The Behavioural Finance Revolution

A New Approach to Financial Policies and Regulations

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BEHAVIOURAL FINANCIAL REGULATION AND POLICY (BEFAIRLY) SERIES

Edward Elgar PUBLISHING

Cheltenham, UK • Northampton, MA, USA

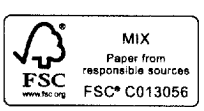
Published by
Edward Elgar Publishing Limited
The Lypiatts
15 Lansdown Road
Cheltenham
Glos GL50 2JA
UK

Edward Elgar Publishing, Inc.
William Pratt House
9 Dewey Court
Northampton
Massachusetts 01060
USA

A catalogue record for this book
is available from the British Library

Library of Congress Control Number: 2018954371

This book is available electronically in the **Elgar**online
Economics subject collection
DOI 10.4337/9781788973069



ISBN 978 1 78897 305 2 (cased)
ISBN 978 1 78897 306 9 (eBook)

Typeset by Servis Filmsetting Ltd, Stockport, Cheshire
Printed and bound in Great Britain by TJ International Ltd, Padstow

10. The heuristics revolution: rethinking the role of uncertainty in finance

Gerd Gigerenzer

Ants use heuristics to measure the area of a candidate nest cavity. Humans rely on elimination heuristics to choose a smartphone from hundreds of options. Animals, humans and machines may even use one and the same heuristic. The gaze heuristic is relied on by dogs to catch frisbees, by baseball outfielders to catch fly balls and by the Sidewinder air-to-air missile to intercept enemy planes (Hamlin, 2017). Scientific discovery has also been based on heuristics; the term appears in the title of Einstein's 1905 Nobel Prize winning paper on quantum physics.

The term *heuristic* is of Greek origin, meaning "serving to find out or discover". Heuristics and analysis are not contraries but instead tools for different problems. For the mathematician George Polya, heuristics are needed for finding a proof and analysis for checking it. The economist Frank Knight distinguished situations of risk, where probabilities are known by design or through long-run frequencies, from situations of uncertainty, where probabilities are not knowable. Jimmy Savage (1954), the "father" of Bayesian decision theory, limited the theory to problems where the full state space is known, such as when playing a lottery, and emphasized that it does not apply to situations where unexpected events may happen, such as planning a picnic (1954, p. 16). Finally, Herbert Simon introduced the term *satisficing* for decision making under uncertainty, where the assumptions of neoclassical economics do not hold.

In finance, however, the distinction between risk and uncertainty is rarely made. Following the portfolio allocation framework of Markowitz and Merton, the assumption is that problems can be treated as if they involved risk only. The behavioral finance revolution, as it is called, has not challenged this assumption; rather, it has largely accepted risk models as a universal norm and attributed deviating behavior to flaws in the human mind rather than in the risk model. In this chapter, I argue that finance might consider taking uncertainty and heuristics more seriously.

Specifically, I argue:

1. *In situations of risk where the future state space is known, fine-tuned complex risk modeling is likely to succeed.* A state space is the exhaustive and mutually exclusive set of future states of the world, their consequences and their probabilities (Savage, 1954). Situations of risk do not require heuristics, except for saving time by attaining quick-and-dirty solutions.
2. *In situations of uncertainty where the future state space is not known, fast and frugal heuristics are likely to succeed.* Under uncertainty, fine-tuned optimization models tend to be fragile, overfit noise and create illusions of certainty.

The aim of this chapter is to use some of the insights from the study of the ecological rationality of heuristics (for example, Gigerenzer et al., 2011; Gigerenzer and Selten, 2001a) to sketch a new framework for rethinking behavioral finance. This is not to say that fine-tuned models should be dispensed with, but that these should be understood as one tool in the toolbox, alongside heuristic tools. In reference to the "probabilistic revolution", I will call this program the "heuristics revolution" (Gigerenzer, 2014).

THE PROBABILISTIC REVOLUTION

The probabilistic revolution differs from the scientific revolutions of Galileo, Darwin or Einstein. Unlike these, it did not revolutionize a specific discipline, but instead provided new intellectual tools – probability theory and statistics – that eventually transformed theories in many disciplines (Krüger et al., 1987). The probabilistic revolution replaced the determinism of Newtonian physics with the indeterminism of statistical mechanics and quantum mechanics while also revolutionizing genetics, evolutionary theory and scientific experimentation. The beginning of probability theory dates back to 1654, when the mathematicians Blaise Pascal and Pierre Fermat solved gambling problems. From the beginning, mathematical probability has had three interpretations: design, as of roulette tables; relative frequencies in the long run, as in mortality tables; and degrees of belief, as in the evaluation of eye witness testimony in court (Daston, 1988). Design and frequency became the definition of what Knight (1921) called "risk". Risk can be insured against, but not genuine uncertainty. Yet uncertainty, as opposed to risk, allows for profit. The probabilistic revolution also provided the mathematical tools for the central pillars of finance, such as the mean-variance model of Markowitz in the 1950s, the

capital asset pricing model (CAPM) of the 1960s and the option theory of Black, Scholes and Merton. These tools have created an impressive body of theory tailored to situations of risk.

The problem with applying these tools to finance is that banks do not play roulette or lotteries; they act in an uncertain world. Under uncertainty, risk models can create illusions of certainty. For instance, in 2003, the distinguished macroeconomist Robert Lucas declared in his Presidential Address to the American Economic Association that economic theory had learned its lesson from the Great Depression and succeeded in protecting us from future disaster: "Its central problem of depression-prevention has been solved, for all practical purposes, and has in fact been solved for many decades" (Lucas, 2003, p. 1). Four years later, the precision of modern economic theory proved to be an illusion.

Behavioral finance emerged with the intention of eliminating the psychological blind spot in finance but ended up portraying psychology as the source of irrationality. Although it could have extended the risk models and systematically studied how people *should* make decisions under uncertainty, the dominant version did not. Rather, it mostly took risk models, or *Homo economicus*, as the benchmark for rational decisions and attributed deviations to shortcomings in people rather than in models. The result is a large catalogue of anomalies and cognitive biases (Thaler, 2015). These biases have attained the status of truisms, ignoring psychological research that cautions against this overly negative view of human nature. For example, what has been called gambler's fallacy, the hot-hand fallacy, overconfidence and framing errors have been shown to reflect realistic judgments, except under very specific situations (for example, Gigerenzer, 2015; Hahn and Warren, 2009; Miller and Sanjuro, 2018; Mousavi and Gigerenzer, 2011).

In the wake of designing ever more sophisticated mathematical models that assume risk, curiosity about how successful investors actually make decisions has been lost. As Soros (2008) put it,

> I contend that rational expectations theory totally misinterprets how financial markets operate. Although rational expectations theory is no longer taken seriously outside academic circles, the idea that financial markets are self-correcting and tend towards equilibrium remains the prevailing paradigm. [. . .] I contend that the prevailing paradigm is false and urgently needs to be replaced. (p. 6)

Behavioral finance would have gone in a very different direction had it followed Herbert Simon's lead to take uncertainty seriously, take heuristics seriously and study the heuristics that help make good decisions under uncertainty.

THE HEURISTICS REVOLUTION

Like the probabilistic revolution, the heuristics revolution is not specific to a discipline but provides intellectual tools. The heuristics revolution complements the probabilistic revolution in three ways:

1. takes uncertainty seriously rather than generally assuming risk;
2. studies the heuristics in individuals' and organizations' toolbox of strategies; and
3. studies the ecological rationality of heuristics, that is, the environmental conditions under which heuristics can be expected to outperform more complex strategies.

Taking Uncertainty Seriously

The former governor of the Bank of England, Mervin King, once said: "If only banks were playing in a casino, then we probably could calculate approximate risk weights."[1] So true. But even a casino has to face uncertainty. Taleb (2007) describes how the management of a Las Vegas casino handled their core business risk. They calculated gambling odds, diversified risk across tables and countered cheating. Nevertheless, they experienced their main losses outside these situations of risk. The worst loss occurred when their star artist, performing his famous tiger act, was attacked by the tiger. The second-worst loss occurred when a disgruntled former contractor tried to dynamite the casino. Next, a clerical employee failed to file tax reports over a long period, exposing the casino to a major fine and almost losing its license. Finally, the daughter of the owner was kidnapped and the owner violated gambling laws by using casino money to pay her ransom.

To an even greater extent than the world of a casino, the world of finance is largely one of uncertainty. Under uncertainty, fine-tuned risk models lead to overactive policy and modeling noise. In his Nobel lecture "The pretense of knowledge", Hayek (1974) spoke about the perils of assuming omniscience. Friedman (1960) proposed a k-percent policy heuristic in the absence of certainty and Simon (1989) called for a systematic study of how people make decisions when the assumptions of neoclassical theory are not met. Despite these calls, we do not yet have such a theory of finance under uncertainty.

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[1] http://www.bbc.co.uk/news/business-11624994.

The Study of the Adaptive Toolbox

The adaptive toolbox of an individual or institution is the repertoire of heuristics at their disposal. The study of the adaptive toolbox is descriptive (as opposed to the prescriptive study of ecological rationality; see below) and models the heuristics people use, including their building blocks. Building blocks of heuristics include rules for how to search for information, when to stop searching and how to make a final choice. Recombining the building blocks enables heuristics to be adapted to new problems (Gigerenzer and Gaissmaier, 2011). In general, a heuristic is a strategy that uses only limited information, with the goal of making decisions faster, more frugal, more robust, more transparent and more accurate than would be the case with fine-tuned complex strategies. Consider a simple example.

One of the theoretical pillars of modern finance theory is the mean-variance optimization portfolio by Harry Markowitz. When Markowitz made his own investments for the time after his retirement, one would assume that he used his mean-variance method. What he did, however, was to rely on a fast and frugal heuristic known as the 1/N rule: invest your money equally across the N options. If N = 2, this means a 50:50 allocation, and so on. From the point of view of behavioral finance, 1/N is a behavioral bias, the so-called naïve diversification bias, which is attributed to people's cognitive limitations. This attribution clearly would not apply to Markowitz. DeMiguel et al. (2009) tested 1/N against the mean-variance method and reported that 1/N outperformed it in six out of seven allocation problems, as measured by the Sharpe ratio and other criteria. Under uncertainty, the asset weights for the mean-variance portfolio tend to be unstable over time and perform poorly out of sample. Moreover, none of a dozen more sophisticated allocation methods, such as Bayesian models and minimum variance with various constraints, could consistently outperform 1/N. The authors calculated that for N = 50, one would need 500 years of data before mean-variance might surpass the simple heuristic. Even this calculation requires the future to resemble the past, assuming that the same stocks – and the stock market itself – are still around in the year 2500. Thus, the real question is: can we identify the conditions under which heuristics such as 1/N can be expected to outperform more complex strategies? This challenge is the focus of the study of the ecological rationality of heuristics.

The Study of Ecological Rationality

The study of ecological rationality is a normative discipline. Its results are conditions under which the performance of heuristics is expected to

exceed that of more complex methods, and vice versa. Its tools are proof, computer simulation and principles of methodology.

Methodological principles

The study of ecological rationality is based on three principles:

1. formal models of heuristics;
2. competitive testing of heuristics against strong competitors; and
3. testing of predictive accuracy instead of data fitting.

There is room for these principles in current behavioral finance and economics. First, the heuristics proposed to date are mostly vague labels rather than formal models. Prominent examples are the availability heuristic, representativeness, and the affect heuristic. These labels cannot predict behavior, but only "explain" almost every behavior after the fact. For instance, the meaning of *availability* is constantly changed in the literature, from ease of recall to the number of instances recalled to the vividness of instances recalled, and so on, even though these are not the same psychological processes and appear not even to be correlated (Sedlmeier et al., 1998). In contrast, heuristics such as 1/N, fast-and-frugal trees or the recognition heuristic make predictions that can be tested. Second, formal models of heuristics need to be tested against the strongest competitors in a field, such as machine learning algorithms (Brighton and Gigerenzer, 2015). Finally, prediction means that performance is evaluated in foresight (out-of-sample or out-of-population) rather than in hindsight by fitting parameters to known data. For Friedman (1953), prediction is the goal of economic models, not realism of assumptions. This maxim cautions against models with many free parameters, which can easily achieve a better fit than simpler models, whereas the simple models may achieve better prediction.

Why less can be more

A formal way to understand when and why heuristics can predict better than complex models with more free parameters is the bias-variance dilemma from machine learning (Brighton and Gigerenzer, 2015; Geman et al., 1992). Consider the problem of estimating the true value μ in a population on the basis of random samples. Each of S samples ($s = 1, \ldots, S$) generates an estimate x_s. The variability of these estimates x_s around their mean $\bar{x}$, which is called *variance* in machine learning, is another source of prediction error. The variance component reflects the sensitivity of the predictions to different samples drawn from the same population. Thus, the prediction error (the sum of squared error) can be captured in the equation:

$$\text{Prediction error} = \text{bias}^2 + \text{variance} + \varepsilon,$$

where bias = $\bar{x} - \mu$, that is, the average deviation of the mean of the sample estimates from the true value, and variance = $1/s\ \Sigma(x_s - \bar{x})^2$, that is, the mean squared deviation of the sample estimates from their mean $\bar{x}$.

The term "bias-variance dilemma" refers to the empirical fact that by reducing bias one typically increases variance, and vice versa. For instance, one can reduce bias by adding free parameters, but this is likely to increase error due to variance. Or one can reduce variance by deleting free parameters, but that is likely to increase error due to bias.

Let us apply the bias-variance dilemma to understand the conditions under which 1/N can outperform mean-variance. The mean-variance method has both bias and variance as sources of error. Bias means that its modeling assumptions deviate from the unknown true state. Variance is the key factor in why its estimates are empirically unstable, because of overly fine-tuning from historical samples, where small changes in the estimated asset returns or correlations can have large effects on the estimates. In contrast, 1/N has no free parameters, that is, its allocation is not sensitive to the peculiarities of samples. Thus, 1/N has zero error due to variance. Yet this comes at the price that it is likely to have a larger bias than mean-variance.

Therefore, the question is whether the squared bias of the heuristic is larger than the sum of the squared bias and the variance of the mean-variance portfolio. The size of the bias can only be known if the true value is known. However, we know that the sample size and number of free parameters (which is a function of N) influence variance. This leads to the hypothesis that the smaller the sample size and the larger the number N of assets, the greater the advantage of 1/N over mean variance.

Note that the bias-variance analysis assumes repeated sampling from a stable population and thus represents only a minimal form of uncertainty due to sampling error. In contrast, the situation in investment rarely corresponds to sampling from a stable population, which means that other factors besides sample size and number of assets will determine whether the heuristic or mean-variance can be expected to lead to better returns. There are studies that report that 1/N is superior to complex methods and others that report the opposite. Typically, the debate is about whether the heuristic or the complex methods are better. That is the wrong question. The actual question concerns ecological rationality: what is the set of conditions under which we can expect 1/N to outperform mean-variance or similar fine-tuning methods, and what are the conditions under which we can expect fine-tuning to pay?

In sum, heuristics are reasonable tools for making decisions under

uncertainty and not mental quirks, as often portrayed in behavioral economics and behavioral finance. In what follows, I sketch out a systematic program for analyzing heuristics in finance in three areas of application: financial literacy of the general public, professional investment and design of regulatory rules.

FINANCIAL LITERACY FOR THE GENERAL PUBLIC

Literacy is the ability to read and write. Financial literacy is the ability to manage personal finances. In the Western world, we have taught almost everyone reading and writing, but not financial literacy. The Jump$tart Survey administered every two years to 12th-grade students demonstrates the lack of progress made in the US. Similarly, a representative study in Germany showed that 18 to 84-year-olds could correctly answer, on average, only 59 percent of questions measuring "minimal economic knowledge". People with a college or university degree performed 10 percentage points better than those without, readers of serious newspapers also performed 10 points better than readers of the yellow press and men 8 points better than women (Wobker et al., 2014). For every hour per day a person watched TV, his or her score dropped by 1.5 points. Most alarmingly, people who said they had taken an economics course performed no better than those who hadn't. Similar lack of financial literacy has been documented worldwide, and I will not attempt to provide an overview here (see Drexler et al., 2014).

But knowledge is not enough. In Germany, two-thirds of adults know that stocks and bonds result in higher returns yet prefer to invest their money in savings accounts and insurances (Ergo, 2018). Few studies have analyzed what people actually do when they invest. A study with customers in Italian cooperative banks is an exception. Cooperative banks are non-profit institutions whose aim is to support the economic development of people living in the area.

What do Bank Customers Think about Risk?

Ninety-nine active bank customers at an Italian cooperative bank who had investments of at least 40000 euros were asked to list three associations that came to mind when they thought about risk (Monti et al., 2011). The most prevalent associations, in the order of their frequency, were: "loss", "equities", "investment", "fear", "attention: danger!", "Argentinian bonds", "bankruptcy", "negative" and "avoid".

Most of these associations were emotionally negative, and none corresponded to economic definitions of financial risk such as volatility. The advisors of the customers reported that it was very difficult to help them arrive at an appropriate understanding. Customers were also asked how highly they trusted the nation's bank system. On an 11-point Likert scale, with 11 indicating high trust, the majority of customers responded with 3 to 5 (Monti et al., 2014). That is, customers were fairly distrustful of the banking industry. Given this distrust, one might think that customers would take time to learn how to protect their money. However, more than 40 percent of the customers said that they spend less than one hour a month on thinking about their investments and insurances, despite (or because of) their lack of basic financial literacy.

How do Bank Customers Invest?

How do bank customers make investment decisions given that they lack financial literacy, perceive risk-taking negatively, lack trust in the nation's banking system and spend little time thinking about how to invest? The answer is: they trust their personal advisor. The vast majority of the customers gave trust scores of 8 to 10 for their financial advisor, compared to only 3 to 5 for the nation's banking system (Monti et al., 2014). The average customer proceeds roughly in this way:

- *Step 1: Check trustworthiness.* Customers first check whether they can trust a financial advisor. This decision is made by social signals alone, not by matter-of-fact questions that test the advisor's competence. Psychological research suggests that in the absence of financial literacy, trust is inferred from interaction cues such as whether the advisor listens, smiles, nods and maintains eye contact. If these cues are in place, the customer finds the advisor trustworthy.
- *Step 2: Delegate decision.* If Step 1 results in trust, then customers delegate the decision about their investment to the advisor. As a result, the vast majority of bank customers do not play an active role in the management of their money. A common request is: "Please help me make this decision as if I were your mother (father)".
- *Step 3: Go with what you know and avoid risk.* If advisors suggest more than one option to invest in, customers rely on two elimination criteria to choose the final investment. The first is name recognition: investments from companies whose name the customer recognizes are preferred; others tend to be eliminated. The second criterion is risk: if an investment is said to have low risk, this is preferred; if it

is said to have moderate or high risk, it is likely eliminated (Monti et al., 2012).

The typical Italian bank customer is woefully unprepared to make an informed decision. The same appears to hold in most countries. There is also a striking similarity between financial and medical decision-making. As surveys have documented, few European citizens are health literate (Gigerenzer et al., 2009; Mata et al., 2014). In this situation, most patients go through Steps 1 and 2 outlined above and rely on the *white-coat heuristic*, that is, trust their doctor (Wegwarth and Gigerenzer, 2013). Step 3, in contrast, is specific to bank customers. Lack of health literacy exposes people to health risks, such as by not vaccinating children against MMR or exposing them to unnecessary CT scans with high doses of radiation. Lack of financial literacy exposes people to becoming victims of fraudulent activities, as the subprime crisis showed, which dealt with largely inexperienced and uninformed customers.

Financial Heuristics for the General Public

What can be done to improve the situation? Governments and non-governmental organizations across the world have begun to teach financial literacy. The operational definition of financial literacy in most programs is "knowledge of financial concepts and facts" such as compound interest, stocks and bonds, and product attributes. The problem we have to face is that these interventions to improve financial literacy explain only 0.1 percent of the variance in financial behavior, as a meta-analysis of 201 studies concluded (Fernandes et al., 2014). Larger effects reported in correlational studies appear to be due to lack of control of intervening factors. This result is consistent with the previously reported fact that economic courses did not improve minimal economic knowledge in Germany (Wobker et al., 2014). Is there an alternative to teaching facts?

I propose teaching not just financial concepts but heuristics. Financial heuristics are rules that specify what to do in a given situation. 1/N is an example, as is "invest 1/3 in stocks, 1/3 in bonds, and 1/3 in real estate" or "don't buy financial products you don't understand". Had the latter rule been observed before 2007 by everyone on both sides of the Atlantic, the financial crisis would probably not have happened on such a large scale. Teaching heuristics means teaching behavior, and it should be taught "just-in-time", that is, at a time when the behavior is relevant to an individual.

In a randomized study with more than 1000 micro-entrepreneurs in the Dominican Republic, one group received standard accounting training, a second training in financial heuristics and a third group served as control

(Drexler et al., 2014). The classes were offered in a weekly three-hour session for a period of five to six weeks. For example, the standard accounting training taught the participants how to separate business and personal accounts by calculating profits based on a typical accounting curriculum. In contrast, the heuristics training taught a concrete physical rule: to keep their money in two separate drawers or purses and only transfer money with an explicit IOU ("I owe you"). The authors reported that the accounting training failed to improve financial practices, while the heuristics training led to better practices: its participants were more likely to keep accounting records, calculate monthly revenues and separate their business and personal books. In addition, objective reporting quality improved and errors were reduced. Similarly, Shefrin and Nicols (2014) describe fast and frugal heuristics that help consumers make effective budgeting decisions when using credit cards.

We need a research program that systematically studies which heuristics are useful for the general public and which teaching methods can successfully add these heuristics to people's adaptive toolbox. Finally, we need to find out how to teach individuals about the ecological rationality of heuristics, that is, in what situation to use what heuristic.

Financial Literacy versus Nudging

Teaching heuristics aims at making people competent and self-reliant. In contrast, the program of "nudging" relies on methods from marketing and advertising to steer people into behavior that is deemed desirable by government authorities (Thaler and Sunstein, 2008). This program of "libertarian paternalism" is based on the claim that because people have systematic cognitive biases that lead to harmful decisions and can hardly be educated out of these biases, governments should step in and steer people toward their own good. The claim that people can hardly learn how to deal with risk and uncertainty, however, is incorrect. Experiments have shown that people can learn quickly if they are taught in an adequate way (Bond, 2009; Gigerenzer, 2015). For instance, people are said to fall prey to the base rate fallacy, which means ignoring base rate information when making Bayesian-type inferences (Kahneman, 2011; Thaler and Sunstein, 2008). In contrast, psychological research has shown that people can learn in less than two hours to make correct Bayesian inferences (Sedlmeier and Gigerenzer, 2001) and even fourth-graders can reason the Bayesian way (Zhu and Gigerenzer, 2006). Nudging may be an effective short-term solution, but in the long term, it will not teach people to manage their personal finances, leaving them instead in the same state of ignorance as that of the Italian bank customers described above. Moreover, nudging

may serve as an excuse for not protecting consumers from industry that markets unhealthy products. The House of Lords (2011) criticized the British government for nudging citizens rather than considering more efficient options such as prohibiting television advertising of products high in sugar, salt and fat.

A few centuries ago it was said that ordinary people would never learn to read and write. When finally schooling became mandatory for every child, as in many countries across the world, this assumption proved to be wrong. Today, it is said that the general public might never learn to take care of their personal finances. We need to repeat the same experiment, this time for financial literacy, with everyone, in school and beyond.

HEURISTICS FOR INVESTMENT

Traders have always used trading rules that resemble heuristics, going back to the pioneers of "technical analysis" (Forbes et al., 2015; Lo and Hasanhodzic, 2010). A source for heuristics is Graham's *The Intelligent Investor* (1973 [2003]), which Warren Buffet praises as "by far the best book on investing ever written" (p. ix). Haug and Taleb (2011) argue that option traders use heuristics, not the Black–Scholes–Merton formula: "Option traders use (and evidently have used since 1902) sophisticated heuristics and tricks more compatible with the previous version of the formula of Louis Bachelier and Edward O. Thorp" (p. 1). For traders, hedging, pricing and trading are an extremely rich craft based on heuristics, with traders learning from traders or by copying successful traders. In the absence of probability theory, such rules have often been dismissed by academics. Finance theory has to some extent lost its curiosity about what successful investors actually do and instead teaches risk models that traders should allegedly use, thereby "lecturing birds how to fly" (Haug and Taleb, 2011).

Overviews on heuristics in business can be found in Gigerenzer et al. (2011) and Gigerenzer and Gaissmaier (2011). Here, I will illustrate professional decision making with a single class of heuristics: satisficing. Satisficing applies to situations where one has to choose one option among many, and where the state space is unknown or unknowable.

Satisficing: Set an aspiration level α, and invest in the first object that meets α.

Consider investment decisions in the real estate business. Berg (2014) studied entrepreneurs in the Dallas–Fort Worth greater metropolitan area who need to decide in which location to invest, that is, where to develop a commercial high-rise or a residential area. He reports that

every single one of the 49 professionals relied on a version of the above satisficing heuristic:

> If I believe I can get at least x return within y years, then I take the option.

The time horizon y was typically one to three years, and x a *prominent* number. Prominent numbers are powers of 10, their halves, and their doubles (that is, 1, 2, 5, 10, 20, 50, . . .). For instance, convenience store and gas station investors required at least 10 percent annual return on capital within one or two years. Most of the entrepreneurs considered only one, two or three options; not a single one tried to determine the point at which the marginal benefit of search equals its costs. Many expressed skepticism that such calculations could be made in one-off decisions in high-stakes and quickly changing environments.

Every heuristic can be adapted if it does not work. In the case of satisficing, the aspiration level can be adapted:

> *Satisficing with aspiration level adaptation*: Set an aspiration level α and invest in the first object that meets α. If no object meets α within time β, then lower alpha by γ and start again.

A study of 628 BMW dealers offering 328000 used cars showed that 97 percent of the dealers priced their used cars with aspiration-level adaptation, including 19 percent that relied on satisficing without adaptation (Artinger and Gigerenzer, 2016). The most frequent version was to set an initial price in the middle of the price range of similar cars, to keep the price constant for about four weeks and, if the car is not sold, then lower the price by 2 to 3 percent. Dealers adapted their choice of parameter values to the characteristics of the environment in which the dealership is located. Consider the duration β. With every additional competing dealer in the region, the duration the price was kept constant decreased by about 3 percent. For every 1000 euros in GDP per capita in the region, β increased by 1 percent. There was no fine-tuning of prices to market conditions during the observation period, despite drastic changes of up to 50 percent in supply. Randomizing prices was also absent. A comparison with the best "mixed strategy" pricing model showed that the aspiration-level heuristics made substantially higher profit, in fact more than doubling the profit. Even the simple constant price satisficing strategy was superior.

Satisficing also provides a realistic alternative to the concept of "net present value" (Magni, 2009). To determine the net present value of a project or option, it needs to be compared to the return rate r of the next-best

option available, which is known as the opportunity cost of capital. That is, by investing in a project, one forgoes the opportunity to earn a rate of return on one's capital. Trying to maximize the net present value is an impossible task in many investment decisions, given the usually enormous number of options and ways to produce a given commodity, which rules out exhaustive search across all possibilities.

The satisficing rule replaces the return r of the next-best option with the aspiration level α. This spares the investor from wasting time on solving a task that is, by definition, not solvable under uncertainty. By satisficing, knowing and evaluating all future options are no longer necessary.

Besides satisficing, numerous other investment heuristics have been documented, some of which have been put to competitive testing in prediction. For instance, Peter Lynch (1994) suggested that a lack of name recognition is grounds for eliminating a stock from consideration. This rule is a version of the recognition heuristic "invest only in stocks you have heard of". The heuristic is ecologically rational if there is a relationship between recognition, market share and profitability of companies. Borges et al. (1999) tested the recognition heuristic with laypeople and business students in Chicago and Munich, measuring their recognition of hundreds of American and German stocks. Then they created eight "recognition portfolios", that is, portfolios containing the most recognized stocks (laypersons vs. students; Americans vs. Germans; US stocks vs. German stocks). The recognition portfolios outperformed randomly chosen portfolios, the Dow and Dax, the American Fidelity Blue Chip Growth Fund and the German Hypobank Investment Capital Fund. The recognition portfolios also outperformed control portfolios with the most unrecognized stocks. Ortmann et al. (2008) report similar results for a bear market (but see Boyd, 2001). The conditions under which the recognition heuristic can succeed are generally known (Goldstein and Gigerenzer, 2002), but no such analysis exists for financial investment.

In sum: under uncertainty, investors rely on satisficing and a rich repertoire of other heuristics. Finance can profit from extending its scope from risk models to uncertainty and to the study of the ecological rationality of heuristics under these conditions.

COMPLEX OR SIMPLE REGULATION?

Although the Federal Reserve in Washington DC hosts some 300 PhD economists, they did not foresee the subprime crisis. Financial regulation, as embodied in Basel II and III, relies on complex models such as value at

risk (VaR). To compute its value at risk, a large bank may have to estimate thousands of risk factors and, because these are dependent, additionally estimate the matrix of millions of correlations. Such a procedure might increase safety in a casino, but there is no evidence that it has done the same in the uncertain world of banking. For financial regulation, it may in fact have the opposite effect. Complex risk estimation increases the opportunities for gaming the system and creates new opportunities for excessive risk taking while following the rules. For instance, the requirement of estimating millions of risk factors offers many degrees of freedom and, by using internal models, banks can reduce their capital by picking the "right" estimates.

Complexity breeds complexity. When complex regulations fail, the idea is to make them more complex. The Basel Accord of 1988, the first genuinely international prudent regulatory agreement, was only 30 pages long. Basel II, agreed on in 2004, came in at 347 pages. A few years later the financial crisis hit. The revised framework from 2010, Basel III had grown to 616 pages.

Against this background, Andy Haldane, then Executive Director of Financial Stability of the Bank of England, gave a noteworthy Jackson Hole speech in 2012, entitled "The dog and the frisbee" (Haldane and Madouros, 2012). The title referred to the gaze heuristic, used by dogs to catch frisbees and baseball outfielders to catch fly balls (Gigerenzer and Selten, 2001b). Haldane began systematically to study the potential of heuristics in regulation in a collaborative project between the Bank of England and the Max Planck Institute for Human Development (Aikman et al., 2014). This research indicates that simple methods can dominate more complex modeling approaches for calculating banks' capital requirements, especially when data is limited and with fat-tailed distributions. It also showed that simple leverage ratios outperformed risk-weighted metrics in predicting individual bank failure in a sample of 100 large global banks at the end of 2006. Finally, fast-and-frugal trees – robust trees that rely on only a few indicators – can provide transparent alternatives to information-intensive regression techniques and are easier to communicate. Under conditions that are not yet understood, fast-and-frugal trees can be even better at prediction than the most sophisticated tools of machine learning (Katsikopoulos et al., 2017). The bias-variance dilemma provides a first approximation to understand why this is so.

In his 2005 Mais Lecture, Mervyn King, then governor of the Bank of England, made a similar case for using fast-and-frugal heuristics in central banking. Specifically, he suggests heuristics for setting interest rates and controlling inflation, depending on environmental conditions

such as whether or not the economy has been hit by a large shock. The proposal to simplify the regulatory framework, however, requires a philosophical shift in regulators' thinking. In financial regulation, less may be more.

A systematic study of heuristics for regulation would also need to deal with the moral hazard problem. Taleb and Sandis (2013) describe the "skin in the game" heuristic for protection against tail events. They propose that everyone who makes financial decisions should have his or her own money in the game. J.P. Morgan, the preeminent financier of his time, operated his firm as a partnership with unlimited liability, which meant that with every deal, Morgan put his own personal wealth on the line (Dowd et al., 2011). This liability changes the focus from short-term to long-term profitability, reduces extensive risk taking to careful risk taking and makes gaming the system to get away with inadequate capital largely pointless. Personal liability can also reduce the practice of hiding risks in off-balance sheet vehicles that mask the true leverage ratio of banks. More generally, skin in the game can be considered as a heuristic for a safer and more just society. Implementing "skin in the game" together with other heuristics (Taleb, 2015) would be a promising move toward a safer world of finance. It also would free banks of much of the complicated paperwork, stress testing and supervision.

TOWARD A SYSTEMATIC STUDY OF HEURISTICS IN FINANCE

Herbert Simon left us with an unfinished task: a theory of decision making under uncertainty. Such a theory should make two contributions. First, it should describe how individuals and institutions actually make decisions. This entails going beyond "as-if" theories of expected utility maximization. Second, the theory should be able to deal with situations of uncertainty where "the conditions for rationality postulated by the model of neoclassical economics are not met" (Simon, 1989, p.377). In other words, it should extend beyond risk to realistic situations where the future state space is not knowable.

The world of finance is a prime candidate for Simon's program. This chapter provides only a sketch of how we could get there. This sketch can be worked out in more concrete detail. And it may help in rethinking the nature of behavioral finance.

REFERENCES

Aikman, D., Galesic, M., Gigerenzer, G., Kapadia, S., Katsikopoulos, K.V., Kothiyal, A., Murphy, E. et al. (2014), 'Taking uncertainty seriously: Simplicity versus complexity in financial regulation', Bank of England Financial Stability Paper, No. 28, London: Bank of England.

Artinger, F.M. and Gigerenzer, G. (2016), 'The cheap twin: From the ecological rationality of heuristic pricing to the aggregate market', in J. Humphreys (ed.), *Proceedings of the Seventy-sixth Annual Meeting of the Academy of Management*, online ISSN: 2151-6561.

Berg, N. (2014), 'Success from satisficing and imitation: Entrepreneurs' location choice and implications of heuristics for local economic development', *Journal of Business Research*, **67**, 1700–709.

Bond, M. (2009), 'Risk school', *Nature*, **461**, 1189–92.

Borges, B., Goldstein, D.G., Ortmann, A. and Gigerenzer, G. (1999), 'Can ignorance beat the stock market?', in G. Gigerenzer, P.M. Todd and the ABC Research Group, *Simple Heuristics That Make Us Smart*, New York, NY: Oxford University Press, pp. 59–72.

Boyd, M. (2001), 'On ignorance, intuition and investing: A bear market test of the recognition heuristic', *Journal of Psychology and Financial Markets*, **2**, 150–56.

Brighton, H. and Gigerenzer, G. (2015), 'The bias bias', *Journal of Business Research*, **68**, 1772–84.

Daston, L. (1988), *Classical Probability in the Enlightenment*, Princeton, NJ: Princeton University Press.

DeMiguel, V., Garlappi, L. and Uppal, R. (2009), 'Optimal versus naive diversification: How inefficient is the 1/N portfolio strategy?', *Review of Financial Studies*, **22**, 1915–53.

Dowd, K., Hutchinson, M., Ashby, S. and Hinchcliffe, J.M. (2011), 'Capital inadequacies: The dismal failure of the Basel regime of bank capital regulation', *Policy Analysis*, **681**, 1–38.

Drexler, A., Fischer, G. and Schoar, A. (2014), 'Keeping it simple: Financial literacy and rules of thumb', *American Economic Journal: Applied Economics*, **6**, 1–31.

Ergo (2018), *Ergo Risiko-Report 2018: Über die Risikokompetenz und Eigenverantwortung der Deutschen.* Accessed at https://www.risikoreport.de/assets/files/ergo-risiko-report.pdf.

Fernandes, D., Lynch, J.G. Jr, and Netemeyer, R.G. (2014), 'Financial literacy, financial education, and downstream financial behaviors', *Management Science*, **60**, 1861–83.

Forbes, W., Hudson, R., Skerratt, L. and Soufian, M. (2015), 'Which heuristics can aid financial decision-making?', *International Review of Financial Analysis*, **42**, 199–210.

Friedman, M. (1953), *Essays in Positive Economics*, Chicago, IL: University of Chicago Press.

Friedman, M. (1960), *A Program for Monetary Stability*, New York, NY: Fordham University Press.

Geman, S., Bienenstock, E. and Doursat, R. (1992), 'Neural networks and the bias/variance dilemma', *Neural Computation*, **4**, 1–58.

Gigerenzer, G. (2014), *Risk Savvy: How to Make Good Decisions*, New York, NY: Viking.

Gigerenzer, G. (2015), 'On the supposed evidence for libertarian paternalism', *Review of Philosophy and Psychology*, **6**, 363–83.
Gigerenzer, G. and Gaissmaier, W. (2011), 'Heuristic decision making', *Annual Review of Psychology*, **62**, 451–82.
Gigerenzer, G., and Selten, R. (eds) (2001a), *Bounded Rationality: The Adaptive Toolbox*, Cambridge, MA: MIT Press.
Gigerenzer, G. and Selten, R. (2001b), 'Rethinking rationality', in G. Gigerenzer and R. Selten (eds), *Bounded Rationality: The Adaptive Toolbox*, Cambridge, MA: MIT Press, pp. 1–12.
Gigerenzer, G., Hertwig, R. and Pachur, T. (eds) (2011), *Heuristics: The Foundations of Adaptive Behavior*, New York, NY: Oxford University Press.
Gigerenzer, G., Mata, J. and Frank, R. (2009), 'Public knowledge of benefits of breast and prostate cancer screening in Europe', *Journal of the National Cancer Institute*, **101**, 1216–20.
Goldstein, D.G. and Gigerenzer, G. (2002), 'Models of ecological rationality: The recognition heuristic', *Psychological Review*, **109**, 75–90.
Graham, B. (1973 [2003]), *The Intelligent Investor* (revised edn), New York, NY: HarperBusiness Essentials.
Hahn, U. and Warren, P.A. (2009), 'Perceptions of randomness: Why three heads are better than four', *Psychological Review*, **116**, 454–61.
Haldane, A.G. and Madouros, V. (2012), 'The dog and the frisbee', 31 August, accessed at https://econpapers.repec.org/article/fipfedkpr, pp. 109–59.
Hamlin, R.P. (2017), '"The gaze heuristic:" Biography of an adaptively rational decision process', *Topics in Cognitive Science*, **9**, 264–88.
Haug, E.G. and Taleb, N.N. (2011), 'Option traders use (very) sophisticated heuristics, never the Black–Scholes–Merton formula', unpublished manuscript.
Hayek, F.A. (1974), 'The pretense of knowledge', Nobel Prize Lecture, accessed 12 April 2018 at https://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/1974/hayek-lecture.html.
House of Lords: Science and Technology Select Committee (2011), *2nd Report of Session 2010–12: Behaviour Change*, London: Authority of the House of Lords.
Kahneman, D. (2011), *Thinking, Fast and Slow*, London: Allen Lane.
Katsikopoulos, K.V., Durbach, I.N. and Stewart, T.J. (2017), 'When should we use simple decision models? A synthesis of various research strands', *Omega*, advance online publication.
King, M. (2005), 'Monetary policy: Practice ahead of theory. The Mais Lecture 2005: Speech by the Governor', *Bank of England Quarterly Bulletin*, Summer, accessed at SSRN: https://ssrn.com/abstract=753989.
Knight, F.H. (1921), *Risk, Uncertainty and Profit*, Boston, MA: Houghton-Mifflin.
Krüger, L., Gigerenzer, G. and Morgan, M. (eds) (1987), *The Probabilistic Revolution: Vol. 2. Ideas in the Sciences*, Cambridge, MA: MIT Press.
Lo, A. and Hasanhodzic, J. (2010), *The Evolution of Technical Analysis*, Chichester: Wiley.
Lucas, R.E. (2003), 'Macroeconomic priorities', *American Economic Review*, **93**, 1–14.
Lynch, P. (1994), *Beating the Street*, New York, NY: Simon & Schuster.
Magni, C.A. (2009), 'Investment decisions, net present value and bounded rationality', *Quantitative Finance*, **9**, 967–79.
Mata, J., Frank, R. and Gigerenzer, G. (2014), 'Symptom recognition of heart

attack and stroke in nine European countries: A representative study', *Health Expectations*, **17**, 376–87.
Miller, J.B. and Sanjuro, A. (2018), 'Surprised by the gambler's and hot hand fallacies? A truth in the law of small numbers', *Econometrica*, forthcoming.
Monti, M., Boero, R., Berg, N., Gigerenzer, G. and Martignon, L. (2012), 'How do common investors behave? Information search and portfolio choice among bank customers and university students', *Mind & Society*, **11**, 203–33.
Monti, M., Martignon, L., Pelligra, V. and Guglielmetti, C. (2011), 'The insurance by my side: Better risk assessment for smarter insurance decisions', CAREFIN Working Paper No. 3/2011, Milan: Universita Bocconi.
Monti, M., Pelligra, V., Martignon, L. and Berg, N. (2014), 'Retail investors and financial advisors: New evidence on trust and advice taking heuristics', *Journal of Business Research*, **67**, 1749–57.
Mousavi, S. and Gigerenzer, G. (2011), 'Revisiting the "error" in studies of cognitive errors', in D.A. Hofmann and M. Frese (eds), *Error in Organizations*, New York, NY: Taylor & Francis, pp. 97–112.
Ortmann, A., Gigerenzer, G., Borges, B. and Goldstein, D.G. (2008), 'The recognition heuristic: A fast and frugal way to investment choice?', in C.R. Plott and V.L. Smith (eds), *Handbook of Experimental Economics Results: Vol. 1 (Handbooks in Economics No. 28)*, Amsterdam: North-Holland, pp. 993–1003.
Savage, L.J. (1954), *The Foundations of Statistics*, New York, NY: Wiley.
Sedlmeier, P. and Gigerenzer, G. (2001), 'Teaching Bayesian reasoning in less than two hours', *Journal of Experimental Psychology: General*, **130**, 380–400.
Sedlmeier, P., Hertwig, R. and Gigerenzer, G. (1998), 'Are judgments of the positional frequencies of letters systematically biased due to availability?', *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **24**, 754–70.
Shefrin, H. and Nicols, C.M. (2014), 'Credit card behavior, financial styles and heuristics', *Journal of Business Research*, **67**, 1679–87.
Simon, H.A. (1989), 'The scientist as problem solver', in D. Klahr and K. Kotovsky (eds), *Complex Information Processing: The Impact of Herbert A. Simon*, Hillsdale, NJ: Erlbaum, pp. 375–98.
Soros, G. (2008), *The Crash of 2008 and What it Means*, New York, NY: Public Affairs.
Taleb, N.N. (2007), *The Black Swan: The Impact of the Highly Improbable*, New York, NY: Random House.
Taleb, N.N. (2015), 'Ten principles for a Black Swan-proof world', *Financial Times*, 8 January, accessed 9 April 2018 at http://www.ft.com/cms/s/0/5d5aa24e-23a4-11de-996a-00144feabdc0.html#axzz3ODQQN9bc.
Taleb, N.N. and Sandis, C. (2013), 'The Skin In The Game heuristic for protection against tail events', *Review of Behavioral Economics*, **1**(1), 115–35.
Thaler, R. (2015), *Misbehaving: The Making of Behavioral Economics*, New York, NY: Norton.
Thaler, R.H. and Sunstein, C.R. (2008), *Nudge: Improving Decisions About Health, Wealth, and Happiness*, New Haven, CT: Yale University Press.
Wegwarth, O. and Gigerenzer, G. (2013), 'Trust-your-doctor: A simple heuristic in need of a proper social environment', in R. Hertwig, U. Hoffrage and the ABC Research Group, *Simple Heuristics in a Social World*, New York, NY: Oxford University Press, pp. 67–102.

Wobker, I., Kenning, P., Lehmann-Waffenschmidt, M. and Gigerenzer, G. (2014), 'What do consumers know about the economy? A test of minimal economic knowledge in Germany', *Journal für Verbraucherschutz und Lebensmittelsicherheit*, **9**, 231–42.

Zhu, L. and Gigerenzer, G. (2006), 'Children can solve Bayesian problems: The role of representation in mental computation', *Cognition*, **98**, 287–308.