FOUNDATIONS OF A POSTMODERN TURN IN SCIENCE, VERSION 2.0: POSTMODERN FUZZY SET AND FUZZY SYSTEM THEORY

In Honor of the 80th Birthday of Prof. C. V. Negoiță, a Pioneer of Fuzzy Sets, Cybernetics and Postmodern Science

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ABSTRACT:

The postmodern subjective representation of reality in our minds has two stages: 1) reconstruction of reality (rather than simple reflection) based on cognitive, emotional and behavioral mechanisms and 2) subjective evaluations of reality. The 20th century postmodern turn in science went straight to 2) without uncovering and quantifying 1). The need for a 21st century "postmodern turn in science version 2.0" is argued here and a postmodern "deconstruction" method is proposed to uncover and quantify the reconstruction process by the reverse engineering of the subjective evaluations which were quantified by the 20th century postmodern turn in science version 1.0. Postmodern fuzzy sets and fuzzy systems can help the postmodern turn version 2.0 in life, behavioral and social sciences including economics and finance. This is because fuzzy sets and fuzzy systems are ideally positioned at the interplay between exact sciences on one side and life, behavioral and social sciences on the other side. A Kabbalah based postmodern fuzzy set and fuzzy system theory version 2.0 has been developed and applied to advance foundations for postmodern versions 2.0 of: 1) behavioral and knowledge based economics, 2) cybernetics and system theory, 3) complex system modelling and 4) artificial intelligence and knowledge engineering.

KEYWORDS: postmodernism, deconstruction, postmodern turn in science, postmodern turn, postmodern turn in social sciences, fuzzy sets, fuzzy systems, fuzzy logic, multiple valued logics, semantics, system theory, control engineering, cybernetics, information theory, entropy, relativity theory, quantum physics, Newtonian physics, artificial intelligence, knowledge engineering, behavioral economics, behavioral finance, knowledge economics, neuroeconomics, Kabbalah, possible worlds, pullback, feedback, internal model principle, structural stability, robust control.

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1. Postmodernism and the "postmodern turn" in physical and exact sciences versus life, behavioral and social sciences

The philosophy of postmodernism is rooted in the idea that reality is not passively reflected in our understanding but it is ultimately subjectively reconstructed and evaluated in our minds based on our own perspective. Through this subjective representation process of reality, the borders between the knower, knowledge and the known disappear in postmodernism as the objective reality is replaced by the recognition of an interactive reality.

Postmodernism in science marked a shift from universal and macro, truth, certainty, determinism, order and Newtonian physics to particular and micro, perspective, uncertainty, randomness and complexity, chaos and entropy, relativity, thermodynamics and quantum physics (see Figure 1). This is referred to in the literature as the "postmodern turn"[2]. This will be called here the "postmodern turn in science version 1.0". This took place vigorously particularly between 1950s and 1980s in physical and exact sciences (with earlier roots such as 1920s relativity theory[3] leading to new postmodern scientific disciplines such as cybernetics, general system theory, information theory, fuzzy sets and fuzzy logic, artificial intelligence[4].

The paradigmatic postmodern shift from truth to perspective[5] required a new multi-faceted notion of truth and that is how fuzzy logic, fuzzy sets and fuzzy systems appeared as instruments to evaluate and

[2] Steven Best, Douglas Kellner, *The Postmodern Turn*, The Guilford Press, New York, 1997; Donald E. Olkowski, *Postmodern Philosophy and the Scientific Turn*, Indiana University Press, Bloomington, USA, 2012; Simon Susen, *The "Postmodern Turn" in the Social Sciences*, Palgrave Macmillan, New York, USA, 2015; Vladimir Tasić, *Mathematics and the Roots of Postmodern Thought*, Oxford University Press, New York, USA, 2001.

[3] Albert Einstein, *Relativity: The Special and the General Theory*, H. Holt and Company, New York, 1920 (translation of the original 1916 edition).

[4] C. V. Negoiță, D. A. Ralescu, *Applications of Fuzzy Sets to Systems Analysis*, John Wiley & Sons, New York, USA, 1975; C. V. Negoita, *Management Applications of System Theory*, Birkhauser Verlag, Basel, 1979; C. V. Negoita, *Expert Systems and Fuzzy Systems*, Benjamin/Cummings Publishing Co., Menlo Park, USA, 1985; C. V. Negoita, "Postmodernism, cybernetics and fuzzy set theory", *Kybernetes* 31 (2002), pp. 1043–1049; Ludwig von Bertalanffy, *General System Theory*, George Braziller, New York, USA, 1969; Norbert Wiener, *Cybernetics or Control and Communication in the Animal and the Machine*, MIT Press, Cambridge, USA, 1948; L. A. Zadeh, "Quantitative fuzzy semantics", *Information Sciences*, 3 (1971), pp. 159-176.

[5] Simon Susen, *op. cit*.

quantify both perspective and complexity in truth by using multiple (potentially infinite) truth values between 0 and 1 rather than just two truth values, 0 and 1.

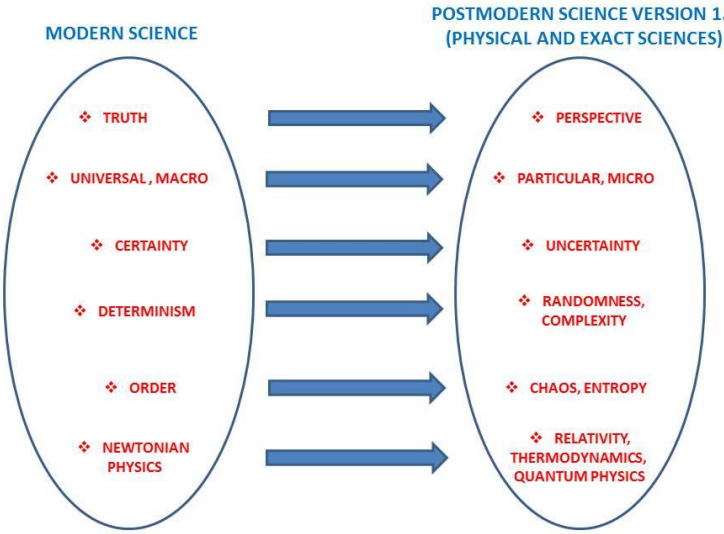

Figure 1. The "Postmodern Turn Version 1.0" in physical and exact sciences

These new disciplines were applied to behavioral, social and life sciences which underwent much later a postmodern turn version 1.0[6]. In particular, this paper will focus on fuzzy sets, fuzzy logic and fuzzy systems[7] because they sit at the interplay between exact and physical sciences on one side and life, behavioral and social sciences, including

[6] *Ibidem*.
[7] C. V. Negoiță, D. A. Ralescu, *Applications of Fuzzy Sets to Systems Analysis*, cited edition; C. V. Negoita, "Postmodernism, cybernetics and fuzzy set theory", cited edition; L. A. Zadeh, "Quantitative fuzzy semantics", cited edition.

economics and finance on the other side. In fact this is probably one of the reasons which motivated the creation of fuzzy sets and fuzzy logic. As such, fuzzy set and fuzzy system theory was an essential part of the domino effect that the postmodern turn in exact sciences had on the postmodern turn in life, behavioral and social sciences.

While fuzzy sets and fuzzy logic, for example, allow indeed the quantitative evaluation of the subjectively reflected reality and complexity (the final outcome, the result), what was left missing was the quantification of the actual reality reconstruction process which takes place in our minds. Specifically, how are the subjective evaluations and their degrees of fuzziness or fuzzy truth values being built in the reconstruction process ? We know how to perform formal operations between fuzzy membership functions of sets but the critics of fuzzy sets always pointed to the arbitrariness of these fuzzy membership functions in the first place as there is no standardized, universal, accepted construction methodology.

The quantification of the reconstruction process is what was missing from the postmodern turn version 1.0 of any science where the human element is central and where we have human systems or man-machine systems such as in life, behavioral sciences, social sciences, artificial intelligence, economics and finance. What was missing was us: the role played by our knowledge and understanding, by our emotions, by our behavior and actions. Version 1.0 provided instruments to evaluate the final outcome or the result of the reconstruction process but not the process itself.

For physics, version 1.0 finished the job by the end of the 20th century with the paradigm shift from Newtonian physics to relativity, quantum physics, thermodynamics[8]. This paper makes the case that for life, behavioral and social sciences what is needed is what will be called here a "Postmodern Turn Version 2.0" for the 21st century (see Figure 2). This should uncover and quantify the reality reconstruction process from our minds and not just its outcomes, the subjective evaluations. This can be done by the reverse engineering of our subjective evaluations in order to include our cognitive, emotional and behavioral mechanisms. This method will be called here "deconstruction", inspired by the concept with the same

[8] Steven Best, Douglas Kellner, *The Postmodern Turn*, cited edition; Donald E. Olkowski, *Postmodern Philosophy and the Scientific Turn*, cited edition.

name proposed in a related context by Derrida and Heidegger in literature (analysis of narratives), linguistics and philosophy[9].

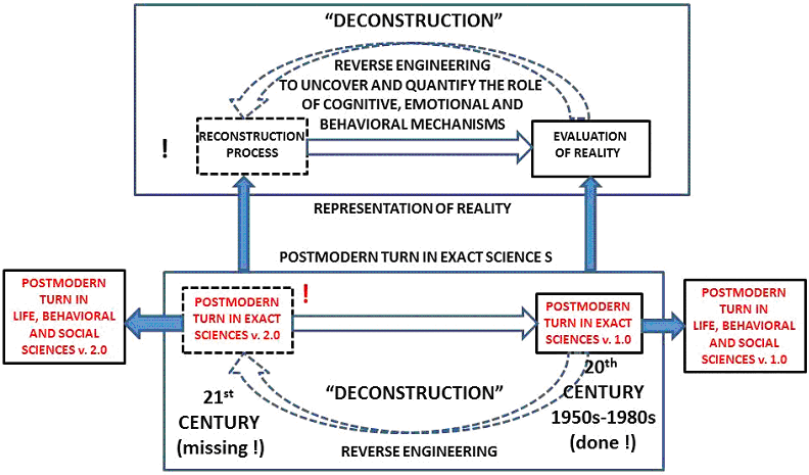

Figure 2. The need for a 21st century "Postmodern Turn In Science version 2.0" as a "deconstruction" of the 20th century's "Postmodern Turn Version 1.0" in order to uncover and quantify the reconstruction process leading to subjective evaluations of reality. This requires a "deconstruction" which amounts to a reverse engineering of the evaluations of reality in order to include the role of cognitive, emotional and behavioral mechanisms.

The reason we focus on fuzzy sets is that a postmodern version 2.0 in fuzzy sets and fuzzy logic, system theory and cybernetics, for example, can contribute to the building of a postmodern version 2.0 of life sciences, behavioral sciences, social sciences, artificial intelligence, economics and finance. Fuzzy sets have already been part of the chain reaction by which the postmodern turn in physical and exact sciences version 1.0 influenced the postmodern turn in life, social and behavioral sciences version 1.0.

[9] Steven Best, Douglas Kellner, *The Postmodern Turn*, cited edition; Simon Susen, *The "Postmodern Turn" in the Social Sciences*, cited edition.

It is symbolic that while one of the first books dealing with the postmodern turn in exact sciences was written in 1997[10], it took until 2015 to have a book on the postmodern turn in social sciences[11]. The postmodern turn in social sciences started later than in physical and exact sciences and will take longer, possibly because it needs both a version 1.0 (for the outcomes) and a version 2.0 (for the reconstruction mechanisms of these outcomes).

The fact that a psychologist, Daniel Kahneman, was awarded the 2002 Nobel Memorial Price in Economics proves clearly the case for a "postmodern turn in science version 2.0" in general! In fact, the work for a version 2.0 in economics and finance in particular is ongoing. While dominated like most modern sciences by rationality assumptions, economics and finance depend crucially on the behavior of human beings which is nothing but rational. Behavioral Economics and Finance is being developed now in the 21st century as a postmodern economics version 2.0 to account for our behavioral perspective and our choices in the laws of economics and finance[12]. Elements for a postmodern economics version 1.0 have already been proposed in the 70s as an immediate outcome of postmodern science developments such as thermodynamics, information theory and entropy, cybernetics and system theory[13].

A Knowledge Economics[14] appeared to quantify the role of our knowledge in economic decisions and processes and the economics of knowledge. The need to grasp the reconstruction process in economics went as far as creating Neuroeconomics[15] which looks at the role of neurophysiological processes in economic decision making. These are each separate directions of postmodern economic science in this beginning of

[10] Steven Best, Douglas Kellner, *The Postmodern Turn*, cited edition.
[11] Simon Susen, *The "Postmodern Turn" in the Social Sciences*, cited edition.
[12] Richard H. Thaler, (editor), *Advances in Behavioral Finance, Vol II*, Russel Sage Foundation, New York, USA, 2005.
[13] Nicholas Georgescu-Roegen, *The Entropy Law and the Economic Process*, Harvard University Press, Cambridge, USA, 1971; Oskar Lange, *Introduction to Economic Cybernetics*, Pergamon Press, London, UK, 1970.
[14] Dominique Foray, *The Economics of Knowledge*, MIT Press, Cambridge, 2006; Brian Kahin, Dominique Foray (editors), *Advancing Knowledge and the Knowledge Economy*, MIT Press, Cambridge, USA, 2006; C.V. Negoita, D. A. Ralescu, *Applications of Fuzzy Sets to Systems Analysis*, cited edition.
[15] Paul W. Glimcher, Ernst Fehr, Colin Camerer, Alan Poldrack Russell (eds), *Neuroeconomics: Decision Making and the Brain*, Academic Press, London, UK, 2009.

21st century. However, we need to account simultaneously, rather than separately, for our knowledge, emotions and behavior in order to fully quantify the multi-faceted reconstruction process of economic reality. Why? Because knowledge, emotions and behavior are inter-connected with each other, besides all of them influencing economic decision making at once. This was exactly the approach of Burstein and Negoiță[16] where foundations for (postmodern) behavioral economics and finance (version 2.0) are proposed combining Kabbalah and system theory.

2. Postmodern fuzzy sets and systems version 1.0

L.A. Zadeh's 1965 journal paper[17] was the proclamation for the fuzzy sets and fuzzy logic mathematical revolution against Boolean classic logic (two truth values 1-true and 0-false) and crisp classical sets. At a much smaller scale but not a smaller relative impact, it did exactly what Einstein's seminal 1920 book (translation of the 1916 initial text)[18] did to trigger the postmodern physics revolution of relativity theory against Newtonian physics. If Zadeh's paper from 1965 was the proclamation for the fuzzy revolution, surely the first "bible" of this postmodern scientific movement version 1.0 was the textbook of Negoita and Ralescu that was published worldwide in English in 1975 and then translated in Japanese and Chinese[19].

Physics was not coincidentally chosen as a parallel here. Fuzzy sets and systems, while being mathematical disciplines, were ultimately rooted in the needs of the bigger postmodern new disciplines of cybernetics and system theory. Just like relativistic physics introduced the role of the observer in Newtonian physics so too cybernetics and system theory represent the switch from the passive understanding of the physical environment to the active control of it by the observer.

[16] Gabriel Burstein, and Constantin Virgil Negoita, "A Kabbalah system theory modelling framework for knowledge based behavioral economics and finance", In *Computational Models of Complex Systems*; Dabbaghian, V., Mago, V., Eds., Springer, Zurich, Switzerland, 53 (2013), pp. 5–23.
[17] L. A. Zadeh, "Fuzzy Sets", *Information and Control*, 8 (1965), pp. 338-353.
[18] Albert Einstein, *Relativity: The Special and the General Theory*, cited edition.
[19] C. V. Negoiță, D. A. Ralescu, *Applications of Fuzzy Sets to Systems Analysis*, cited edition; C. V. Negoita, K. Asai, *Introduction to the Theory of Fuzzy Sets*, Ohm Publishing House, Tokyo, 1978 (in Japanese).

In a fuzzy set, each element has a fuzzy membership degree taking values in the continuum interval of infinite values between 0 and 1 as opposed to taking either the value 1 (belongs) or 0 (does not belong) like in the classical, crisp sets. As a result of this definition, in a fuzzy set, an element can belong to both a set with say a degree of x = 0.7 and also the the complement of that set with a degree of 1-x = 0.3. Hence an element can both "belong" and "not belong", it can be both inside and outside. This is the way to define fuzzy sets by "fuzzifying" the notion of the membership degree of an element to a set. Another way to define fuzzy sets is to "fuzzify" the definition of equality. Classical operations between sets like union and intersection can be generalized to fuzzy sets as follows. The union and intersection between two fuzzy subsets of a given set is a new fuzzy subset with fuzzy membership degree defined elementwise respectively by the max and min operations between the membership degrees of a given element in each of the two given fuzzy subsets[20]. Fuzzy sets quantify nuances in our concepts, language and thinking.

The first and still most important fuzzy sets journal, "Fuzzy Sets and Systems" was launched in 1978. Negoiță, Zadeh and Zimmerman were the founding editors. The birth of this journal was decided in a late night meeting, in one of the seminar rooms at ASE (Academy of Economic Studies in Bucharest) at the 1975 World Congress on Cybernetics and Systems. Negoita, Ralescu, Zimmerman, Klaczko, Malita and many others were there. Negoita describes these beginnings in his novel "Fuzzy Sets"[21].

In recognition for his pioneering role in fuzzy sets and cybernetics, two disciplines of postmodern science, the International Academy for Systems and Cybernetic Sciences (IASCYS) elected Negoita as an Academician on his recent 80th birthday in 2016. He led the Laboratory of Models at the Institute for Management and Information Science (ICI) in Bucharest from 1972 to 1982 and has been a professor of Computer Science at the Hunter College of City University of New York (CUNY) since 1983.

The Laboratory of Models was an applied postmodern science version 1.0 - think tank, perhaps one of the earliest and few in the world where researched topics included fuzzy sets, system theory, large scale systems, optimization, complexity, the category theoretic and topos theoretic approach to fuzzy sets and logic. Great minds such as D. Ralescu,

[20] C. V. Negoiță, D. A. Ralescu, *Applications of Fuzzy Sets to Systems Analysis*, cited edition; L. A. Zadeh, "Fuzzy Sets", cited edition.
[21] Constantin Virgil Negoita, *Fuzzy Sets*, New Falcon Publications, Tempe, USA, 2000 *(novel)*.

P. Flondor, M. Sularia, N. Andrei, F. Stanciulescu, D. Stefanescu, M. Kelemen and others together with Negoita pushed cybernetics, system theory and fuzzy sets in new uncharted, innovative, application oriented territories in the 70s and 80s when postmodern science version 1.0 was under full steam development. Many of these great minds from the Laboratory of Models became the scientific innovation, research and teaching leaders of today.

Negoita explained the momentum of fuzzy sets and systems in the 70s and 80s by the simple fact that after two world wars, Nazism and Communism, people lost the belief that a two valued logic can lead to a better world[22]. The law of Aristotelian excluded middle in real life leads people to destroy each other.

3. The early attempts to uncover and quantify the reconstruction process of reality leading to subjective evaluations

While the postmodern turn in science version 1.0 brought so much progress in quantifying the subjective evaluations of reality in our minds, we still did not have a quantification of the reconstruction process itself. To address this, Negoita and Kelemen proved the mathematical "Fuzzy Internal Model Principle"[23] by generalizing a famous robust control engineering and system theory result of Wonham[24]. Wonham proved, basically, that the controller of a plant must include an amplified internal model of the environment of the plant in order to achieve a robust or structurally stable control of the plant. In addition, the controller must use "feedback" coming from the plant and its environment. Change the controller with the human mind and the plant and its environment with the reality we are trying to grasp and control and you have a general mechanism of how reality may be reconstructed in our mind as we try to control it. The reconstruction process amounts to the creation of a robust or structurally stable fuzzy internal model of reality using fuzzy rules based language and fuzzy concepts.

[22] C. V. Negoiță, "Postmodernism, cybernetics and fuzzy set theory", cited edition.
[23] C. V. Negoiță, M. Kelemen, "On the internal model principle", *Proc.1977 IEEE Conf. on Decision and Control,* 1977, pp. 1343-1344.
[24] W. Murray Wonham, *Linear Multivariable Control: A Geometric Approach*, Applications of Mathematics, Vol. 10, Springer Verlag: New York, USA, 1979.

The problem in this approach was that it was based on the sequential structure of "feedback" control engineering. However, in parallel processing, knowledge engineering, artificial intelligence as well as in life and behavioral sciences, feedback must be replaced by a robust aggregation and synthesis of multiple evaluations and interpretations of complex concepts. In the 80s Negoita proposed the "pullback" operation from category theory to quantify the reconstruction process of reality through aggregation and synthesis[25]. For a different approach on aggregation in information fusion see[26].

Pullback was applied by Negoiță to formalize the foundations of a postmodern theory of human systems management[27]. Conflict resolution is based on literally "pulling back" on higher levels of synthesis or aggregation of multiple conflicting, alternative evaluations in a new structurally stable, robust evaluation. The standard concept of feedback control from control engineering cannot be applied to human systems management as conflict is an intrinsic nature of human systems which must be transcended as it cannot be eliminated completely like the feedback brings error to zero in the classical, sequential, linear philosophy of control theory.

In one of the first postmodern expert systems works and definitely first fuzzy expert system book[28], Negoita uses pullback in concept formation and structurally stable aggregation of the IF-THEN-ELSE fuzzy rule set of an expert system. This book was one of the main reasons that led to the established IEEE, the Institute of Electronic and Electrical Engineering, to award Negoita the 1985 "IEEE Award for New Technical Concepts".

In another approach, Negoiță launched the idea that pre-modern mystical and theological thinking is the ultimate genuine source but also a future continuation path for logics with multiple and infinite values, such as

[25] Constantin Virgil Negoita, *Management Applications of System Theory*, cited edition; C. V. Negoita, "Management by lighthouses", *Human Systems Management*, 1 (1980), pp. 181-183; C.V. Negoita, "Pullback versus Feedback", *Human Systems Management*, 1 (1980), pp. 71-76; C. V. Negoita, *Fuzzy Systems*, Abacus Press, Tunbridge Wells, UK, 1981.

[26] Didier Dubois, Henri Prade, "On the use of aggregation operations in information fusion processes", *Fuzzy Sets and Systems*, 142 (2004), pp. 143-161.

[27] C. V. Negoiță, "Management by lighthouses", cited edition; C.V. Negoiță, C.V. "Pullback versus Feedback", cited edition.

[28] C. V. Negoiță, *Expert Systems and Fuzzy Systems*, cited edition.

fuzzy logic[29]. Divinity is infinite and its revelation to the physical world in mysticism is finite and multi-faceted. Christianity has the Trinity. Kabbalah has a finite, 10-dimensional system of fundamental attributes or properties of existence, creations and creatures revealed to us by the infinite Creator ("Ayn Sof")[30]. The Chassidic Judaic thinking speaks of three types of people: the righteous ("tzaddik"), the wicked or the evil ("rasha") and the intermediate ("beinoni"). It is not about the righteous vs. the evil that is what the excluded middle law generated in the history of humanity!

The word "religion" was willingly avoided above. While mystical thinking and theology propose multivalent finite revelations of the infinite Divinity, the institutionalization of mystical thinking in the form of religions led again to disastrous manifestation of the law of excluded middle. This happened, for example, during the Inquisition and it happens so dangerously today worldwide.

Fuzzy sets and fuzzy logic was just the beginning of a much wider postmodern science inspiration from pre-modern mysticism and theology. For example, inspired by prophets in mysticism and theology, Negoiță proposed a reformulated "management by prophets" principle for a postmodern human system management methodology aimed at conflict avoidance, dissolution or resolution, using fuzzy logic rather than the law of excluded middle[31].

4. Postmodern fuzzy sets and fuzzy systems version 2.0: A Kabbalah based approach

[29] C. V. Negoiță, "Management by lighthouses", cited edition;
C. V. Negoiță, "Postmodernism, cybernetics and fuzzy set theory", cited edition.

[30] Gabriel Burstein, Constantin Virgil Negoiță, "Foundations of a postmodern cybernetics based on Kabbalah", *Kybernetes*, 40 (2011), pp. 331-1352; Gabriel Burstein, Constantin Virgil Negoiță, "A Kabbalah system theory modelling framework for knowledge based behavioral economics and finance", cited edition**;** G. Burstein, C.V. Negoiță, "A Kabbalah system theory of ontological and knowledge engineering for knowledge based systems", *(IJARAI) International Journal of Advanced Research in Artificial Intelligence*, 2 (2013), pp. 9-14; G. Burstein, C.V. Negoiță, M. Kranz, "Kabbalah logic and semantic foundations for a postmodern fuzzy logic and fuzzy set theory", *Appl. Math.* 5 (2014), pp. 1375–1385; G. Burstein, C.V. Negoiță, M. Kranz, "Postmodern fuzzy system theory: A deconstruction approach based on Kabbalah", *Systems* 2 (2014), pp. 590-605; Sanford L. Drob, *Kabbalah and Postmodernism: A Dialogue*, Peter Lang, New York, USA, 2009.

[31] C. V. Negoiță, "Management by lighthouses", cited edition; C.V. Negoiță, C.V. "Pullback versus Feedback", cited edition.

The roots of a future postmodern fuzzy set theory version 2.0 can be also traced back to the search for the meaning or semantics of fuzzy sets by Zadeh, Dubois, Prade and others which led to a possibility theory[32].

In the late 1990s and early 2000s, the need for a new "postmodern fuzzy set theory version 2.0" as an ontological and epistemological exploration of fuzzy sets were felt in the work of Turksen[33] and Resconi, Klir et al.[34] who created a meta-theory of fuzzy sets by looking at the modal facets of truth using modal logic[35] and generalizing the early work on possibility theory. Resconi, Klir et al. used the "possible worlds" method from modal logic to construct fuzzy membership functions. The truth value of a fuzzy predicate or the membership degree are obtained by averaging the different values of truth of the predicate or membership degree as perceived in the different points across a relational network of "possible worlds": different angles of assessment, different perspectives, different experts. This was the ultimate entrance of perspective of truth in a postmodern fuzzy set theory. Negoiță explained[36] that in postmodernism the truth is fragmented and multi-faceted and both truth and meaning are reconstructed. This is the shift from truth to perspective[37] (see Figure 1).

The objective of a postmodern fuzzy set and fuzzy system theory version 2.0 would be to deconstruct, that is to reverse engineer the fuzzy membership functions and fuzzy controlled, state transition maps of fuzzy dynamic systems in order to include in them the cognitive, emotional and behavioral reconstruction process of reality (see Figure 2).

Burstein, Negoiță et al. embarked on such a systematic program to create the foundations of a postmodern fuzzy set and fuzzy system theory version 2.0[38]. The analytical philosophy of Kabbalah offers an ideal 10-

[32] Didier Dubois, Henri Prade, "On the use of aggregation operations in information fusion processes", cited edition; L. A. Zadeh, "Quantitative fuzzy semantics", cited edition.
[33] I. Burhan Türksen, *An Ontological and Epistemological Perspective of Fuzzy Set Theory*, Elsevier, Amsterdam, The Netherlands, 2006.
[34] G. Resconi, G.J. Klir, Ute St. Clair, "Hierarchical uncertainty metatheory based upon modal logic", *Int. J. General Systems* 21 (1992), pp. 23–50.
[35] G. E. Hughes, M. J. Cresswell, *A New Introduction to Modal Logic*, Routledge, New York, USA, 2001.
[36] C. V. Negoiță, "Postmodernism, cybernetics and fuzzy set theory", cited edition.
[37] Simon Susen, *The "Postmodern Turn" in the Social Sciences*, Palgrave Macmillan, New York, USA, 2015.
[38] G. Burstein, C. V. Negoiță, M. Kranz, "Kabbalah logic and semantic foundations for a postmodern fuzzy logic and fuzzy set theory", cited edition; G. Burstein, C. V. Negoiță, M.

dimensional, fractal, hierarchical system which parametrizes and integrates the cognitive, emotional and behavioral levels of existence: the "Tree of Life" with its 10 "sefirot" (elements) corresponding to 10 fundamental attributes or properties of existence[39]. This can be used to deconstruct fuzzy membership functions and fuzzy controlled, state transition maps in order to include the cognitive, emotional and behavioral mechanisms of the reconstruction of reality in our minds. This is in a nutshell the essence of the program carried out in the works above[40].

Resconi, Klir et al. meta-theory of fuzzy sets based on possible worlds was a great step forward to uncover the missing reconstruction mechanism that leads to the fuzzy membership function. However, neither them nor those that fathered the "possible worlds" in modal logic (Hintikka and Kripke)[41] have looked into how to actually construct the possible worlds in practice by a standardized methodology, mainly because for them it was a formal theorem proof tool. Fuzzy set theory main critique is exactly that: the lack of an unique systematic methodology to build fuzzy membership functions. In the above works related to Kabbalah, the interconnected, hierarchical system of 10 cognitive, emotional and behavioral angles or perspectives of reality and existence from Kabbalah are used as a network of possible worlds. A fuzzy membership degree averages the values of truth in the different "possible worlds" points or "sefirot" (components) by using the relative connectivity pattern between the sefirot in Kabbalah.

Kranz, "Postmodern fuzzy system theory: A deconstruction approach based on Kabbalah", cited edition.

[39] Gabriel Burstein, Constantin Virgil Negoiță, "Foundations of a postmodern cybernetics based on Kabbalah", *Kybernetes*, 40 (2011), pp. 1331-1352; G. Burstein, C. V. Negoiță, M. Kranz, "Kabbalah logic and semantic foundations for a postmodern fuzzy logic and fuzzy set theory", cited edition; G. Burstein, C. V. Negoiță, M. Kranz, "Postmodern fuzzy system theory: A deconstruction approach based on Kabbalah", cited edition.

[40] Gabriel Burstein, Constantin Virgil Negoiță, "Foundations of a postmodern cybernetics based on Kabbalah", cited edition; G. Burstein, C. V. Negoiță, "A Kabbalah system theory modelling framework for knowledge based behavioral economics and finance", cited edition; G. Burstein, C. V. Negoiță, "A Kabbalah system theory of ontological and knowledge engineering for knowledge based systems", cited edition; G. Burstein, C. V. Negoiță, M. Kranz, "Kabbalah logic and semantic foundations for a postmodern fuzzy logic and fuzzy set theory", cited edition; G. Burstein, C. V. Negoiță, M. Kranz, "Postmodern fuzzy system theory: A deconstruction approach based on Kabbalah", cited edition.

[41] G. E. Hughes, M. J, Cresswell, *A New Introduction to Modal Logic*, cited edition.

The beauty of this approach is that just like there is a representation theorem for fuzzy sets[42], now one has cognitive-emotional-behavioral canonical deconstructions for postmodern fuzzy sets and fuzzy systems version 2.0. The membership function of a fuzzy set, for example, can be canonically represented as the sum between a cognitive fuzzy membership function, an emotional fuzzy membership function and a behavioral fuzzy membership function. The objective was achieved: deconstructing fuzzy sets and fuzzy systems to include the cognitive, emotional and behavioral reconstruction mechanisms into the fuzzy membership degrees and state transition functions.

5. Foundations for postmodern version 2.0 economics and finance, artificial intelligence, cybernetics, system theory and complex system modelling: the Kabbalah based approach

As quoted above, Burstein and Negoiță also used a Kabbalah-based approach to include our cognitive, emotional and behavioral mechanisms in the foundations of a postmodern version 2.0 of 1) behavioral and knowledge economics and finance, 2) cybernetics and system theory, 3) knowledge engineering and artificial intelligence and 4) complex system modelling.

We have witnessed the development of a behavioral and, separately, of a knowledge based postmodern economics version 2.0 in the last 15 years[43]. However, behavior and knowledge are strongly inter-connected before we even bring the emotional mechanisms in discussion, some of which are covered in the recent neuroeconomics[44]. However, economic decision making takes place, as we stressed earlier, under the simultaneous interconnected cognitive, emotional and behavioral mechanisms rather than under the separate influence of each. Hence an integrative, simultaneous cognitive, emotional and behavioral deconstruction of economic decision making is required in an economics and finance version 2.0.

[42] C.V. Negoiță, D. A. Ralescu, *Applications of Fuzzy Sets to Systems Analysis*, John Wiley & Sons, New York, USA, 1975.

[43] Dominique Foray, *The Economics of Knowledge*, cited edition; Brian Kahin, Dominique Foray (editors), *Advancing Knowledge and the Knowledge Economy*, cited edition; Richard H. Thaler (editor), *Advances in Behavioral Finance, Vol II*, cited edition.

[44] Paul W. Glimcher, Ernst Fehr, Colin Camerer, Alan Poldrack Russell (eds), *Neuroeconomics: Decision Making and the Brain*, cited edition.

A Kabbalah system theory version 2.0 is used to account simultaneously for the hierarchical and fractal interconnection between the cognitive, emotional and behavioral mechanisms of reality reconstruction.

References

[1] Best, S., Kellner, D. *The Postmodern Turn*, The Guilford Press, New York, 1997.
[2] Burstein, G., Negoiță, C.V. Foundations of a postmodern cybernetics based on Kabbalah, *Kybernetes*, 40 (2011), 331-1352.
[3] Burstein, G., Negoiță, C.V. A Kabbalah system theory modelling framework for knowledge based behavioral economics and finance, In *Computational Models of Complex Systems*; Dabbaghian, V., Mago, V., Eds., Springer, Zurich, Switzerland, 53 (2013), 5–23.
[4] Burstein, G., Negoiță, C.V. A Kabbalah system theory of ontological and knowledge engineering for knowledge based systems, *(IJARAI) International Journal of Advanced Research in Artificial Intelligence*, 2 (2013), 9-14.
[5] Burstein, G., Negoiță, C.V., Kranz, M. Kabbalah logic and semantic foundations for a postmodern fuzzy logic and fuzzy set theory. *Appl. Math.* 5 (2014), 1375–1385.
[6] Burstein, G., Negoiță, C.V., Kranz, M. Postmodern fuzzy system theory: A deconstruction approach based on Kabbalah. *Systems* 2 (2014), 590-605.
[7] Drob, S. *Kabbalah and Postmodernism: A Dialogue*, Peter Lang, New York, USA, 2009.
[8] Dubois, D., Prade, H. The three semantics of fuzzy sets, *Fuzzy Sets and Systems*, 90 (1997), 141-150.
[9] Dubois, D., Prade, H. On the use of aggregation operations in information fusion processes, *Fuzzy Sets and Systems*, 142 (2004), 143-161
[10] Dubois, D., Prade, H. Possibility theory and its applications: a retrospective and prospective view. *Decision Theory and Multi-Agent Planning, CISM International Centre for Mechanical Sciences*, 482 (2006), 89-109.
[11] Einstein, A. *Relativity: The Special and the General Theory*, H. Holt and Company, New York, 1920 (translation of the original

1916 edition)
[12] Foray, D. *The Economics of Knowledge*, MIT Press, Cambridge, 2006.
[13] Georgescu-Roegen, N. *The Entropy Law and the Economic Process*, Harvard University Press, Cambridge, USA, 1971.
[14] Glimcher, P.W. et al. (eds), *Neuroeconomics: Decision Making and the Brain*, Academic Press, London, UK, 2009.
[15] Hughes, G.E., Cresswell, M.J. *A New Introduction to Modal Logic*, Routledge, New York, USA, 2001.
[16] Kahin, B., Foray (editors), D. *Advancing Knowledge and the Knowledge Economy*, MIT Press, Cambridge, USA, 2006.
[17] Lange, O. *Introduction to Economic Cybernetics*, Pergamon Press, London, UK, 1970.
[18] Leydesdorff, L. *The Knowledge-Based Economy: Modeled, Measured, Simulated*, Universal Publishers, Boca Raton, USA, 2006.
[19] Negoiță, C.V., Ralescu, D.A. *Applications of Fuzzy Sets to Systems Analysis*, John Wiley & Sons, New York, USA, 1975.
[20] Negoiță, C.V., Kelemen, M. On the internal model principle, *Proc.1977 IEEE Conf. on Decision and Control*, 1977, 1343-1344.
[21] Negoiță, C.V., Asai, K. *Introduction to the Theory of Fuzzy Sets*, Ohm Publishing House, Tokyo, 1978 (in Japanese).
[22] Negoiță, C.V., *Management Applications of System Theory*, Birkhauser Verlag, Basel, 1979.
[23] Negoiță, C.V. Management by lighthouses, *Human Systems Management*, 1 (1980), 181-183.
[24] Negoiță, C.V. Pullback versus Feedback, *Human Systems Management*, 1 (1980), 71-76.
[25] Negoiță, C.V. *Fuzzy Systems*, Abacus Press, Tunbridge Wells, UK, 1981.
[26] Negoiță, C.V. *Expert Systems and Fuzzy Systems*, Benjamin/Cummings Publishing Co., Menlo Park, USA, 1985.
[27] Negoiță, C.V. Fuzzy Sets, New Falcon Publications, Tempe, USA, 2000 (novel)
[28] Negoiță, C.V. Postmodernism, cybernetics and fuzzy set theory. *Kybernetes* 31 (2002), 1043–1049.
[29] Olkowski, D.E. *Postmodern Philosophy and the Scientific Turn*, Indiana University Press, Bloomington, USA, 2012.

[30] Resconi, G., Klir, G.J., St. Clair, U. Hierarchical uncertainty metatheory based upon modal logic. *Int. J. General Systems* 21 (1992), 23–50.
[31] Susen, S. *The "Postmodern Turn" in the Social Sciences*, Palgrave Macmillan, New York, USA, 2015.
[32] Tasić, V. *Mathematics and the Roots of Postmodern Thought*, Oxford University Press, New York, USA, 2001.
[33] Thaler, R.H. (editor), *Advances in Behavioral Finance, Vol II*, Russel Sage Foundation, New York, USA, 2005.
[34] Turksen, I.B. *An Ontological and Epistemological Perspective of Fuzzy Set Theory*, Elsevier, Amsterdam, The Netherlands, 2006.
[35] von Bertalanffy, L. *General System Theory*, George Braziller, New York, USA, 1969.
[36] Wiener, N. *Cybernetics or Control and Communication in the Animal and the Machine*, MIT Press, Cambridge, USA, 1948.
[37] Wonham, W.M. *Linear Multivariable Control: A Geometric Approach*, Applications of Mathematics, Vol. 10, Springer Verlag: New York, USA, 1979.
[38] Zadeh, L.A. Fuzzy Sets, *Information and Control*, 8 (1965), 338-353.
[39] Zadeh, L.A. Quantitative fuzzy semantics, Information Sciences, 3 (1971), 159-176.