THEORY OF DECISION-MAKING:
THE LOGICAL-MATHEMATICAL ASPECTS

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This article is dedicated to an extensive and rather modern scientific area – to a decision-making theory. The author uses logical-mathematical bases of the decision-making theory to explicate the existential features of a choice based on the four main martingales: trend, time, people and phobia. Consistent with earlier research the study supported the hypothesis that these four constituents «have power» over people and influence they're making a decision.

The purpose of the study is to consider the logical-mathematical aspects of decision theory.

The author pays attention to mathematical models of social changes, mathematical statistics, and game theory, the theory of probability, theory of social conditions, social physics and neurolinguistics. In the article, there used interpretive and hermeneutics methods, narrative and conceptual analysis and configuring.

The analysis of factors which influence decision making allows us to minimize risks, to predict the results and to create optimal and effective strategies of behavior.

The novelty of this study is that, firstly, a model was presented for a generalized description of decision-making, which coordinates the apparatus of logical-mathematical and existential analysis. Secondly, when analyzing the psychological aspects of human decision-making, it is proposed to use the tools of temporal and modal logics.

The results can be applied to existential systems in decision making. The using area of the software of existential systems in decision making is wide: from human's daily requests in personal questions of the existential character, the stock market, financial consulting and

negotiation to market strategies, PR-companies and even AI (Artificial Intelligence).

Keywords: *decision-making theory; trends; people; time; world; phobia; situation; strategies; stratagems.*

ТЕОРИЯ ПРИНЯТИЯ РЕШЕНИЙ: ЛОГИКО-МАТЕМАТИЧЕСКИЕ АСПЕКТЫ

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Данная статья посвящена достаточно обширной и современной научной области – теории принятия решений. Автор обращается к логико-математическим основам теории принятия решений для экспликации экзистенциальных особенностей выбора, основанных на четырех основных мартингалах: тренд, время, люди и страх. В соответствии с предшествующими результатами, исследование подтвердило предположение о том, что последние четыре составляющие «управляют» человеческим существом и влияют на его принятие решений.

Целью исследования является рассмотрение логико-математических аспектов теории принятия решений.

Автор обращается к математическим моделям социальных изменений, математической статистике, теории игр, теории вероятности, теории социальных условий, социальной физике и нейролингвистике. В статье использовались методы интерпретации и герменевтики, нарративный и концептуальный анализ, а также конфигурирование.

Анализ факторов, влияющих на принятие решений, позволяет минимизировать риски, предсказывать результаты событий, а также конструировать оптимальные и эффективные стратегии поведения.

Новизна этого исследования состоит в том, что, во-первых, была представлена модель общего описания принятия решений, которая обобщает аппарат логико-математического и экзистенци-

ального анализа. Во-вторых, при анализе психологических аспектов принятия решений человека предлагается использовать инструменты временной и модальной логики.

Полученные результаты могут быть использованы в экзистенциальных системах принятия решения. Область использования данных программ экзистенциальных систем принятия решений широка: от решения повседневных вопросов человеческой жизнедеятельности, анализа фондового рынка, финансового консалтинга и переговоров, до маркетинговых стратегий, различных PR-кампаний и даже ИИ (Искусственного интеллекта).

Ключевые слова: *теория принятия решений; тренды; люди; время; мир; страх; ситуация; стратегии; стратегемы.*

Introduction

The decision theory is important in economic management and financial trading of investments at the market, in the political and social area, ethics, bioethics and legal studies.

This theory has a large theoretical base of exact science achievements: mathematical statistics, the theory of possibility, prediction, games and interdisciplinary sciences: neuroeconomics and economical psychology, which are quite popular nowadays. However, in the decision theory it is shown that there is an imbalance between technical, statistical and psychological methods. Thus, this research is aimed to use technical, statistical and psychological methods.

The decision theory belongs to the area of people *ethical responsibility* because it is based on existential factors and making a choice situations. So making a decision is a choice of a person who is impressed by ethical features of the society where he or she was born, grew up and where that person still lives [19; 20; 21]. In this case the ethic adds some information into the situation of a choice and routine to create a space of *personal responsibility*. The decision is a definite variant of an answer, it is necessary to interpret the situation of a choice. It is possible to minimize risks of a choice with the help of the model of *equilibrium ethics* – managing ethical and existential structure which

connects all processes in the world and it is «the internal law and principle for us» according to Kant's ethical model; it is also the answer to the second main philosophical question – «What should I do?». In other words: what should I do in this situation to minimize my risks and to succeed? [1, 102].

In our case this connection tries to fix laws of people behavior which is typical for definite trends-pricing trends, market mechanisms and trends and others. The idea of *ethical trends* (market, politics, technologies, culture etc.) has the following purpose to create a model of equilibrium management of trends, to rule any situation of decision making and to minimize risks and losses, to increase positive results [11, 199].

In economics the last conflicts are financial crises that show changes of the price policy in the market. Earlier the main forms of exchange were gold, jewelries, lands or monarchs' daughters that were exchanged for a favorable union, peace or for something else. When national and international currencies appeared people began to compare the definite weight and the price of gold. Marshall's plan about the restoration of Europe after the Second World War made dollar the main currency. It is worth talking about the turning point in pricing which shows the change of valuable structure in the world. This moment modified prices and removed features of natural economics as a market. The price (dollar, euro, Yuan and even gold and oil) depends on psychological component and trading of any product. This is called the circle of the exchange when the exchange currency is used in the market as a factor and as a result of trade relations.

Methods

The theme of this research means the use of methods in three scientific spheres: humanity, exact and interdisciplinary sciences. In the article there used interpretive and hermeneutics methods, narrative and conceptual analysis and configuring. The author pays attention to mathematical models of social changes, mathematical statistics, and game theory, theory of probability, theory of social conditions, social physics and neurolinguistics.

Results

The ethical possible achievement of a case. With the development of a real and semantically rich logical language for cases described in Voishvillo's theory about «possible worlds» [7, 216], there appeared an opportunity to arrange a choice of a logical situation. A logical situation is an opportunity (not a possibility) in the case achievement. However the logical situation shows the technical method in solution of existential situation of a choice. The situation of making a choice is an existential situation.

The idea of making a choice is based on a hypothesis where a decision maker chooses more often not an absolutely minimum risky variant but the most minimum risky variant of the society where he or she exists. In any situation a simple choice of a human's decision relates to the choice to be human if it is clear and it has not got changeable features. This simple and obvious statement is often underestimated. Although the exact interpretation of a human being means the exact interpretation of an existential situation where he or she lives. Under the interpretation of the situation we understand the interpretation of the society and main constituents which create it: trends, time, men, phobia [25, 184]. Most of the modern theories of decision making use human as an automated machine of decision making and consider one as a definite constituent which has limited and final number of features. In spite of some advantages there are some disadvantages in this method. The main one is modern management technologies which are not effective enough to represent human as a given model. We consider this disadvantage to be one of the reasons why it is impossible to create a possible world which will be the most similar to the reality and which will reach the possibility of forecasted result. Human as the main element in the system of decision making should not stand at the beginning of analyses. Human is a result. Such methodology of decision making changes the theory.

The logical possible achievement of a case. On the bases of the ethical possibility [26] of the situation in a choice it is necessary to explicate the logical meaning in the situation of decision making. The

explication of its logical meaning allows to represent the decision making and to give the problem of decision making a practical meaning.

It is worth noticing the fact that logical and ethical possibility is characterized by predictive narrative. In this meaning for forecasting possible cases the presence of one real world is not enough. Such existence of other worlds is in our consciousness, for example Husserl wrote: «correlate of a definite experience which is called «a real world» is a special case of many possible worlds and non-worlds. All these worlds and non-worlds are the correlate of possible ideas «in the experience of the consciousness» with the definite experience connection» [2, 144]. Here it is worth saying about an important notice: a logical possibility is not formed as a tendency out of the given situation. It is not a result of thinking of creative consciousness. It is initially prepared by the experience and the experience itself influences modeling of sequence of possible events. The interconnections which Husserl talks about are the main connection with the world which become at the same time prerequisites of such a situation. «The availability of experience never means only logical possibility – it is always a possibility which is motivated inside an experienced interconnection» [1, 145].That is why any decision belongs to the past situation; it exists and it is prepared for us with the experience even if this experience is not definite and not formalized enough. «Everything which is reality but not tested timely may become entity and it means that such a thing belongs to not definite but definable horizon of my actual experience. Such a horizon is a correlate of all components of uncertainty which depend on experience and which are always open for fulfilling and realization; they are always forecasted and motivated by their kinds» [2, 146].

Husserl says that possibilities are intended to be in advance in our present condition. Our possible experience is always limited by our present experience and the latter is limited by the past. That is why we can discuss a causality of situations and the past condition in the world system. The past influences the development of the presence and it makes it so causally so that the past does not allow the development to deviate, the past becomes the absolute possibility for the present. The

present logically comes from the past because the past becomes the measure and assessment of actions in the future.

The instruments of the events of a natural language are the semantics of possible worlds in intuitionistic logic which is represented by Saul Kripke [23].

The semantics of possible worlds in intuitionistic propositional logic

A model – tuple $<W, w_0, R, I>$, where:

(1) $W \neq \varnothing$

(2) $w_0 \in W$

(3) R – binary relation, which is set by w ($R \leq w \times w$) and which has features of reflexivity and transitivity

(4) $I(\gamma,w) \in \{1,0\}$, where γ is derivative proposition variable, $w \in W$, I has a property of constancy: if $I(\gamma,w) = 1 \wedge R(w_1,w_2) \rightarrow I(\gamma,w_2) = 1$

Functions of an assessment in possible worlds:

1. $|\gamma|_w = 1 \leftrightarrow I(\gamma, w) = 1$

   $|\gamma|_w = 1 \leftrightarrow I(\gamma, w) = 0$

2. $|\bar{A}|_w = 1 \leftrightarrow \forall w^1 (R(w, w^1)) \implies |A|_w = 0$

   $|\bar{A}|_w = 0 \leftrightarrow \exists w^1 (R(w, w^1)) \wedge |A|_{w^1} = 1$

However Kripke's logic is evolutionary logic according to its internal characteristic and this is where its main disadvantage. It describes stationary situation with initially given features which are not changeable during the whole analyses. Indeed, where $w_2 \Leftarrow w_1$, w_2 can be cardinally different from w_1, because time sequence of w_1 and w_2 mustn't be exchanged by causal reason of each other. And the causal reason of w_1 cannot be the reason of w_2 only because of one condition took place earlier than the other one and followed it $w_2 \Leftarrow w_1$, while ($w_2 \in w_1 \vee w_2 \notin w_1$).

In the evolutionary logic there is a principle of *a pyramid* where like in a child's toy different levels of knowledge form layers. But it is not always like that, the scientific history cannot be represented as *a sack of knowledge*. The scientific history is a screening process. Old information is rewritten in a new way. The terminology and methods change. The technical approaches which were actual 100 years ago

are changed by the others which are more «optimal and relevant». The history of the science is not an increment but a more difficult process.

The rhizome of possible events. The logic-ethical interconnection of events creates a complicated picture which is characterized by logical compliance and ethical responsibility. The logical possibility tries to represent the principal law of the ontological sequence of events. The ethical one limits it which is connected with men being in the world (society, trends, moral, etc.). The interconnection between two possibilities can be represented by the *rhizome of possible events* corresponding two martingales which enrich the meaning of each other.
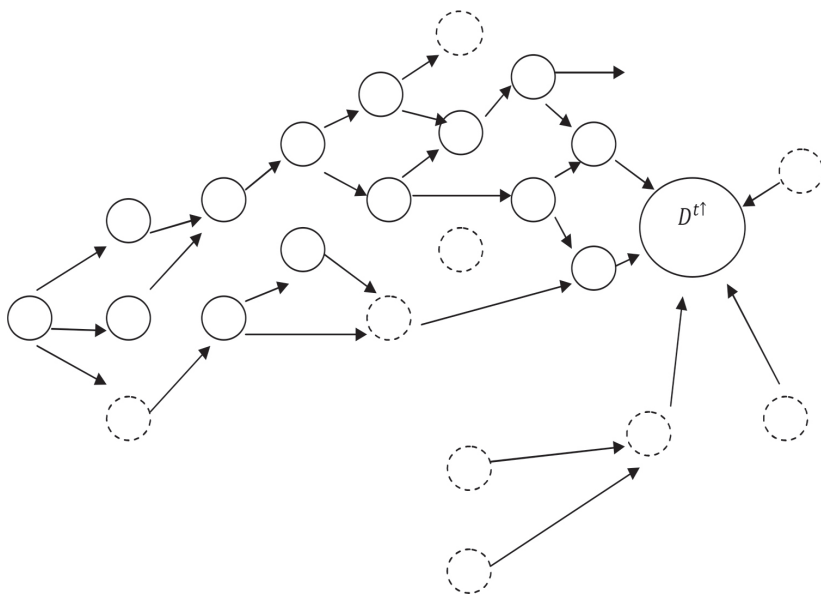
Pic. 1. The rhizome of possible events

Let's assimilate each possible event S a world – W so that an event $S = 1 \Rightarrow S_w$, where $S_w \in W_n$, where $W_n \in \{W ...\}$ of series of worlds W. Each event corresponds to its possible world where it reaches the meaning of the truth as logical features of a definite and concrete possible world influence its truth.

The rhizome above is a great number of events (causal, complicated – causal, independent, linear and discrete) which lead to a situation – $D^{\uparrow}$. The Rhizome consists of elements; most of them are real events which are connected with causal relations which reflect a definite state of a model in a definite period of time and factor influence, but in the model there are also abstract, hypothetical and possible worlds where the situation did not start developing but they influenced the development of the situation in whole. Human who makes a decision is not a physical element of the world but an element which creates other possible systems of the existence – virtual worlds: mental, religious, family, moral, personal, cultural, aesthetic, that's why an analysis should pay attention to this choice influence. As the analysis of such influences faces some difficulties and problems it is important to change the method – to create artificial situations for decision making.

The rhizome of possible events is given through a task by a *possible world*. Indeed we live in some worlds everywhere; some of them are defined by the society we live in, some of them are defined by us. There is a great variety of such worlds [15, 347]. For example in physics we deal with a physical possible world. It is a classical physical map of the world which is represented by Cartesian coordinate system where definite events find their proper description. There are historical worlds of one or another epoch where the hermeneutics of events can be carried out. There is a mental world of human which can get a certain interpretation based on the theory describing it and on the definite world of Freud's, Jung's or Lacan's therapy or on a patient's mental world. The worlds which we are describing are connected with decision or choice that is why the possible world we will describe is existential and therefore it has existential features. Considering its characteristics we can affirm its fundamental constants or existential coordinates which define an existential world of an event.

In a Robert Cialdini's book [3; 4] such situations are described in details. He writes that nowadays many of our actions are reflexive as the method called «signal-reaction» because of the lack of time, high emotional pressure, limited information but a huge need in it. To create

such situations where a decision is made by the method «signal-reaction» [6, 85] is the main goal of existential analytics of decision making or of an artificial modelling of decision making. Existential analytics of the situations of decision making can facilitate and simplify this task: in the situation itself there can be found constants which are the main canals of our existence in the world. The function of the existence or presence in the world is a constructive operator of architectonics of the world. The famous proofs by Thomas Aquinas, Anselm of Canterbury, John Duns Scotus and Immanuel Kant demonstrate it. It is obvious that first there was created a world and a situation to outline a territory for something, for their existence or for being human.
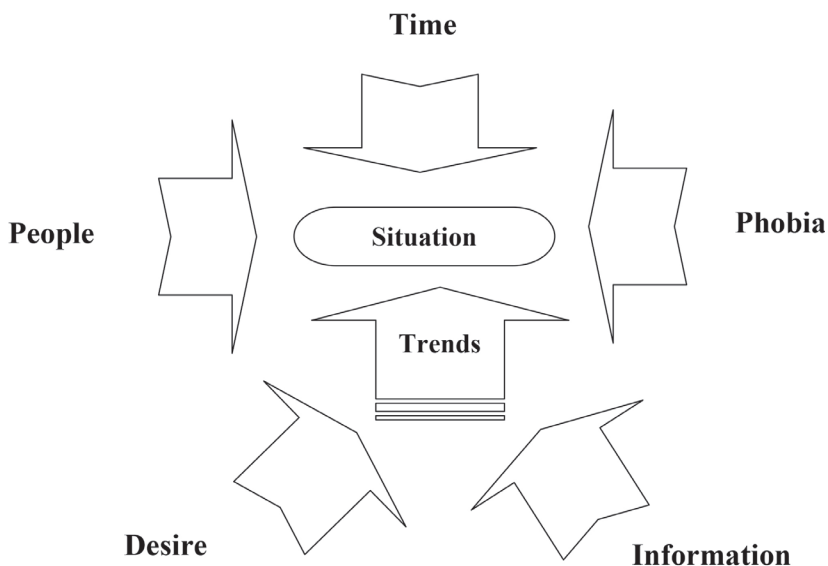
Pic. 2. The fundamental constituents of decision-making in existential analytics

Discussion

The revealed necessity of ethical and logical possibility as well as the explication of the rhizome of possible worlds and fundamental constituents which influence its formation prepares the scientific area for technologization and automation of decision making process. Howev-

er the methodological system described above faces the fundamental problem of any theory of decision making – the problem of an appropriate translation of events, reasons, a world etc. into a technical language. That is why this theory of decision making has the aim – the necessity to develop an appropriate translation of events into a logic language. In our case this is the language of intuitive and modal logic. However the function of reference (from events into statements) prejudices its marketability and completeness. One of the solutions of this problem was undertaken in «*a new theory of references*» (K. Doneman, S. Kripke, H. Patnem) [4; 17] which reinterpreted critically the classical method of reference of a natural language into LLFRT which was executed within the bounds of logicism (Frege, Russel, Carnap) [8; 9; 10; 14].

The central place of critics there takes the description of intension of the natural language whose analytical character in *a new theory of reference* is under doubt. Indeed the intension in the «natural language» is not analytical and it cannot be a priori. It is static. For example think of three concepts: gold, a lemon and a tiger. According to a Carnap's theory of reference the descriptions of these three concepts will be the following:

Gold = *(A)* – solid, precious metal.

Lemon = *(B)* – a yellow sour fruit.

Tiger = *(C)* – a striped mammal animal, a predator.

Gold can be in gaseous or liquid state without changing its chemical composition, but the definition given above will not correspond to a real observed object. A lemon which grows on a tree is not yellow yet and a tiger can be born with gene mutation and have three paws or it can be white [12]. In these cases the intension complies with essential characteristic of the object and the characteristic itself being external complies with senses which mean that it cannot be analytical, but descriptive. In other words the intension we use is not a priori; indeed it is a definite type of the description of an object.

That is why we will change a little these three definitions:

$\{A\} \approx \{A^1\}$

$\{B\} \approx \{B^1\}$

$\{C\} \approx \{C^1\}$

Giving an exact description to each concept we enrich them. «{…}» – here we talk about conditional of each definition. Initially we do not know that $A^1 \in A$ and it is similarly to the others, that is why in the operation $\{A\} \approx \{A^1\}$… we start collecting the description to make $A - \varnothing$. «$\approx$» means a logical description of an object or filling an area with some meaning. Before the description of an object or an event it is worth noticing that the conditions of the *logical description influence the description of that object*.

Indeed the Frege's idea that every person has a meaning of a concept is incorrect. It is incorrect if a «mental content» is recognized as a meaning which we have about an object before dealing with it. In this case Frege based on a Platon's idea about the eternity of ideas which always exist and never disappear. Ideas initially exist in every person through their recall. That is why an object description of Platon and Frege is *déjà vu*. But it is not always like that. A child who has just been born can't know the definitions of «a mother», «a father» or favourite toys. A child meets an object of the world first of all. This meeting with an object does not mean a direct contact with it; it means that the meeting with an object takes place while learning it. These boundaries of object learning are conditional and descriptive. Thus the meaning of an object is defined not as memory but as «an optimal situation». Kripke and Patnem also write about it speaking about definite theoretical and pragmatic constitution of objects [7, 201].

Indeed in life we often use *fragments* or *flash* meanings, these meanings are simplified into simple mechanisms and schemes which are more general (not simple for memorizing but for fundamental and multi-purpose forms of our relation to the world). Some of them later we can use separately or together again. Flash meanings are the main constituents of our situation in the world – «an optimal situation» [13, 45]. Every person in any situation finds a definite basis, a set of universal mechanisms which are used while this person is living. And people live in an existential world, in the world of a constant choice. The

meaning does not always say something or give information. Sometimes it just appeals and attracts and sometimes it repels without giving details on the intuitive level.

An Eremeev's article [17; 18] approaches closer to the questions of logical interpretation of decision making, however this interpretation only offers the way of modeling of decision making which would be logically true but the logical truth of the made decision is not always effective. And this theory has some features like the others. It is too ideal and there is no translation of the situation into the logical language.

In Smirnov's researches [19] there are analyzed different approaches to temporal opinions which are the statements about the future. With one approach the statements about the future are considered as the statements about the past and the present. In this case the statement «whenever there will be *p*» is true at the period of time *t*; if at time *t'* which follows after *t*, *p* is true. If the future state is determined by the present the statements about the future will be either true or false. However the situation is closer to the reality when the future is not predetermined by the present and different variants of the development of the situation are possible. With the second approach which is alternative the statements about the future events are considered not as assertive but as modal statements [16]. In this case the statements «there will always be *p*», «one day there will be *p*», «in some period of time there will be *p*» are incorrect in the case of the first approach.

The statements which are correct:

G☐p –«necessarily (in any case) there will always be p»;

G◊p – «possibly (in some cases) there will always be p»;

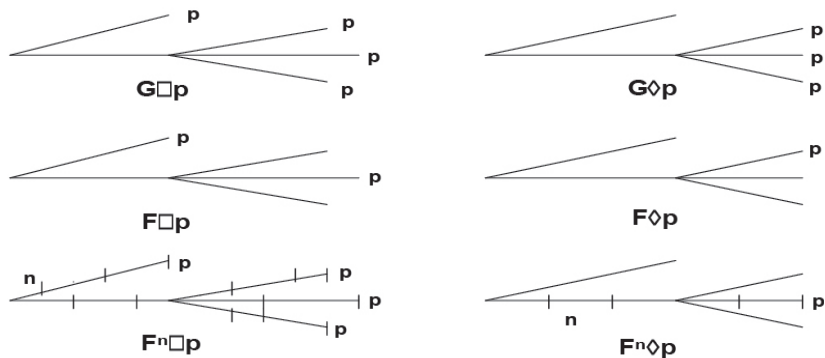F☐p – «necessarily one day there will be p»;

F◊p – «possibly one day there will be p»;

Fn☐p – «in some period of time necessarily there will be p»;

Fn◊p – «in some period of time possibly there will be p».

For each operator given the development process of events is represented in the form of a tree branching into the future (Picture 3).

Pic. 3. The graphical representation of temporary operators

The introduced operators are united which are also modalized temporary ones; they are not a combination of modal and temporary operators. This method is quite perspective in the meaning of the conception expressiveness but it is not developed enough in its practical realization.

Acknowledgements

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