12. Chang, Y. Nonstationarity in time series of state densities [Text] / Y. Chang, C. Sik Kim, J. Y. Park // Journal of Econometrics. – 2016. – Vol. 192, Issue 1. – P. 152–167. doi: 10.1016/j.jeconom.2015.06.025
13. Geche, F., Mulesa, O., Myronyuk, I., Vashkeba, M. (). Forecasting quantitative characteristics of officially registered hiv-infected persons in the region [Text] / F. Geche, O. Mulesa, I. Myronyuk, M. Vashkeba // Technology audit and production reserves. – 20154. – Vol. 4, Issue 2 (24). – P. 34–39. doi: 10.15587/2312-8372.2015.47907
14. Mulesa, O. Yu. Methods of considering the subjective character of input data in voting [Text] / O. Yu. Mulesa // Eastern-European Journal of Enterprise Technologies. – 2015. – Vol. 1, Issue 3 (73). – P. 20–25. doi: 10.15587/1729-4061.2015.36699
15. Geche, F. E. Development of synthesis method of predictive schemes based on basic predictive models [Text] / F. E. Geche, O. Yu. Mulesa, S. F. Geche, M. M. Vashkeba // Technology audit and production reserves. – 2015. – Vol. 3, Issue 2 (23). – P. 36–41. doi: 10.15587/2312-8372.2015.44932
16. HIV infection in Ukraine. Newsletter № 43 [Text]. – Kyiv, Health of Ukraine, Ukr. control center for socially dangerous diseases, 2015. – 109 p.

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MODEL OF START-UPS ASSESSMENT UNDER CONDITIONS OF INFORMATION UNCERTAINTY

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Розроблено модель оцінювання ефективності та вибору стартап проектів в умовах невизначеності вхідних даних. Модель зменшує суб'єктивізм експертних оцінок, показує місце «ідеї» серед інших, дозволяє встановити рівень її ризику та враховувати побажання особи, що приймає рішення. Сформовано множину критеріїв оцінювання та запропонована класифікація їх по групах. Наведено приклад роботи моделі оцінювання стартапу

Ключові слова: стартап проекти, багатокритеріальна оцінка, група критеріїв, функція належності, «бажані значення»

Разработана модель оценки эффективности и выбора стартап проектов в условиях неопределенности исходных данных. Модель уменьшает субъективизм экспертных оценок, показывает место «идеи» среди других, позволяет установить уровень ее риска и учитывать пожелания лица, принимающего решение. Сформировано множество критериев оценивания и предложена классификация их по группам. Приведен пример работы модели оценки стартапа

Ключевые слова: стартап проекты, многокритериальная оценка, группа критериев, функция принадлежности, «желаемые значения»

1. Introduction

With the development of information technologies and the globalization of the information society, the concept of a start-up develops, which is closely connected with the modern economy. Assessment of a start-up project is in the evaluation of an "idea", which may bring profits in future. The cost of such "idea" cannot be evaluated (commercially) without introducing it to the market. Yesterday's "bad idea" may turn successful today, due to the rapid changes in the industry or areas of business where it is implemented. In this regard, the problem (poorly structured now) of assessment of efficiency of start-up projects arises, the solution to which is interested for either venture funds or the startuppers themselves.

Any startup is a project at the level of "ideas", directed into the future by definition, and the project that has strategic character is directed into distant future. The future cannot be predicted at one hundred percent while the decision about the launch of implementation of the project (start-up) must be taken today. Therefore, there is an actual problem of the development of the models for the assessment of startups under conditions of information uncertainty.

Startups have different stages of commercial development. The first stage is the introduction of the product to the market. After a successful implementation of the first stage, the second stage is to conquer the market as a competitive player in the industry. Therefore, investing in startups by venture funds is made in stages. There are a great number of the designed models to assess the amount of the funding for the second stage, since this stage is related to the funding of an investment project, which already exists in the market [1]. Moreover, the assessment and funding of the first stage boils down to the studied problem – the task of a multi-criteria assessment of an "idea".

The relevance of the work consists in the design of technology of assessment and selection of efficient start-up projects by using fuzzy mathematics for those entities wishing to support and finance them.

2. Analysis of scientific literature and the problem statement

Today there are a number of methods for assessment of start-ups, which are based on the basis of simulation and expert models using economic quantitative indicators. These methods include: method of index value of start-ups launch [2], method of assessment of a startup value [3], model of assessment of start-ups by qualitative features [4] and others. All these methods can be used only for approximate evaluation, which is not quite correct for such a complex and poorly structured problem.

The problem of organization and development of innovation activity is tackled in the paper [5], which shows the problems of long-term venture financing of startup companies by analyzing the value of the investor's share in the innovative project. The available methods of assessment of investment projects are used, which is not quite correct for start-up projects. The study of the experience of venture capital usage is given in the paper [6], but not enough attention is paid to the analysis of the practice of calculation of efficiency of start-up projects. The paper [7] shows cognitive model of startups assessment that can be used only as an additional tool to improve the accuracy of decision making by venture funds. And only the paper [8] proposes fuzzy model of management, which can help to select and filter grants applications. This model considers on the one hand business ideas, and on the other – entrepreneur's personality. The approach is based on linguistic variables, allowing the objectifying the subjective.

There are various modifications of the models that assess the startups during the second stage. Assessment of the start-ups on the stage of the introduction of a product to a market is paid less attention to.

In addition to the above-mentioned, the subject of the study crosses over to several related areas of knowledge, including economy, industry, decision-making support systems, and fuzzy math. By using modern methods of research, let us analyze the scientific literature relating to the application of fuzzy mathematics apparatus for designing the systems of support of decision making for different sectors of the economy, which are potentially interested in launching startups. For example, the papers [9, 10] reviewed general ideas and advantages on which modern views on the use of fuzzy logic in decision-making support systems are based. The use of the apparatus of fuzzy mathematics to optimize transportation problems is considered in the article [11]. The papers [12, 13] presented the application of fuzzy logic in the industry that enables determination of optimal parameters of technological processes under conditions of uncertainty of input variables. The use of methods of fuzzy analysis in the assessment of economic effect of projects planned for implementation, and design of the appropriate decision-making support systems for the experts in the relevant field is presented in [14, 15].

Thus, the design of a model for assessment and selection of efficient start-up projects based on fuzzy mathematics is actual in the development of innovative business. The most effective in this case are considered the models that perform complex, multi-factor assessment and are based on the principles of fuzzy logic. That is why designing a decision-making support model that will grasp the essence and show the position of an "idea" among others will be very promising.

We will define the task of assessment as follows. Let there be a set of "ideas" $S=\{S_1,S_2,...,S_n\}$ which must be assessed by many indicators (criteria) and arranged by a specific rule. Not reducing the totality, let us continue considering one startup. In the case of a set of startups, they can be arranged by the obtained output values.

3. The purpose and objectives of the study

The aim of this work is to design a model of assessment of startups under conditions of uncertainty by using the fuzzy mathematics apparatus.

To achieve the goal of a scientific study, the following tasks are to be solved:

– to form a set of criteria for the assessment of start-ups and divide them in groups;

– to design a gradation point scale based on the gathered criteria;

– to design a model of assessment of start-up projects that will: reduce the subjectivity of expert evaluations; grasp the essence and show the position of the "idea" among others; set the level of assessment of the "idea" and take into account requests of the person who makes decisions (Decision Maker) during consideration, assessment and selection of start-ups;

– to present an example of the assessment model of start-ups in action.

4. Model of assessment of start-up projects

4. 1. Models of input data

Let us propose a general set of criteria for the assessment of "ideas" and try to categorize them according to five groups of criteria:

G_1 – the essence of the idea;
G_2 – authors of the idea;
G_3 – comparative characteristic of the idea;
G_4 – commercial validity of the idea;
G_5 – expected results.

Let us present each group of criteria in the form of the following indicators, some of which are described, for example, in the paper [4]. Thus a group of criteria G_1 – "the essence of the idea" – may include the following indicators:

K_1^1 – product type;
K_2^1 – application field;
K_3^1 – social importance;

K_4^1 – power of the idea;
– authors of idea;
K_1^2 – level of business experience;
K_2^2 – experience of top management roles in the start-up's field;
K_3^2 – quantity of hours of personal time invested in the start-up development;
G_3 – "comparative characteristic of idea";
K_1^3 – main competitors (meeting the same need of customer);
K_2^3 – other start-ups in this field at the similar stage of development received venture financing in the amount;
G_4 – commercial validity of idea;
K_1^4 – strategic partners;
K_2^4 – intellectual property;
K_3^4 – presence of a business plan;
K_4^4 – amount of own investments in a start-up;
K_5^4 – availability of corporate lawyer;
K_6^4 – availability of a specialist in intellectual property;
K_7^4 – available sales and marketing plans;
G_5 – "expected results";
K_1^5 – start-up will compete with the products with annual turnover of;
K_2^5 – the given start-up market growth in per cent;
K_3^5 – value of expected income in the next 12 months;
K_4^5 – value of expected income in 5 years;
K_5^5 – expected value of gross profit after start-up's market entry.

Of course, this set of criteria may not cover all aspects for any start-up of various industries, but a Decision Maker can add other criteria to it, depending on the business area of a start-up's activity.

Let us consider the first group of criteria G_1 in more detail. This group of criteria has the greatest priority, because it contains criteria that reflect the essence and the meaning of an "idea". To receive a value for each criterion, we will present it in the form of a question and describe an appropriate gradation point scale. For the assessment, we need to choose the variant that is close to the truth.

K_1^1 – proposed idea – is it a product or a service?:
1. That occurred in certain time (5 points);
2. That currently is in the design stage, with marketing research and business plan (20 points);
3. That is in a working model stage, being tested by potential customers (25 points);
4. That is generating income now (30 points).

K_2^1 – in what field does the developed idea belong?:
1. The product is relevant for sale to the general public (retail, food, entertainment etc.) (10 points);
2. Proposed idea still has not been recognized as industry (20 points);
3. The product was popular with investors a few years ago (20 points);
4. The product is currently popular among investors (medical devices, nanotechnology, security software, saving money on corporate software, etc.) (30 points).

K_3^1 – social importance of the idea?:
1. Negligible value of novelty (5 points);
2. To make life a little easier and more enjoyable for many people, but it does not solve any fundamental problems (20 points);
3. Helping people or businesses in their work (25 points);
4. It will help save many lives and/or cash (i. e., the product based on the idea is urgently needed in the market) (30 points).

K_4^1 – the power of the idea (if the venture companies decided to allocate their resources to competitors in this area, then will tomorrow the product based on the idea exist?):
1. It will cease (0 points);
2. I understand that the market currently is grabbed by a major player, but I will have to settle for a smaller share of the market (5 points);
3. The chance to stay a step ahead due to innovation, agility and speed (20 points);
4. I am just happy to collaborate with them for our technology as there is no way that competitors can conquer this market (25 points).

The attached scale of points by the answers to the questions is heuristic and it characterizes the level of a start-up. The larger the number of points for the answers, the more promising the project is.

The expert selects one of the variants of answers for each criterion, to which the corresponding score is assigned. Let us define the convolution of points, for example, as the total of the points for the answers of gradation scale for a group of criteria G_1 which we denote as g_1.

Thus, we obtain a set of numeric variables $g=\{g_1, g_2, g_3, g_4, g_5\}$ for groups of criteria of points respectively $G=\{G_1, G_2, G_3, G_4, G_5\}$ that accept the values at a particular numeric line. Each of these numeric variables will be considered as a set – the carrier of linguistic variable U that consists of the following terms:

– U_{i1} – "assessment of a group of criteria G_i is much lower relative to the "desired value";
– U_{i2} – "assessment of a group of criteria G_i is lower relative to the "desired value";
– U_{i3} – "assessment of a group of criteria G_i is close to the "desired value";
– U_{i4} – "assessment of a group of criteria G_i is slightly better relative to the "desired value";
– U_{i5} – "assessment of a group of criteria G_i is much better relative to the "desired value";

"Desired value" is a conditional convolution of points that satisfies the person who makes decisions when considering, evaluating and choosing start-ups.

Similarly determined are gradations scales and the convolution of points for other groups of considered criteria.

4. 2. Mathematical model of assessment of startups

Let us consider a two-level mathematical model of assessment of start-ups. As the input data are presented in the form of a questionnaire, by which the points are gathered that have subjective character, then on the first level one must evaluate the uncertainty of input data of these groups of criteria. On the second level, the set of "desired values" will be projected to the set – carrier of linguistic variables U.

Let us consider the first level – phasing of input data.

Since the obtained numerical variables $\{g_1, g_2, g_3, g_4, g_5\}$ take different numeric values, then for comparing them, normalized values must be available. With this purpose, let us build an s-shaped membership function in the following form [16]:

$$\mu_{G_i}(g_i,a,b)=\begin{cases} 0, & g_i \le a; \\ 2\left(\dfrac{g_i-a}{b-a}\right)^2, & a<g_i\le\dfrac{a+b}{2}; \\ 1-2\left(\dfrac{b-g_i}{b-a}\right)^2, & \dfrac{a+b}{2}<g_i<b; \\ 1, & g_i\ge b. \end{cases} \quad (1)$$

Where a is the convolution of the total of minimal points, b is the convolution of the total of maximal points of gradation scale of assessment by criteria in group G_i, g_i is the convolution of the total of points by gradation scale for the considered start-up $(i=\overline{1,5})$.

Thus, the obtained input data will be normalized and comparable.

Let us denote $x_i=\mu_G(g_i)$ as the value of membership function of the given start-up by the groups of criteria G_i, $(i=\overline{1,5})$. Then, upon calculating the convolution of points for each group of criteria G_i and finding their membership functions by the formula (1), let us proceed to the next step.

For each group of criteria, Decision Maker has own considerations, which should be "desired values", i. e. the total of points according to each group of criteria. Let us denote them by the vector $T=(t_1,t_2,...,t_5)$ according to groups of criteria G_i, $(i\ \overline{1,5})$, and for each value we calculate membership function by the formula (1). The vector of the membership function of "desired values" is denoted by $\alpha=(\alpha_1,\alpha_2,...,\alpha_5)$, where $\alpha_i=\mu_{G_i}(t_i)$, $(i=\overline{1,5})$. Received values can be presented according to Table 1.

Table 1

Received data according to the first level

Group of criteria	Point estimation	Membership function of point estimation	"Desired values" T	Membership function of "desired values" α
G_1	g_1	x_1	t_1	α_1
G_2	g_2	x_2	t_2	α_2
...	...	...	...	...
G_5	g_5	x_5	t_5	α_5

On the second level of the model, relative to the "desired values" and the obtained results for each group of criteria G_i, we project the value of membership function to a set of carrier of linguistic variable U. This will reveal the essence of the considered "idea" relative to the "desired values", Fig. 1.

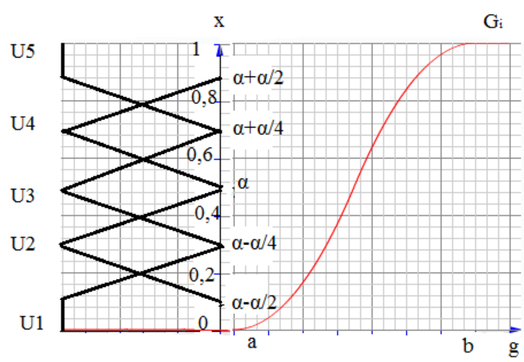

Fig. 1. Diagram of an s-shaped membership function and linguistic variable U, x is the value of membership function, g is the convolution of points, α is the membership function of "desired values"

For each term U we will build the membership function as follows (2)–(6).

$$\mu_{U1}\left(x;\alpha-\frac{\alpha}{2};\alpha-\frac{\alpha}{4}\right)=\begin{cases}1, & x\le\alpha-\frac{\alpha}{2};\\ \frac{3\alpha-4x}{\alpha}, & \alpha-\frac{\alpha}{2}<x\le\alpha-\frac{\alpha}{4}.\end{cases}\qquad(2)$$

$$\mu_{U2}\left(x;\alpha-\frac{\alpha}{2};\alpha-\frac{\alpha}{4};\alpha\right)=\begin{cases}\frac{4x-2\alpha}{\alpha}, & \alpha-\frac{\alpha}{2}<x\le\alpha-\frac{\alpha}{4};\\ \frac{4\alpha-4x}{\alpha}, & \alpha-\frac{\alpha}{4}<x\le\alpha.\end{cases}\qquad(3)$$

$$\mu_{U3}\left(x;\alpha-\frac{\alpha}{4};\alpha;\alpha+\frac{\alpha}{4}\right)=\begin{cases}\frac{4x-3\alpha}{\alpha}, & \alpha-\frac{\alpha}{4}<x\le\alpha;\\ \frac{5\alpha-4x}{\alpha}, & \alpha<x\le\alpha+\frac{\alpha}{4}.\end{cases}\qquad(4)$$

$$\mu_{U4}\left(x;\alpha;\alpha+\frac{\alpha}{4};\alpha+\frac{\alpha}{2}\right)=\begin{cases}\frac{4x-4\alpha}{\alpha}, & \alpha<x\le\alpha+\frac{\alpha}{4};\\ \frac{6\alpha-4x}{\alpha}, & \alpha+\frac{\alpha}{4}<x\le\alpha+\frac{\alpha}{2}.\end{cases}\qquad(5)$$

$$\mu_{U5}\left(x;\alpha+\frac{\alpha}{4};\alpha+\frac{\alpha}{2}\right)=\begin{cases}\frac{4x-5\alpha}{\alpha}, & \alpha+\frac{\alpha}{4}<x\le\alpha+\frac{\alpha}{2};\\ 1, & x\ge\alpha+\frac{\alpha}{2}.\end{cases}\qquad(6)$$

Depending on which interval x belongs in, for each group of criteria G_i we choose one or another membership function relative to the "desired value" α. We compute a membership function relative to terms $U_{ij},(i,j=\overline{1,5})$ for the considered start-up. As a result, for each group of criteria G_i we will receive linguistic value and the assessment of the reliability of a start-up. That is, the accuracy of that the assessment of a group of criteria belongs in one or another term. This will make it possible to receive an interpretation for the gathered expert points, revealing their subjectivity, and to have an understanding of what a start-up is really up to.

Let the Decision Maker have own considerations regarding what the terms for the groups of criteria G_i should be. Such terms are denoted as U^*, Table 2.

Table 2

Received data according to the second level

Groups of criteria	Resulting term	The authenticity of the term (the value of the membership function)	«Desired values» of term
G_1	U_{1j}	μ_{U1j}	U^*_{1j}
G_2	U_{2j}	μ_{U2j}	U^*_{2j}
...	....	....	....
G_5	U_{5j}	μ_{U5j}	U^*_{5j}

The next step is to calculate the points relative to the received and desired terms using the following membership function (7):

$$\mu(O_i)=\max\{\mu(A_i);\mu(B_i)\},\qquad(7)$$

where

$$\mu(A_i)=\begin{cases}\mu_{Uij}, & U_{ij}=U^*_{ij},\\ 0, & U_{ij}\ne U^*_{ij}.\end{cases}$$

and

$$\mu(B_i)=\begin{cases}\frac{\mu_{Uij}}{2}, & U_{i(j\pm1)}=U^*_{ij},\\ 0, & U_{i(j\pm1)}\ne U^*_{ij}.\end{cases}\quad(i=\overline{1,5}).$$

Received membership function shows to which extent a considered start-up satisfies the requests of the decision maker by each group of criteria.

As the constructed membership functions (2)–(6) have intersections, then for the groups of criteria we will receive both one or two terms and the same number of reliabilities, accordingly. Therefore, if we have two points by a group of criteria, then the constructed membership function (7) selects the largest of them for the next stage.

Let the decision maker know or can set weight coefficients to each group of performance criteria $\{p_1, p_2, ..., p_5\}$ from the interval [1; 10]. Then one can define normalized weight coefficients for each group of criteria [17]:

$$w_i = \frac{p_i}{\sum_{i=1}^{5} p_i}, i = \overline{1,5}; \; w_i \in [0,1]; \quad (8)$$

which meet the condition $\sum_{i=1}^{5} w_i = 1$.

Let us consider one of the convolutions for building aggregated assessment [17]. For example, take the average weighted convolution:

$$m = \sum_{i=1}^{5} w_i \cdot \mu(O_i), i = \overline{1,5}. \quad (9)$$

We enter a linguistic variable M(m)=«idea assessment». The universal set for the variable M(m) is the segment [0; 1] and a set for the values of the variable m is a term-set $M=\{m_1, m_2, m_3, m_4, m_5\}$, where:

m_1 =“assessment of idea is very low”;

m_2 =“assessment of idea is low”;

m_3 =“assessment of idea is average”;

m_4 =“assessment of idea is above average”;

m_5 =“assessment of idea is high”.

To determine linguistic assessment of an “idea”, the value, received by the formula (9), is entered into one of the term-set $M=\{m_1, m_2, m_5, m_4, m_5\}$. The points scale can be defined by: $m \in (0{,}67; 1]$ – m_5; $m \in (0{,}47; 0{,}67]$ – m_4; $m \in (0{,}36; 0{,}47]$ – m_5; $m \in (0{,}21; 0{,}36]$ – m_2; $m \in [0; 0{,}21]$ – m_1.

Thus, for the considered start-up, the output data of the model will be the assessment of an “idea” and its linguistic value. Based on that, a further decision regarding the start-up project is taken.

4. 3. Algorithm for building an output assessment

We can describe a general algorithm for constructing the assessment of an “idea” as follows.

1 step. For the considered start-up S, to carry out an expert poll and calculate the convolution of the total of points by corresponding groups of criteria $\{G_1, G_2, ..., G_5\}$.

2 step. The decision maker sets own requests regarding the “desired values” by the vector $T = (t_1, t_2, ..., t_5)$ by groups of criteria.

3 step. We calculate the value of the membership function for the received points for the start-up and the “desired values”, according to (1).

4 step. We find the value of the membership function μ_{Uij} relative to points score and the “desired value” according to (2)–(6). As a result, for each group of criteria G_i on the considered start-up, we receive linguistic value and the assessment of its reliability.

5 step. Decision Maker expresses own considerations regarding terms (desired terms) by the groups of criteria U^*.

6 step. We calculate the values $\mu(O_i)$, $(i = \overline{1,5})$ relative to received and desired terms according to (7).

7 step. Decision Maker sets the weight coefficients for each group of criteria $\{p_1, p_2, ..., p_5\}$ and we perform their normalization according to (8).

8 step. By using an average-weighted convolution (9), we compute the aggregated assessment and compare it to the term-set M for obtaining linguistic assessment of the considered “idea”.

5. The results of the study on the example of the application of the designed model for assessing a startup

Let us apply designed mathematical model for assessing a start-up S – “A multi-purpose monitoring of a smart home” [18]. This start-up passed an expert poll and received the following convolution of points by groups of criteria, Table 3.

Table 3

Incoming data on the start-up

Groups of criteria	G_1	G_2	G_3	G_4	G_5
Resulting number of points	70	50	40	150	65
Convolution of the sum of the worst answers, i. e. minimal points	20	15	10	50	25
Convolution of the sum of the best answers, i. e. maximal points	115	60	50	225	90

It is required to assess the considered start-up by the received input data and to derive a linguistic assessment of the “idea”.

Let us consider the first level of the proposed model.

Let the Decision Maker have own preferences regarding the “desired values”. They are denoted by the vector T=(80; 55; 35; 165; 50), whose values correspond to each group of criteria.

For the resulting number of points and the “desired values” we calculate the values of the membership function according to (1). All values are presented according to Table. 4.

Table 4

Received data on the startup according to the first level

Groups of criteria	Point estimation	Membership function of point estimation	“Desired values” T	Membership function of the “desired values” α
G_1	70	0,55	80	0,73
G_2	50	0,90	55	0,98
G_3	40	0,88	35	0,72
G_4	150	0,63	165	0,76
G_5	65	0,70	50	0,76

Next, let us pass on to the second level of the model.

For the evaluation of subjectivity of expert data, we project the values of membership function to the set of carrier of linguistic variable U relative to the “desired values” and received results. We choose one or another membership function μ_{Uij} according to (2)–(6) relative to a point estimation and the “desired value”. Thus, for each group of criteria G_i on the considered start-up we receive a linguistic value and the assessment of its credibility.

The results of the calculation and the requests of the Decision Maker relative to terms by groups of criteria are presented in Table 5.

Table 5

Received data on the startup according to the second level

Groups of criteria	Received term	Term's reliability (the value of membership function)	Requests values of terms by Decision Maker
G_1	U_{12} or U_{13}	$\mu_{U12} = 0,98$ or $\mu_{U13} = 0,02$	U_{13}
G_2	U_{22} or U_{23}	$\mu_{U22} = 0,33$ or $\mu_{U23} = 0,67$	U_{23}
G_3	U_{33} or U_{34}	$\mu_{U33} = 0,1$ or $\mu_{U34} = 0,9$	U_{35}
G_4	U_{42} or U_{43}	$\mu_{U42} = 0,68$ or $\mu_{U43} = 0,32$	U_{44}
G_5	U_{52} or U_{53}	$\mu_{U52} = 0,32$ or $\mu_{U53} = 0,68$	U_{53}

During the next step we calculate the points relative to the received and desired terms according to (7), Table 6:

Table 6

Value of points by groups of criteria

Groups of criteria	Received points
G1	0,49
G2	0,67
G3	0,45
G4	0,16
G5	0,68

Let the Decision Maker determine weight coefficients by each group of criteria as follows {10; 8; 6; 7; 4}. Then we define normalized weight coefficients according to (8) – {0,29; 0,23; 0,17; 0,2; 0,11} for each group of criteria.

Next, we use the convolution (9) for construction of aggregated and linguistic assessment of the considered "idea":

$$m = 0,49 \cdot 0,29 + 0,67 \cdot 0,23 + 0,45 \cdot 0,17 + \\ +0,16 \cdot 0,2 + 0,68 \cdot 0,11 = 0,4795.$$

Let us compare received result to the linguistic variables and we will receive that the estimated start-up refers to the term m_4 –"assessment of idea is above average."

Thus, we presented an example of application of a mathematical model that allows evaluating the uncertainty of the input data, assessing a start-up and positioning the "idea" among others.

6. Discussion of the results of the designed startups assessment model under conditions of information uncertainty

An "idea" itself is not worth anything, which is why to assess it, we designed a model, based on the "desired value" of the result for the construction of linguistic variables. An "idea" is assessed relative to the proposed indicators, which reveal the uncertainty and determine the reliability of their belonging in satisfied requirements of the Decision Maker.

Thus, the designed model has a number of advantages, namely: it gives the possibility to understand the essence of the proposed "idea" in the points area; this model is easily customized depending on the purpose of the assessment; it reveals the uncertainty of the input data (expert estimates) by using the set-carrier of linguistic variable U relative to the "desired values"; it shows the position of the "idea" among others thanks to the "desired value"; it reveals the structured concept of developers that facilitates finding rationale behind the considered "idea" for investors or Decision Maker.

The disadvantages of this approach include the use of different models of membership functions that can lead to ambiguity of the final results.

The received result of the study is a model of assessment of start-ups under conditions of information uncertainty, the output of which is the linguistic assessment of the considered "idea". The rationality of such an assessment is proven by the advantages of the designed model. The accuracy of the received results is ensured by correct use of the apparatus of fuzzy logic and fuzzy sets, which is confirmed by the results of the research.

Creation of technology for the assessment and selection of efficient start-up projects based on the designed mathematical model that works with fuzzy data and increases the validity of the decision-making process will be a necessary tool for either venture companies or startuppers during the development of innovative business.

Further studies of these issues as we see them are in the approbation of the designed model for a broad sample of start-ups and the development of methods for learning this technology.

7. Conclusions

The study of an actual task of a start-up projects assessment on the stage of the introduction of the product on the market was carried out. The model of start-ups assessment under conditions of uncertainty using the apparatus of fuzzy math was designed. We obtained the following results:

– a set of 21 criteria was compiled for the assessment of startups, which are divided into five groups, revealing the general aspects of the assessment of any startup based on heuristic principle;

– the gradation points scale of assessment was proposed in the form of question-answer to receive evaluation by each criterion. The work shows it in more detail on the first group of criteria, which is "the essence of idea";

– the model of start-up projects assessment was designed, which allows reducing the subjectivity of expert evaluation by setting normalized input data of gradation scale of assessment and the introduction of the "desired values" of a Decision Maker. A characteristic feature of the model is that it allows finding the essence and the position of an "idea" among others, based on the "desired values" and the received results for each group of criteria, by projecting the values of membership function to the set of carrier of linguistic variable. The model also sets the level of the assessment of an "idea" and its linguistic value, taking into account the requests of the Decision Maker when considering, evaluating and choosing start-ups;

– an example of a model application is presented and it was tested for the start-up "A multi-purpose monitoring of a smart home" that was presented at the "Kickstarter" (a community that helps translate start-up ideas into practice). We received the result, according to which the considered start-up belonged in the term m_4 which is "assessment of idea is above average."

Therefore, the designed model will be a useful tool to increase the validity of decision-making process by venture funds and "investment angels" who wish to support and finance start-ups.

References

1. Malyar, M. Choice and evaluation methodics of investment projects [Text] / M. Malyar, V. Polishchuk // Košická bezpečnostná revue, Košice. – 2013. – Vol. 1. – P. 117–126.
2. Vartist pre-money i post-money [Electronic resource]. – Available at: http://gaap.ru/articles/stoimost_pre_money_i_post_money
3. Zvyahintseva, O. D. Intehrovana otsinka startap–proektiv [Text] / O. D. Zvyahintseva, I. O. Zolotarova, O. V. Shcherbakov // Systemy obrobky informatsiyi. – 2015. – Vol. 4. – P. 163–165.
4. High Tech Startup Valuation Estimator [Electronic resource]. – Available at: https://www.caycon.com/valuation.php#bottom
5. Pylypenko, D. H. Metody rozrakhunku efektyvnosti finansuvannya dovhostrokovykh venchurnykh proektiv [Text] / D. H. Pylypenko // Aktualni problemy ekonomiky. – 2015. – Vol. 2. – P. 450–460.
6. Denysyuk, V. A. Venchurne investuvannya v natsionalniy innovatsiyniy systemi: analiz mekhanizmiv rozvytku ta osnovy kontseptsiyi dlya Ukrayiny [Text] / V. A. Denysyuk // Problemy innovatsiyno-investytsiynoho rozvytku. – 2011. – Vol. 3. – P. 190–201.
7. Csaszar, F. Strategic and cognitive criteria for the selection of startups [Text] / F. Csaszar, M. Nussbaum, M. Sepulveda // Technovation. – 2006. – Vol. 26, Issue 2. – P. 151–161. doi: 10.1016/j.technovation.2005.01.010
8. Mendialdua, J. C. Using fuzzy logic in selecting people and ideas to participate in public programs of support to business start-ups [Text] / J. C. Mendialdua, P. M. Orizaola Iniesta, M. J. López // Cuadernos de Gestión. – 2014. – Vol. 14, Issue 2. – P. 73–98.
9. Roldán-López-de-Hierro, A.-F. Some new fixed point theorems in fuzzy metric spaces [Text] / A.-F. Roldán-López-de-Hierro, E. Karapınar, S. Manro // Journal of Intelligent and Fuzzy Systems. – 2014. – Vol. 27, Issue 5. – P. 2257–2264.
10. Kutc, A. M. Method of presentation of expert information by means of fuzzy logic and obtaining the group assessment of expert opinions [Text] / A. M. Kutc // Technology Audit and Production Reserves. – 2015. – Vol. 2, Issue 2(22). – P. 17–21. doi: 10.15587/2312-8372.2015.40778
11. Lomotko, D. V. Formation of fuzzy support system for decision-making on merchantability of rolling stock in its allocation [Text] / D. V. Lomotko, A. O. Kovalov, O. V. Kovalova // Eastern-European Journal of Enterprise Technologies. – 2015. – Vol. 6, Issue 3(78). – P. 11. doi: 10.15587/1729-4061.2015.54496
12. Cebeci, U. Fuzzy AHP-based decision support system for selecting ERP systems in textile industry by using balanced scorecard [Text] / U. Cebeci // Expert Systems with Applications. – 2009. – Vol. 36, Issue 5. – P. 8900–8909. doi: 10.1016/j.eswa.2008.11.046
13. Domin, D. A. Synthesis of optimal temperature regulator of electroarc holding furnace bath [Text] / D. A. Domin // Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu. – 2012. – Vol. 6 – P. 52–58.
14. Kuo, R. J. An intelligent stock trading decision support system through integration of genetic algorithm based fuzzy neural network and artificial neural network [Text] / R. J. Kuo, C. H. Chen, Y. C. Hwang // Fuzzy Sets and Systems. – 2001. – Vol. 118, Issue 1. – P. 21–45. doi: 10.1016/s0165-0114(98)00399-6
15. Chase, G. Evaluating the economic impact of cruise tourism: a case study of Barbados [Text] / G. Chase, I. Alon // Anatolia. – 2002. – Vol. 13, Issue 1. – P. 5–18. doi: 10.1080/13032917.2002.9687011
16. Malyar, M. M. Dvukhurovnevaya model nechetkogo ratsionalnogo vybora [Text] / M. M. Malyar, V. V. Polishchuk // ITHEA International Journal "Problem of Computer Intellectualizacion". – 2012. – P. 242–248.
17. Malyar, M. M. Vykorystannya dynamichnykh kryteriyiv u modelyakh bahatokryterialnoho vyboru [Text] / M. M. Malyar, V. V. Polishchuk, M. M. Sharkadi // Kompyuternaya matematyka. – 2015. – Vol. 1. – P. 125–133.
18. Featured project in Technology [Electronic resource]. – Available at: https://www.kickstarter.com/discover/categories/technology?ref=discover_index