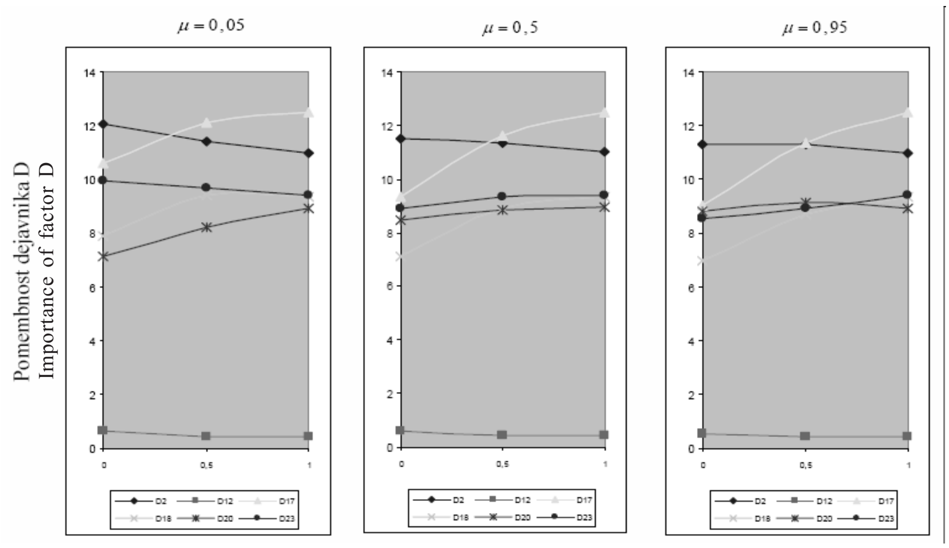
$$UD_{17} = 0,3279\cdot 0,3547 = 0,1163 \qquad UD_{18} = 0,3279\cdot 0,2715 = 0,0890$$

Preglednica 2. *Pomembnost kategorij negotovosti v odvisnosti od stopnje zaupanja in optimističnosti ocene*
Table 2. *The importance of uncertainty categories in relation to the level of trust in optimistic estimates*

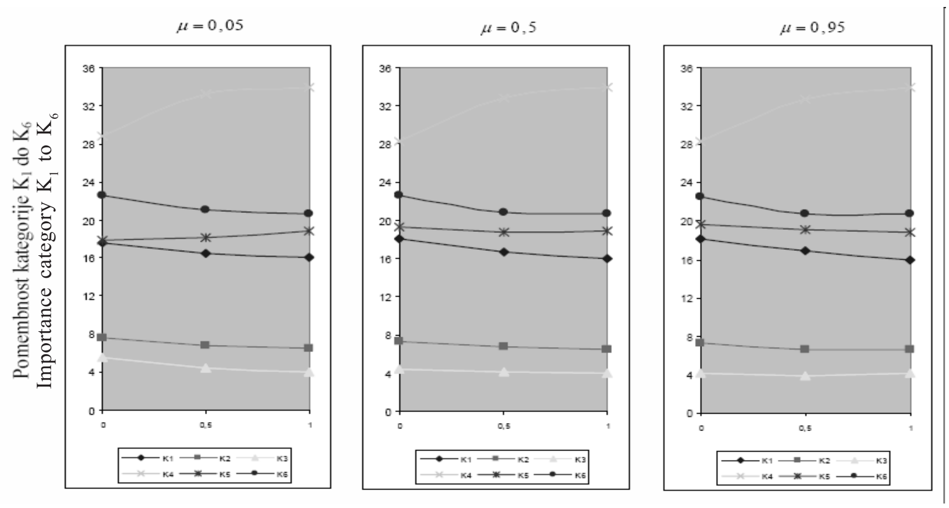
	Pomembnost kategorije (utež) / Importance of category (weight)						
Kategorija Category	$\alpha = 0$			$\alpha = 0{,}5$			$\alpha = 1$
	$\mu = 0{,}05$	$\mu = 0{,}5$	$\mu = 0{,}95$	$\mu = 0{,}05$	$\mu = 0{,}5$	$\mu = 0{,}95$	
K_1	0,1753	0,1801	0,1814	0,1641	0,1675	0,1691	0,1600
K_2	0,0765	0,0737	0,0728	0,0681	0,0669	0,0662	0,0653
K_3	0,0553	0,0446	0,0415	0,0446	0,0411	0,0391	0,0406
K_4	0,2879	0,2828	0,2835	0,3324	0,3279	0,3264	0,3388
K_5	0,1788	0,1926	0,1960	0,1809	0,1879	0,1913	0,1884
K_6	0,2262	0,2262	0,2248	0,2099	0,2087	0,2079	0,2069

Preglednica 3. *Pomembnost dejavnika negotovosti (utež)*
Table 3. *Importance of the uncertainty factor (weight)*

Dejavnik negotovosti Factor of uncertainty	$\alpha = 0$			$\alpha = 0{,}5$			$\alpha = 1$
	$\mu = 0{,}05$	$\mu = 0{,}5$	$\mu = 0{,}95$	$\mu = 0{,}05$	$\mu = 0{,}5$	$\mu = 0{,}95$	
D_1	0,0295	0,0344	0,0357	0,0298	0,0318	0,0329	0,0298
D_2	0,1208	0,1151	0,1132	0,1138	0,1134	0,1129	0,1099
D_3	0,0249	0,0306	0,0324	0,0204	0,0222	0,0233	0,0202
D_4	0,0277	0,0281	0,0282	0,0267	0,0269	0,0269	0,0253
D_5	0,0296	0,0294	0,0292	0,0263	0,0262	0,0260	0,0265
D_6	0,0123	0,0103	0,0098	0,0099	0,0090	0,0086	0,0088
D_7	0,0069	0,0059	0,0056	0,0052	0,0048	0,0046	0,0046
D_8	0,0082	0,0079	0,0077	0,0069	0,0070	0,0070	0,0063
D_9	0,0255	0,0171	0,0151	0,0217	0,0185	0,0169	0,0192
D_{10}	0,0083	0,0078	0,0075	0,0068	0,0065	0,0063	0,0063
D_{11}	0,0068	0,0061	0,0058	0,0048	0,0048	0,0047	0,0045
D_{12}	0,0065	0,0057	0,0054	0,0044	0,0043	0,0042	0,0043
D_{13}	0,0213	0,0216	0,0216	0,0226	0,0223	0,0221	0,0225
D_{14}	0,0306	0,0400	0,0433	0,0366	0,0410	0,0436	0,0380
D_{15}	0,0254	0,0289	0,0301	0,0274	0,0287	0,0294	0,0290
D_{16}	0,0258	0,0275	0,0282	0,0305	0,0307	0,0310	0,0310
D_{17}	0,1059	0,0936	0,0904	0,1213	0,1163	0,1135	0,1247
D_{18}	0,0790	0,0712	0,0699	0,0941	0,0890	0,0868	0,0936
D_{19}	0,0648	0,0563	0,0532	0,0599	0,0578	0,0562	0,0588
D_{20}	0,0716	0,0844	0,0881	0,0824	0,0883	0,0915	0,0894
D_{21}	0,0209	0,0237	0,0243	0,0206	0,0217	0,0223	0,0212
D_{22}	0,0215	0,0282	0,0304	0,0180	0,0201	0,0213	0,0191
D_{23}	0,0997	0,0892	0,0856	0,0966	0,0932	0,0894	0,0938
D_{24}	0,0323	0,0318	0,0315	0,0295	0,0294	0,0288	0,0287
D_{25}	0,0523	0,0588	0,0604	0,0486	0,0490	0,0524	0,0486
D_{26}	0,0156	0,0140	0,0134	0,0121	0,0117	0,0112	0,0113
D_{27}	0,0263	0,0324	0,0340	0,0231	0,0254	0,0262	0,0246



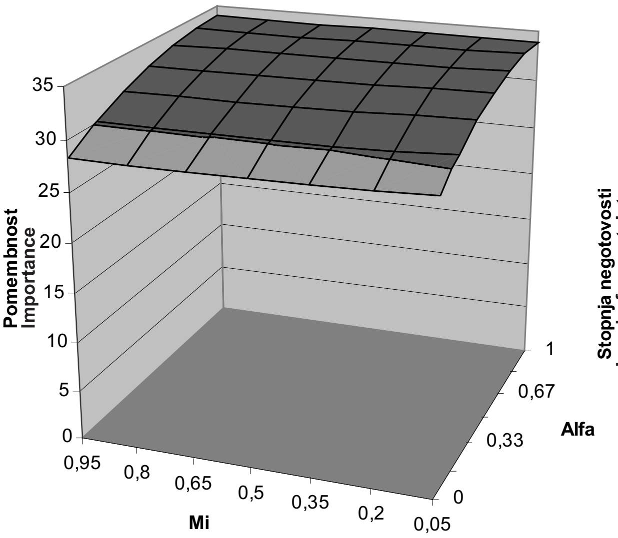
Sl. 3. *Pomembnost kategorij in dejavnikov negotovosti*
Fig. 3. *Importance of factors in relation to the level of trust in optimistic estimates*



Sl. 4. *Pomembnost kategorij in dejavnikov negotovosti*
Fig. 4. *Importance of categories and uncertainty factors*

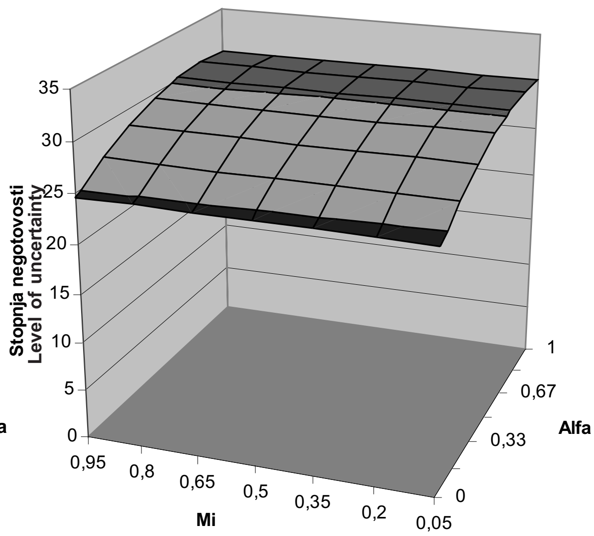
Preglednica 3. *Stopnja negotovosti kategorij v odvisnosti od stopnje zaupanja in optimističnosti ocene*
Table 3. *The level of uncertainty of categories in relation to the level of trust in optimistic estimates*

	Negotovost kategorije (utež) / Uncertainty of category (weight)						
Kategorija Category	α = 0			α = 0,5			α = 1
	μ = 0,05	μ = 0,5	μ = 0,95	μ = 0,05	μ = 0,5	μ = 0,95	
K_1	0,1101	0,1041	0,1021	0,0994	0,0991	0,0986	0,0944
K_2	0,2542	0,2378	0,2328	0,2639	0,2572	0,2535	0,2613
K_3	0,2423	0,2451	0,2465	0,2943	0,2944	0,2949	0,3023
K_4	0,1187	0,1215	0,1224	0,1018	0,1042	0,1053	0,1028
K_5	0,1190	0,1263	0,1284	0,0997	0,1015	0,1026	0,0979
K_6	0,1557	0,1652	0,1678	0,1409	0,1436	0,1451	0,1413



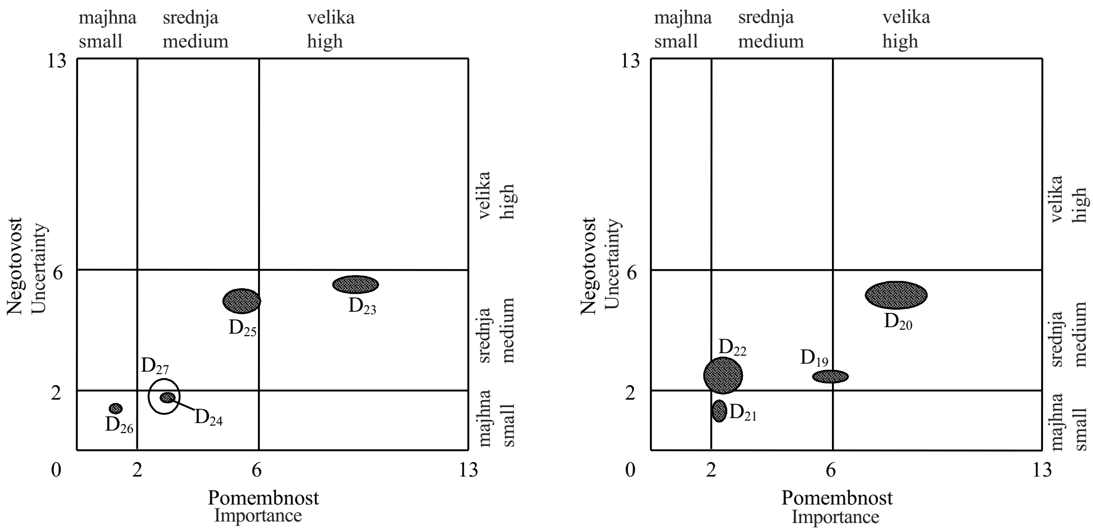
Sl. 5. *Prostorski diagram pomembnosti kategorije K4*

Fig. 5. *Space diagram of the importance of category K4*



Sl. 7. *Prostorski diagram stopnje negotovosti kategorije K3*

Fig. 7. *Space diagram of the level of uncertainty of category K3*



Sl. 8. *Lega dejavnikov kategorije K5 in K6*

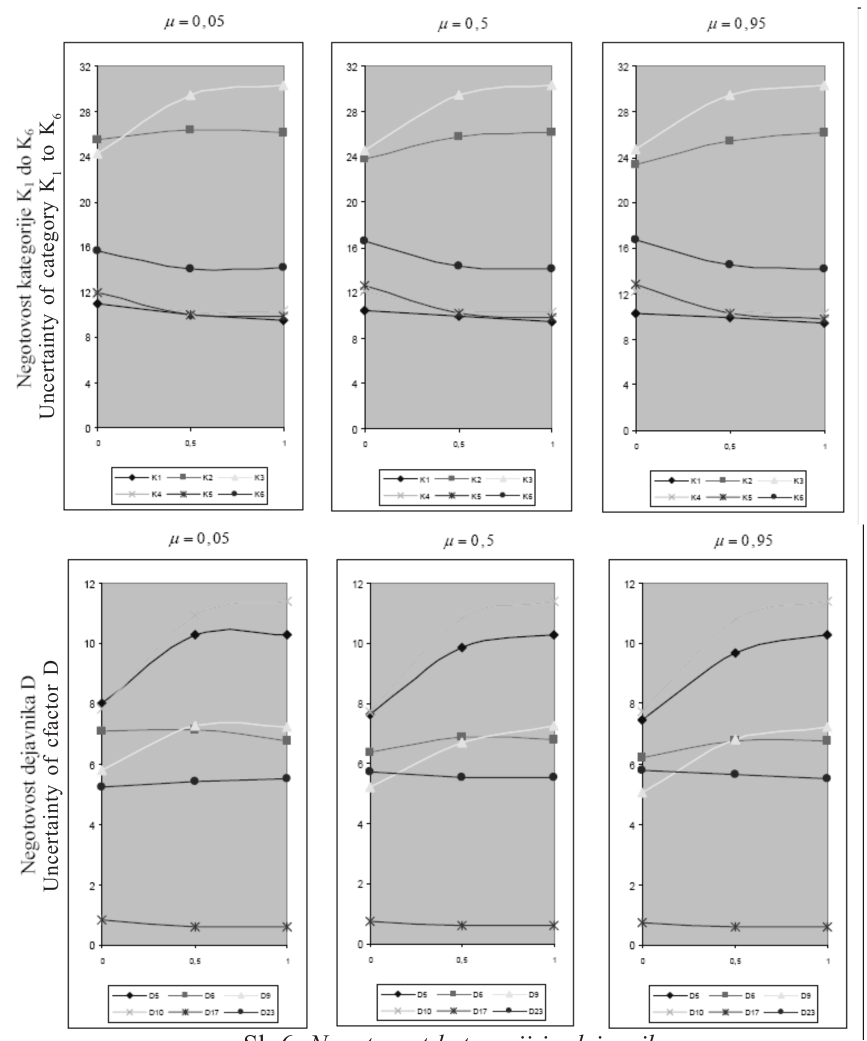
Fig. 8. *Position of the factors of categories K5 and K6*

Določitev stopnje negotovosti dejavnikov: Razmerja med kategorijami oz. dejavniki so izražena z vprašanjem: "Kolikokrat bolj je kategorija/dejavnik *i* negotov od kategorije/dejavnika *j* glede na cilj oz. nadrejeno kategorijo?"

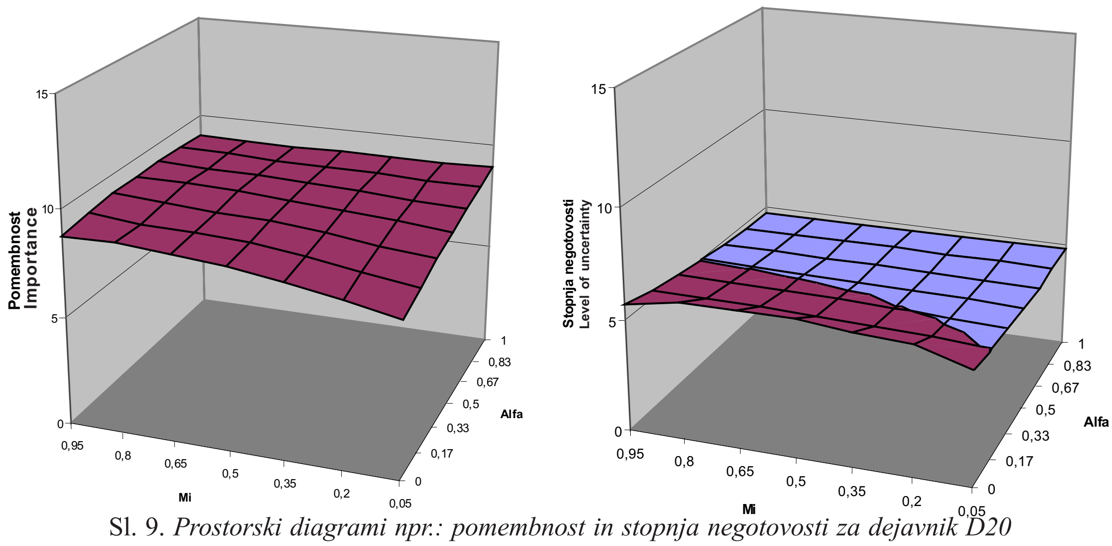
S primerjavo dejavnikov in kategorij po dvojicah (po podani ocenitveni lestvici, prirejeni na stopnjo negotovosti) in rabo trikotno porazdeljenih mehkih števil dobimo mehke matrike po vseh ravneh hierarhije.

The ratios between the categories or factors are expressed with the question: "How many times is the category/factor *i* more important than the category/factor *j* according to the aim or the superior category?"

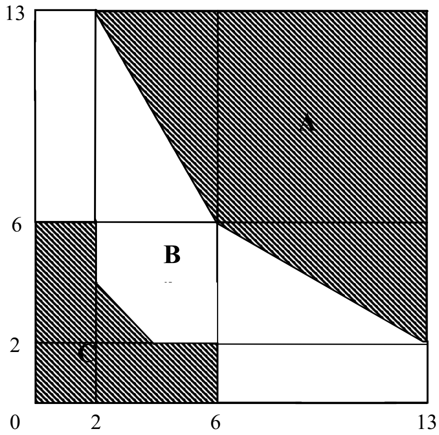
With a pair-wise comparison of the factors and categories (according to the provided estimation scale, adapted for the level of uncertainty) and the use of triangularly divided fuzzy numbers, we arrive at the following fuzzy matrix on all levels of hierarchy:



Sl. 6. *Negotovost kategorij in dejavnikov*
Fig. 6. *Uncertainty categories and factors*



Sl. 9. *Prostorski diagrami npr.: pomembnost in stopnja negotovosti za dejavnik D20*
Fig. 9. *Space diagrams of the importance and level of uncertainty for the factor D20*



Sl. 10. *Področje pozornosti (A $\rightarrow$ večje, B $\rightarrow$ srednje, C $\rightarrow$ manjše)*
Fig. 10. *Area of attention (A $\rightarrow$ larger, B $\rightarrow$ medium, C $\rightarrow$ smaller)*

3.2 Integralna ocena negotovosti

Z metodo mehkega AHP smo določili področja stopnje pomembnosti in negotovosti za vsak dejavnik, ki so omogočila tudi ustrezen izbor bolj ali manj kritičnih dejavnikov. Omejena področja vrednosti uporabimo za:
- izgradnjo vektorja pomembnosti dejavnikov,
- izgradnjo vektorja negotovosti dejavnikov.

Integralna (celotna) ocena negotovosti (ION) je skalarni produkt obeh vektorjev:

3.2 Integral uncertainty estimate

With the method of fuzzy AHP we have determined the areas (intervals) of the level of importance and the uncertainty for every factor, which has given us the opportunity for a correct selection of the more or less critical factors. The mentioned areas of value can be used for the following:
- design of the factor importance vector,
- design of the uncertainty factor vector.

The integral (total) uncertainty estimate (ION) is a scalar product of vectors $\vec{P}$ and $\vec{N}$:

$$ION = \vec{P} \cdot \vec{N}$$

Mejno integralno oceno negotovosti dobimo z uporabo enakih povprečnih uteži pri vseh komponentah vektorjev, torej pri *n* dejavnikih:

The fringe integral uncertainty estimate can be obtained by using the same mean weights with all the vector components, therefore, with *n* factors:

$$ION_m = \sum_{i=1}^{n} \left[\left(\frac{100}{n} \right) \cdot \left(\frac{100}{n} \right) \right] = n \cdot \frac{100}{n} \cdot \frac{100}{n} = \frac{10000}{n}$$

Pri konkretnem obravnavanem primeru razvoja proizvodnih zmogljivosti imamo 27 dejavnikov. Mejna integralna ocena negotovosti znaša:

In this actual example of the development of production capacity we have 27 factors. The fringe integral uncertainty estimate is:

$$ION_m = \frac{10000}{27} = 370$$

Vektor $\vec{P}$ ima naslednje člene:

Vector $\vec{P}$ has the following terms:

$$\vec{P} = \{3{,}26;\ 11{,}54;\ 2{,}63;\ 2{,}68;\ 2{,}78;\ 1{,}05;\ 0{,}58;\ 0{,}73;\ 2{,}03;\ 0{,}73;\ 0{,}57;\ 0{,}54;\ 2{,}20;\ 3{,}71;\ 2{,}78;\ 2{,}84;\ 10{,}76;\ 8{,}2;\ 5{,}9;\ 8{,}16;\ 2{,}25;\ 2{,}42;\ 9{,}27;\ 3{,}05;\ 5{,}45;\ 1{,}34;\ 2{,}86\}$$

Vektor $\vec{N}$ ima naslednje člene:

Vector $\vec{N}$ has the following terms:

$$\vec{N} = \{4{,}05;\ 3{,}88;\ 2{,}45;\ 4{,}33;\ 8{,}89;\ 6{,}66;\ 5{,}17;\ 5{,}22;\ 6{,}16;\ 9{,}56;\ 2{,}42;\ 3{,}72;\ 2{,}65;\ 1{,}03;\ 1{,}38;\ 2{,}56;\ 0{,}72;\ 3{,}05;\ 2{,}42;\ 5{,}23;\ 1{,}29;\ 2{,}46;\ 5{,}52;\ 1{,}78;\ 4{,}88;\ 1{,}43;\ 1{,}77\}$$

4 SKLEP

Prispevek obsega izvirno sintezo teorije stvarnih možnosti, upravljanja tveganja, modeliranja negotovosti, metode analitičnega hierarhičnega postopka in mehke logike ter pomeni prispevek pri izgradnji orodij za podporo odločanju pri usmerjanju razvoja zmogljivosti v organizacijskem sistemu. Postopek je zasnovan na zmernem in obvladljivem številu vplivnih veličin in zagotavlja celovito obvladovanje problematike pri iskanju sprejemljivih rešitev. Izdelan hevristični model razvoja zmogljivosti je ustrezen, kar potrjuje tudi izveden praktični primer na livarskem sistemu.

V prikazanem primeru z odpravljanjem negotovosti praktično zmanjšamo možnosti negativnih učinkov in se s tem, z vidika vseh virov, približamo optimizaciji proizvodnega sistema.

Postopkovni del je namenjen vrednotenju analiziranih dejavnikov. Osnovna uporabljena metoda je mehki analitični hierarhični postopek (v osnovi se uporablja za podporo večkriterijskemu odločanju), ki temelji na medsebojnem določanju razmerij med posameznimi kategorijami in dejavniki negotovosti (najprej glede pomembnosti, v naslednji fazi pa še glede stopnje negotovosti dejavnikov) in na matematičnem preračunu uteži, ki kažejo že omenjeno pomembnost in stopnjo negotovosti. Prednost metode je prav v medsebojnem določanju razmerij, saj bistveno lažje ocenjujemo s primerjanjem po dvojicah, in v uporabi mehkih števil, ko v samo ocenitev vgradimo možnost napake ocenjevalca za en razred (v levo ali desno, večja napaka je praktično izločena) in to računsko upoštevamo, saj se rezultati kažejo v določenih koračnih območjih. Pomanjkljivost uporabljene metode je v razmeroma velikem številu potrebnih ocenitev, čemur pa se izognemo s tem, da imamo dejavnike že v analitičnem delu razvrščene po kategorijah, ter v nevarnosti pretirano neskladnih ocenitev, kar bi terjalo ponovitev postopka primerjanja oziroma popravek izbranih ocenitev.

V prispevku smo uporabili intervalne rezultate mehke metode AHP za izgradnjo vektorja pomembnosti dejavnikov in vektorja negotovosti dejavnikov, katerih skalarni produkt nam daje integralno oceno negotovosti, ki v primerjavi z mejno oceno opredeljuje tveganje obravnavanega postopka. Na osnovi izvirnih diagramov 'Negotovost/Pomembnost' je bil oblikovan diagram

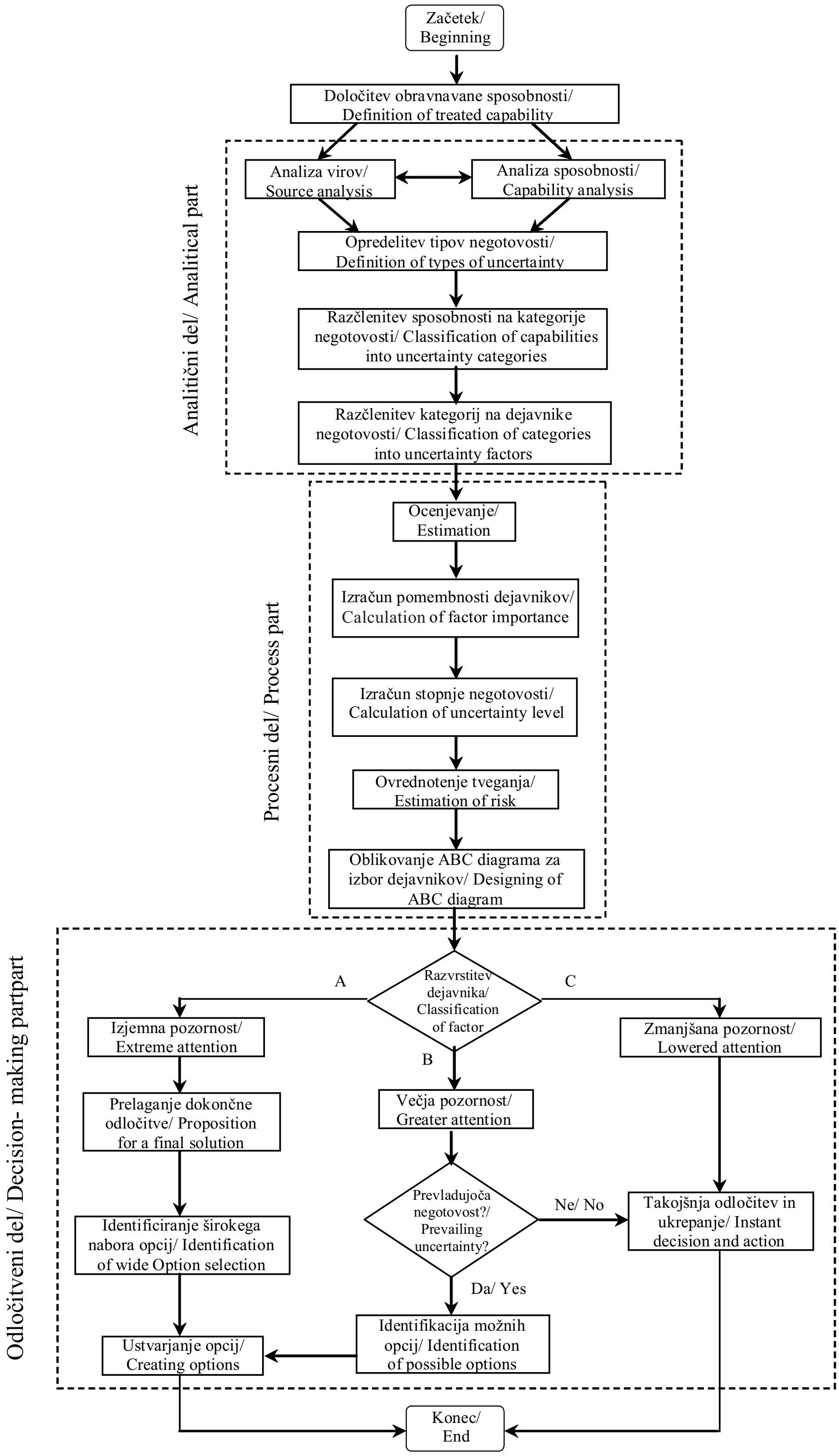
4 CONCLUSION

This paper encompasses the original synthesis of the theory of real options, risk management, modelling uncertainty, the method of analytic hierarchy process and fuzzy logic, and it represents a contribution to the construction of tools for decision-making support for directing the capability development process in an organisational system. The procedure is based on a moderate and manageable number of influential sizes and provides a comprehensive management of the problem by searching for suitable solutions. The designed heuristic model of the development of capabilities is appropriate, which we confirmed by the practical example on a castings system.

In the presented example, with the elimination of the uncertainties, we practically minimise the possibilities of negative effects, and with it, from the viewpoint of all the sources, come close to optimisation of the production system.

The processing part is intended for an evaluation of the analysed factors. The basic method used is the soft analytical hierarchical process (basically used as a support to multiple criteria decision-making), based on a mutual determining of the relationships between individual categories and the factors of uncertainty (first with regard to importance and in the second stage with regard to the uncertainty level of factors) and on the mathematical calculation of weights reflecting the aforementioned importance and level of uncertainty. The advantage of this method lies in the mutual determining of relationships, as the evaluation is much easier with a comparison by pairs, and in the use of soft numbers when the evaluation itself includes the possibility of the evaluator's error by a class (to the left or to the right, a bigger error is virtually excluded) and the calculation takes it into account as the results are presented in particular intervals. The disadvantage of the used method lies in the relatively large number of evaluations required, which can be avoided by grouping factors in the categories already in the analytical part, and in the danger of excessively diverging evaluations, which would require repeating the procedure of the comparison and adjustment of the selected evaluations.

In the paper we have used interval results of the soft AHP method to build the vector of the importance of factors and the vector of the uncertainty of factors, the scalar product of which provides us with the integral evaluation of uncertainty, which in comparison with the limit evaluation determines the risk of the underlying process. On the basis of the original diagrams "Uncertainty/Importance", we have formed



Sl. 11. *Sistemski postopek za obravnavanje razvoja zmogljivosti*
Fig. 11. *A systematic approach to handling-capability development*

pozornosti ABC, ki je namenjen izbiri oziroma razvrstitvi dejavnikov negotovosti, na kateri gradi odločitveni del sistemskega postopka.

Odločitveni del je najpomembnejši del postopka glede na kriterij uporabnosti modela. V tem delu je bila logika modela prenesena v resnične odločitve. Odločitveni model se prične z razvrstitvijo dejavnika. Dejavniki C so tisti, ki jim ni treba dajati večje pozornosti glede na stopnjo pomembnosti in negotovosti. Kadar tovrstni dejavniki terjajo določene odločitve ali ukrepe, je te mogoče hitro in učinkovito izvesti, ne da bi nas skrbelo, kako lahko negotovost vpliva na posledice odločitve. Dejavniki A predstavljajo nasprotni pol dejavnikov glede na pomembnost in negotovost. Tovrstnim dejavnikom je treba posvetiti izjemno pozornost. Podrobneje je treba osvetliti navodilo, naj se predlagajo dokončne odločitve. To navodilo se ne sme razumeti kot predlog za nesprejetje odločitev. Navodilo pravi, da se v tem primeru ne smejo sprejemati odločitve, ki bi bile dokončne in ne bi omogočale prilagodljivega ravnanja. Te odločitve morajo biti usmerjene v ustvarjanje širokega nabora možnosti, ki omogočajo ukrepanje v primeru različnih scenarijev razvoja. Preden se sprejmejo odločitve, ki ustvarjajo možnosti v prihodnosti, je treba razpoznati širok nabor mogočih možnosti. Dejavniki B ležijo, glede na svoj pomen in glede na stopnjo negotovosti, med dejavniki A in C. Gre vsekakor za dejavnike, ki jim je treba posvetiti ustrezno pozornost. Delež pozornosti je seveda odvisen tudi od števila dejavnikov, ki so opredeljeni kot dejavniki stopnje A. Če dobimo veliko število dejavnikov stopnje A, potem bo pozornost dejavnikom stopnje B nekoliko manjša kakor v primeru, če imamo med A zgolj nekaj dejavnikov. V primeru, ko so dejavniki prišli v kategorijo B zato, ker so pomembni, niso pa nagnjeni k negotovosti, je mogoče sprejeti iste ukrepe kakor za dejavnike C. V primeru večje negotovosti se morajo tudi za dejavnike B sprejemati odločitve, ki omogočajo prilagodljivo ravnanje v prihodnosti.

Izvirni prispevek v prispevku obsega:

- Obravnavanje ustreznosti – uporabnosti logike teorije stvarnih možnosti pri razvoju strateških zmogljivosti, kakor tudi ovir, ki omejujejo njeno uporabnost (na primerih odločanja v proizvodnem sistemu).
- Razvoj hevrističnega sistemskega postopka, ki na podlagi teorije stvarnih možnosti podpira odločanje pri razvoju zmogljivosti v organizacijskih sistemih.

the ABC diagram of attention, which is used for selecting and classifying the uncertainty factors on which the decision-making part of the systematic approach builds.

The decision-making part represents the most important part of the approach with regard to the model's applicability criterion. In this part the model's logic was transferred to real-life decisions. The decision-making model begins by classifying factors. C factors are those that do not require larger attention with regard to the levels of importance and uncertainty. When such factors require certain decisions or measures, they can be implemented quickly and effectively without worrying about how the uncertainty might affect the consequences of the decision. A factors are the opposite pole of factors with regard to importance and uncertainty. These factors require extra attention. The instructions regarding the proposing of the final decisions should be elaborated in greater detail. These instructions should not be interpreted as a proposal for not taking any decisions. The instructions say that in such a case no decisions can be taken that would be final and prevent the flexibility of action. These decisions should be directed towards creating a wide range of options, enabling reaction in the case of different development scenarios. Before adopting decisions that create future options, the wide range of available options should be identified. B factors lie between A and C factors with regard to their importance and the level of uncertainty. These are by all means factors that require an appropriate level of attention. The proportion of attention naturally also depends on the number of factors being defined as A-level factors. If we get a large number of A-level factors, the attention given to B-level factors will be slightly lower than in cases where there are only a few A-level factors. In the case that factors are classified in the B category, because they are important but not subject to uncertainty, the same measures as for C factors can be adopted. In the case of increased uncertainty, decisions enabling the flexibility of future actions should also be adopted for B factors.

The original contribution in this paper is composed of:

- Dealing with suitability – usefulness of the logic of the theory of real options with the development of strategic capacities, as well as obstacles, which limit its usefulness (with the examples of decision-making in the production process).
- The development of a heuristic system approach which, on the basis of the theory of real options, encourages the decision-making in capabilities-development in organisational systems.

- Dopolnitev hevrističnega postopka za učinkovito razlago numeričnih rezultatov in njihovo podporo postopku odločanja:
  - uporaba mehke metode AHP za določanje stopnje negotovosti je popolnoma izvirna zamisel, saj se omenjena metoda uporablja le za določanje pomembnosti,
  - izvirni sestavljeni diagrami 'Pomembnost – Negotovost' in diagram pozornosti ABC omogočajo izbiro in razvrstitev dejavnikov (in kategorij),
  - integralna ocena negotovosti (ION) je izvirni prispevek pri ovrednotenju negotovosti. Razvita je tudi metodologija za določitev mejne integralne ocene, tako da je omogočena splošna opredelitev tveganja vsake obravnavane dejavnosti.

Osnovni izziv za prihodnost je izdelava enovitega programskega orodja, ki bi vključevalo vse v raziskavi uporabljene tehnike in metode in zajelo celotne preračune, od vnosa potrebnih podatkov do izpisa rezultatov in izrisa vseh diagramov ter predlaganih smernic pri sprejemanju odločitev.

- The completion of a heuristic approach for the effective interpretation of numerical results and their support in the decision making process:
  - the use of the fuzzy AHP method for determining the uncertainty level is an entirely original idea, for the above-mentioned method it is used only for defining the importance,
  - the original combined diagrams "Importance – Uncertainty" and the ABC diagram of attention, which enable the selection and classification of factors (and categories),
  - the integral uncertainty estimation (ION) represents an original method for estimating uncertainty. There is also the methodology for determining the fringe integral estimate, which enables the common estimation of risk for every activity involved.

The fundamental challenge for the future is the design of a uniform software tool that would incorporate all the used techniques and methods, and encompass all the calculations, from the input of the necessary data to the printout of results, and the design of all the diagrams and the proposed guidelines for decision-making.

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