AFOSR Workshop on Catastrophic Risks June 1 & 2, 2012 at SRI Stanford, California

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Abstracts

1. "Bliss, Catastrophe, and Rational Policy"

by Kenneth J. Arrow

Professor of Economics (Emeritus), Stanford University

I will review the standard arguments that risk-bearing can be represented as maximization of the expected value of a bounded utility function. These go back to Daniel Bernoulli's original resolution of the St. Petersburg paradox (1738) and the critical analysis by Karl Menger (1935). These are based on continuity assumptions, which are crucial. These original arguments were directed to the possibility of an infinitely-valued state of bliss, but they apply equally or even more strongly to the notion of the opposite, a catastrophe. I will argue informally that human behavior does not really seem to imply an infinite negative value of any state. Finally, I consider the argument that fat-tailed distributions are peculiarly likely to lead to infinite optimal values (positive or negative). This is offset by the consideration that the distributions of natural or anthropogenic events are usually bounded away from infinities by physical or biological considerations. This is related to an alternative analysis of the St. Petersburg paradox based on the impossibility that the stakes can actually be paid.

2. "Probability, Conditionals and Strategic Decisions"

by Brian Skyrms

Distinguished Professor of Social Science, Logic & Philosophy of Science School of Social Sciences, University of California, Irvine; Professor of Philosophy at Stanford University

Some catastrophic risks are strategic, involving other decision makers. These essentially involve conditional reasoning of the form, "what would they do if I did this" and "what would I do in return". Sometimes the hypothesis of the conditional involves irrational, or counter-theoretical

actions. The logic of such conditionals is well-understood in the case of a known deterministic theory of actions, but not so well-understood in a probabilistic setting. I present a probabilistic theory involving families of partitions (or sigma-algebras), which gives the received deterministic theory as a special case. This theory fits well with modified probability frameworks to be discussed by other participants.

3. "Economic Crises: Natural or Unnatural Catastrophes?"

by Alan P. Kirman

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We are accustomed to discussing the stochastic processes underlying extreme events in general and natural catastrophes in particular but the events which arguably cause the most harm are economic crises. Yet, in macroeconomic models, sudden and major upheavals in the state of the economy with disastrous consequences are attributed to exogenous shocks for which little explanation is provided. This contribution suggests how we can develop models in which such large shocks are endogenous and describes the sort of process the states of the economy would follow. Whilst the exact predictability of the onset of major crises may not be enhanced by this approach, such models do exhibit crises, and may help us to identify the symptoms that warn of their onset.

4. "Catastrophes, Rare Events, and Black Swans: Some Methodological Issues"

by Peter J. Hammond

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Villegas, Arrow and Fishburn all introduced a monotonicity axiom so that Savage's characterization of subjective probability within an expected utility (EU) decision model could be extended to demonstrate existence of a countably additive subjective probability measure. In several recent papers, Chichilnisky has explored a particular weakening of this monotonicity

axiom that allows a revised decision theory in which rare events, catastrophes, perhaps even "black swans" can be given more prominence. It may be useful to contrast her approach with some alternative attempts to treat such issues. First, economic catastrophes can be modeled as events so extreme that a suitable money metric utility function is undefined unless the probability of a catastrophe is sufficiently low. Second, rare events can be modeled as having infinitesimal probability in an extended EU theory that is formulated to have "non-Archimedean" probabilities in the metric space completion of the smallest algebraic field that contains both real numbers and one basic infinitesimal. Third, there can be "true" black swans --- like members of the biological species cygnus atratus, which were unknown to most of the world before Willem de Vlamingh voyaged to Western Australia in 1697. Such events, unlike those described in Taleb's book, may not even be imagined ex ante. Even so, their possible effects on the consequences of modeled current decisions can be allowed for, at least in principle, within a suitably modeled EU decision model using an "enlivened" version of the usual decision tree.

5. "Optimal Statistic Decisions with Catastrophic Risks"

by Graciela Chichilnisky

Columbia University

We introduced new axioms for the foundations of probability and statistics with catastrophic risks, and characterized all the distributions and decision criteria that they imply. Catastrophic risks are rare events with unknown frequencies which cause devastating losses and discontinuous system change. The axioms give rise to new foundations for probability and statistics and to new criteria for optimal statistical decisions in samples with catastrophic events. In samples without catastrophic events, the new theory coincides with existing ones, and implies expected utility analysis. The three new axioms are (1) sensitivity to rare event (2) sensitivity to frequent events, and (3) continuity and linearity. The second and third are standard but the first is new – and it is violated by expected utility. Based on the new axioms the research has established (i) new forms of likelihood analysis, (ii) revised foundations for probability and statistics, and for Bayesian analysis; (iii) new forms of risk assessment and decision analysis that are appropriate for situations involving standard and catastrophic risks; and (iv) practical applications for the

assessment and decisions of catastrophic risks - both natural and human made. Examples are asteroid impacts, climate change, which the Pentagon identifies as a national security risk, and risks of disruption of energy supplies including catastrophic incidents in oil pipelines. The research has led to a number of theoretical, experimental and empirical publications by the PI and several co-authors in collaborating institutions, the preparation of a book outline on the basis of the research completed and the organization of this Workshop on Catastrophic Risks with the purpose of extending the work and its applications, explaining the links with the work of others, and publishing a book that can serve as providing a basic introduction for the theory and the uses of a new probability theory and statistics that incorporate and is sensitive to catastrophic risks.

6. "Subjective Rationality in Decision Making"

by Louis E. Narens

Professor, Cognitive Sciences, School of Social Sciences, University of California, Irvine

The arguments in favor of Kolmogorov probability theory and its generalization to finite additivity as the rational quantitative theory of probability assume a boolean algebra of events. This paper questions the generality of that assumption and presents examples of applicable, non-boolean probability theories. The generalizations are shown to be not only useful for understanding rationality as usually described in economics and philosophy but also form the basis for alternative characterizations to the economic and psychological models of utility described in the literature. In the alternative characterizations, the "irrationality" induced by psychological processing impacts the logical structure of the subjective event space, unlike economic and psychological models that put the impact on the utility function. From most perspectives, such "irrationality" looks rational when considerations about human processing of information are taken into account, e.g., they satisfy the Dutch Book Argument for finitely additive Kolmogorov probability when the Argument is applied to subjective interpretations (instead of objective behavior). Such results suggest the development of a new concept of rationality, called "subjective rationality", that is designed to capture a form of rationality that is inherent in some human decision making. The new concept is applied to various decision making

situations including those involving catastrophic risk described in recent publications by Graciela Chichilnisky.

7. "Decision Making Under Uncertainty: Catastrophic Climate Change Risk"

by Peter Eisenberger

Columbia University

Knowledge about the future state of a complex systems is fundamentally limited and Godel's theorem provides a fundamental limitation on the decision making process itself. These generic limitations will be described and applied to the specific case of catastrophic climate change risk. The best available decision making process is described in terms of using the Chichilnisky approach to catastrophic risk and valuing the present and the future and the use of the Bayesian approach to evaluate the available knowledge . The solution suggested for dealing with catastrophic climate change risk combines these approaches with understanding of how to technologically manage complex systems to minimize the risk they represent . This analysis differs from the way the climate change risk is currently described and its risk evaluated and the solution proposed. They result in a using a reductionist paradigm that overstates the certainty of the risk and a solution that tries to avoid the risk by reducing human impact rather than managing the climate system.

8. "Modeling Preference in Non-Hausdorff Topological Spaces"

by Jun Zhang

University of Michigan

I will discuss topological characterization of preference relations and of preference aggregation. As both involve non-Hausdorff topological spaces, I argue that proper treatment of rare events with catastrophic risk requires new tools for representing utility and uncertainty without assuming Hausdorff (T_2) separability.

9. "Insurance, Beliefs and Affects: Using Psychophysic Paradigm to Explore Insurance Behaviors Facing Catastrophic Risk"

by Sébastien Massoni

University of Paris 1 Panthéon Sorbonne

by Olivier Chanel

Groupement de Recherche en Économie Quantitative d'Aix-Marseille (GREQAM)

by Jean-Christophe Vergnaud

Directeur de Recherché, Centre d'Economie de la Sorbonne

We study insurance behaviors facing catastrophic risk in an emotional framing induced by house money effect and loss aversion. We use a perceptual task to predict subjects' performances and beliefs by Signal Detection Theory. First subjects perform the task to accumulate rewards; then they play a bingo with gain-loss framing. To succeed the bingo, subjects have to reach a minimal score over ten trials. In the loss bingo subjects can lose all their money whereas in gain bingo they can win this money. Subjects can insure themselves. The probability of failure (1% or 10%) and the stakes (20 or 200€) vary. BDM mechanisms are used to elicit insurance coverage, confidence levels and a scale of worry is filled before each bingo. Preliminary results show that insurance behaviors are affected by loss framing and level of worry. Interestingly, metacognitive abilities are positively correlated with more efficient insurance behavior.

10. "Fear, Risk, Conflict Escalation, and Conciliation"

by Jean-Louis Arcand and Urs Luterbacher

Graduate Institute of International and Development Studies, Geneva

Catastrophic risks often result from high levels of violence and conflict, which lead to massacres and genocides. Fear appears to be a powerful motivator for such extreme behavioral responses, which seem irrational and cannot be explained through standard expected utility perspectives. This paper adopts a new perspective. We extend a model developed previously and then reformulate it in terms of of Rank-Dependant Expected Utility (RDEU) axiomatics. We show that optimistic preferences, as defined by a concave probability distortion function, lead to a greater likelihood of conflict-escalation equilibrium behavior within the Harsanyi-Zeuthen

bargaining framework, while pessimistic preferences, as defined by a convex distortion function, increase the likelihood of conciliation.

11. "Preference Representations in the Face of Catastrophic Risks"

by Richard E. Ericson

Chair & Professor, Department of Economics, East Carolina University

by Jamie B. Kruse

Professor and Director of Center for Natural Hazards Research, East Carolina University

We survey preference representations that allow adequate formal modeling of the behavioral response to catastrophic risks posed by rare, but recurring, natural events. Both formulations of utility functions developed in behavioral economics, often based on experimental evidence, and formulations that arise from introducing uncertainties about the underlying distribution of the risks, often modeled as ambiguity aversion, will be explored. We begin development of a unified framework integrating insights about the nature of decision making from recent theoretical and empirical work in environmental, experimental, and behavioral microeconomics and from models used in recent dynamic analyses of macroeconomic time series. It also explores integration of these extensions of the classical model of decision making in the face of risk with models extending the expected utility functional to include evaluation of non-measurable sets of (catastrophic) events.

12. "Risk Management for Heavy Tails, Black Swans and Other Catastrophes"

by Jose M. Garrido

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Risk measures are commonly used now in actuarial and financial risk management alike, for problems such as pricing, reinsurance, capital allocations, portfolio management or credit risk. With the notable exception of Value at Risk (VaR), most well accepted measures apply only to risks with finite moments. Mathematically this restricts the set of risks random variables to L^p, for some p larger or equal to 1, which excludes heavy tailed risks in L^0. Without getting into

the subjective choice of what properties are reasonable for a risk measure, we revisit the risk management problem for heavy tailed risks through a personal survey of ideas in functional analysis and convex optimization.

13. "Global Warming and Economic Externalities: Some Implications for Discounting"

by Armon Rezai

Assistant Professor of Environmental Economics, Vienna University of Economics and Business

Our paper forms a prelude to the discussion of catastrophic risks in the light of climate change. Discount rates have been taking the center stage in climate change economics due to their potential to reduce any catastrophe to a negligible event as long as its advent is sufficiently far in the future. However, in cost-benefit the discount rate is not a free parameter to be determined by some general methodological considerations. It necessarily depends on the GHG concentration scenario itself through production and consumption levels. There is a lot of confusion on this point in the literature, even among very eminent welfare economists. It is reasonable enough to regard the pure rate of time preference of a representative agent and the utility-elasticity of consumption as arbitrary parameters, but not the growth rate of consumption. The "Euler equation," which has to hold on an optimal path at each instant, states that delta = rho + eta*g. It is potentially deceptive in this regard. In this context the g term represents the instantaneous (or short-horizon) growth rate of consumption. But unless we assume that consumption is very smooth, so that g is more or less constant on the realized growth path, it is not correct to treat g as a free parameter. We present consumption paths in the presence of an uncorrected externality where consumption levels collapse due to climate change. Along such a trajectory there can be significant time periods over which the discount rate becomes negative. This inverts the usual discounting effect in this period.

14. "Scaling Approach to the Calculation of Catastrophic Risk for Natural Hazards"

by Christopher C. Barton

Prof. of Nonlinear Dynamics and Complex Systems, Wright State University, Dayton, OH

A new approach, based on size-number scaling, is applied to river floods and tsunami's.
In this new approach a power function is used as the basis for calculating risk over a range of sizes including catastrophic.

15. "Catastrophic Risks and Extreme Events: Statistical Insights with Applications to Climate Change"

by Bala Rajaratnam

Department of Statistics, Department of Environmental Earth System Science, The Woods Institute for the Environment, Stanford University

The last decade and a half have seen various methods for reconstructing past temperatures based on regression models relating historical instrumental temperature to temperature-sensitive paleoclimate proxies. How to model current and past climate extremes is a challenging topic, and is of great interest due to the catastrophic risks associated with extreme climatic events (such as droughts, floods and heat waves). We propose a regression based approach which model extremes in the climate context, the explicit goal of which is to understand whether temperature extremes can be predicted by temperature-sensitive paleoclimate proxies. This endeavor is a first step in the direction of understanding whether extremes observed in the last decade are anomalous in a millennial context. Time permitting, applications to finance and the biomedical sciences will also be discussed (this is joint work with Lucas Janson).

16. "Ambiguity Aversion with Three or More Outcomes"

by Mark J. Machina

Professor of Economics, University of California, San Diego

Ambiguous choice problems which involve three or more outcome values can reveal aspects of ambiguity aversion which cannot be displayed in the classic two-outcome Ellsberg urn problems, and hence are not always captured by models designed to accommodate them. This is primarily due to features of the models which have little bite in the classic examples but which impose

strong restrictions in choice over more general prospects. This paper considers several such examples and examines how the standard models of ambiguity aversion perform in such cases.

17. "Is the Political Economy Stable or Chaotic?"

by Norman J. Schofield

William Taussig Professor of Political Economy, Washington University in St. Louis

Recent events in the global economy have caused many writers to argue that the market is driven by animal spirits, by irrational exuberance or speculation. At the same time, the economic downturn has apparently caused many voters in the United States, and other countries, to change their opinion about the proper role of government. Unfortunately, there does not exist a general equilibrium model of the political economy, combining a formal model of the existence, and convergence to a price equilibrium, as well as an equilibrium model of political choice. One impediment to such a theory is the so-called chaos theorem which suggests that existence of a political equilibrium is non- generic. This paper surveys results in the theory of dynamical systems, emphasizing the role of structural stability and chaos. We consider models of celestial mechanics where the notion of chaos first developed, and then examine applications in models of climate change and economics. There is discussion of the past influences of climate on human society, and particularly how agriculture developed during the holocene, the past ten thousand years of benign climate. The recent period of globalization is likened to the holocene, and the question is raised whether future climate change may bring economic and political chaos.