



Risk, uncertainty, and heuristics[☆]

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ARTICLE INFO

Article history:

Received 1 September 2013

Received in revised form 1 December 2013

Accepted 1 January 2014

Available online 19 March 2014

Keywords:

Uncertainty

Fast-and-frugal heuristics

Business decision-making

Complexity

ABSTRACT

Nearly a century ago, Frank Knight famously distinguished between risk and uncertainty with respect to the nature of decisions made in a business enterprise. He associated generating economic profit with making entrepreneurial decisions in the face of fundamental uncertainties. This uncertainty is complex because it cannot be reliably hedged unless it is reducible to risk. In making sense of uncertainty, the mathematics of probability that is used for risk calculations may lose relevance. Fast-and-frugal heuristics, on the other hand, provide robust strategies that can perform well under uncertainty. The present paper describes the structure and nature of such heuristics and provides conditions under which each class of heuristics performs successfully. Dealing with uncertainty requires knowledge but not necessarily an exhaustive use of information. In many business situations, effective heuristic decision-making deliberately ignores information and hence uses fewer resources. In an uncertain world, less often proves to be more.

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If we are to understand the workings of the economic system we must examine the meaning and significance of *uncertainty*; and to this end some inquiry into the nature and function of *knowledge* itself is necessary. (Frank Knight, 1921, p. 199)

1. Introduction

At the Federal Reserve's annual policy conference in August 2012, Bank of England's executive director for financial stability, Andrew Haldane, proclaimed: "Modern finance is complex, perhaps too complex. Regulation of modern finance is complex, almost certainly too complex. That configuration spells trouble. As you do not fight fire with fire, you do not fight complexity with complexity. Because complexity generates uncertainty, not risk, it requires a regulatory

response grounded in simplicity, not complexity" (Haldane, 2012). Financial media praised his proposed reform of financial regulations through the use of simple heuristics that can deal with complexity, and *The Wall Street Journal* named Haldane's talk "Speech of the Year." The exploration of simple rules, which can outperform complex algorithms in real world situations—namely, the study of fast-and-frugal heuristics—is the content of a research program that investigates ecological rationality. The term *ecological rationality* refers to functional matches between cognition and environment, and thus generates insight for engineering environments that are most conducive to achieving certain tasks (Gigerenzer, Hertwig, & Pachur, 2011; Todd, Gigerenzer, & the ABC Research group, 2012). A heuristic is ecologically rational to the degree it matches the structure of the environment. Haldane's talk, "The dog and the Frisbee," was named after one of these simple rules – the gaze heuristic – which both dogs and baseball players rely on to solve a difficult problem, namely how to catch an object which is flying against a noisy background (Gigerenzer, 2007).

If dogs or people could reliably estimate all factors that affect the trajectory of a ball or Frisbee, including spin and wind, no heuristics would be needed. Similarly, in most real-world tasks such as reducing the chances of another financial crisis or increasing the financial stability in the economic system environment, these factors are hard to estimate, and calculations can provide illusory certainty (Shefrin, 2013). The study of ecological rationality characterizes both heuristics and the environmental structures in which a given heuristic can be successful for a given task. Heuristic strategies are structurally simple and reliable when optimization algorithms lose feasibility, which makes them

[☆] The title of this paper was inspired by Frank Knight's *Risk, Uncertainty, and Profit*, a work that underlies a major part of the arguments presented here. The authors are grateful to Florian Artinger, Nathan Berg, Jerry Busby, Mario Fific, Mirta Galesic, Kevin Gluck, Hans Haller, Edi Karni, Christian Kim, Sharon Kim, Konstantinos Katsikopoulos, Amit Kothiyal, Adam Litwin, Julian Marewski, Henrik Olsson, Phil Phan, Markus Raab, Florian von Wangenheim, Arch Woodside, and Meng Zhu for providing valuable input in developing this volume, and for pointing us to related literature for this article. Comments and discussions following presentation of this paper at the Department of Economics at Virginia Tech were also extremely helpful. The usual disclaimer applies.

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potentially the best strategies available for particular problems; in cognitive sciences this coincides with normativity.

According to the ecological rationality framework, the knowledge of how people *should* make decisions cannot be studied without considering how people *are able to* make decisions. This view of knowledge, in turn, rejects the segregation of psychology from disciplines such as logic, statistics, and philosophy. In sum, the study of simple heuristics has generated precisely the type of knowledge that allows for normative statements to be made based on descriptive assessments of the human adaptive toolbox, that is, the heuristics people have in their repertoire. Gigerenzer and Sturm (2012) provide a detailed argument for the normativity and naturalization of heuristics, illustrated by cases where norms can be derived from empirical studies of human reasoning.

Heuristics are tools that are developed by direct learning or over the course of evolution. This paper summarizes findings from the study of heuristics in different contexts. When comparing uncertainty of real-world situations with the architecture of calculated risk, it becomes clear that most daily business decision-making situations are of the former type. Moreover, a complex uncertain problem often calls for a simple robust solution. Heuristic strategies are simple rules of thumb that solve complex uncertain situations precisely because of their simplicity, not despite it (Gigerenzer, Todd, & the ABC Research Group, 1999). More calculation, time, and information are not always better. Less can be more.

In the traditional literature on risk management, decision-making situations are classified into three categories: certainty, risk, and uncertainty. Under certainty, each action is known to lead to a certain outcome. Under risk, all outcomes as well as the probabilities of each outcome are known. Under uncertainty, outcomes are still known but not necessarily all their probabilities. Managerial perspectives on risk taking are thus customarily studied with respect to this categorization (Shapira, 1994). While acknowledging the abovementioned situations, we go beyond them to include situations of fundamental uncertainty, in which *some of the alternatives and outcomes, in addition to probabilities*, can be unknown. The term *uncertainty*, here, always means fundamental uncertainty. Many scholars have tried to reduce uncertainty to risk. For instance, Bewley (2002) develops a formalized interpretation of Knightian uncertainty, wherein he treated unknown outcomes by assigning to them an initial probability of zero that can consequently take on non-zero values in the process of decision-making. However, not all problems can be best approached by using the tool of probability theory only. An alternative introduced here is a toolbox of fast and frugal heuristics for decision-making under uncertainty.

2. Decisions under uncertainty are not the same as decisions under risk

Do we live in a world of risk? At the roulette table, yes; in the world of business, rarely. Observe, however, that most of decision theory is based on a risk characterization of the uncertain world. But can risk-based rules successfully apply to a world of uncertainty? It depends. The structural difference between risk and uncertainty calls for rules of dealing with uncertainty that are not compatible with risk calculations unless uncertainty can be reliably reduced to a form of risk. Unique situations, uninsurable risk, and lack of properties that satisfy the mathematics of probabilities are all cases in point. In a world of uncertainty, heuristics are indispensable tools, not second-best solutions.

Frank Knight famously made a consequential distinction between risk and uncertainty in relation to the process of profit generation in the markets. In one of the most interesting reads in economics to date, *Risk, Uncertainty, and Profit* (1921), he first established that perfect competition co-exists with insurable risk. Notably, he argued that the limitations of perfect competition are embedded in the true uncertainty of situation rather than in the imperfection of knowledge. For Knight, generation of economic profit takes place under fundamental or true

uncertainty. Situations of uncertainty are not limited to entrepreneurial cases. In fact, the presence of uncertainty is paramount in a wide range of choice situations in real life. Each of these uncertain situations can be too unique to lend any useful data to statistical analysis and hence preclude not only explicit attainment of even near-perfect knowledge but also measurable probability. Knight provided an illustration (p. 223):

Suppose we are allowed to look into the urn containing a large number of black and red balls before making a wager, but are not allowed to count the balls: this would give rise to an estimate of probability in the correct sense; it is something very different from either the mere consciousness or ignorance on which we act if we know only that there are balls of both colors without any knowledge or opinion as to the numbers or the exact knowledge of real probability attained by an accurate counting of the balls. In the second place, we must admit that the actual basis of action in a large proportion of real cases is an estimate. Neither of these interpretations, however, justifies identifying probability with an estimate. [...] [T]he exact science of inference has little place in forming the opinions upon which decisions of conduct are based, and that this is true whether the implicit logic of the case is prediction on the ground of exhaustive analysis or a probability judgment, a priori or statistical. We act upon estimates rather than inferences, upon “judgment” or “intuition”, not reasoning, for the most part.

Notice that these statements were made prior to the modern formalization of decision theory. A reading of Knight's insights in the post-Savage era goes like this: Where perfect knowledge and measurable probabilities are the pillars of profit maximization in the competitive market and of expected utility maximization for rational individuals, the same methods lose relevance to a good deal of real-world problems on a different scale.

Looked at from the familiar decision theory framework, what Knight provided is a typology of the ways in which the unknown feature of a situation can be formally characterized and assessed. The first type of assessment is a priori probability, which corresponds to propensities, that is, probabilities known by the design of a die or slot machine, not by observation (Daston, 1988). The second type of assessment is based on collecting empirical and experimental evidence/data from repeated observations in the presence of homogeneity towards establishing what Knight called *statistical* probability. These two constitute types of measurable risk. On the other hand, Knight observes that “the actual basis of action in a large proportion of real cases is an *estimate*.” (Ibid., p. 223), which is the type of probability of interest to “the student of business.” For each type of assessment, the process of information and formation of actionable knowledge can be understood as follows. Probability judgment for the a priori (designed) type is deductive, and for the statistical type inductive, whereas decisions of conduct are based on forming an opinion of a Knightian *estimate*. We argue that actions in situations under uncertainty are for the most part based on heuristics not on statistical reasoning.

Table 1 connects Knight's typology with the study of heuristics. For type-1 risk (Knightian a priori probability), a probability distribution is known for the limited known space of outcomes, and the information is used to form a deductive knowledge of the situation. The best action simply requires an optimization, or maximization of utility. Type-2 risk (Knightian statistical probability) deals with situations of inductive reasoning. Here, samples and observations have to be collected and aggregated to infer the properties of the true probability distributions. These statistical processes are subject to the trade-off between accuracy and effort. In contrast, decision making under uncertainty refers to situations in which the probabilities cannot be reliably estimated (what Knight called “estimates” or “intuition”) or where the set of alternatives and their consequences are not known in the first place (what we refer to as *uncertainty*). In this situation, probability theory and statistics can no longer find the best solution and other inductive tools are needed, such as heuristics. These heuristics are not subject to the accuracy-effort trade-off — their simplicity is the reason they perform well, by properly matching the heuristic strategy with the environment. Finding the optimal course of action can become infeasible in novel and unique

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