New Frontiers Beyond Risk and Uncertainty:

Ignorance, Group Decision, and Unanticipated Themes

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What are the major challenges confronting the world today? Among the top few, many people would list recovering from the world's prolonged recession, dealing with Islamist terrorism, and coping with climate change. Yet a mere fifteen years ago, none of these issues would have been a prominent concern. Big surprises in the policy sphere vividly illustrate the uncertainty of our world and the importance of strategies for coping with uncertainty. Many of the chapters in this volume point the way for policy makers. Our concern here as well will be with individuals making decisions on their own behalf.

Risk, which is a situation where probabilities are well defined, is much less important than uncertainty. Casinos, which rely on dice, cards and mechanical devices, and insurance companies, blessed with vast stockpiles of data,[1] have good reason to think about risk. But most of us have to worry about risk only if we are foolish enough to dally at those casinos or to buy lottery cards to a significant extent. Indeed, we should now understand that many phenomena that were often defined as involving risk – notably those in the financial sphere before 2008 – actually involve uncertainty. Portfolio theory built on assumed normal distributions is a beautiful edifice, but in the real financial world, tails are much fatter than normality would predict.[2] And when future prices depend on the choices of millions of human beings and on the way those humans respond to current prices and recent price movements, we are no longer in the land of martingales protected from contagions of irrationality. Herd behavior, with occasional stampedes, outperforms Brownian motion in explaining important price movements.

[1]Actually, many insurance companies cannot do this, because changes in risk levels may affect many of their policyholders simultaneously. For example, an insurance company writing annuities based on old life tables would have gone broke given the rapid increases in life expectancy since 1900.

[2] Thus, the stock market can drop 20% in one day in October 1987, without any clear explanatory event.

The medical field is another realm where risk gets vast attention. Terms such as *relative risk ratios* and *survival risk* pepper the literature. But a patient who presses a physician will learn that aggregate statistics do not apply to the individual's case, that the physician and delivery institution can significantly affect risk levels, and that no data are so finely parsed as to predict individual outcomes. Uncertainty rules.

Though risky situations themselves play only a limited role, sophisticated thinking about risk has proved beneficial to decision makers ever since Daniel Bernoulli presented his solution to the St. Petersburg paradox nearly 400 years ago.[3] Utility theory is now a well-developed field that is built on an axiomatic basis, and most economists and decision theorists (EDTs) know how to make choices when confronted with lotteries that have outcomes with well-defined probabilities. (See chapters 1-4.) Unfortunately, the way most EDTs would counsel people to make choices is not the way most individuals do make choices. The last several decades saw major efforts in two realms chronicling the discrepancies between prescribed behavior and actual behavior. (See chapter 14.) First, a vast number of experiments were conducted asking individuals to make choices that involve the use of marbles and urns, or their equivalents. .The most famous early investigations produced the Allais and Ellsberg Paradoxes. Then, with psychologists originally taking the lead, experimental methods became a mainstay of the economics literature, most particularly when examining choices under risk and uncertainty. An array of significant heuristics and biases were identified; prospect theory was developed (Kahneman and Tversky,

[3] Pioneering work on probability by Blaise Pascal and Pierre Fermat a century earlier was primarily oriented to predicting distributions, not to making choices. Pascal's wager, of course, is helpful to those who take seriously the possibility of infinite negative utility, a possible outcome with, for example, the frequently employed logarithmic utility function for money. Studies of the value of statistical life – see chapter 7 – make clear that such infinite valuations make little sense, since the loss of life is a very bad outcome, much worse than the loss of money.

1979). Second, significant analytic work was undertaken by economists to develop alternative frameworks for rational choice, frequently relaxing or altering one of the classic axioms. (See chapters 12 and 13.) Among EDTs, there is somewhat less agreement than there was a few decades ago on how individuals should make choices, though the classical model still has overwhelming majority support. And the greater question, of what we should do if individuals' actual behavior departs from EDT-prescribed behavior, is much debated. For example, if individuals do greatly feel regret, if they find themselves to be naturally strongly ambiguity-averse, should scholars in the field wag their fingers in disapproval or incorporate these proclivities into the prescriptive model?

Let's posit that we accept utility theory, without specifying which particular strand of utility theory. Such an understanding is essential if we need to make decisions where one can only define the probabilities of outcomes on a subjective basis. The other essential is determining how to define those subjective probabilities.

1. Uncertainty, Always With Us, But Not Always Recognized by Economists

Uncertainty plays a major role at the individual scale (how to invest or what medical treatment to select) and at the societal scale (how to bolster the economy or confront terrorism). Uncertainty also plays a leading role at the middle scale, in describing and explaining market behavior. However, fifty years ago, in economists' study of economy-wide, market, and individual behavior, uncertainty did not receive much attention.

In an interesting twist, the great economists of the more distant past attended to the overwhelming role of uncertainty, and the difficulties individuals had in making decisions in uncertain contexts. Adam Smith was perhaps the first economist to recognize that individuals making real-world decisions were not only confronted with unknowable outcomes, but that, in dealing with such outcomes, the mathematical theory of probability was not helpful (Brady, 2013).

Ricardo and Keynes were extraordinarily successful speculators who understood that prices – reflections of uncertainty – could easily go awry in financial markets. I suspect that they knew then, intuitively, much that has only in recent decades become established in decision theory.

After World War II, academic economics moved into the modern era with a big extra dose of mathematical formalist; the rigor was good. But a negative side effect was that uncertainty was left by the wayside for a period. Drawing inspiration from the highly uncertain real world was not sufficient to spur the profession. It seemed that the study of economics had to wait for an appropriate theory before it could catch up. (Chapters 5-11, which focus on uncertainty, demonstrate that the discipline has caught up.)

Turn back the clock 50 years. In 1962, Stigler's classic piece on the "Economics of information" was just one year old (Stigler, 1961). Kenneth Arrow published his famed paper on "Uncertainty and the welfare economics of medical care" in 1963 (Arrow, 1963).[4] Were these symptoms of a

[4] To be sure, Arrow and Debreu had, in the prior decade, elegantly identified the conditions for general equilibrium given uncertainty. However, as Arrow points out in this volume, the applicability was limited, since all bets were made contingent on exogenous events.

broad movement, or mere early movers in a lagging literature? Let's examine the American Economic Review, the Journal of Political Economy, and the Quarterly Journal of Economics of that period. In 1962, few articles dealt with risk or uncertainty. By contrast, today's journals bristle with articles recognizing the difficulties for market participants of making choices when outcomes are not known. The table below tells the story.

Table 1. Articles on Risk and Uncertainty in Leading Journals (American Economic Review, Journal of Political Economy, Quarterly Journal of Economics)[*]

1962

	Theoretical	Empirical	Both	Total
Neither	51	51	5	107
Risk	1	0	0	1
Uncertainty	3	2	0	5
Both	0	0	0	0
Total	55	53	5	113

2012

	Theoretical	Empirical	Both	Total
Neither	50	94	5	149
Risk	13	15	2	30
Uncertainty	9	3	1	13
Both	4	1	0	5
Total	76	113	8	197

Percentages

	1962	2012
% Articles with Risk	0.9%	15.2%
% Articles with Uncertainty	4.4%	6.6%
% Articles with Either Risk or Uncertainty	5.3%	21.8%

[*] Andrew Kim compiled this table. Details are available from the author.

In 1962, a mere 5.3% of articles in these three leading journals addressed risk or uncertainty. Fifty years later, the percentage had risen to 21.8%. Our scholarly undertakings today are doing a better job of reflecting the real world.

The world was no more certain in 1962 than it is today. At that time, few macroeconomists thought that the business cycle had been conquered; 40 years later, most did. (Then, the collapse of 2007-08 surprised virtually everyone, including economists.) In the 1960s, the biggest threat ever to world civilization, namely nuclear war, was a major and highly uncertain prospect. In those years, people were still starting businesses that would fail or succeed; students were deciding whether or not to invest in college educations; and folks were speculating on financial markets. There was plenty of raw material for the study of uncertainty. However, uncertainty had not yet made its grand entrance into economic theory, perhaps because the field had not yet made sufficient intellectual progress. Modern portfolio theory, a very elegant apparatus that developed from the 1950s through the 1970s, did not offer much insight into uncertainty. Portfolio theory assumed efficient markets and rational decisions makers, implying that prices reflected expected values and that the world was described by normal distributions and by their godchild, Brownian motion. Black-swan events, sucker investors, and enormously successful speculators existed, but not in economists' models.

Note the contrast between blinkered economics and open-eyed physics, a field that receives a great deal of envy from economists. Several centuries ago, pioneering physicists accurately described the world of our everyday experience. More than one century ago, they started describing real-world phenomena that few of us can even contemplate, such as subatomic

particles, relativity, and quantum mechanics, often at the submicroscopic or cosmic level. No doubt the empirical revolution in economics – the rush of the field to observe and explain in great detail happenings in the marketplace – helped to promote the delayed venture of the economics field into the realm of uncertainty.

This handbook documents the arrival, admittedly belated, of social-science understanding of this realm. Virtually all bases are covered in its pages. In the preceding preface, Kenneth Arrow, an economist who has contributed as much as any to our understanding of risk and uncertainty, briefly traces the path of a number of giants on whose shoulders we stand. Not surprisingly, physicists and mathematicians get as much mention in his essay as economists. The volume's theme chapters consist of fifteen essays that describe the current economic understanding of risk and uncertainty.

My preface, though following directly on Arrow, is metaphorically a back bookend. It speculates on some issues that might be added to this manual when it is updated a decade from now.

2. Ignorance

Economists now understand that risk is a terrific subject for gamblers, for students in high school math, and for insurance companies having data that enable them to predict the probabilities of micro outcomes with reasonable reliability.[5] But for investors, business folks, government

[5] A while back, this tally might (mistakenly) have included bettors on pari-mutuel markets. Equity markets, in effect, represent specialized versions of such markets, where there is only a single price for expected values. The

officials, physicians, international diplomats, those in romantic pursuit, and parents of young children, indeed for almost anybody else, risk is an intriguing subject that bears little relation to the real decisions they face. Unknown outcomes confront these players every day, and the probabilities are virtually never known nor knowable. Uncertainty, not risk, is the difficulty regularly before us. That is, we can identify the states of the world, but not their probabilities. A disturbing statistic about the present literature is in the table above: only 30% of the 2012 articles on risk and uncertainty address uncertainty. [6] Yet the distinction between risk and uncertainty was drawn more than 90 years earlier by Frank Knight in the classic Risk, Uncertainty and Profit (Knight, 1921). More important, uncertainty characterizes much more of economic activity than does risk.

I propose that there exists a third class of situation, which I call *Ignorance*, that is likely to get substantial attention in a future handbook. Ignorance arises in a situation where some potential states of the world cannot be identified. Ignorance is an important phenomenon, I would argue, ranking alongside uncertainty and above risk. Ignorance achieves its importance, not only by being widespread, but also by involving outcomes of great consequence.

Consider the societal level and the case of the United States. Among the major problems currently confronting that nation are terrorism, climate change, and an unforeseen financial collapse and the subsequent economic crisis. As the century turned, the United States basked in the knowledge that significant terrorism could not be experienced on its soil. Yet, the next year

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behavioral finance literature, combined with such phenomena as the Internet bubble of the late 1990s and the financial meltdown of 2008, belies the ability of such markets to reflect regularly accurate valuations.

[6] Interestingly, more than 80% of the few 1962 articles on risk and/or uncertainty addressed uncertainty.

the US suffered a massive attack by an unforeseen means. Twenty-five years ago, climate change hardly registered among public concerns. Yet today it is considered by many experts to be the greatest long-term threat to the nation and the world. But our ignorance continues. Those experts, much less worried citizens, have little idea in what ways climate change will prove most consequential. And from a US national defense standpoint, the most consequential event of the past quarter century was hardly anticipated: the Soviet Union simply collapsed. The US, with thousands of experts providing guidance, proved poorly equipped to identify a significant state of the world that actually did occur.

Ignorance comes in two modes: Recognized and Unrecognized. Unrecognized means that we are venturing forth, not anticipating that something we have not even conjectured might occur. Minor developments, those of little consequence, may surprise us. Thus, we run into an old roommate while wandering in the bazaar in Marrakech or sell out the first run of our book, occurrences we thought impossible. But these are not our concern. However, major unexpected developments, those of great consequence, also happen and they are our topic. Discovering that one's wife is having an affair with one's best friend, that one's minor research idea blossoms into a grand economic insight, or that one's widow-safe investment plummets in price by 90%, these are amazing events that come out of the blue. And to the individual, they are highly consequential. They make Ignorance important to consider.

Ignorance, although it cannot be conquered, can be defended against. An attentive decision theorist cannot see into the future, but should always contemplate the possibility of consequential surprise. A decision maker should always be aware of the factor of Ignorance and should try to

draw inferences about its nature from the lessons taught by history, from experiences recounted by others, from accounts given in the media, from possibilities developed in literature, etc.[7] Decision makers who anticipate Ignorance in this fashion are in a situation of Recognized Ignorance.

To assess how important is Ignorance, once Recognized, one must pay attention to consequences, c, probabilities, p, and the number of discrete events, n, about which one is ignorant. Here c is measured in absolute value; a big consequence can be positive or negative. In theory at least, one would have a prior on each of p and c. The expected consequences of Ignorance would then be computed as

$$\sum_{i=1}^{n} p_i \bullet c_i \, .$$

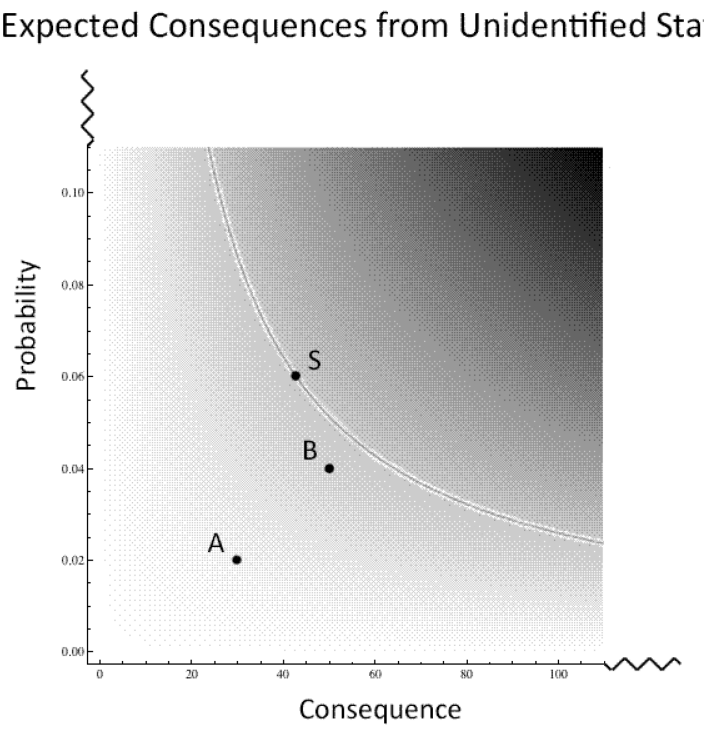
An exactly equivalent estimate would be derived by assessing the overall likelihood of a consequential surprise (the sum of the p_i values), and then multiplying that sum by the weighted average of the consequences. This latter approach might be simpler to think about. But we must admit that assessing these values given Ignorance is pushing the limits of subjective assessment. Perhaps a better term would be conjectural assessment.[8]

Here is an illustration of our Ignorance estimation involving two events, labeled A and B, of which decision makers might be ignorant. Note, when measuring consequences, an upside outcome is just as important as a downside outcome. Thus, c is measured in absolute values.

[7] Some of these ideas are developed in *Ignorance: Lessons from the Laboratory of Literature*, written jointly with English literature scholar Devjani Roy.

[8] A further complexity would recognize uncertainty on n, which would require a summation as well over different values of n. Moreover, it would be desirable to have a joint distribution on n and the p values, since with more unimagined states, there is less density available for each one.

The figure shows the expected consequences, with darker shading indicating greater expected consequences. Taking A and B together takes us to point S, where its consequence is the expected value of consequence given that A or B occurs. Along the rectangular hyperbola through S, or indeed along any rectangular hyperbola, expected consequences are constant.



Though this summation is exact, another way to get the same result would be to assess the overall probability of a consequential unexpected event and multiply it by the expected consequence of such an event. We believe this shortcut might be helpful in thinking about this very intractable problem. Unfortunately, numerous behavioral biases, such as overconfidence and the availability heuristic, can lead us to under- or overestimate the importance of Ignorance.[9]

[9] Alas, a number of biases would also impede our ability to learn from past unexpected events. For instance, cognitive dissonance might lead us to believe that we had anticipated an event which, in fact, we had not imagined at all. See the paper cited in footnote 7.

The rational study of the prevalence of Ignorance, and of how to cope with Ignorance, we expect, will get considerable attention in the next Handbook of the Economics of Risk and Uncertainty. If so, the title should be expanded to include Ignorance.

3. Group Decision

A large portion of the most important decisions are made in groups. Many of those groups are informal, a family or a collection of friends. Often, the group will have some official status, such as a tenured faculty or a corporate board, but their decision processes will resemble informal decision making. A typical pattern would be a discussion, a struggle for consensus, and then a decision. A large portion of group decisions, like many individual decisions, are made under conditions of uncertainty, and often of Ignorance.

Kenneth Arrow's book, Social Choice and Individual Values (Arrow, 1951), launched an extensive literature on the potential for, or, more accurately, the impossibility of, effective collective decision. For decades, scholars have cherry picked axioms, starting with those of Arrow, to either barely cross into the territory of satisfactory collective decision processes or into the territory of unsatisfactory ones. This literature, however, has not yet led to many contributions that could be cited in this volume. Quite simply, despite the real world importance of the subject, economics has made little progress in explaining how groups should or do make decisions when confronted with risk and uncertainty. Arrow's Theorem deals with the certainty case and with individuals who know their preferences. Moreover, his Independence of Irrelevant Alternatives axiom effectively rules out cardinal preferences, such as von Neumann-Morgenstern utilities, which are required for decision making under uncertainty.

However, the literature on asymmetric information is highly relevant not only to uncertainty issues (see chapters 5 and 6), but also to group decision. Even though a group's decision may face no uncertainties, its member's preferences may be private.[10] Can those preferences be accurately elicited and still processed into an optimal decision? The Gibbard-Satterthwaite Theorem (Gibbard, 1973; Satterthwaite, 1975), an early major contribution, revealed the answer to be negative.[11] For any voting system, either voters have an incentive to vote strategically, or some other highly unattractive situation must obtain, such as dictatorship; otherwise, certain alternatives have no potential to be chosen. Here, we see the beginnings of the curse of asymmetric information in group decision processes.

Now consider a much more complex situation where uncertainty prevails about the state of the world. Moreover, individuals possess private information about the likelihood of various outcomes, and they also have their own preferences, and those preferences may be private information. This sounds like a cascade of complications piled upon a framework such as the Gibbard-Satterthwaite Theorem. Yet this is the world that surrounds us, one that we encounter when we step into a legislative body, a business negotiation, or a family meeting.

Group decisions under uncertainty, on matters large and small, pervade our lives. It seems clear that no mechanism to ensure wondrously satisfying choices across a broad range of contexts will ever emerge. But surely we can do better than the current undisciplined approaches that

[10] See Weyl (2013) for a recent analysis of successful group decision processes when cardinal preferences are permitted, yet information on preferences must be solicited.
[11] Zeckhauser (1973) presents a closely related negative result for voting schemes.

characterize so many group decisions. Many members of important groups could not even describe the procedures by which their groups make choices. Many groups have no routines, much less agreed-upon procedures, by which they gather assessments on possible outcomes, their probabilities, and the payoffs to participants that depend on the alternative selected and the outcome realized.[12]

Moreover, many decisions are made by multiple agents who share information but are in no sense members of a group. Exemplars would be the macroeconomists who adjust their predictions for the economy in light of the predictions made by others, and the investment banks which "learned and got reassurance" from one another as they invested heavily in mortgage-backed securities before the 2008 meltdown. When relatively orderly, such clusters of agents might be described as *decision webs*; when disorderly, as *decision tangles*. Frequently, the decisions in such clusters exert strong reciprocal externalities – as they do in research consortia – and the agents develop informal modes of cooperation. Sometimes there is a coordinating entity, equivalent to the center in economic theory models or to the owner of a shopping mall, that facilitates coordination. The center's goal should be to turn tangles into webs that are effective decision-making instruments.

In short, the situation described above represents a grab bag of methods. Most methods were chosen for considerations (for example, that all votes should count equally) other than effective decision making. Many have just evolved with too little time for natural selection to work its

[12] Some groups, notably legislatures, have formal rules that discipline discussion and voting procedures. But those rules hardly require agents to provide information in the most useful form, such as separating probability assessments from preferences. And most legislatures on most issues only secure information input from a small percentage of their members.

wonders. Few have been tested to see how well they facilitate well-reasoned decisions. And none, as we remarked, is likely to produce wondrously satisfying choices.

By the time the next handbook is published, it is to be hoped, economics will have made progress on better mechanisms for making group decisions under uncertainty. This will require that theories and experimentation, and perhaps some cross-sectional analyses, to come together to upgrade our current and inadequate methods. Research on how to improve group decisions will resemble less players' efforts to improve their personal skills than a team's efforts to maximize overall performance.

The potential for effectively addressing uncertainty in group decisions will be boosted if some helpful assumptions are made. Positing that agents have common interests goes a long way. Robert Wilson's rigorous theory of syndicates (Wilson, 1968) showed that, absent common interests, side payments have great potential to help.[13] In addition, two assumptions that are commonly invoked are that there is agreement on the prior distribution of all parameters and that the search should be for a Bayesian equilibrium. The combination of side payments and these two assumptions enables group decision makers to elicit honest information on both probabilities and preferences and to decide optimally when certain reasonable conditions are met on payoff structures (Miller et al., 2007). Unfortunately, few group decisions allow for side payments, and for fewer still do the agents have common priors on all parameters. We suspect that in future studies on the theoretical potential of effective group decision under uncertainty, negative results

[13] An extension of the Vickrey (1961) second-price auction successfully elicits honest preferences when making a public decision. Individuals vote the amount by which they prefer one alternative over another. The high total wins, and an individual whose vote changes the outcome is charged the net amount other players lose due to the change. (See subsequent work on this subject by Edward Clarke, Theodore Groves, Nicolaus Tideman and Gordon Tullock.)

will far outweigh the positive. No doubt, some decision processes will work on a decentralized basis, perhaps with individuals anonymously feeding in information via the Internet. Large numbers have some potential to ameliorate some problems; they tend to dampen and possibly eliminate the rewards to strategic behavior. We can hope.

Whatever technologies are developed for modes of collective decision making, we must recognize that most group decisions are still likely to fall far short of the optimum. Information will be hidden or misreported, preferences will be distorted implying that decision A will be taken when decision B would be better for all. This suggests that we should lower our aspirations and that the search should be for solid second-best performers, for doing fairly well on average.

A distinctive challenge of behavioral decision making is that individuals are concerned not only with what decision is taken, but with their standing within the group. Think of an ordinary classroom, and the potential to utilize the wisdom of crowds. The teacher asks a question. If all 25 students could work on it together, whether it be factual or conceptual, the prospects for success would be great. Consider the simplest case of multiple-choice answers. The class members could go beyond mere voting, even achieving sophisticated voting in which they changed their choices to reflect how others had voted in prior rounds until they reached an equilibrium.

A far superior strategy would milk more information, with individuals revealing why they did not pick particular alternatives and sharing whatever information they had about alternatives.

Posit two very favorable conditions: 1. A big payoff, perhaps $1,000, to each for each correct answer. 2. The students would have no future connections besides the single classroom exercise. With a bit of practice, we suspect that the students would do extremely well. However, most classrooms and most decision problems do not enjoy these two favorable conditions. Thus, individuals are concerned not only with what decision is taken, but also with their standing within the group. In an ordinary classroom, the first two students are called upon and answer alternative B. It then becomes difficult for the third cold-called student to recommend C, though that was his original choice. From what he has learned from others, he may actually think that B is the most likely correct answer, and he does not want to be embarrassed in front of the class. In this way, vast amounts of information can get suppressed. Indeed, the second student may have had little independent information suggesting that the first student, who thought B was slightly more likely than A or C could well influence the entire class to B, when there was substantial information in the class favoring C.

This problem would be compounded if the answers had political salience, or were thought to. Other-directed individuals would be hesitant to express an answer they thought others might not like. Even if there were no political sensitivities, merely the thought that there might be could lead to information suppression or distorted reports. In an agency context, concerns about the boss's views could lead to misreports if both probabilities and preferences were in play. Posit that the boss has proposed a project and asks for reactions. A loyal employee, who fully shares the boss's preferences, might be hesitant to express doubts about the project's success for fear that the boss might think he didn't like the project's goals.

No doubt, thinking along these lines has helped support the role of the secret ballot over the years. But such ballots are employed in highly specialized contexts, rarely as part of ordinary decision processes. Anonymous decision processes have advantages, but they also have grave weaknesses. For example, if we wish agents to invest to gain information, a public good, anonymous decision processes permit free riding. When both preferences and probabilities are involved, agents lose the chance to interpret shared information on the basis of: "I know where you are coming from. Might more anonymous decision processes – now much more feasible given social media – improve outcomes in some realms? Economics, now venturing strongly into becoming an experimental science, might yield some answers in the future.

4. Unanticipated Themes

Consistent with the discussion of Ignorance above, some of the greatest advances in the realms of risk and uncertainty will be in areas that we cannot currently identify. New technologies and new scientific understandings will surely develop. What do the human brain and the disembodied Internet have in common? They both have almost incomprehensible levels of information-processing capacity. The US has recently committed to a major research undertaking on the structure and functioning of the brain, recognizing that it represents an important new frontier. The Internet, a technology that hardly existed a couple of decades ago, is enabling remarkable new information-gathering, data-processing, and decision-making opportunities. Surely our improved understanding and use of super processors, as well as the steady march forward of the Internet and of those who build on it, will lead to bold discoveries of ways to deal with uncertainty.

It is worth reiterating that the economics of risk and uncertainty lost its vitality in a prison of methodology that did not admit the real world. Uncertainty pervades many important real-world phenomena that have received less attention from economics than they deserve. Their study will provide not merely improved understanding of those phenomena, but, more generally, of uncertainty.

Macroeconomics surely will have a different bent ten years from now, when its leading practitioners will have digested the lessons of the unforeseen financial meltdown and its lingering aftermath. Technological advance is a watchword on the lips of most political and business leaders, but our mastery of our expanding capabilities remains rudimentary, as does our understanding of the entrepreneurs who are impelling us forward. Venturing beyond the traditional confines of economics, how can we understand the often precipitous and unexpected social movements – the products of decisions taken by millions of individuals, and now accelerated by social media – that disrupt social mores, topple empires, and bring about religious revivals and declines? This is surely an arena where experts in uncertainty and decision making can make contributions.

5. A Final Word

Uncertainty and its much more elusive cousin Ignorance make it virtually impossible for a handbook to provide a definitive statement of what is known about situations in which outcomes are unknown and unknowable. Use this handbook as a launching pad. Recognize the role of Ignorance in life. Then help to create the breakthroughs in decision theory – those that can be hoped for and those that we cannot yet contemplate – that will make life better for all.

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