Herbert A. Simon on making decisions: enduring insights and bounded rationality

Behrooz Kalantari

Abstract

Purpose – The paper aims to explore the life and contributions of one of the most influential management scholars (Herbert A. Simon), who is known as the founder and contributor to many scientific fields. Simon’s interdisciplinary approach in conducting his research in management has made him a significant figure in many disciplines.

Design/methodology/approach – The paper is of a qualitative nature, and information is collected from the books and articles that are written by Simon as well as those who have been familiar with his work. This paper concentrates on Simon’s contribution to the decision-making theory and, more specifically, his insights into the process of decision making in real world situations. It explores the tenets of the classical and neoclassical approach to decision making and argues that because of Simon’s work, attention was diverted from concentration on studying the organizational structure to the behavior of the decision makers during the process of making decisions. This new orientation brought more attention to the behavioral approach in studying decision making in organizations. Special attention is given to Simon’s “bounded rationality” model and its relation to the process of decision making. This paper also deals with Simon’s view on the role of intuition in decision making and explores the practicality of using his model in the real world.

Findings – Simon opened up a new world of scientific inquiry that its main focus is on the development of the most effective and realistic model for the decision makers to predict future outcomes.

Research limitations/implications – The paper only concentrates on the core contribution of Herbert Simon’s work on the decision-making process. It does not indulge itself in Simon’s related work in other disciplines such as computer science and artificial intelligence. In addition, this paper does not deal with the new developments in the theories of decision making. Future research could concentrate on the new discoveries concerning the ability of humans to construct thinking machines in order to improve productivity in organizations.

Originality/value – The paper examines the productive life of Herbert Simon and develops a realistic portrait of his core contributions to humanity (decision making). It involves the reader with the intricacies of the decision making process as it is examined and studied by Simon.

Keywords Decision making, Management theory, Intuition

Paper type Research paper

Introduction

Herbert Simon was born in 1916 in Milwaukee, Wisconsin. His father was an electrical engineer and his mother was a pianist. He entered the University of Chicago in 1933 and completed his BA in 1936 and later his PhD in 1943, both in Political Science. He is often referred to as a “behavioral economist” (Augier and March, 2002, 2004). Simon’s first academic job was in 1939 as the director of a research project that lasted three years and was conducted for the University of California at Berkeley. Later, he taught at the Illinois Institute of Technology and became involved with the Cowel Commission. Most notable
was his career at Carnegie Mellon University where he joined in 1947 and continued until the last day of his life. While at Carnegie Mellon, Simon was instrumental in founding several departments and colleges including: Humanities and Social Sciences, Graduate School of Industrial Administration, Psychology, School of Computer Science, and more importantly, the creation of the “cognitive group” (Kalantari and Wigfall, 2001).

Simon received the Nobel Memorial Award in 1978 for his research on “decision making process” within economic organizations. He also received many other awards and recognitions, including the A.M. Turing Award for his contribution to computer science in 1975, the National Medal of Science in 1986, the Dwight Waldo Award, the John Gaus Lecture Award, the James Madison Award from the American Political Science Association, the Gold Medal Award for Life Achievement in Psychological Science from the American Psychological Association, the American Society of Public Administration Award, as well as the American Economic Association Award.

Simon received 24 honorary doctoral degrees from many colleges and universities, including Harvard University, Columbia University, Yale University, and the University of Chicago. He published 27 books and close to 1,000 articles on different subjects and in a variety of disciplines. He can be viewed as a barometer of change for several disciples during his productive life.

Simon is claimed by many disciplines such as political science, public administration, administrative theory, philosophy, economics, computer science, psychology, and artificial intelligence (AI) to be the founder and major contributor. His lifelong contribution to those disciplines makes him a unique personality among the pioneers in science and technology as well as management and economics in the world. He collaborated with several scholars from different disciplines including Allen Newell (Computer Science and Cognitive Psychology) from Rand Corporation, Edward Feigenbaum (Computer Science and AI), Anders Ericsson (Psychology), James March (Psychology and Behavioral Sciences), and others to make his everlasting contributions. Simon believed in an interdisciplinary social research and opposed the social pressure that represented the postwar tendencies for development of disciplinary specializations (Crowther-Heyck, 2006). He fostered a new field of scientific inquiry that recognized no disciplinary boundaries.

The main idea that occupied Simon’s mind since his early age was to discover how human behavior could be studied scientifically. His ideas on human decision making and problem solving, as well as bounded rationality and causal reasoning, are considered his unique contributions to management. He profoundly challenged our fundamental assumptions on human cognition. His central goal was to explain the nature and mechanism of thought process that people use in making decisions. In 1947, Simon published his doctoral dissertation that he wrote for his Political Science degree at the University of Chicago on the topic of Administrative Behavior: A Study of Decision-making Processes In Administrative Organizations. In this monumental book, Simon challenged the age-old assumptions in administration and launched his first critique of the classical principles of management. He effectively questioned the notion of “principles” in administration and called them “proverbs” of administration. He argued that those so-called principles often conflict with each other and do not hold up to scientific inquiry. Therefore, they are not applicable in complex situations and cannot be called “principles.” He convincingly demonstrated how every single principle in administration can be nullified through systematic logical reasoning (Kalantari and
Wigfall, 2001). For example, Simon argued that principles of “delegation of authority” and “unity of commend” are contradictory to each other. One principle suggests a manager should delegate authority and responsibility and the other principle contradicts the foundation of the former principle by advocating organizational control through a centrally based command (Simon, 1997a, pp. 32-4).

Simon advocated concentration on “factual propositions” for conducting scientific inquiry. His emphasis on rationality led him to believe in separation of “facts” and “values” and argued that facts are empirical and can be scientifically verified. However, he believed that values not only can be verified but also are subject to different interpretations by individuals because they deal with certain ideals and cannot be measured and used in scientific inquiries (Kalantari and Wigfall, 2001). He believed that the main job of administrators is to separate facts from values in order to be able to set realistic goals for organizations.

In order to fulfill his interest in finding a more reliable model for humans to make decisions, Simon involved himself with areas beyond the administration discipline. Simon’s intention was to use hard science, such as mathematics, to explain social phenomena (McCorduck, 1974). In other words, he insisted on making “administration” a science in order to make administrative decisions more rationally. His deep interest in decision making led him to other disciplines such as Psychology, AI, and Economics by which he developed the theory of bounded rationality that won him the Nobel Memorial Prize. He believed that organizational decision making is a complex process that is influenced by many factors in the organization. It can be argued that since the time he wrote his dissertation and its publication in 1947, Simon set the stage for the development of a new approach in understanding and studying organizational decision making with an emphasis on the limitations of the rationality of decision-making agents.

Simon viewed human beings as an uncomplicated phenomenon and argued that humans are composed of quite simple “behaving systems”; however, “the apparent complexity of our behavior over time is largely a reflection of the complexity of the environment in which we find ourselves” (Simon, 1969, p. 110). Therefore, using this view on human behavior, he taught that understanding human environment and uncertainty that surrounds the decision-making process is the major challenge of our time. Simon asserted that decision making is the most important part of administration and the outcome of decisions depend on the process that is used in making decisions. He developed the bounded rationality model which advocates the idea that humans are only partially rational. He also believed that organizational decision making had a social aspect and no decision in an organization was the function of one individual (Mitchell and Scott, 1988, p. 354).

An interdisciplinary scholar
Simon was a true interdisciplinary scholar and has contributed to many disciplines. More notably, he worked with Newell to create a new science of AI which set the ground for studying human thought patterns using computational models. His pioneer work in this area is considered to be a milestone in the study and foundation of the first artificial thinking machine and a revolution in the psychology of the mind. His work in the development of AI is directly related to psychology and computer science. He also worked with Edward Feigenbaum in order to develop new programs in verbal learning and worked on “specialized computer programs that can make expert judgments in
a particular field” (Augier and March, 2004, p. 24). Simon’s contributions to economics and business have received more publicity since he won the Nobel Prize in economics as it is related to his decision making model. Simon “built his work precisely on a close examination of the basic premises upon which economic theory is built. He did this in terms of the psychology of individual choice and the social architecture of decision making in organizations” (Day, 2004, p. 89). It can be argued that Simon’s major contribution and lifelong work was in the decision-making arena. Simon’s thirst for knowledge and understanding of the “human decision making process” took him to many related disciplines such as Psychology, Economics, Business, Computer Science, Sociology, and AI.

It is vital to realize that Simon was part of the World War II movement that was driven by using scientific inquiry in the social science discipline from development of theories to the ability of producing scientific results. His contribution in many disciplines was directly related to the better understanding of the decision making process in organizations. Those disciplines were directly or indirectly related to studying the behavior of decision makers and working of human mind. It can be argued that he was a true behavioralist who focused on decision making theory building. His main argument that contradicted the classical and neoclassical theories of decision-making dealt with the concept of rationality of the decision-making process. He developed the bounded rationality model that revolutionized the nature of organizational decision making. He postulated that, in reality, organizations do not make decisions but people do, and their decisions are not rational as it is claimed by the neoclassical and classical schools of management. His decision-making model is applicable to all relevant disciplines including economics where he received his Nobel Prize for his work. He stated that, “it was not possible to improve economic decision making without a better understanding of human behavior.” (Schwartz, 2002, p. 185).

Classical and neoclassical theories versus the bounded rationality model

According to classical and neoclassical theories, the main goal of decision making is to be rational by first collecting all the relevant information regarding the issues under investigation. The next step is to generate all possible alternatives and examine the consequences of those alternatives and finally choose the most optimal alternative. Neoclassical theory’s main contribution was its genuine concern for human needs and sometimes is referred to as the human relations school. Simon asserted that the classical and neoclassical approaches in dealing with decision-making concept are not realistic and do not correspond with the real world. He contended that decision makers cannot be rational unless the decision maker has perfect control on the environmental factors as well as his mental capabilities.

Simon also argued that those traditional theories perceive decision making from the viewpoint of a rational actor; however, this is not a complete picture and we have to take into consideration the limitations on human computational ability and how those limitations influence his rational behavior. He believed that limitations on human rationality and calculation exist “by the disparity between the complexity of the world and the fitness of human computational capabilities, with or without computers” (Simon, 1997b, p. 319). In the final analysis, it can be stated that neoclassical theory might be a good start to thinking about rational decision making; however, the major flaw in the theory is that it considers the decision maker as an observer in the
Bounded rationality challenges the assumption of “rationality” of the decision maker and emphasizes his cognitive limitations and argues that the outcome of such a process will be “satisficing” decisions which indicates that such decisions are not guaranteed to be “optimal”. Simon’s bounded rationality theory is based on the behavioral theory of bounded rationality. He stated that “rationality is bounded when it falls short of omniscience. And the failures of omniscience are largely failures of knowing all the alternatives, uncertainty about relevant exogenous events, and inability to calculate consequences” (Simon, 1979a, p. 502). Concerning other characteristics of bounded rationality, Simon referred to the:

[...] limits of human capability to calculate, the sever deficiencies in human knowledge about the consequences of choice, and the limits of human ability to adjudicate among multiple goals (Simon, 1979b, p. 270).

Simon stated that bounded rationality theory:

[...] does not come from the assumption of rationality but rather from the assumption that rationality is, at least in some important respects, bounded. Human computational limits do matter, and postulating them is essential to explaining the phenomenon” (Simon, 1997a, p. 332).

He remarked that, “the concept of bounded rationality provides a starting point for economic theory that deals with the areas of neglect without negating those findings of classical theory that have a good basis in empirical evidence” (Simon, 1997a, p. 330). In other words, Simon’s behavioral model promotes the idea that although rationality is the goal of organizational decision making, the decision maker is limited by cognitive abilities (habits, values, reflexes, knowledge, etc.) as well as external (environmental) factors; therefore, the decision cannot be optimized. Some use Simon’s assertions and argue that “theories of bounded rationality were opposed to neoclassical theories” (Sent, 2005, p. 227). But it is important to note that Simon (1976a) does not argue against rationality as a false premise and believes that a decision maker has to strive for more rational outcomes by influencing the environment. Simon’s bounded rationality is simply a process model that corresponds with the real world practical decision making process. For example, he believed that classical theory may be able to “be patched up sufficiently to handle a wide range of situations where uncertainty and outguessing phenomena do not play a central role – that is, to handle the behaviors of economies that are relatively stable and not too distant from a competitive equilibrium” (Simon, 1979a, p. 497). Therefore, it can be argued that Simon does not explicitly oppose the neoclassical theory of decision making but thinks that it is incomplete and does not correspond with reality of the decision-making process. The bounded rationality concept has been originally introduced as a psychological concept and how the human mind works (Simon, 1976a).

Simon used theories of cognitive science to show that new alternatives can be discovered through heuristic search. In his attempt to explain his decision-making theory of “bounded rationality”, Simon’s model for heuristic search helps us to develop realistic alternatives. He criticized neoclassical theory for not providing any explanation for how certain alternatives are generated and made available for the decision maker to decide because it only deals with the theoretical aspects of decision.
making as opposed to the real world cases. On the contrary, in the bounded rationality model, the main factor that determines what items should be on the agenda for the decision maker is the “attention” phenomenon which is directly related to organizational needs. Simon explained that this process “must assure that two kinds of needs are attended to sufficiently account for survival: real-time needs, which can be thought of as representing threats (or opportunities) presented by the environment and periodic needs for the replenishment of resources on which there is a continuing drain” (Simon, 1997b, p. 325).

In the same vein with the classical and neoclassical theory, after World War II, a great surge occurred in the development of a powerful model of decision making and problem solving in academia. This new phenomenon helped the development and usage of a prescriptive model of decision making called, theory of subjective expected utility (SEU). The SEU theory “assumes that a decision maker has a well-defined utility function, and hence he can assign a cardinal number as a measure of his liking of any particular scenario of events over the future. Second, it assumes that the decision maker is confronted with well-defined set of alternatives to choose from” (Simon, 1983, p. 12). Simon acknowledged the usefulness of SEU in some situations; however, he argued that it has major limitations in complex situations and in dealing with the real world problems. Therefore, Simon has similar reservations concerning SEU as he has concerning the classical and neoclassical models.

In summary, it can be noted that Simon (1947) criticized neoclassical theory for ignoring limitations on human rationality and that the theory does not correspond with the real world circumstances. He believed that the model of rational economic man that considers human as a “utility maximizer” does not apply in the real world. According to him, organizational factors (environment) are instrumental in influencing the conditions and resources that are available to the decision maker. This environment places the decision maker in an uncertain circumstance that is hard to control. In this uncertain environment, “the task of administration is so to design this environment that the individual will approach as close as practicable to rationality (judged in terms of the organization’s goals) in his decision” (Simon, 1976a, pp. 240-41). In the final analysis, Simon seriously challenged the neoclassical approach in being able to predict the collective behavior of humans based on the assumption that they act rationally “theory of rational man.” He reasoned that the capability of the human “mind for formulating and solving complex problems is very small when compared with the size of the problems whose solutions are required for objective rational behavior in the real – world or even for a reasonable approximation to such objective rationality” (Simon, 1957, p. 198).

**Rationality nature of organizational decision making**

According to Simon, rationality is a contextual phenomenon depending on the circumstances and there is a distinction between substantive rationality and procedural rationality. He contended that his reference to decisions not being rational is related to the irrationality of the decision making process. According to Simon, if the decision maker acts in the direction of the organizational goals within the limited constraints that are present in the decision making process, the decision is substantively rational, not procedurally. Therefore, Simon’s (1976b) emphasis is on procedural rationality rather than substantive. He referred to rational decision making when procedural rationality is followed. He thought that “behavior is procedurally rational when it is the outcome of
appropriate deliberation. Its procedural rationality depends on the process that generated it" (Simon, 1976b, p. 131). Simon (1976b) stated that “rationality of behavior depends upon the actor in only a single respect – his goals. Given these goals, the rational behavior is determined entirely by the characteristics of the environment in which it takes place” (p. 130).

According to Simon (1955), due to the limited knowledge and lack of proper procedural rationality, decision makers make “satisficing” decisions as opposed to optimal ones which make those decisions more opportunistic rather than rational. He argued that the human mind is capable of exercising a limited degree of rationality. Therefore, the individual decision maker constructs a simplified model of rationality for himself, taking into consideration the limitations that surround him, in order to be able to satisfy him in dealing with his circumstances. Within this small and unpredictable world that is the creation of the decision maker, the decision maker searches for a course of action that is satisfactory or good enough and is based on his previous experiences (Simon, 1976a). Simon also referred to other limitations in the decision making process such as skills, habits, and values or perceptions that might not necessarily be compatible with organizational goals and objectives. Those factors also make the decision making process more complicated (Simon, 1976a, p. 241). Simon (1976a, p. 271) used “satisficing” rule as one empirical and realistic substitute for the “maximization rule” that is the core of the classical theory and neoclassical theories.

### Decision making process in the real world

Since his early age, Simon was interested in studying the decision making process at the individual as well as organizational levels. He was very concerned about the core notion of classical theory which advocated that decision makers’ behaviors follow the classical principle of the “utility maximization” theory. He studied the individual actor’s behavior in the decision making process to understand how the real world decisions were made. Simon asserted that survivability of man on the planet earth depends on his ability to make decisions in an ever changing and uncertain environment. The degree that human being adapts and fits in such environment solely depends on the quality of his decision-making skills (Simon, 2005).

Simon (1979a, p. 501) tried to understand and communicate behavioral realism in the context of organization theory and contended that public and private organizations that are created by humans to produce products or services “can only be understood as machinery for coping with the limits of man’s abilities to comprehend and compute in the face of complexity and uncertainty”.

According to Simon, the decision maker who faces limitations has to make two adjustments. The first one is related to his “aspiration level,” which deals with the way an individual decision maker explores alternatives for action. Following the adjustment phase, the decision maker adjusts his set of alternatives because he cannot reach the optimal level using the “stop rule.” Adjusting the set of alternatives is an elaboration and part of the information gathering process (Simon, 1975). According to Simon, setting the aspiration levels is related and based on the past experience of the decision maker. In this process, the problem solver uses his past experience to form an expectation of what he can attain (taking into consideration the amount of effort that he is willing to put out) which demonstrates his level of aspiration (Simon, 1957). He further explained the decision maker’s search for acceptable alternatives using the “stop rule.” Simon asserted
that when alternatives are generated through heuristic search, there is a way of deciding when the search should be stopped and an alternative be chosen. The decision maker simply chooses the first alternative that is “satisfactory” to him and that no alternative is guaranteed to be optimal. If a satisficing alternative cannot be found, “then aspiration levels will drop until an alternative is found” (Simon 1997a, p. 324). As soon as the decision maker reaches a satisficing alternative, the search will be halted (Simon, 1955). Simon (1955, p. 333) stated that, “aspirations tend to rise as it proves easy to find improved new alternatives and to fall if the search becomes unproductive”.

Simon (1956) has coined the process of finding alternatives through “heuristic search” and “stop rule,” as well as “adjustable aspirations” as “satisficing”. As for the place of “reason” within the scope of the decision making process, he stated that “reason is wholly instrumental. It cannot tell us where to go; at best it can tell us how to get there. It is a gun for hire that can be employed in the service of whatever goals we have, good or bad” (Simon, 1983, p. 8).

**Intuition and the decision making process**

Most of the literature on Simon’s work is concentrated on Simon’s bounded rationality model. One important aspect of his work that has not received enough attention is his contribution regarding the role of intuition in decision making. He used the mechanism of how a human brain functions. Simon (1987) postulated that we usually associate rational decisions with those decisions that use conscious analytical investigations to reach a decision while refer to decisions that are intuitive or judgmental as irrational (p. 57). He challenged this view and argued that if the intuitive response is based on the past knowledge that is gathered by the decision maker’s brain in the past, it can be as satisficing as a conscious analytical process of decision making. Therefore, he believed that a theory of decision making had to “give an account of both conscious and subconscious processes” (p. 58). He based his argument on the premise that both the conscious and unconscious parts of the decision making process function the same way and “they involve drawing on factual premises and value premises, and operating on them to form conclusions” (p. 58). Accordingly, the decisions that were formed by those conclusions could be originated through any of the conscious or unconscious processes. He used the analogy of a grandmaster chess player to explain that the player makes his moves very quickly without going through any conscious analysis using his “professional judgment to the situation” (p. 59). He calls this process as intuitive decision making.

Simon contended that stress and time pressure are the major contributors to nonproductive decisions. He believed that we need to make a distinction between “nonrational” decisions which are produced through expert intuition and “irrational” decisions that are produced under stressful conditions and emotions (p. 62). In the final analysis, he argued that good managers are those who are able to make decisions using any of those processes depending on the situation (p. 63). As indicated earlier, Simon’s main focus in the decision making and problem solving arena dealt mainly with its process. That is why, in order to understand Simon’s work, we need to keep a close eye on this central theme.

In cooperation with Newell, Simon developed a computer model called general problem solver (GPS). The main premise of this program was that in the real world, decision makers choose a problem to be solved or a decision to be made as a main goal
and use a “means-end approach” to reach a solution. In this process, the decision maker uses subgoals to remove the distance between his present state with the desired goal (Anderson, 2001, p. 517).

**Contributors to Simon’s views and practically of his model**

Simon’s view on the decision making process was partially influenced by the general systems theory that was originally developed by the biologist Ludwig von Bertalanffy in 1928. Simon used this theory to claim that decision making is the heart of any organization and that it directly influences other part of the organization. He remarked that organizations are composed of interconnected parts and each part contributes to the functioning or malfunctioning of the whole. In addition, Simon himself believed that he was influenced by Chester Irving Barnard. In an interview in 1988, Simon indicated that he “built squarely on Barnard” (Mitchell and Scott, 1988, p. 352). As a major contributor to organization theory, Barnard focused on the decision processes in organizations and he “recognized human limitations in this process” (p. 352).

Simon is also influenced by Pareto who distinguished among different types of human behavior including logical, non-logical, and illogical. Pareto used individual or organizational goals as the yardstick to separate those behaviors that contribute to the achievement of organizational goals. The rational person is considered to be totally logical; on the contrary, an illogical behavior has no root in rationality. Finally, non-logical behavior is demonstrated by those who are goal oriented and rational, but their behaviors interfere by their “sentiments and residues.” Pareto’s idea of differentiated behavior challenged the decision makers’ total rationality and led the way for Simon’s bounded rationality model. Finally, according to Forest and Mehier (2001), Simon and John R. Commons have some commonalities including the concept of human nature. Commons also believed in “internalization of customs through habits as a central point for collective action” (pp. 591-2). In other words, Commons acknowledged the significance of habitual influences in driving his behavior in organizations.

Practicality and accuracy of Simon’s bounded rationality model of decision making has been substantiated through many case studies and research. According to those studies, the neoclassical theory of decision making has been refuted and human experience in organizational decision making clearly indicates that in the real world, the rational model of decision making will not be applicable (Sahpiro, 1997). Many research studies confirm that individual decision makers are not capable of examining all alternatives when facing a decision making situation. In addition, studies show that even in development of different alternatives, individuals do not explore different ramification of those decisions and there are a great deal of evidence that support Simon’s bounded rationality model. Those studies seriously question the rationality of decision making in different areas (Carley and Behres, 1999; Conlisk, 1996; Shleifer, 2000; Thaler, 1988).

**Summary**

Simon was a political scientist by training and started with his work in public administration and political science. Eventually, he moved his ideas more specifically to the economic arena and later devoted his work to cognitive science and finally to psychology. His original book in 1948, as well as his main work in decision making with James March, is considered a major contribution to decision theory (March and Simon, 1958). He created
a revolution in decision making more specifically in delineating the true nature of rational decision making process in public and private organizations. By studying decision making patterns of organizations, he realized that the decision making behavior does not correspond with the “rational theories” of classical and neoclassical approach. Therefore, Simon developed a new theory called “bounded rationality” which is based on the behavior theory. Bounded rationality is originally a psychological concept that has been introduced to economics and administration. He remarked that environmental factors as well as mental constraints limit the behavior of the decision makers in dealing with organizational decision making and in reaching an optimum level of alternatives. Simon postulated that environmental factors such as cost associated with acquiring information, as well as uncertainty about the future events, can severely control the behavior of decision makers. He also stated that asymmetry and incompleteness of information can contribute to the unrealistic view of making rational decisions. These limitations prevent the decision maker from making fully rational decisions that are based on the classical theory of “utility maximization.” Therefore, in the real world the decision makers only make satisficing decisions by using a heuristic approach in searching for alternatives of actions. In the final analysis, regardless of the desire of the decision maker to be rational, he makes satisficing rather than optimizing decisions.

Simon contended that decision makers have to understand the limitation of their decisions in order to make more realistic and accurate predictions. He believed that in order to reach more rational decisions, decision makers have to develop more practical methods of decision making and reach out to other disciplines for assistance. For example, development of more intelligent programs such as AI to assist them in problem solving and decision making is highly effective. Although Simon challenged main premises of classical theory, neoclassical, and SEU model, he did not advocate that they are totally useless. His main point was that they do not work in times of instability, uncertainty, and in a complex world. He argued that those models cannot generate realistic predictions of future events.

References


Further reading

Corresponding author
Behrooz Kalantari can be contacted at: kalantab@savannahstate.edu