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ROBUSTNESS, ITERATIVE STOCHASTIC QUASIGRADIENT PROCEDURES, AND ADAPTIVE (ARTIFICIAL INTELLIGENCE) LEARNING FOR CAT RISKS MANAGEMENT

Introduction. Traditional statistical decision theory deals with situations in which the model of uncertainty, the optimal solution ("true parameters") and its performance are defined by the sampling model. The robustness in this case is characterized by a continuity of estimates w.r.t. low probability "outlyers". In general problems of decision making, feasible solutions, concepts of optimality and robustness have to be characterized from the context of decision making situations (e.g., socio-economic, technological, environmental, risk perspectives). Unlike statistical robustness, general decision problems may have rather different facets of robustness. In particular, a key issue is, in a sense, discontinuity with respect to low-probability catastrophic events. That is, robust decisions in the presence of catastrophic events are fundamentally different from decisions ignoring them. Specifically, proper treatment of catastrophic events requires new sets of feasible decisions, adjusted to risk performance indicators, and new spatial, social and temporal dimensions, in particular, explicit representation of various agents. The inertia of the global process and the possibility of abrupt catastrophic changes restrict purely adaptive "wait-and-see" approaches. Moreover, rare extreme events of high consequences, which have to play a decisive role in the evaluations of global changes, are considered on average often as improbable events during a human lifetime and, hence, they are simply ignored. A 500-year disaster (say, an extreme flood that occurs on average once in 500 years) may, in fact, occur next year. However, it is impossible to research all the details connected with such an occurrence in order to achieve evaluations required by the traditional models in economics, insurance, risk-management, and extreme value theory. For example, standard insurance theory essentially relies on the assumption of independent, frequent, low-consequence (conventional) risks, such as car accidents, for which decisions on premiums, claims estimates and the likelihood of insolvency can be calculated via rich historical data. Existing extremal value theory also deals primarily with independent variables quantifiable by a single number (e.g., money). Catastrophes are definitely not quantifiable events in this sense. Under inherent uncertainty and heterogeneity of global processes the role of models and Decision Support Systems (DSS) rests on the ability to guide comparative analysis of the feasible decisions.

The notion of robustness critically depends on the nature of decision problems. This talk is primarily focused on some issues relevant to on-going modelling activities at IIASA and in the Joint IIASA-NASU project on “Integrated robust management of food-energy-water-land use nexus for sustainable development”. We discuss differences between standard “insurable” and catastrophic risks, which present methodological and practical challenges. Catastrophes are “unknown” risks, as catastrophe never strikes twice, the need for big data assimilation, endogenous nature of catastrophic (systemic) risks dependent on policies, and the need to design robust computerized DSS for effective cat risk management, combining catastrophe generators, socio-economic models, vulnerability models, and appropriate (iterative) SQG-based stochastic optimization procedures enabling two-stage decision making for robust combination of ex-ante anticipative and ex-post adaptive decisions. The iterative STO enables to “learn” the DSS towards newly arrived information/model results/scenarios thus updating decisions and policy recommendation towards fulfilling safety and security constraints of all involved stakeholders, ensuring the robustness of the overall system. We discuss novel approaches to the choice of discounting for long-term vulnerability modelling and catastrophic management. Arbitrary discount factors can be linked to irreversible “stopping time” catastrophic (“killing”) events. Any “stopping time” event induces discounting. In general, catastrophic events affect discount rates, which alter the optimal mitigation efforts that, in turn, change events. This endogeneity of discounting calls for using equivalent undiscounted random stopping time criteria and iterative “learning” SQG STO procedures.

Conclusion. Iterative SQGs can “learn” DSS towards robust decision support and policy recomendation enabling stability of socio-economic developments and food-water-energy-environmental security.

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