The Science and Art Of Decision Making

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Abstract— Decision makers of today routinely encounter increasingly complex and interrelated problems, preceding the necessity for a large number of significant decisions to be dynamic in nature. Frequently rather than a single decision the requirement of a number of decisions exists, conventionally being interdependent on each other in an environment of progressive change.

For thousands of years people have endeavoured to document observations of the environment and surroundings, with the aspiration of comprehending situations, which in turn enable a form of anticipation or prediction of the future. Through the contributions of a range of scientists and philosophers' humanity has affected the achievement of an improved quality of life, commencement of influence on the essence of life and encouragement to attempt to gain even further knowledge through travel to other planets. Without any doubt science is exceptional and dynamic and by far the optimum means of discovering the world and all that it encompasses. What hasn't changed is the curiosity, imagination and intelligence of those doing science [1].

Despite the fact that scientific discoveries and inventions invariably enhance life to a large degree as well as being accredited with expanding the expected lifespan of humans, scientific and technological improvements may equally precipitate alienation, loss of privacy, environmental problems (chemical and electronic waste), and a greater uncertainty or a black swan event.

Science is perceived to be subject about knowledge with curiosity lying at the heart of it, differing from technology in that technology is preferably explained as doing. The 19th century scientist Pierre Laplace elevated determinism to a key place in science. He linked determinism and the ability to predict to the very notion of success in science [2]. For technical decisions science is an unrivalled tool to use, however, for managerial, institutional and personal daily life decisions the same recommendation cannot be given.

Numerous key systems incorporated in the life of humans exhibit diverse complexities. Markets compromised of various buyers and sellers all categorized in groups participating in mutual funds, economies with hierarchies of workers, departments, firms, and industries; multi-celled organisms consisting of proteins, membranes, organelles, cells, and organs, the internet with users, stations, servers, and websites. Each of these complex systems exhibits a distinctive property called "emergence" roughly described by a phrase "the whole is more than the sum of the actions of the parts [3].

Scientists depend on the law of rationality; however, the fact that emotion habitually dominates humans on innumerable occasions is well recognized. Perhaps a more effective method for solving the problems of humanity should include deciphering the laws of human nature.

As an alternative to the law of rationality, consideration could be given to whether it is preferable for scientists use the law of bounded rationality which may entail radical paradigm shift in scientific studies.

The fundamental gap between the explicit accomplishments of knowledge acquisition in the natural sciences versus the rather minimal successes in understanding the dynamics of the social realm is the inherent nonlinearity, instability, and uncertainty of behaviour consistent with social systems. However, the possibility that an alternative strategy exists to close this gap is highly feasible.

This article aims at showing the justification for the discarding the rule of rationality assumption in engagement and comprehension of scientific studies, and as a substitute insert human behaviours and emotions. Our emotional self is the principal power behind our creativity and passion and constitutes humanity. Controlling the nature may be easier than controlling the human nature. Today the study of chaos, and systemic thinking (emphasis is given to complexity, networks and patterns of organization) has emerged at the forefront of natural sciences too.

Disquiet exists concerning events that may lead to the destruction of our civilization even the elimination of life on Earth. In 2050 the World population will reach 9.7 billion. There is also an urgent need to introduce eco-ethical standards into science.

Decision making is not merely a science; there is a requisite for creative and individuality aspects of it to be examined. In the development of technologies, the human nature, psychological and sociological impacts of these technologies must be analysed in a holistic way. The main aim of the paper is to show that decision making especially under uncertainty is partly scientific partly heuristic or artistic phenomenon. The art side of decision making shouldn't be expelled from science.

Keywords—complexity neuroeconomics, styling, decision-making

I. INTRODUCTION

Historically the social sciences have emulated both the intellectual and methodological paradigms of the natural sciences. From the behavioural revolution, to applications such as cybernetics, to a predominant reliance on and the stability of the Newtonian paradigm, the social sciences have followed the lead of the natural sciences. This trend continues as new discoveries in the natural sciences have led to a reconsideration of the relevance of the Newtonian paradigm to all natural phenomena [4].

A world is deterministic if its current state completely defines its future. Chaos is the name given to the mechanism which allows for rapid growth of uncertainty in mathematical models [2]. Sensitivity, determinism and recurrence are the constraints that allow mathematical

chaos, and although particular scientists deny it, some scientists and mathematicians have foreseen the coming of chaos both into natural and especially into social sciences, yet predominately in the latter. Chaos has its origin both in science fiction and science fact.

Today there are dozens, hundreds of young philosophers who do have solid interdisciplinary training in cognitive science, neuroscience, and computer science [5].

A decision is made by formulating opinions and selecting certain actions via mental processes which are shaped by personal bias, reason, emotion and memories. In non-programmed (one-shot, ill structured, novel) decisions, deservedly tools such as rule of thumb, intuition, judgment, creativity should be given opportunities equivalent to scientific mechanisms. To exclude the contributions of these techniques of decision making in scientific studies is conceivably a grave error. To label them unscientific or to underestimate their importance is an impediment to keep humans as humans on earth.

The demands of astronomers for accurate predictions of celestial motion, led Jacob Bernoulli, Pierre-Simon Laplace and Carl Friedrich Gauss to develop a theory of errors which assists in signal extraction from noise. In regards to complex physical systems this may be partially true; however complex adaptive systems with inflexible elements obligate the recognition of the significance of philosophy and psychology in science.

Everyman is a forecaster, although proficiently made decisions are unfamiliar to most. Under the observation of numerous improvements in technology and science, a struggle to make precise predictions about the future still exists. Customarily decisions are made by relying on expectations of the future. By what means expectations are shaped is an additional scientific field that still necessitates further contributions. Understanding in what manner ability to predict the future can develop (mental accounting) may also enhance the quality of decisions.

Many important problems involve decision making under uncertainty. Also the influence of emotions on decision-making is largely ignored. How to design life is a very difficult task. Sometimes life is painful. We are all caught up in a hopeless cycle of wanting things, getting them and then wanting more things. Schopenhour asserted that there are some experiences that can make life bearable. These come mostly from art and music.

Decision making is the thought process of selecting a logical choice from the available options. Intelligent machines, the developments of artificial intelligence, the use of virtual reality may dominate the analytic skills of humans. However, creativity, passion, character, collaborative spirit and essentially benevolence will empower superiority and distinction in humans since these skills cannot be programmed to software.

To induce people to be happier, healthier and wealthier, an instrumental solution would be to accept people as humans, to value independence, openness of mind, creativity and problem solving skills of people rather than to consider them as machine type creators. It is unwarranted conduct to be techno-sceptic and create myths to frighten people such as, “Artificial Intelligence” (AI) will control humans; robots can turn into evils and the like. To build beneficial AI a revised kind of thinking in science is demanded, wherein elements are both mechanistic and holistic. Fear is contagious, and the rationale behind Max Tegmark’s mention in his book named “Life 3.0” of fear of machines turning evil, cyborgs with red eyes being a diversion that warrants caution. The escalation of Neo Luddism, the philosophy opposing many forms of modern technologies is unmerited.

However, there are some other concerns that we need to be careful about which are eco-ethical standards. These standards must be the “sine qua non” condition of scientific studies

Physicists can design weapons systems of mass destruction, chemists can contaminate the global environment, biologists can release new and unknown types of microorganisms without knowing the consequences, psychologists and other scientists may be torturing animals in the name of scientific progress. It seems there is an urgent need to introduce eco-ethical standards into science [6].

Chaos, complex systems, the systems view of reality, cybernetics, eco-ethical standards into science are some of the most important topics of science and decision-making process today.

In the second part of the paper the basic problems of decision making under uncertainty and complexity are reviewed. Then in the third section the importance of behavioural economics and neuroeconomics are examined. The main aim of the paper is to show that decision making especially under uncertainty is partly scientific partly heuristic or artistic phenomenon. The art side of decision making shouldn’t be expelled from science.

II. CHAOPLEXITY, INTELLIGENT SYSTEMS AND MEASUREMENT PROBLEMS

The Newtonian framework, which had guided scientific inquiry for three centuries, was initially challenged by developments in physics, the iconic discipline of classical science. In exposing the limitations of the mechanistic and reductionist orientation inherent in that approach, relativity theory and quantum mechanics transformed humanity’s collective understanding of matter, energy, and time as being less rigidly fixed than previously conceived. More importantly, these theories called into question reigning assumptions about predictability, determinism, and scientific objectivity. The observer

could no longer be seen as outside and separate from the phenomena being observed [7].

Until recently mainstream science required a favourable solution to be well behaved although some scientists and mathematicians had previously foreseen the coming of chaos. Chaos has its origin both in science fiction and science fact. Chaos literally means disorder and existence of turbulence. It is very difficult to capture it. It can occur in nonlinear and dynamic systems. Chaos theory is subfield of mathematics, but it has different application to physics, engineering, economics and social sciences. Some scientists still dislike problems when their results are expected to be irreproducible even in theory.

Living systems are characterized by the capability of response and education processes which are circular and nonlinear, and function according to the basic systems research framework, observe, reflect, plan, and act. The decision-making process can be unconscious and pre-determined (in most physical and biological systems) or subject to conscious evaluation and choice (in most human systems).

The trait that distinguishes humans from any other animal or entity is the aptitude to think and use logic in connection with daily obligations of life. Unfortunately emotional energy is also encompassed within the trait having the negative impact of blindness to probability. Human systems are distinct in that, Intuition, judgement and experience always play a significant role in decision making.

Laplace made fundamental contributions to the theory of errors. When we make an observation, the measurement is never exact in a mathematical sense, so there is always some uncertainty as to the "true value". Scientists say that any uncertainty in an observation is due to noise.

It is believed that noise gives rise to observational uncertainty, chaos helps us to understand how small uncertainties can become large uncertainities, once we have a model for the noise [2].

Chaos is one of the concepts that most rapidly have been expanded in what research topics respects. Considering that relationships in non-linear systems are unstable, chaos theory aims to understand and to explain this kind of unpredictable aspects of nature, social life, the uncertainties, the nonlinearities, the disorders and confusion, scientifically it represents a disarray connection, but basically it involves much more than that [8].

Chaotic systems are nonlinear, they are deterministic, they are unstable (they display sensitivity to an initial condition). Linear systems always respond proportionately, nonlinear systems show a disproportionate response. We can use perhaps the term "chaoplexity" which was used by John Hogan to express the order hidden within chaos and complexity characterized by non-linearity, self-organization and emergence.

"Complex Physical Systems" are different from "Complex Adaptive Systems". Complex Physical System follow fixed physical laws which are usually expressed by differential equations. Neither the laws nor the elements change over time, only the positions of elements change. With this determinism systems with similar starting points will unfold in similar ways. If initial points change the prediction will be very difficult like the prediction of weather. Complex Adaptive Systems are composed of elements, called agents, that learn or adapt in response to interactions with other agents.

Adaptive agents are not additive. The changing interactions between adaptive agents are not simply additive. This "non-linearity" rules out the direct use of partial differential equations in most cases. The theory of partial differential equations are based on the assumption of additivity [2].

Uncertainty could be defined as unknown future events that cannot be predicted quantitatively within useful limits. At the core of the decision-making process is the need for quality information that allows the decision makers to better understand the impact of e.g., feedback processes, non-linear relationships between variables, and time delays on the performance of the complex system.

One of the most important sources of such information is the outcome of the both the model building process and the application of the model of the complex system. Modelling supports decision making by providing specific "what-ifs" scenario analysis opportunity to the decision makers in a "non-threatening" manner [9].

Walker classified the uncertainties into six types for scientific evidence about generic causation. These are; concept uncertainty, measurement uncertainty, calculation uncertainty, sampling uncertainty, mathematical modelling uncertainty and causal uncertainty [10].

Under all these uncertainties it could be very difficult to talk about perfect modelling.

III. NEUROECONOMICS AND DEVIATIONS FROM RATIONALITY

Neuroeconomics endeavours to link the disciplines of neuroscience, psychology, and economics. In pragmatic terms, neuroeconomics incorporates the analysis of various brain functions utilized in the decision-making process.

In traditional economic theories it is assumed that people often objectively evaluate costs and benefits of each activity and give rational reactions or take rational decisions. A considerable dispute exists between economists in regards to whether economy is law-bound

or anarchic. Some economist believe that the economy is unfair, unstable, unsustainable and needs a scientific revolution [11].

At micro level behavioural economics has shown that human behaviour does not always follow economic theory or optimize utility. Insight into the mechanisms driving individuals can help to better predict the future of economies.

Behavioural economics attempts to enrich economic analyses of behaviour grounded as it is in theories about preferences, incentives, decision-making and strategies with insights from psychology, sociology, cognitive neuroscience and evolutionary biology [12].

Neuroeconomics provides insight into why humans do not act to optimize utility and avoid financial difficulty. Typically, emotions profoundly influence individuals' decision-making.

The brain often reacts more to losses than to gains, which can stimulate irrational behaviour. While emotional responses are not always suboptimal, they are rarely consistent with the concept of rationality.

There are three central areas of neuroeconomics: intertemporal choice, game theory, and decision-making under risk and uncertainty. Intertemporal choice is the process by which people decide what and how much to do at various times; choices made at one time influence the choices available at other times. Game theory applies mathematical models of conflict and cooperation between rational, intelligent decision-makers.

Decision-making under risk and uncertainty describes the demanding position of managers who incorporate risk into their strategy decisions, which requires information on the probability distribution of outcomes such as the expected value of the distribution, the variance and standard deviation, and coefficient of variation.

Traditional research approaches necessitate the scope of focus to be more limited as in the ethos of Descartes, isolating a small part of the problem/situation/phenomenon (i.e., the system, using the term inclusively to encompass any kind of entity that can be studied), in order to understand its behaviour under varying conditions. This calls to mind the often-quoted maxim, “all other things being equal.” Classical science has had a tendency to marginalize and trivialize those “other things.” And perhaps most critical among those other things is the role of *subjectivity* and *agency* that play such a fundamental role in the social science side of the divide [7]

In both theoretical and applied natural science, the perception of reality as being mechanistic is generally an unquestioned assumption. The capacity of comprehension is absent in this worldview for agency, purpose, or intelligence (other than human of course, although the question of how that evolved and functions in a mechanistic universe is never sufficiently explained).

The Arrow-Debreu theory fails to take into account adaptive interactions typical of a complex adaptive systems. From complex adaptive system viewpoint, the fully rational agent assumption is a very strong assumption [3]. Each agent must act on full knowledge of the future consequences of its actions, including the responses of other agents to those actions. Self-control problems are ignored in economics. There is a difference between “what we want” and “what we choose [13].

At micro level there are some other problems too. Daniel Kahneman and Amos Tversky introduced the idea of cognitive biases, and their impact on decision making in 1974. A forerunner of Kahneman and Tversky was Herbert Simon. He wrote about what he called “bounded rationality”. He meant that people lack the cognitive ability to solve complex problems [13].

Instead of using big numbers perhaps it is recommendable to use small numbers in order to realize a more advanced picture of the economic facts. We are observing new fields in economics like neuroeconomics (behavioural finance) and new disciplines such as complexity, ecosystem, biology, psychology, control theory (the control of linear and non-linear systems) and the like are associated with economics.

This can be achieved through the cooperation and coordination of many scientific fields. Data is turned into information and information is turned into knowledge. Excessive information could bring inordinate choice. Yet, engineers are essential because information does not signify greater power. Sometimes even making decisions with more information achieves more complexity in everything. It would be adequate for software to deliver only vital information.

IV. CONCLUSION

Plausibly several potential dangers and risks face humanity: climate change, a nuclear war, a pandemics, or a giant asteroid striking planet earth, the destruction of biodiversity, resource depletion, overpopulation. By what means it is conceivable to lessen the existential risks?

Every culture provides a clue conducive to understanding the world, none should be neglected. It would be a mistake to think that uniformity facilitates easier understanding: it simply masks differences.

Education, science, culture and communication are pillars in the construction of a united human community and the foundations of sustainable development. Not everybody lives in a corresponding “real world, life is lived by each individual within their own perceptions. The influence of emotions on decision-making is largely ignored.

Accepting the existence of complex adaptive systems and chaos does not imply that prediction is hopeless. In many cases it is known that perfect models do not exist, and it is impossible to have all-weather plans.

A state of uncertainty refers to a situation in which the decision maker is unaware of all the alternatives and the risks associated with each, or what consequences each is likely to have. Long-term perspective is not generally a human attribute.

"Artificial intelligence, cloning, genetic engineering, virtual reality, robots, nanotechnology, bio-hacking, space colonization, and autonomous machines are all likely coming, at one point in time. But we must persevere in our insistence that human values are folded into the development of each and every one of them."

"Achieving a higher human value such as universal justice is not a question of engineering. Blockchains and robots don't address the fundamental problem of humanity's widespread refusal to value one another and the world we share."

West Churchman, former President of the ISSS, offered some compelling observations in this regard. Described by Robert Flood (1999) as the moral conscience of the systems field, Churchman believed that science should address itself to the serious problems confronting humanity, and further that scientists should be responsible for the social also ecological consequences of their discoveries [7].

Thanks to science humans have cultivated themselves in order to control the world around them, but still we had little control over the world inside us. The explanatory power of some sciences such as economics, ecology, astrology, immunology, toxicology, neurobiology, psychology, meteorology, may not be as successful as the explanatory power of general relativity, quantum electrodynamics or DNA-based genetic code. It could be better to cover the progression of the science of complexity and theories of chaos especially in some fields. This requires an important paradigm change and we need to reconsider the idea of "science is only about invariance laws".

Social systems are typically chaotic, non-linear and/or non-equilibrium and therefore complex systems. Sometimes it is better to use heuristic which is a simple procedure that helps us to find adequate, though often imperfect, answers to difficult questions [14].

As it is formulated by Nassim Taleb (2012), in decision making; model-based probabilistic decision making is fragile, heuristic based decision making is robust and convex heuristic is antifragile.

He argues that it is better to use randomness, uncertainty, chaos, no need to hide from them. Someone or something is antifragile if it benefits from shocks, thrives and grows when exposed to volatility, randomness, disorder, and stressors and love risk and uncertainty.

Antifragility is beyond resilience or robustness. The resilience resists shocks and stays the same. The antifragile gets better. If something is harmed by volatility this is fragile. If something benefits from it it is antifragile [15].

In the formulation of many technical decisions and in natural sciences the principles of order, reductionism, predictability and determinism will keep being the base of explaining, understanding and solving the problems. But when we deal with complex adaptive systems both in nature and social systems we need a paradigmatic shift. This will not refute Newton. Just we need the acceptance that many phenomena were not orderly, reducible, predictable or determined. These properties shouldn't leave these studies out of science. We may enjoy our lives more by knowing that sometimes this world is not knowable especially knowable by means of rationality. Decision making is partly science partly art.

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