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STUDY ON THE CLASSIFICATION PROBLEMS WITH UNCERTAINTY IN INNOVATIVE ENTREPRENEURSHIP*

The paper presents the results of investigation of the problem of uncertainties in innovative business. Groups of uncertainties, adherent to innovative business, have been classified. A map of uncertainty is formed with some zones containing information on what an entrepreneur can face, when and under what circumstances.

Keywords: *uncertainty; innovative entrepreneurship; classification; uncertainty map.*

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ДОСЛІДЖЕННЯ ПРОБЛЕМИ КЛАСИФІКАЦІЇ НЕВИЗНАЧЕНОСТЕЙ У ІННОВАЦІЙНОМУ ПІДПРИЄМНИЦТВІ

У статті представлено результати дослідження проблеми невизначеностей в інноваційному підприємництві. Класифіковано групи невизначеностей, які притаманні інноваційному бізнесу. Сформовано карту невизначеностей з метою виділення зон, що містять інформацію про те, з чим саме, коли і за яких обставин підприємець може зіткнутися.

Ключові слова: *невизначеність; інноваційне підприємництво; класифікація; карта невизначеностей.*

Форм. 7. Табл. 3. Рис. 3. Літ. 16.

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ИССЛЕДОВАНИЕ ПРОБЛЕМЫ КЛАССИФИКАЦИИ НЕОПРЕДЕЛЁННОСТЕЙ В ИННОВАЦИОННОМ ПРЕДПРИНИМАТЕЛЬСТВЕ

В статье представлены результаты исследования проблемы неопределённостей в инновационном предпринимательстве. Классифицированы группы неопределённостей, присущих инновационному бизнесу. Сформирована карта неопределённостей с целью выделения зон, содержащих информацию о том, с чем именно, когда и при каких обстоятельствах предприниматель может столкнуться.

Ключевые слова: *неопределенность; инновационное предпринимательство; классификация; карта неопределенностей.*

Problems setting. Managing uncertainties in today's macroeconomic environment seems one of the most important tasks. Macroeconomic nature of uncertainties in business was for the first time described in detail by (Knight, 1964), and the primary role there was attributed to such factors as capital, land and competitive advantages.

M.G. Klasen (2005) srares that the nature of uncertainties may relate to internal environment of an organization and may occur at a very early stage of a business process.

Completely different opinion belongs to the representatives of behavioral economics (Camerer, Loewenstein and Rabin, 2003) and the prospects theory (Hastie and Dawes, 2001; Polak, 2010), who examine the nature of uncertainty from financial results perspective.

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Consideration of uncertainty in terms of management theory is defined in planning, organization, control, regulation and motivation (Harris and Woolley, 2009; Jalonen and Lehtonen, 2011; McKinney, 2011; Wilson, 1997).

Organization of transactions, the emergence of transaction costs are reflected in the theory of conflict resolution by THE Nobel laureate O.E. Williamson (1992). It is also assumed that uncertainty arises from the behavior of people waiting for failures (Das and Teng, 1998).

In mathematics, uncertainty in economic systems is considered as the nature of existence (Borch, 1963).

In philosophy uncertainty has an ontological nature, i.e. causes relations being developed both inside and outside (Lane and Maxfield, 2005).

The main task. In order to consider the management of uncertainties in the implementation of innovations, it is important to understand when and what exactly an entrepreneur will face. Developing system solution is simplified, if we set the time, the essential characteristics of environment and uncertainties. For designated tasks it is necessary to determine the classification for uncertainties.

Methodology. After analyzing the collected information on uncertainties it is obvious that the formal principle of classification will be significantly impeded and possible outcomes will be descriptive only.

Interesting is the use of the classification theory (Mejen and Schreider, 1976). To describe the sets of uncertainties as groups we'll use the simple approach of the set theory (Petrovsky, 2005).

The research basis. Consideration of uncertainties classification in innovative business from the theoretical perspective begins with determining the parameters of this procedure.

Implementation of effective innovations is defined, in our opinion, by the following characteristics:

- the timing factor of uncertainty;
- environmental factors;
- relation to the nature of uncertainty.

Studying the existing theoretical sources on the theory of innovation and risks we have identified 70 types of uncertainties (Appendix 1). We denote them as xij, belonging to a certain set.

To simplify working with them and using the formal sign 10 taxons were set (the subset of the classification field): Market (*T1*); Law (*T2*); Information (*T3*); Financial (*T4*); Time (*T5*); Relationship (*T6*); Organizational (*T7*); Technical and technological (*T8*); Labor (*T9*); Other (*T10*).

Obviously, each uncertainty may correspond to one or more taxons simultaneously.

Using the multiset theory as a description for the classification of relations we use the following logical system:

$$f_i(x) = \begin{cases} 1, if\ x \in T_i \\ 0, if\ x \notin T_i \end{cases}. \quad (1)$$

Herewith $f_i(x) \to Z_{01}$, i.e. $Z_{01} = \{0,1\}$.

Thus, each taxon is represented by the aggregate of binary numbers that indicate the presence of uncertainty (1) or its absence (0).

This approach simplifies work with data space and the introduction of metric for the analysis and subsequent classification of uncertainties.

Determining the analysis system. The problem of multiplicity and frequency of factors characterizing taxons is eliminated.

To determine the structure and the properties of uncertainties we introduce the following verbal criteria identifying them with quantitative characteristics:

1. The ratio of each type of uncertainty to the environment (env_i): external environment; internal environment; conjugate environment (the nature of both environments).

2. Relationship to time of occurrence and flow (t_1); before implementation (t_2); at the time of implementation (t_3); upon completion (t_4); throughout (t_5); before and at the time of (t_6); before and after (t_7); at the time of and after (t_8).

Analysis procedures. Thus, each uncertainty (x_i) is expressed by a combination of the following factors (2): belonging to a taxon, time and environment management.

$$X_i = \{(T_i^{es(1)}, ..., T_i^{es(10)}), (t_i^{es(1)}, ..., t_i^{es(7)}), (env_i^{es(1)}, ..., env_i^{es(3)})\}. \quad (2)$$

Endowing each uncertainty by quantitative measure (0 or 1) and based on the logic of definition we obtain a set of characteristics, their processing is not difficult.

For the analysis of the time factor and classification of uncertainties from the time of occurence and the process for separation of taxon we construct a neural network using hyperbolic tangent, since it is suitable for partition attributes into classes.

For building the classification of uncertainties on taxon, temporal and environmental factors we use the method of cluster analysis.

Results. The input layer neurons we define as temporary factors. Thus, the first layer is comprised of 7 neurons. Output layer are the taxons.

The binary feature of input and output signals are preferably implemented in the form of the sigmoid function:

$$f(x) = \frac{1}{1+\exp(-x)}. \quad (3)$$

The function of the hyperbolic tangent activation can be applicable for identity matrix:

$$\tanh(x) = \frac{\sinh x}{\cosh x} = \frac{e^x - e^{-x}}{e^x + e^{-x}}. \quad (4)$$

Activation potential will be determined as follows:

$$v_t = \sum_{i=0}^{n} w_{ti} x_i, \quad (5)$$

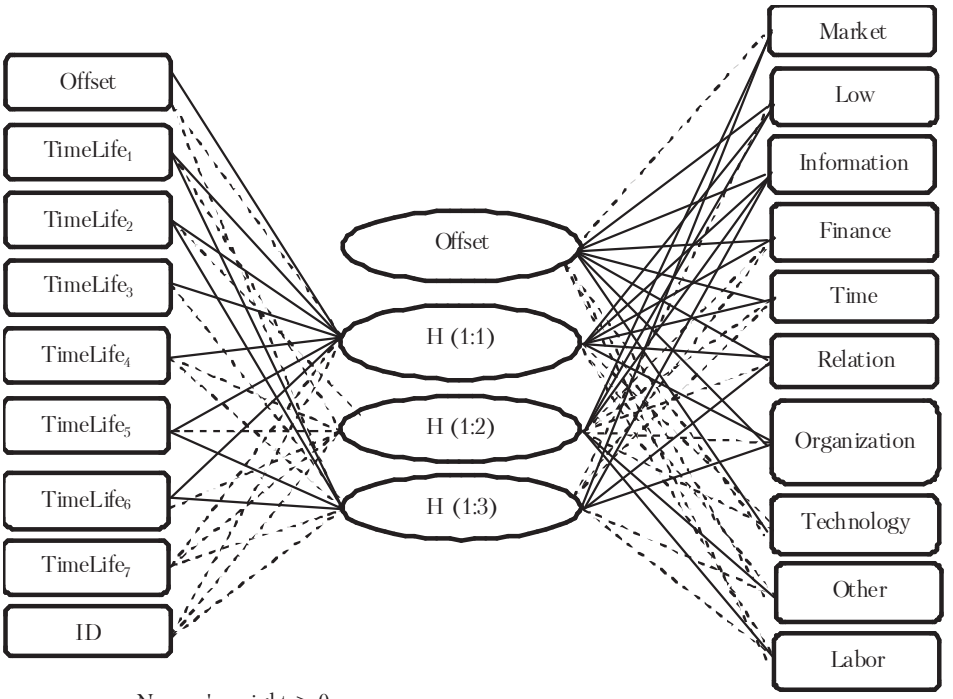
value of the activation function is defined by the formula:

$$y_t = \varphi(v_t), \quad (6)$$

where x_i – components of the time factor; w_i – synaptic weights of neuron.

As a measure of distance we use the Euclidean measure:

$$d(x, w_i) = \|x - w_i\| = \sqrt{\sum_{i=1}^{N} (x_i - w_{ij})^2}. \quad (7)$$



– Neuron's weight > 0.

– Neuron's weight < 0.

$TimeLife_{1,...,7}$ – the serial number of the time of uncertainty $t_{1,...,7}$.

Figure 1. **Neural Network,** *made by the author using SPSS*

Table 1. **Neural analysis results,** *author's*

Summary of model			
Teaching	Error sum of squares		198.093
	Average total relative error, %		0.777
	The relative error for quantitative dependent variables, %	Market taxon	0.128
		Law taxon	1.019
		Information taxon	0.871
		Financial taxon	0.869
		Time taxon	0.764
		Relation taxon	0.945
		Organization taxon	0.810
		Technical and technological taxon	1.011
		Taxon of other uncertainties	0.406
		Labor taxon	0.946
Control	Error sum of squares		101.720
	Average total relative error, %		0.852
	The relative error for quantitative dependent variables, %	Market taxon	0.100
		Law taxon	0.928
		Information taxon	1.020
		Financial taxon	–
		Time taxon	0.841
		Relation taxon	1.058
		Organization taxon	0.978
		Technical and technological taxon	1.054
		Taxon of other uncertainties	0.515
		Labor taxon	0.938

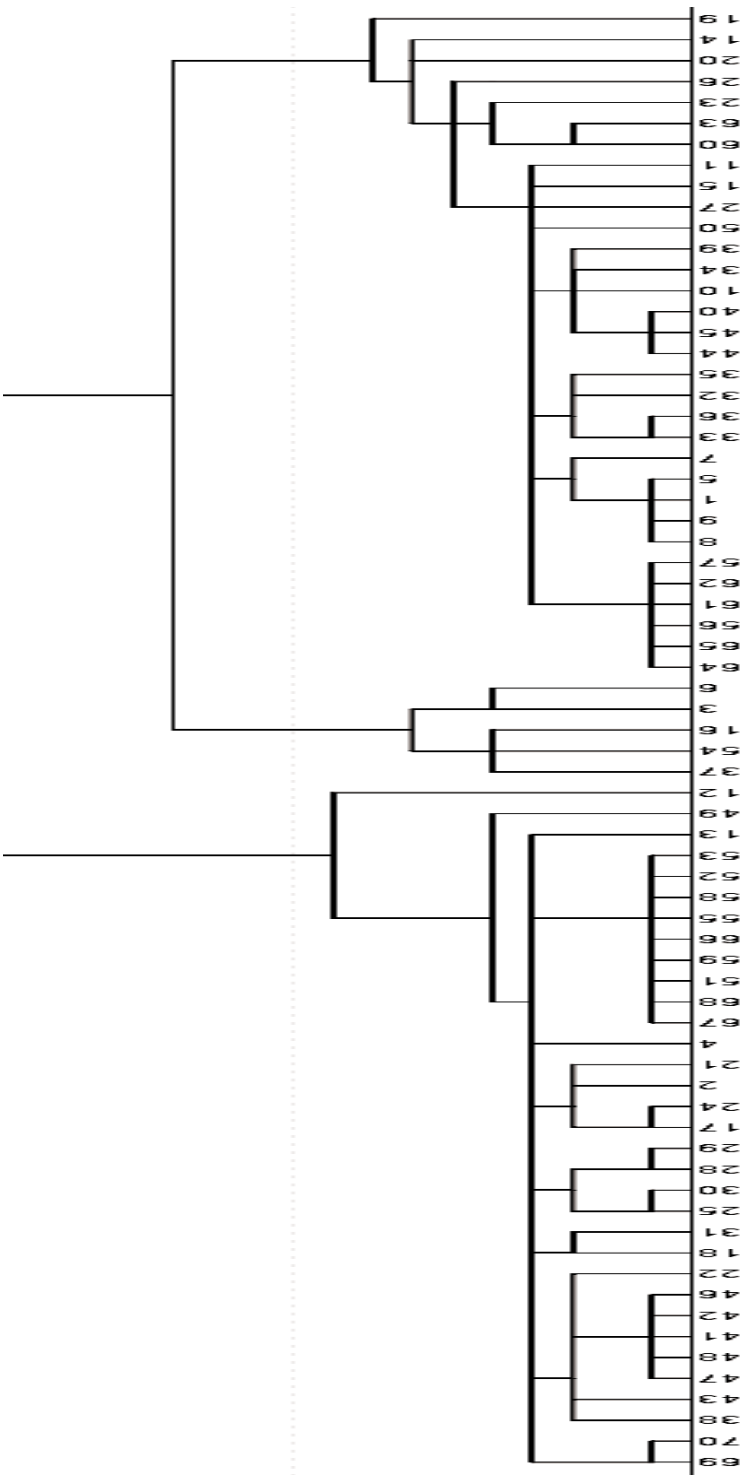


Figure 2. **Tree diagram for 70 uncertainties,** *made by the author using SPSS*

Based on this analysis the following results have been obtained:

1. Before starting, at the time and on completion there will be always be uncertainties following the taxon: financial; time; relationship; organizational; technical and technological.

2. At the time of implementation and on completion there will be the following taxons: legislation; technical and technological; labor; other uncertainties.

3. Upon completion there are the derived taxons: legislation; finance; time; labor; other uncertainties.

It turns out that a business innovator will face with all the groups of uncertainty, but their appearance will be expressed differently in each individual time interval.

Cluster analysis. Next, we proceed with analyzing the uncertainties. Using the cluster analysis by types of uncertainties (70 items) with the occurrence and course of events constraints, related to the environment and allocation to taxons we have got quite interesting results (Figure 2).

Table 2. **Cluster analysis results, author's**

1 Cluster				2 Cluster				3 Cluster				4 Cluster			
Uncertainty	Environment	Time	Taxon	Uncertainty	Environment	Time	Taxon	Uncertainty	Environment	Time	Taxon	Uncertainty	Environment	Time	Taxon
1	ex	4	1	2	ex	1	1;3	3	ex	6	1;6;7	12	ex	2	1;7;8;10
5	in	4	1	4	e/i	1	1	6	ex	6	1	-	-	-	-
7	ex	3	1	13	in	1	2	16	in	7	2	-	-	-	-
8	ex	4	1	17	in	2	3	37	ex	7	5	-	-	-	-
9	ex	4	1	18	in	1	3;5	54	e/i	7	10	-	-	-	-
10	ex	4	1;7	21	in	1	3	-	-	-	-	-	-	-	-
11	ex	4	1;7;10	22	ex	1	3;7	-	-	-	-	-	-	-	-
14	ex	5	2;6;7	24	ex	2	3	-	-	-	-	-	-	-	-
15	in	4	2	25	in	1	4	-	-	-	-	-	-	-	-
19	in	3	3;5	28	in	1	4;5	-	-	-	-	-	-	-	-
20	in	5	3;8	29	e/i	1	4	-	-	-	-	-	-	-	-
23	ex	5	3;7	30	in	1	5	-	-	-	-	-	-	-	-
26	ex	5	4;7	31	ex	1	5;6;7	-	-	-	-	-	-	-	-
27	in	4	4	38	ex	2	7	-	-	-	-	-	-	-	-
32	ex	5	7	41	e/i	1	7	-	-	-	-	-	-	-	-
33	ex	4	5	42	in	1	7	-	-	-	-	-	-	-	-
34	in	4	5;6;7	43	in	1	7	-	-	-	-	-	-	-	-
35	ex	5	5	46	in	1	7	-	-	-	-	-	-	-	-
36	ex	4	5	47	in	1	7	-	-	-	-	-	-	-	-
39	ex	4	6;7	48	in	1	7	-	-	-	-	-	-	-	-
40	ex	4	7	49	in	2	8	-	-	-	-	-	-	-	-
44	ex	4	7	51	ex	1	10	-	-	-	-	-	-	-	-
45	in	4	7	52	in	1	10	-	-	-	-	-	-	-	-
50	e/i	4	8	53	in	1	10	-	-	-	-	-	-	-	-
56	ex	4	10	55	ex	1	10	-	-	-	-	-	-	-	-
57	ex	4	10	58	in	1	10	-	-	-	-	-	-	-	-
60	e/i	5	10	59	e/i	1	10	-	-	-	-	-	-	-	-
61	e/i	4	10	66	in	1	10	-	-	-	-	-	-	-	-
62	e/i	4	10	67	in	1	10	-	-	-	-	-	-	-	-
63	e/i	6	10	68	e/i	1	10	-	-	-	-	-	-	-	-
64	e/i	4	10	69	in	1	9	-	-	-	-	-	-	-	-
65	e/i	4	10	70	in	1	9	-	-	-	-	-	-	-	-

ex – external environment; in – internal environment; e/i –nature of uncertainty is dual.

	t_1	t_2	t_3	t_4	t_5	t_6	t_7
External environment	2 (T1, T3) 22 (T3, T7) 31 (T5) 51 (T10) 55 (T10)	24 (T3) 38 (T5, T6, T7) 12 (T1, T7, T8, T10)	7 (T1)	1 (T1) 44 (T7) 8 (T1) 56 (T10) 9 (T1) 57 (T10) 10 (T1, T7) 36 (T5) 11 (T1, T7, T10) 33 (T5) 40 (T7) 39 (T6, T7)	3 (T1, T6, T7) 6 (T1) 14 (T2, T6, T7) 23 (T3, T7) 26(T4, T7) 32 (T7) 35 (T5)	Not available	37 (T5)
External and internal environment	4 (T1) 29 (T4, T5) 41 (T7) 59 (T10) 68(T10)	Not available	Not available	50 (T8) 61 (T10) 62 (T10) 64 (T10) 65 (T10)	60 (T10)	63 (T10)	54 (T10)
Internal environment	13 (T2) 18 (T3, T5) 21 (T3) 25 (T4) 28 (T4, T5) 30 (T4) 42 (T7) 43 (T7) 46 (T7) 47 (T7) 48 (T7) 52 (T10) 53 (T10) 58 (T10) 66(T10) 67 (T10) 69 (T9) 70 (T9)	17 (T3) 49 (T8)	19 (T3, T5)	5 (T1) 15 (T2) 27 (T4) 34 (T5, T6, T7) 45 (T7)	20 (T3, T8)	Not available	16 (T2)

Figure 3. **Tree diagram for 70 uncertainties,** *author's*

So, uncertainties are classified into 4 clusters. Now we can summarize the results of data analysis into a table (Table 2).

Thus, it becomes possible to arrange the analysis results in the summary table – map (Figure 3).

Conclusion. Having analyzed the uncertainties related to innovative entrepreneurship, we managed to generate a temporary, environmental and formal groups. We can also highlight the important features of the theory of innovation management from the perspective of the theory of uncertainty:

1. Uncertainties accompany innovator over the entire cycle of innovation.

2. Over 40% of the external environment uncertainties occur from external environment, 40% – in the internal environment and only 19% have a dual nature and can be controlled.

3. Before the beginning of an innovation an uncertainty can occur of the organizational type. At the active phase of activity the innovator will be accompanied by technical, technological and informational uncertainties. Upon completion – the uncertainty of the market, time and other types of uncertainties. Throughout, from the start to the finish (diffusion of innovation) – market, organizational, and other. Before and at the time of the active phase – organization. Before and at the end – other uncertainties. In the active phase and at the end – legal, temporary and "other" taxons.

As seen in the analysis results all other groups of uncertainties have a fragmented nature of origin and belong to the single period, enabling to anticipate and avoid them.

All other types of uncertainties may accompany innovations from their start to finish.

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Appendix 1. **Types of uncertainties***

Number of observation	Uncertainty
1	Low demand for new goods, works, services
2	Lack of information on markets
3	Undeveloped innovation infrastructure
4	Degree of uniqueness of a case
5	Uncertainties associated with the market and determining the selling price of a product
6	Volumes of expected proposals from other manufacturers as well as needs and purchasing power
7	Changing people's needs
8	Market uncertainty
9	Secondary uncertainty
10	Vartation uncertainty
11	Ontological uncertainty
12	The intensity of R&D
13	Lack of legislative and regulatory documents
14	Political uncertainty
15	Social and political uncertainty
16	Uncertainty of approval and legitimacy
17	Lack of information about new technologies
18	Prospective uncertainty
19	Retrospective uncertainty
20	Technical uncertainty
21	Uncertainty sources and environmental factors
22	Uncertainty conditions
23	Uncertainty of action
24	Information uncertainty
25	Lack of own funds
26	Lack of financial support from the state
27	High cost of innovation
28	Expectation of future income from capitalization
29	Social progress in the material aspect
30	Money illusion
31	Vision of the future
32	The uncertainty associated with the increment of knowledge
33	Cyclical
34	Uncertainty conjugate to business operations
35	Uncertainty of timing
36	Random fluctuations in the course of progress
37	Uncertainty effects
38	Undeveloped cooperative ties
39	Uncertain economic benefits from the use of intellectual property
40	High economic risks
41	Low innovation capacity of the organization
42	Uncertainty "things" and circumstances that lead to a solution
43	Degree of uniqueness of the case
44	Communication with aspects or factors of progress that have an existence
45	Regulatory uncertainty

Continuation of *Appendix 1*

Number of observation	Uncertainty
46	Uncertainty of institutional heritage
47	Experience
48	Organizational structure
49	Specificity of innovation
50	Production uncertainty
51	Spatial redistribution of population
52	Fear of loss
53	Egoistic bias
54	Disappointment
55	Initial uncertainty
56	Behavioral uncertainty
57	Relational uncertainty
58	Uncertainty of purpose
59	Zero uncertainty
60	Quasi terming uncertainty
61	Stochastic uncertainty of a linear type
62	Uncertainty with a known distribution of events
63	Uncertainty of the unknown distribution of damages
64	Strong stochastic uncertainty
65	Non-stochastic uncertainty
66	Uncertainty truth
67	Semantic ambiguity
68	Innovation strategy
69	Shortage of qualified personnel
70	R&D Team

* All names are collected by the author.

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