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HILBERT SPACE / QUANTUM THEORY OF THE FINANCIAL DECISION AND ROLE OF THE PREFRONTAL CORTEX WITH A VIEW TO EMOTIONS

Ana Njegovanović [1]

[1]*Croatia, 10000 Zagreb, Voćarska 38, Croatia*
Email: ana.njegovanovic@gmail.com

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ABSTRACT

In this paper we present several questions: can we use quantum theory in financial decision making? Is there a way that quantum theory influences financial decision-making in terms of risk and uncertainty? What are the relations of quantum theory of decision-making and the role of prefrontal cortex and emotion in the conditions of risk and uncertainty? Perhaps there are already answers to these questions, perhaps they are already answered or need further research and development in the participation of financial decision-making in the conditions of risk and uncertainty in quantum theory of decision-making. Expanding on the role of prefrontal cortex and emotion work seeks to provide a consistent and integrated view of the complexity of financial decision-making in the conditions of risk and uncertainty. This study combines various scientific disciplines, concepts and mathematical (classical financial mathematics-based on the theory of stochastic processes) of the financial decision-making structure in terms of risk and uncertainty. One of the key factors in making financial decisions that lead to quantum dynamics is risk, uncertainty and emotion. The quantum decision theory were developed based on the mathematical techniques of complex Hilbert spaces through composite perspective lattices. Quantum decisional theory analyzes the decision-making process and types of dynamic inconsistency, quantum approaches to decision-making in the conditions of risk and uncertainty, taking Allais paradox and reinterpretation not on the subject's side but on the side of the observer (Allais paradox concerning the quantum measurement problem and the effect of the observer). Relationships between financial decision-making in risk and uncertainty and prefrontal cortex (frontal, cingulate parietal cortex, and striatum and emotion) show the motives of rational / irrational financial decision-making. Financial decision-making explains theoretical foundations (from the aspect of traditional economy) while neuroscience considers physiological aspects and somatic variables that influence financial decision-making.

1. INTRODUCTION

Work encourages and explores theoretical literature: can we use quantum theory in financial decision-making? Is there a way that quantum theory influences financial decision-making in terms of risk and uncertainty? What are the relations of quantum theory of decision-making and the role of the prefrontal cortex and the role of emotions in the conditions of risk and uncertainty?

The purpose of the research is to inspect financial decision-making through various scientific disciplines (quantum theory of decision making, economics, neuroscience) and participation in quantum decision-making theory in financial decision-making with the role of prefrontal cortex, emotion in risk and uncertainty.

Quantum theory is the most intuitive intellectual construct in the intellectual history of the human race. Applies to light and matter, from the least to the mesoscopic scale. Enables understanding of the evolution of the universe and the development of technology as the basis of today's and future evolution. Quantum information processing, quantum computing and quantum games (previously analyzed by classical means) contribute to the growth and development of human civilization.

Quantum decision theory was developed based on the mathematical techniques of complex Hilbert spaces through composite perspective lattices. Financial risk and uncertainty of quantum decision theory describes decision-making processes and types of dynamic inconsistencies (time inconsistency, paradox, and planning), adapting the quantum approach to decision-making in risk and uncertainty taking Allais paradox and reinterpretation not on the subject's side but on the side of the observer.

Relationships between financial decision-making in risk and uncertainty and prefrontal cortex, frontal, cingulate, parietal cortex and striatum and human emotions show the motives of rational / irrational financial decision-making. The traditional economy makes financial decision making clear through theoretical foundations, while neuroscience considers physiological aspects and somatic variables that influence financial decision making.

The concept of (fundamental) insecurity was introduced in the Keynes (1921;1936;1937) and Knight (1921). They pointed to the need to differentiate risks and uncertainties.

In the event of a risk, all possible events or consequences of actions or decisions are known. However, the events that will be realized in advance are a big unknown. In the case of a risk, a probability account is provided that provides a solid basis for risk management, cost and benefit analysis, budget planning.

Both Keynes and Knight argue that often in human decisions cannot be known all possible outcomes of actions or decisions. These are cases of (basic) insecurity. There are things people just do not know in advance. In uncertainty situations, the probability account does not have a solid foundation. There is no objective basis for risk management, cost and benefit analysis, and other control techniques. The risk and its assessment must be understandable within the theory of decision making, and achieving optimal results in science means making the right decisions as a result of the decision made.

The classical decision theory is based on the utility theory that Bernoulli has improved and shaped into a rigorous mathematical theory out of Neumanna and Morgensern. Although classical decision-making theory has been a success in broad application, it has led to different paradoxes (which remain unresolved) such as Allais' paradox, Ellsberg, Kahneman-Tversky - common misconception, disjunctive effect, and Rabin's paradox.

The starting point for assessing and assessing the risk under uncertainty is the decision maker's rationality, but research into neuroscience suggests that people make irrational decisions (buying, selling stock-risk always refers to emotions), numerous empirical studies point to the "partial rationality" of decision-makers behavioral economics, neuroeconomics).

The general idea of quantum theory describes the behavior of a sub-atomic particle instead of human behavior. Current probability models come from Newton's physics, not necessarily suitable for modeling the ambiguity of the human mind. By contrast, the possibility of uncertainty of the quantum system adequately describes some aspects of cognitive behavior.

The theory of quantum decision-making is the technique of complex Hilbert spaces (the interpretation of Hilbert's space is used in quantum theory in the context of decision-making in uncertainty conditions), a mathematical tool that provides a conservative and efficient descriptive of complex processes involved in decision-making. Namely, the quantum measurement theory is often classified as a quantum decision theory. The event in the decision theory corresponds to the measurement of the observed, this analogy corresponds to simple test events that can be tested. In the case of complex composites, the relationship of decisions in uncertainty and uncertainty conditions reflects the toughest point.

The quantum theory of decision-making describes the decision maker as a stochastic event that occurs with the probability that is the sum of the objective factor of utility and the subjective attracting factor. Quantitative decision theory provides a prediction of the average effect of subjectivity on decision makers. We are constantly confronted with different types of decision-making in an uncertain / insecure, risky environment. Research based on brain imaging techniques suggests that decision-making risk is associated with activities in the dorsolateral prefrontal cortex (DLPFC). Technological progress has allowed researchers to improve understanding of how our brain works when making decisions. Different factors may influence decision-making at the neuropsychological level (Camerer *et al.*, 2005) and open the door to the development of neuroeconomics (a study of financial decision-making (Camerer *et al.*, 2004). Decisions require careful weighing of risks and benefits. Because of excessive risk or excessive caution can have adverse consequences for both health, safety and financial well-being. "Adaptive decision-making implies an assessment and selection of risky, less risky behavioral choices and prediction of potential outcomes (Ernst and Paulus, 2005).

Understanding and explaining the decision making process is different in economics and neuroscience. Traditional economic theory explains behavior primarily through theoretical foundations such as utility, preferences, and axioms. On the other hand, neuroscience considers physiological aspects and somatic variables that influence decision making. In recent years, neuroeconomics has emerged as a multidisciplinary research area that integrates knowledge from neuroscience, psychology and economics to better understand economic decision-making and determine more precise models of choice and decision. Multiple options are always characterized by decisive situations with multiple possibilities, each carrying potential awards, risks and related probabilities of outcome.

While the classic theory of probability is limited in the description of human decision making, quantum theory provides a promising framework for modeling human knowledge. With the accuracy of gambling prediction and prison dilemma, the quantum model also agrees with empirical evidence that people make the same decision in identical scenarios. In classical models, on the other hand, electoral transition remains probable, which does not explain human behavior.

"Classical probability theory, including Mark's processes, must abide by the law on total probability," emphasizes Busemeyer. "However, human judgments often have implications for disturbances that violate the law of total probability, quantum probabilities originally developed specifically for the purpose of explaining the effects of interference in physics." This same mathematical formalism gives an explanation for interfering with thought in human judgment. "

Pothos and Busemeyer are hoping that further research into quantum probability models of human knowledge will help answer the fundamental questions about nature as we think. For example, what does it mean to be rational? Another example is the Schrodinger equation, which predicts periodic oscillation between choices after the minimum length of time. The oscillation corresponds to electroencephalography signals and can explain why we are discussing the decision longer. If our brains use quantum principles, quantum computing is significantly faster than classic computer counting, perhaps quantum principles can explain the success of human cognition.

Decision-making follows the metacognition through which the decision-maker follows the uncertainty regarding the decision and can subsequently redesign. You can check in before or in the absence of feedback. It is necessary to emphasize that the neural mechanisms of metacognition remain controversial. Thus, one theory suggests an independent neural system for metacognition in the prefrontal cortex (PFC); while the other theory suggests that metacognitive processes coincide and overlap with the systems used for the decision-making process.

In the 2018 experiment (published in PLOS), 21 participants (ages 19-33, 12 women) were subjected to perceptual decision-making and decision-making law based on fMRI (functional magnetic resonance imaging), it was discovered that anterior prefrontal cortex (PFC) including dorsal anterior cingulate cortex (dACC) and lateral frontopolar cortex (IFPC) were more active after initial decision. Thus, the dACC's re-designing activity was positively scaled by making uncertainty decisions and correlating it with the individual ability to monitor metacognitive insecurity (most commonly occurring in both tasks) indicating that dACC was specifically involved in monitoring uncertainty of decision-making. While IFPC activity seen in the re-decision process was scaled with reduced decision-making in uncertainty and correlated with individual changes in accuracy - positively in policy-based decision-making and negative in perceptual decision-making. The final result showed that a separate neural system in the prefrontal cortex is involved in meta cognition and that the PFC functions in metacognition are non-social.

Researchers knew that the links between the two parts of the brain, the amygdala and the middle prefrontal cortex (mPFC) were involved in the development of affective disorders such as depression and anxiety. However, new research suggests that this same brain system plays a role in the ability of a person to tolerate economic risk (published by Neuron on April 5, 2018, researchers from the University of Pennsylvania found that the structural and functional links between the amygdala and mPFC are related to individual differences in the degree to which a person accepts the risk in order to achieve a higher financial return). The experiment was performed to measure the structural and functional links between the different parts of the brain by means of MRI and diffusion tensor recording (DTI), measurements of the amygdal size, including the volume of gray and white substance to assess tolerance of the individual at risk (the scientists correlated with the risk tolerance estimator brain structure measures and brain function). "Three measurements - structural and functional links and the volume of amygdala gray matter - are intensifying each other to point to something important about the function of this system that relates to the differences in how tolerant people take the risk," adds Kable. "Just by looking at these features of your brain, we might have a reasonable idea of whether you are someone who will risk it or not." . "Thus, individuals with higher risk tolerance in the study possessed a larger amygdala (more gray matter) and more functional link between amygdala and mPFC measured by MRI. And greater tolerance to risk was identified in individuals with less structured bonds or paths between these areas, as measured by DTI.

2. THEORETICAL BACKGROUND

Research into the application of quantum mechanics in decision-making in economics mainly focuses on the mathematical framework of the Hilbert space of wave functions. It should be emphasized the problems in the interpretation of the wave function and their interference and superposition in the context of decision-making. A series of papers give us frameworks for decision-making under the ambiguous quantum mechanics methods (Aerts and Sozzo, 2011; Aerts and Sozzo, 2012; Aerts *et al.*, 2012; Aerts and Sozzo, 2012b; Aerts *et al.*, 2013). The Urn version of Ellsberg (1961) paradigm in three colors, Aerts *et al.* (2012). They interpret complex Hilbert space as a deterrent of probability and function as a projector from basic elements of Hilbert space for outputs or disbursements; they are given interference with the protracted pre-probabilities of extreme composite urns. While in the decision model (Yukalov and Sornette, 2011) based on the Hilbert space waves, different intentions or deliberate actions are interpreted as waves functions.

Quantum mechanics has opened the door to descriptive mind and observational choices that play a fundamental game in the nature of reality. Quantum measurement remains a challenge for the theory and interpretation of quantum experiments (Kafatos, 2015). Newton's view of the universe acts like a tangled mechanical clock assuming that the atom has at any time a well-defined location in the 3D space. Kafatos and Nadeau (2000) demonstrated that one-on-one correspondence between physical aspects assumed the ontological "right" assumption and the theory that describes such a physical aspect. Thus, physical properties are entirely determined by their former physical properties, and Werner Heisenberg emphasizes that in the Newtonian universe "mental" reality is determined by the properties associated with the brain and the nervous system (Stapp, 2017).

If we analyze Newton's physics and the mechanistic approach to economic theory, we could pull the parallel. The mechanic paradigm is considered to be atoms as rigid, solid, non-visible particles, so is the economic theory of individual preferences or individual behavior. Newton's law "General Gravity" and "Law of Motion" determine the entire history. The whole universe could be explained by Newton's approach as a precision value. If economic behavior is observed as a mechanical phenomenon of an individual's behavior as a mechanical robot, the works are programmed, controlled, predictive, and finally modeled by recalling the "Newtonian Clockwork Universe", signifying a man as "homoeconomicus", which is selfish, rational, perfectly maximizing profits.

In 1921 economist Frank Knight defined uncertainty as "risk" or "ambiguity". Knight defined risk as an amount with well-known outcome values and known probability of outcome and ambiguities as quantities with known outcome values and unknown probabilities. Basically, Knight defined "risk" as a measurable amount of insecurity that varies from immense uncertainty (ambiguity).

Encoding the economic risk for some neurons in the orbitofrontal cortex has been shown that the effects of ventromedial prefrontal cortex (VMPFC) damage in humans have implications for decision-making in uncertainty conditions in hazardous tasks involving probabilistic judgments (Rogers *et al.*, 1999; Clark *et al.*, 2008) and economic risk (Sanfey *et al.*, 2003). Activation in the orbital frontal cortex (OFC), which is adjacent to VMPFC, varies with economic risk (Critchley *et al.*, 2001; Hsu *et al.*, 2005; Tobler *et al.*, 2005). Although these studies point to the role of orbital frontal cortex in the risk assessment process, it is not possible to directly deduce the role of certain neurons in OFC based on lesion or recording techniques such as fMRI (functional magnetic resonance) that do not have the required spatial and temporal resolution. Specifically, lesion surveys give information that results from the absence of neurons and fMRI data records the oxygen flow in the blood (BOLD signal) within voices containing several thousands of neurons. Also, the time pattern of the BOLD signal is too low to detect brain activity at the rate of ignition of certain neurons. Therefore, detection of specific signals from certain neurons related to certain decision variables, such as risk and value, is not possible with current fMRI techniques.

The new trend in psychology does not only use quantum physics to explain (sometimes) paradoxical thinking to people, but it can also help researchers resolve certain contradictions between the results of previous psychological research. According to Zheng Joyce Wang and others who are mathematically trying to model our decision-making processes, equations and axioms that are closest to human behavior can be those who are rooted in quantum physics. "So far, we have collected so many paradoxical findings in the field of knowledge, especially in decision-making," said Wang, associate professor of communications and director of the Laboratory of Communication and Psychophysiology at Ohio State University.

"Whenever something that does not conform to classical theories appears, we often label it as" irrational. "But from the perspective of quantum recognition, some finds are no longer unreasonable, they are in line with quantum theory - and how people really behave. "Their work suggests that quantum thinking - essentially does not follow a conventional approach based on classical theory of probability - enables people to make decisions by dealing with insecurity and allowing confusion despite complex issues in spite of our limited mental resources.

When we mention the area of quantum physics, there are thoughts that describe the behavior of sub-atomic particles rather than human behavior. But the idea is not so intense (Wang) Their research and research programs do not assume or suggest that our brains are quantum computers. Other research groups work on this idea; Wang and colleagues do not focus on physical aspects of the brain, but how abstract mathematical principles of quantum theory can illuminate human knowledge and behavior.

"Our brain cannot store it all." We do not always have clear attitudes about things. "It is quantum knowledge." "I think mathematical formalism provided by quantum theory is consistent with what we feel intuitive. Quantum theory may not be intuitive at all when it is used to describe the particle behavior but is actually very intuitive when used to describe our typically uncertain and ambiguous minds. "An example of Schrödinger's cats - a thought experiment in which a cat inside a box is likely to be alive or dead, both have potential in our mind, in that sense the cat has the potential to become dead or alive at the same time, the effect being called the quantum superposition. When we open the box, both options are no longer set, and the cat must be alive or dead. So with quantum knowledge, as if every decision we make is our unique Schrödinger's cat. The characteristic of quantum mechanics - quantum bits, non-locality, interference, tunneling, particle interaction, Bose-Einstein condensate, waves, and fields that are equivalent to matter - open the understanding of our brain (Hameroff and Penrose, 2003).

Anomalies in human judgment and decision-making were developed mathematical frameworks of quantum theory (Busemeyer *et al.*, 2009; Conte *et al.*, 2009; Yukalov and Sornette, 2010; Cheon and Takahashi, 2012). Since quantum theory is the generalization of classical (physical) theory based on classical theory of probability and local realism, quantum decisions and cognitive theories have successfully modeled anomalies in human judgment and decision making. Boundary Deterioration (Blutner *et al.*, 2013) the question of tasks (Wang and Busemeyer, 2013) episodic superposition of human memory (Brainerd *et al.*, 2013) time dynamics of stable perception (Atmanspacher and Filk, 2010) contextually, disturbance, embarrassment and appearance in human thought (Aerts *et al.*, 2013) and cooperative and competitive human decision making processes (Fuss and Navarro, 2013) are quantitatively modeled. Wang's and Busemeyer's quantum theory of order effect can be quite useful because almost all kinds of psychological experiments include sequential (or comparable) measurements of human choices / answers to questionnaires.

Quantum mechanics brings a super complex image of reality at the fundamental level. Moving particle space time (4D) can be described as "wave". A special kind of wave, far different from our "classical" understanding. From a technical point of view, we associate a wavelet function with movable or interacting particles, wave function is the solution of Schrödinger's equation. Copenhagen interpretation of quantum mechanics "wave function is the most complete description that can be given to the physical system. Solutions to Schrödinger's equation describe not only molecular, atomic and subatomic systems but also macroscopic systems, probably even the entire universe. Schrödinger's equation is central to all quantum mechanics applications including a quantum field theory that combines special relativity with quantum mechanics. Quantum gravitation theories, like the theory of the string, also do not change Schrödinger's equation. "

There are several areas that make emotions work in the brain. Prefrontal cortex is involved in emotional regulation and decision-making. We store our feelings of self, our value system, our self-control. We use prefrontal cortex to suppress emotions. Our next key area is the amygdala that assesses our environment for potential dangers and causes anxiety, fear and anger. In the amygdala, we also store emotional memory. Our talamus receives information from the senses (vision, touch, smell, hearing, taste) and sends them to relevant areas of the brain. In the hippocampus we store memory, physical sensations of emotion and use it for navigation.

The electrical impulse that the brain has sent starts the avalanche of neurochemical-muscle processes in our body. The team of neurobiologists (2004) led by Massimo Scanziani of California University of San Diego discovered evidence that illuminates long-standing mysteries as the brain gives meaning to the information contained in the electrical impulses sent to him by millions of neurons from the body. Every second we are bombarded with thousands of information. As information is subdivided into the brain, the question is open. The group found that different neurons in the brain were devoted to the response to certain pieces of information. How in the process of brilliant brain work define human thought as an electrical impulse or series of impulses in a specific formulation. Maybe we can look for answers in physics. The thought that comes out of our "intellect" or "consciousness" is associated with a series of elementary particles (for example electrons) that "run" (true athletes) through our body, whether it is possible to "spread per room" or "around the world" or even "around the universe? "Thought can be seen in the quantum world as a time-dependent evolution of (charged) particles in the form of a wave function in a given quantum state. Is brain activity "releasing" a group of particles to describe their quantum state as a whole - a quantum plot.

3. RISK DECISION, MODELING INCOMPATIBILITY OF ECONOMIC BEHAVIOR IN MAKING FINANCIAL DECISIONS

Risk is a complex issue and requirement for research, understanding and identification in investment processes. Theoretical and empirical analysis and understanding are extremely important for studying investment risk. Theory of risk is the starting point in gathering information and the beginning of investment risk analysis. Thus, the analysis of decision-making in economic theory shows that the decision-making process is based on: 1. goal, timely investment analysis and its possible outcomes and calculated payments; but also 2. on the subjective perspective of the investor. Investments in most cases have a lower or higher risk. Risk and insecurity are subjective perceptions and include psychological and emotional factors. Neuroeconomic research shows that psychological and emotional influences on decision making (including risk and uncertainty) can have an informative and useful role in the decision-making process. Therefore, an investment risk analysis and a behavioral economy are needed, not just as objective components. Investigative risk studies and perceptions of risk in decision-making indicate that risk influences the decision.

The idea that psychological processes can be described by quantum theory starts from the assumption that human comprehension involves discussions between several possible actions and can be modeled as a quantum process (Bohr, 1933; 1958). The consideration of several complementary actions is analogous to the interference between several quantum states (Bohr). The possible influences of disturbances in decision-making have revealed numerous researches, suggesting different models for solving paradoxes in classical decision-making and explaining the diversity of cognitive phenomena (linking trends and history, summarized in Busemeyer and Bruza (2011).

The most famous contribution of quantum mechanics by Werner Heisenberg is "Principle of uncertainty", which carries his name. By concluding the principle, Heisenberg was not aware of the probability discussion announced by John Maynard Keynes in 1921. Keynes makes a sharp distinction between risk or uncertainty structured by an objective distribution of probability and real uncertainty. Should Heisenberg's Principle be called the "risk principle"? That would be a bit odd. The Heisenberg principle deals not with conscious creatures but with elemental components of matter. But (this is an important point) while the behavior of any particular constituent accidentally, collectively follows the objective distribution of probabilities predicted by quantum theory (experiments statistically confirm). The uncertainty in the core of quantum mechanics can be philosophically disturbing (Einstein never accepted: "God does not cube," as he wrote in a letter to his colleague and friend Max Born) but operational, whether in a computer, laser, nuclear reactor or in magnetic resonance, that is irrelevant: man is always dealing with such a large number of particles (electrons, photons, neutrons) and only perfectly static laws are relevant.

Mathematical physicist Asghar (1978) emphasized that quantum mechanics are more acceptable than classical mechanics for modeling indecision of economic behavior. In the 1990s, numerous researchers working in social sciences have shown that our decisions on individual or social levels can be modeled and even predicted by quantum formalism (psychology). Ras was visible in the area of quantum cognition and later in quantum social science. Political scientist Alexander Wendt of Quantum Mind and Social Science (2015) pointed out that the situation was similar to physics at the beginning of the 20th century: 'In both domains rigorous testing of classical theories has produced a series of anomalies; efforts to explain them to new classical models were ad hoc and partial; and then a quantum theory emerged that predicted everything with great precision. "

At the same time, other researchers apply quantum formalism to the area of quantitative finance, which is used to model the behavior of financial markets. Many formulas that regularly use "quantities" for the value of derivatives such as options (right to buy or sell securities for a certain price at a future date) may be revised as quantum effects. For example, the Black-Scholes equation can be expressed as a version of Schrödinger's equation of quantum physics. Markets even have their own version of the principle of insecurity (which will not be a surprise to investors).

So far, the focus on quantum financing and quantum knowledge was primarily the reproduction of the results of the neoclassic or behavioral economy using the quantum physics method. Instead of assuming that market prices represent curve crossing and optimizing utility, prices can be seen as a result of a new measurement. The theory of complexity and network theory are more appropriate for studying living systems. One of the modeling tools, where the economy appears indirectly from the action of heterogeneous individuals who are allowed to interact and influence each other, reflects the collective dance of quantum particles. Intermediate-based models have succeeded in reproducing the characteristic nature of the stock market or the impact of people's expectations on inflation. The network theory can be used to illustrate processes and detect vulnerabilities in complex relationships and financial system traps.

The quantum version also comes up with different conclusions and predictions, seen by economists as complex feedback loops, including those affecting the creation and destruction of money by private banks. Risk models currently being taught at universities and business schools - which rely on business and financial institutions - are not suitable for this purpose (as many speculated after the last crisis).

The "rational" decision makers selfishly decides to optimize their personal benefit, hence, a soloist approach. Milton Friedman wrote in 1953 that the economy "is in principle independent of any ethical position or normative judgment ... [That is] or could be" objective "While the economy, by applying quantum principles, sees it as a living system in which ethics plays an important role One lesson from the crisis was that economists were heavily involved in the financial system that was responsible for regulation, for example through highly paid consultations, as in quantum physics, the observer is never separated from the system.

4. HIGH FREQUENCY TRADING AND QUANTUM DECISIONS THEORY AND QUANTUM NEUROBIOLOGY

"High Frequency Trading is an automated trading platform used by large investment banks, hedge funds and institutional investors who use powerful computers to perform a large number of orders at extremely high speeds. High-frequency trading platforms allow marketers to execute millions of orders and scans multiple markets and exchanges in seconds, allowing platform-based institutions to take great advantage of the open market". (Investopedia).

How High Frequency Trading can be analyzed within quantum theory of decision making ?.

High technology has become an integral tool for financial activity and decision making. This is especially important in High Frequency Trading (HFT) and algorithmic trading or algo-trading (AT). A few milliseconds means the difference between earning and losing. These time scales are shorter. Markets move faster, (we enter into the world of computers) responding in a time of computer scale. The beginning of the twentieth century marks the discovery of matter whose behavior when approaching the light is different than it does at lower speeds (Einstein, 1905). We can use physical insights to see what traps can emerge in understanding and regulating high market speeds. Aspinwall (1993) emphasizes that financial markets have multiple and often counterproductive goals such as consumer protection, fairness, resource allocation, economic efficiency, capital formation, financial institution reliability and economic stability.

There are problems in the world of high speeds. Information can travel at light speed. Two occurrences occur simultaneously for one observer at a time, another observer in another reference frame. If the two exchanges are geographically separate, then the information that one exchange has a better price might not have reached the other exchange before trading.

Some high-frequency trading strategies such as arbitrage and market intelligence help market operational effectiveness. News Market Response Strategies help to get information on the market faster. On the other hand, we have a market race among the communications vendors to ensure faster and more expensive links between data centers.

One of the lessons of quantum physics is that occasional extreme events can occur. In a very complex and non-linear market, "unusual events" will appear. Unusual events can be triggered by program failures in which less harmless changes lead to a major catastrophe (a disaster that occurred on August 1, 2012, Knight Capital Group, 2012- failed to track $ 440 million software malware). Namely, no matter how many quality control procedures in the financial industry, sooner or later, a catastrophic failure will be found by a "quantum tunnel". Therefore, plans are needed to prevent damage when something like this happens.

The nervous system is a nonlinear dynamically complex system with many feedback loops. Because of the extreme sensitivity to initial conditions, complex systems can increase microscopic fluctuations and thus affect the behavior of the system. In this way quantum dynamics can affect neuronal computing. Accumulation of evidence in non-neuronal systems suggests that biological evolution can utilize quantum stochasticity. Growth and development of quantum biology (at the boundary between quantum physics and life sciences) suggests that quantum events can play a non-trivial role in non-neuronal cells. Direct experimental evidence for this is still missing, but future research will be concerned with the possibility that quantum events will contribute to the extremely complex complexity, variability, and computational power of non-neuronal dynamics.

5. DUAL NATURE OF DECISION- MAKING

Many phenomena in judgment and decision-making are often attributed to the interaction of two thinking systems. The dual process theories can explain many types of behavior, rarely formalized as mathematical or computer models. Dual process models are usually verbal theories, which are difficult to evaluate or test.

The relationship between the brainstem is extremely intricate. Each system performs different functions and each function requires several systems intervention. Neuroscientist refer to brain modularity. Decision-making, problem-solving, or performing a task engine requires coordinating functions and hence participating in different systems. Depending on the nature of the function and the degree of overlapping between the system, they will produce a response that is as if they are interfering or competing with each other.

Widespread belief shows that the human brain during the decision-making process acts as a complex and powerful computer. The neuron network within the brain accepts external signals and transforms them into decision-making subjects by realizing proper action (K. Mainzer). The appearance of many paradoxes (Allais paradox, Ellsberg's paradox, Kahneman-Tversky paradox, Rabin paradox, Ariely paradox, disengagement effect, error connectivity, paradoxical planning, and many others) can not be solved by the approach that involves modifying expected utility theory into theory (Safra and Segal, 2008; Al-Najjar and Weinstein, 2009). The emergence of numerous paradoxes in decision-making, based on utility theory, suggests that this theory does not take into account the emotional components that are an integral part of the decision-making, influencing the change of decisions that could only result from the benefit process. The decision maker not only evaluates the use of an objective perspective, but also influenced by subjective feelings, emotions, and behavioral disorders that are a subconscious product of brain activity. The brain makes the decision by combining objective knowledge of usefulness, evaluating factors of usefulness with a subjective attraction, which has perceived the emotion of the subconscious. Dualism of the brain combines objectively conscious action with the subjective subconscious, indicating that its functions can be described by generalizing the actual value by determining the utility weight of an approach by involving complex values. Thus it points to the techniques of quantum theory where the probability weights are defined by complex values such as wave functions. The idea of using quantum theory to describe brain functions has progressed to Bohro. By analyzing the quantum measurement theory, von Neuman mentions that measurements could be observed up to a certain point as decision-making. Quantum techniques provide the simplest way to generalize decision making taking into account the dual functioning of the brain.

There is a large symmetry between quantum processes and the number of processes in biology, ecology, economics and behavior.

"We have presented the Quantum Decision Theory that we have developed in the last four years, which is based on combining utility-like calculations with emotional influences in the representation of the decision making processes. We have emphasized that decision making by humans is principally different from the direct calculations by, even the most powerful, computers. This basic difference is in the duality of the human decision-making procedure. The brain makes decisions by a parallel processing of two different jobs: by consciously estimating the utility of the available prospects and by subconsciously evaluating their attractiveness".

„We have shown how the duality of the brain functioning can be adequately represented by the techniques of quantum theory. The process of decision making has been described as mathematically similar to the procedure of quantum measurement. The self-consistent mathematical theory of human decision making that we have been developed contains paradoxes typical of classical decision making. It is important to stress that this theory is the first theory allowing for it quantitative predictions taking into account behavioral biases".

„We stress that the description of the functioning of the human brain by means of quantum techniques does not require that the brain be a quantum object, but this approach serves as an appropriate mathematical tool for characterizing the conscious-subconscious duality of the brain processes. This duality must be taken into account when one attempts to create an artificial intelligence imitating the human brain. Such an artificial intelligence has to be quantum in the sense explained above „ (Horton *et al.*, 2013)".

6. INSTEAD CONCLUSION

„The Hilbert space multidimensional theory / HSM / - context of measurement refers to the subset of psychological variables that an individual evaluates at a certain opportunity. Different contexts are formed by estimating different, but possibly overlapping subset of variables. Contextual effects arise when context-based judgments cannot be derived from a common distribution of probabilities across a set of values of the observed variables. The theory of HSM provides a way of modeling these contextual effects using quantum probability theory that represents all variables within the low dimensional vector space. HSM models make estimates of parameters that provide a simple and informative interpretation of a complex collection of judgments in different contexts „ (Busemeyer *et al.*, 2011) „ Hilbert space multidimensional theory „).

The quantum model of decision making shows useful insights into the allocation and application of individual and group choices. Quantitative decision theory could be applied as a new framework in theoretical economics, and the model also improves the modeling of choices with regard to the existing paradoxes of decision making and neuroscientific evidence. The quantum theory of decision making using neuroscientific evidence provides normative and positive implications for the economy. Neuroscience (prefrontal cortex) shows deeper insights into decision making while the quantum model mitigates the deficiencies.

Newtonian causality has emerged as economic determinism in economic theory. Quantum physics challenges the philosophy of determinism and focuses on the possibility rather than on security. Risk and uncertainty of decision-making were investigated by various disciplines. Since it has been discovered that the behavior of an individual is in opposition to the basic set of theories; economists, psychologists, neurologists and physicists try to better understand the basic motives that are subject to irrational behavior.

Quantum mechanics, has a wide range of applicability in physics, chemistry, biology, cosmology. In social sciences (psychology, economics) the application of quantum mechanics offers promising insights. The success of quantum models (eg. Pothos and Busemeyer, 2009; Khrennikov, 2010; Yukalov and Sornette, 2010) in the analysis of experimental psychological results for example the observed disjunctive effect (Tversky and Shafir, 1992) cannot be explained by classical theories.

The application of quantum theory in social sciences on the other hand is a rapidly growing area, especially through ecophysiology (Saptsin and Soloviev, 2009). "Econo physics is a relatively new interdisciplinary science school, which is rapidly evolving and shaped in the late 90s of the 20th century, with the number of original works and articles on the Internet, the survey and the monograph already exceeded thousands. Schools of far and near countries.

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