# Theoretical Model to Estimate System Uncertainty in Economics

Kuzmin, Evgeny A.

Ural State University of Economics

July 2016

Journal INFORMATION, Volume 19, Issue 7A, July 2016, Pages 2577-2588

# Theoretical Model to Estimate System Uncertainty in Economics

Evgeny A. Kuzmin *

** Chair of Corporate Economics, Ural State University of Economics,*
*62/45, 8-e Marta / Narodnoy Voli Str., 620144, Ekaterinburg, Russian Federation*
*Email: KuzminEA@gmail.com*

**Abstract**

The purpose of this article - more precisely definition for the approach to a quantitative assessment of the system uncertainty in view of identified methodological assumptions. According to academic ideas in today's economic studies, all cases of represented uncertainty are usually divided into three groups, i.e. the environmental uncertainty, the decision-making uncertainty and the uncertainty of consequences from made decisions. Such kinds of unpredictability only cover a part of an economic cooperation. There are aspects in place that go beyond the conventional view. Their synthesis through the prism of the system uncertainty is a pressing research objective. Prerequisites have been identified that contribute into method justification and specify the requirements to it; an approach to the estimation has been presented in a formalized way with a specified number of essential points. The content of common uncertainty errors has been also revealed. In the approach development, as a result, existing uncertainty circles (cycles) have been recognised.

**Key Words:** System uncertainty, Group of polensive entropy, Group of singular entropy, Uncertainty circle.

## 1. Introduction

The research develops and itemizes the ideas with regard to the system uncertainty, given earlier in other papers by the author [1]. The first solution to a task of a quantitative estimation was completely approximate, and therefore it did not include, for instance, a check for specific errors that would be subsequently labelled as the common uncertainty errors. Another important point refers to the overlapping dependent or independent subsystems. A nature of development, as otherwise a degree of the uncertainty influence in them are different. These and other points, mentioned among the prerequisites, have made it obvious that there was a need in updating the approach to calculations of the system uncertainty, which is a focus of the research.

A starting point for academic formalization of the uncertainty theory is a vision of its observability evaluation in the economic space. It is generally agreed that the system uncertainty represents an influence of the uncertainty of particular kinds. It was conventional to include in their number the environmental uncertainty, the decision-making uncertainty and the uncertainty of consequences from made decisions [2]. The author’s methodological additions have made it possible to identify the new kind, i.e. the vartational uncertainty. With its emergence, the view of systemacity has been

somewhat changed. It has become a demarcation barrier in dividing cycles of a sequential change to the uncertainties. Accumulating emerging institutional contradictions, the vartational uncertainty has been somewhat keeping away from the daily routine of an economic cooperation, getting over it and essentially covering an opportunity of self-organization in a saltation.

Such circumstances have served as a starting point for the approach itself to be clarified, as it is understanding of general unpredictability, randomness and ambiguity, on which stability and sustainability of the economic system development depend. In a development of conscious managerial responses [3] (as opposed to self-organization processes) we should also take in mind that particular types of the uncertainty have a number of distinctive features able to distort a directional impact on the uncertainty. A unique feature of projectionness within the economic mechanism in terms of both a conversion of the uncertainty into a potential risk, and a conversion of the entropy measure between various types of the uncertainty, set a relevant problem of the method to be formalized to calculate the system uncertainty.

The uncertainty objectively relates to the entropy concept, seen as an assessment of information completeness degree and quality. A significant contribution into formalization of the information entropy calculation was made with papers by Shannon [4] and Brillouin [5], main provisions from which had overlapped with research on the uncertainty within physical systems by Wainwright, Magie and Clausius. Ideas of the uncertainty perceived as a state with respect to the conditions when the information has been known and totally defined, are given by Walker, Harremoes, Rotmans and Janssen [6], Thunnisen [7], Kulikova [8], Volkova and Gracheva [9], Baniassadi, Markazi and Karami [10], Peng and Iwamura [11], etc. All the mentioned researchers conclude that the uncertainty is a gap between an expected condition and an actual development. Such an interpretation for the uncertainty is not common, but sounds reasonable.

In studies on the uncertainty, many researchers point out to the fact that to achieve the full awareness by a subject, who makes managerial decisions, of an object and the environment in real and even in perfect conditions, is impossible [12, 13]. Next milestone in the uncertainty research was a transition to discussions of the subjects' internal environment and the uncertainty established in terms of sources that generate it, such as in Miles and Snow [14]. A wider view of the uncertainty sources was given by Priem, Love and Shaffer [15].

Knight's opinion presents some features of interest. He restricts applications of the uncertainty as a term to cases of a non-quantitative kind, denoting such uncertainty as "genuine" [16]. For a more detailed reading, his view of the probability and its types is worth reviewing. According to Knight,

probabilities are divided into three types: the a priori probability (for totally homogeneous cases), the statistical probability (in the form of an empirical evaluation of frequency for connections between predicates, indivisible into volatile combinations of equally probable alternatives) and estimates. Knight's position assumes that it is the third type that is considered the uncertainty. This is confirmed with his statement of differences between different types of the probability, where he emphasises that it does not relate to any classification and is "an assessment of assessments" [16].

In this regard, Shannon's opinion is worth mentioning. It deals with the calculation of the uncertainty as a measure of a choice. Shannon clearly establishes parameters used to calculate the uncertainty, assuming that other values remain unknown. As the sample parameters to calculate the uncertainty, he considers a variety of possible events with the known probability [17].

The given review of literature makes it possible to elaborate specifics of the quantification calculation for the uncertainty. In the estimates, the main point is making an ensemble of alternatives, which has a measurable frequency or the achievement probability. An availability and adequacy of expectative hypotheses to calculate the uncertainty become a key factor in its subsequent research. However, at the same time, the probability features let us state that we deal with a clear breakdown, i.e. accurate and specific. A real economic picture differs from the given assumption and involves intervals of estimates; hence, the system uncertainty should be represented using a certain interval. A solution to this problem cannot obviously do without the specified approach to the system uncertainty calculation, which is a focus of this research.

## 2. Methodological prerequisites

Not diminishing validation importance for the uncertainty system estimation method, it is worth making a number of comments, which play a fundamental role to develop the approach. The review of literature makes it possible to identify some fundamental aspects in the uncertainty as a system phenomenon in economics, which, by the way, conventionally confirms and reinforces an idea of its nature's adherence to pluralism.

*Firstly, the event uncertainty arises from a single process, i.e. the process, in which, there is only one correct choice among a variety of probable alternatives.* At the same time, the so-called unit solution is in place for each of the uncertainty types that, to the author's mind, is an exception to the rules. In the most general case, such an assumption is possible for the uncertainty of decision making and that of the consequences from such decisions. Herewith, it is appropriate to pay

attention to specifics in calculating the uncertainty for dependent and independent subsystems. It seems that the criterion of overlapping solutions is key to elaborate the evaluation method.

Similar considerations are also applicable to the uncertainty of consequences from made decisions. Coming short of a choice for a script for acts, the uncertainty of their future result is also subject to the outcome ambiguity. *A simultaneous increase in the choice of decisions and their outcomes leads to a persuasive conclusion that these both types of the uncertainty make a pair combination.* However, such a combination of the uncertainty means an existing distinction with its retroactive effect, an essence of which will be explained below.

*Second, the business system environment is consolidated. Therefore, the environmental uncertainty is concentrated in a variety of options for its conditions.* As the system is always in a motion, its condition is nothing else than a continuous absorption of implemented consequences from made decisions. Thus, the unique uncertainty cycle appears, though it is still incomplete; it does not cover an aspect of compliance with the rules of the game (institutional mistakes, pitfalls and blind alleys). It is in a substitution and a perception of a variety of made decisions, where the common or integrated environmental uncertainty appears as a sublimation of ambiguity from all the made decisions. Herewith, the environmental uncertainty is also instantaneous like other types.

Thus, the system uncertainty expanding goes towards decision-making and implementation of their outcomes. In its character, the unitarily monolithic environment of the business system experiences a reverse-acting force from the uncertainty of other types, closing the small circulation circuit, which includes an original condition (the environment as such), a tree-like decision-making process and a like-wise dendriform search for consequences from their implementation. It is worth mentioning that both the environmental uncertainty (backward), and the *vartational uncertainty* (forward) lock into themselves a manifestation of the conjugated uncertainty, which assumes, in fact, a dual operation, starting from a choice of a script from the ensemble of alternatives and ending with an almost automatic choice of its inevitable outcome. The vartational uncertainty should be understood as the uncertainty in a change to the "rules of the game". Errors from opposing the norms and the institutional regulation mechanisms, a lack or non-conformity between regulation queries and responses to them are also included in a semantic content of the vartational uncertainty.

*Third,* based on the previously made conclusions, *the system uncertainty might be both broadly and narrowly seen as for its required constituents of the estimate.* If the first lies in a complex (although torque) measurement of a chaotic movement degree and an organization in all the possible aspects, the latter implies an exclusion from the vartational uncertainty calculation.

Apparently, *that measure of contingency, uncertainty and obscurity, which is only embodied in peak periods of an organizational order disturbance, falls to the share of the vartational uncertainty.* This a trigger for self-adaptation, self-organizing among the system's institutions, updated rules and regulations within the model of the most reasonable and efficient behaviour, seemingly perfect and brought to the ideal. But this is also and only for the time being, until there are new contradictions, errors and a common lack of solutions (in terms of regulation) to emerging unique cases of behaviour among economic entities. Naturally, the vartational uncertainty does not lose its relevance even with the narrowly seen approach to the assessment of the system uncertainty level, but it is where an assumption is made on all other things being equal in case of events' particularity, which do not apply to totality of the whole system, i.e. those events and phenomena that affect the very small circle of stakeholders, and the most important, that are unable with their consequences to make any significant changes to a balance between the rules of the game.

To a large extent, the mentioned prerequisites make the approach to a well-reasoned solution to the task of the system uncertainty estimation closer. Limitations and terms, arising from the prerequisites, constitute a basic vision of an interaction between various types of the uncertainty. All of them make up a characterful cycle, replacing each other, accumulating and even passing to each other the entropy measure in its systemic symptoms. Bearing in mind this very feature, the author points out to a property of projectionness in the economic mechanism, which, on the one hand, explains a process of transformation of the uncertainty into the potential risk, on the other hand, it specifies a change to its level between various types. However, the measurement of proportions itself between the uncertainties is unthinkable without the estimation of their systemic symptoms. As a result, the system uncertainty summarizes all the complexity in making and implementing a choice, which is not more a single (private) process, but a complex process, that covers the uncertainty of possible consequences [18].

## 3. System uncertainty evaluation method (closer definition)

An objective need to define closer the system uncertainty estimation method depends on the fact that the first solution [19] to this task did not include those restrictions, which have become known from the prerequisites mentioned above. Along with an obvious inclusion into the calculation the calculation error (the uncertainty beta-error) attributable to the error of an estimated probability per alternative, an important role is played by a combined assessment of participation for the uncertainty of decision-making and the uncertainty of consequences from such decisions. Here we

deal with a dual dependence of these types of the entropy, as already mentioned. On the one hand, each of them includes elements of a dependent and independent development. Accordingly, an isolated assessment of each includes an additive addition of components of the dependent and independent uncertainty. On the other hand, decisions and their consequences are often in pairs. An exclusion or addition of an alternative or a hypothesis inevitably results in a transformation of a response. As a result, the high uncertainty of decision-making may also well assume the high uncertainty of their consequences until such decision is made. Then the solution almost instantly fits in, eliminating difficulties from an unconscious choice.

Thus, the system uncertainty in its current form (prior to refinement) contains a number of simplifications that should be specified to deepen methodological concepts of the nature and ontological features of the entropy in economic processes:

$$H(S) = [H_{ee}K_{ee} + H(\overset{combi}{S})_{md}K_{md} + H(\overset{combi}{S})_{cd}K_{cd}] + H_vK_v \pm \sum \varepsilon^{\beta},$$

$$\begin{cases} H(\overset{combi}{S}) = \sum_{m=1}^{m} H_j(D_1 | D_{m-1}) + \sum_{m=1}^{m} H_j(D_m), \\ f = p\log_b(p) \to \varepsilon^{\beta} \approx p\dfrac{\sigma_p}{p\ln(b)}, \end{cases} \quad (1)$$

where $H(S)$ – system uncertainty; $H_{ee}$ – environmental uncertainty; $k_{ee}$ – environmental uncertainty participation factor; $H(\overset{combi}{S})_{md}$ – decision-making combined uncertainty; $k_{md}$ – participation factor of uncertainty in a choice of managerial decisions being made; $H(\overset{combi}{S})_{cd}$ – combined uncertainty of consequences from made decisions; $k_{cd}$ – participation factor of the uncertainty of consequences from made decisions; $H_v$ – vartational uncertainty; $k_v$ – vartational uncertainty participation factor; $\varepsilon^{\beta}$ – calculation Beta-error [20].

It should be said that the uncertainty calculation (1) only includes one of possible standard errors. According to findings from other research, such errors might be reasonably divided into three classes: alpha-, beta- and gamma-.

Firstly, the uncertainty *alpha*-error belongs to the deviations from well-subjective making of the set of alternatives. By all means, all the variety of scenarios for a proposed development of the economic system or an entity have their distinct significance, hence, some of them might be

dismissed from the uncertainty calculation being made. At the same time, within the stochastic system with a special combination of circumstances, the low-probability alternatives might appear, therefore, their exclusion at the estimation stage would be a lapse.

*Secondly,* the uncertainty beta-error. Its essence lies in making the confidence interval towards the estimates of probability or frequency of implemented alternatives. An inclusion of this error into the uncertainty calculation has a number of methodological concerns. Among them, there is also the uncertainty that lies in the confidence interval of probability dispersion. After all, so to say, the estimate of the exact uncertainty is a calculation made for a single event that is for such an event, where the sum of probabilities of alternatives is equal to one. The available confidence interval distorts an overall picture towards both a shortage, and an excess of probabilities for extreme cases (within the interval range).

Thirdly, *the* uncertainty *gamma*-error, which says of subjective reasons for a growth in uncertainty-wise strain. The author believes that interpretation and commitment (tolerance) factors play here the most active role, as they are able to make changes to a balance of priorities, even when uncertainty estimates point out to the contrary.

Thus, based on the intrinsic features of the standard errors related to the uncertainty, the calculation of the entropy system value can for certain include the *alpha* - and *beta* – errors only with a number of exceptions. The *Alpha*-error is only permissible in cases where there is some idealized composition of alternatives. By the way, it should be said *that the idea to include the alpha-error is not lacking in its efficient application*. If we add fictitious hypotheses with a low or a negligible probability of their happening to the composition of alternatives, we will be able to evaluate the two states. There is no doubt that the obtained difference between the uncertainties of these conditions will make it possible to observe an approximate value for the alpha-error.

$$\varepsilon^{\alpha} \approx \left[ [H_{ee}K_{ee} + H(\overset{combi}{S})_{md}K_{md} + H(\overset{combi}{S})_{cd}K_{cd}] + H_v K_v \right]_{\text{ideal alternatives}} - \left[ [H_{ee}K_{ee} + H(\overset{combi}{S})_{md}K_{md} + H(\overset{combi}{S})_{cd}K_{cd}] + H_v K_v \right]_{\text{exact alternatives}} \quad (2)$$

A discrete *role of the uncertainty alpha-error* (2) *lies in its indicative function*. If the beta-error only has its positive values, but actually as such sets the confidence interval, the alpha-error may have both the positive and the negative value. Symptoms in difference deviations of the system uncertainty calculated for the conventionally ideal and conventionally specific situation give an

idea of a quality for the set of alternatives. A search for the alpha-error in the negative area seemingly shows their excess coverage that goes beyond the ideal breakdown, which the plausible hypotheses are only subject to. In case of the positive value for the error, on the contrary, the ensemble of alternatives is only limited to those options of event outcomes that are considered acceptable and logically balanced. On the practical side of the system uncertainty calculation, the totality of errors should only have a positive value. Otherwise, the errors will make up for the effect of each other, while the value of the system uncertainty will become as much exact as possible, which is not typical for the stochastic systems.

$$H(S) = \left[ H_{ee} K_{ee} + H(\overset{combi}{S})_{md} K_{md} + H(\overset{combi}{S})_{cd} K_{cd} \right] + H_v K_v \pm \left[ \varepsilon^{\alpha} + \sum \varepsilon^{\beta} \right]. \quad (3)$$

Then the system uncertainty has a form of the function (3), where calculation errors are fully considered. Within this, the gamma-error looks somehow out-of-body, though its effect covers a cognitive act. In other words, the uncertainty is presented as a pattern comparison between the past situations, where perception experience of which cannot be identical. The description of the proposed approach to the estimation of the system uncertainty has still had issues that require further examination, but we may already state that the approach is getting closer to its methodological completeness.

## 4. Further reasoning

### 4.1. Uncertainty circles (cycles)

Formalization of the approach to the calculation of the system entropy based on the given assumptions and observations suggests *existing small and large circles of the uncertainty.* Coming back to some extent to the cycle specifics, let us point out to closeness of a contour with respect to the environment, decision-making and consequences from decisions. The institutional superstructure then allegedly goes beyond, accumulating the critical mass of contradictions that arise. A nature of random walk of the economic system and a nature of its fluctuation variances suggest an existence of a standard value in a ratio between the system uncertainty and the certainty of the small circle. Seemingly, growing and strengthening in a power of the vartational uncertainty (inside of the large circle) result from exceeded threshold values for acceptable self-organization. Otherwise, it points out to, on the one hand, limited self-setting potential, and, on the other hand,

strain in regulation, which can be eliminated with a saltation. Institutions upgrading or updating naturally produce new terms, in which previous differences in an institutional mechanism are offset.

Figurative unity of the environment and institutional terms is implemented in a unified nature of their formation. If the environmental uncertainty in the small circle sublimates multiple effects of the uncertainty of decision-making and decision consequences, then the vartational uncertainty is rather a response to expressed uncertainties of all the other kinds. The larger and more diverse components within the business systems are, the more likely that critical discrepancies will appear. Then the uncertainty appears owing to fundamental elaboration. Petrakov, Rotar and Ayvazyan quite unambiguously refer to this [21]. Going from the point that in case of the total certainty "there is one alternative situation with probability one, while other situations have probabilities equal to zero" [22], occurrence of the vartational uncertainty implies a simultaneous formation of the set of alternatives, describing options for an institutional solution to accumulated contradictions. A numeric growth in errors in an existing structural order naturally leads to an increase in the alternatives, probability of which washes out the certainty in saving the "rules of the game", those standards and requirements that meet to ideas of a reasonable layout in the economic system.

### 4.2. Groups of uncertainties

We have once again confirmed that the uncertainty is not homogeneous. At the same time, it is reasonable to group the known uncertainty types into two classes, a scientific rationale for which involves a distinct resulting event. The author believes that the uncertainty of decision making and consequences from these decisions belong to the class of the *polensive entropy*, a result of which is either ambiguous or missing. Etymology of the *polensive entropy* concept being introduced into the scientific use derives from the Latin word pollentis that stands for "many-valued", "significant". The author believes that the uncertainty of decision making and the uncertainty of consequences from these decisions have at least two specific features. Firstly, each of them is focused on a description of a process to choose an alternative from the set of permissible ones. Secondly, decisions and their consequences are in a kind of a bunch, in determinism of the almost automatic selection in accordance with an internal organizational structure of the system. However, the available variety of solutions is not completely isolated. It is logical to assume that there are objective reasons for the fact that a number of decisions being made, and consequently, their consequences are dependent on each other.

*The singular entropy* is another class that makes together the environmental and the vartational uncertainties. Etymology of the singular entropy is associated with the Latin term "singularis", meaning "the only consistency". An aspect within this class should be unchanged persistence of an object, at which constituent types of the uncertainty are directed. Thus, an outcome for the singular entropy appears as a combination of parameters of the same object, whether it is the environment or the "rules of the game". Here, the important *transition moment* stands out, which as seen by Petrakov et al. is associated with the uncertainty elimination owing to made elaborated hypotheses and a change to their probability [21]. At the same time, there is a problem of dominance of one alternative over the other acceptable outcome options. It is known that an increase in a number of such hypotheses affects the choice complexity, and hence the uncertainty, aggravating obscurity.

Leshkevich believes that the similar event of a transition "falls on the maturation stage", when "the system is to make a choice" [23]. Having reached a foreseeable limit to the uncertainty, the economic system faces the same limit in self-organization, which seems to produce, though for the time being, the optimum alternative for the new organizational order. In both cases, a transition becomes possible if there is a critical level of the uncertainty, the vartational rather than the system one. This indirectly confirms the assumption that there is a standard value for the relation between the uncertainty and the certainty of the small circle.

As a result, it might be concluded that grouping the uncertainties into *polensive* and *singular* constituents consolidates an influence of the entropy of a similar nature. At the same time, existing differences between them prevent us from saying of the groups of the uncertainty as independent elements within the system uncertainty. At any rate, an influence of a characterful feature of projectionness makes changes to a layout of a dominating participation for each type of the entropy, converts a ratio and proportions between them. Nevertheless, the attempt made to identify groups is efficient. They concentrate in themselves a semantic content of the ambiguity and uncertainty of the environment, whether it was a process of decision-making, or perception of such decisions. Besides the point, in this their role is obvious in identifying active and passive acts of changes.

## 5. Conclusion

It is obvious that it is difficult to overestimate reliable knowledge on the system uncertainty value, a level of its influence and correlations between proportions of individual types of the entropy. Consolidating in itself the known requirements and terms that derive from the prerequisites, the system uncertainty has become a scientifically grounded criterion in decision making and in making

a comprehensive analysis of a situation at hand. Specific errors, included in the calculation, as well as considered dependent and independent developments of the uncertainty in subsystems have made the approach to methodological perfection closer. At the same time, we have not still able to argue that the method to calculate the system uncertainty is comprehensive. The mentioned need to represent the uncertainty with interval values is the next step in simulating the stochastic development in economics. However, even now it is possible to argue with certainty of the efficient solution to the set objective. The hypotheses suggested in a course of the research have expanded on existing theoretical and methodological ideas of grouping (classification) of the uncertainty, as exemplified by the polensive and singular entropies, as well as on the nature of a sequential change to the uncertainty within the small and the large circle (cycle).

## References

[1] Kuzmin, E. A. Statement and proof for threshold self-organization theorem (stability) in economic processes. *Contemporary Economics: Challenges and Solutions,* 6 (30) (2012), 122-136.

[2] Avdiysky, V. I. and Bezdenezhnykh, V. M. Uncertainty, variability and inconsistency in problems of risk analysis in behaviour of economic systems. *Efficient Crisis Management*, 3 (2011), 46-61.

[3] Poddubnaya, L. I. Influence of uncertainty and risk on making information supply to managers. *Contemporary Economics: Challenges and Solutions,* 12 (24) (2011), 98-103.

[4] Shannon, C. E. A mathematical theory of communication. *The Bell System Technical Journal,* 27(3) (1948), 379-423. http://dx.doi.org/10.1002/j.1538-7305.1948.tb01338.x

[5] Brillouin, L. *Science and information theory.* Moscow: Fizmatgiz; 1960.

[6] Walker, W. E, Harremoes, P., Rotmans, J., van der Sluijs, J. P, van Asselt, M.B.A., Janssen, P. and Krayer von Krauss, M. P. Defining uncertainty. A conceptual basis for uncertainty management in model-based decision support. *Journal of Integrated Assessment,* 4(1) (2003), 5-17. http://dx.doi.org/10.1076/iaij.4.1.5.16466

[7] Thunnisen, D. P. *Propagating and mitigating uncertainty in the* design *of complex multidisciplinary systems* [PhD thesis]. Pasadena: California Institute of Technology; 2005.

[8] Kulikova, E. E. *Risk management. Innovative aspect.* Moscow: Berator-Publishing; 2008.

[9] Volkov, M. I. and Gracheva, M. V. *Project Analysis.* Moscow: Banks and Exchange Houses, UNITY, 1998.

[10] Baniassadi, A., Markazi, A. H. D. and Karami, M. Robust Control of a Gas Turbine with Wiener Model Uncertainty. *Indian Journal of Science and Technology*, 5(11) (2012); http://dx.doi.org/10.17485/ijst/2012/v5i11/30645

[11] Peng, Z., and Iwamura, K. A Sufficient and Necessary Condition of Uncertain Measure *Information,* 15 (4) April (2012), 1381-1392.

[12] Katchalov, R. M. *Management of economic risk.* Moscow: Science; 2002.

[13] Meskon, M., Albert, M. and Hedouri, F. *Management fundamentals.* Moscow: Case; 1997.

[14] Miles, R. E. and Snow, C. C. *Organizational strategy, structure, and process.* New York: McGraw-Hill; 1978. http://dx.doi.org/10.5465/AMR.1978.4305755

[15] Priem, R. L., Love, L. G. and Shaffer, M. A. Executive's perception of uncertainty sources: a numerical taxonomy and underlying dimensions. *Journal of Management*, 28 (6) (2002), 725-746. http://dx.doi.org/10.1016/S0149-2063(02)00193-9

[16] Knight, F. H. *Risk, uncertainty and profit*. Boston: Hart, Schaffner & Marx; 1921. http://dx.doi.org/10.1017/CBO9780511817410.005

[17] Shannon, C. E. *Works on information theory and cybernetics.* Moscow: Publishing House of foreign literature; 1963.

[18] Kang, Y., and Zhu, Y. Bang-Bang Optimal Control for Multi-stage Uncertain Systems. *Information*, 15 (8) August (2012), 3229-3238.

[19] Kuzmin EA. Uncertainty and certainty property estimation of organizational-economic system. *European Journal of Social Sciences*. 2012; 3(19): 480-493

[20] Harris, D. C. *Quantitative chemical analysis,* 6th edition. New York: WH Freeman; 2003.

[21] Petrakov, N. Y, Rotar V. I and Ayvazyan, S. A. *Uncertainty factor and management of economic systems.* Moscow: Science; 1985.

[22] Evlanov, L. D. *Theory and practice in decision-making.* Moscow: Economics; 1984.

[23] Leshkevich, T. G. *Uncertainty in the world and the world of uncertainty: philosophical reflections on order and chaos.* Rostov-on-Don: Rostov University Press; 1994.

*Corresponding author: Evgeny A. Kuzmin
Chair of Corporate Economics,
Ural State University of Economics
62/45, 8-e Marta / Narodnoy Voli Str., 620144, Ekaterinburg, Russian Federation
E-mail: KuzminEA@gmail.com