Abstracts


KYOTO UNIVERSITY
Graduate School of Advanced Integrated Studies in Human Survivability
思修館

A Classification of Risks threatening the Future of Humanity

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Abstract for the keynote lecture at the Fifth International Symposium on Human Survivability (21-22 November 2016, Kyoto University, Japan)

Whether by error, by terror, or by war, humanity has reached the technological capability to cause its own extinction. In the 21st century, anthropogenic risks, inter alia stemming from technological advances in fields such as bioengineering, artificial intelligence and weapons systems, have come to exceed geo- or astrophysical risks. The University of Cambridge established the Centre for the Study of Existential Risk (CSER) to study such low-probability, high-impact threat scenarios and produce research that would help prevent or mitigate them, so that humanity can reap the benefits of technological progress, while safely navigating the potentially catastrophic pitfalls.

This keynote lecture presents a novel classification system under development at CSER, which showcases the multifaceted and interdisciplinary nature of catastrophic risks. We take a step back from scenarios that have become overly familiar through disaster movies, and seek the underlying components that make up a catastrophic scenario. This projection of risk components along dimensions of critical life support systems, global spread mechanisms, and human prevention and mitigation efforts exposes commonalities and directs our attention to specific vulnerabilities and opportunities for greater resilience. The dynamic nature of the classification system also carries a clear message for interdisciplinary cooperation to constantly update and stay ahead of emergent future risks.

In order to avoid pressures that tend to push the hardest possibilities off the radar, reducing existential risks necessitates studying success and failure in prevention and mitigation, as well as the complexity of threats. Reaching out to academic communities, working on risk, innovation, and the history and philosophy of science, and revisiting a

number of instructive cases from Japan, the speakers strive to highlight the importance of interdisciplinary research agendas, networks, and institutions in helping to “think the unthinkable.”

Julius Weitzdoerfer is an Affiliated Lecturer at the Faculty of Law, University of Cambridge. With a background in Japanese nuclear-, disaster- and financial law, he recently joined the Centre for the Study of Existential Risk (CSER), where he works on the project "Managing Extreme Technological Risk" under the guidance of Prof Martin Rees.

Dr. Shahar Avin is a research associate at the Centre for the Study of Existential Risk (CSER). With training in physics, software engineering and philosophy of science, he works on the generation of multidisciplinary awareness of catastrophic risks among professionals.

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Guidelines for abstracts

Extreme space weather as an emerging risk

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The sun is a variable star. The energy of the magnetic field of the sunspots stored in the solar atmosphere is sometimes suddenly released to produce large-scale explosion called solar flares. The flares emit intense electromagnetic radiation, high energy particles and huge amount of magnetized plasma into the interplanetary space, and parts of them surge toward the Earth. They cause geomagnetic storms and aurora activities as well as hazards to the satellites and astronauts. Thus the radiation and plasma environments in the outer space, or so-called space weather, are essentially controlled by the solar magnetic activities and their interaction with the Earth's magnetosphere.

The consequence of the space weather has been witnessed as aurora activity for millennia, but it was not a hazard to human civilization until the middle of 20th century. The modern society is becoming more and more vulnerable to the space weather as it relies more and more on the space assets and the large scale power grids. Example of the impacts of space weather on the human activities include followings: The high energy particles from the sun cause significant damages to the satellites as well as serious radiation dose to the astronauts. The UV and X-ray radiation causes disturbances of Earth's ionosphere that lead to the errors in satellite communication and navigation. The disturbance of geomagnetic field induce surges of electric currents in the power grid on the ground that sometimes cause large scale blackout. It is estimated that, if the strongest space weather event ever recorded by the modern observational facilities, which is so-called Carrington event in 1859, hits the Earth now, it will take many years and trillions of dollars to restore.

Thus the space weather is an already known, significant risk for the modern society. Moreover, recent studies have shown that even more catastrophic disaster may occur due to the extremely intense solar flares. A group of researchers and students at Kyoto University analyzed the photometric observations of many stars whose properties (spectral type, rotation

periods etc) are similar to those of the Sun. They have found numerous “superflares”, whose energy exceeds 10^{28} J, 1000 times larger than that of the Carrington event (Maehara et al. 2012; Shibayama et al 2013). Some of the superflares were found in the stars whose spectral type and rotation periods are very close to the Sun, suggesting that such superflares may also occur on it. Independently, researchers at Nagoya University have found anomalously sharp increases in the cosmogenic Carbon-14 isotopes in tree rings, suggesting extremely large flux of cosmic ray (high energy particles) precipitated into the Earth’s atmosphere the outer space sometimes around 775 and 992 (Miyake et al. 2012). The origin of the large cosmic ray flux is unknown, but one possibility is extremely intense superflares in the sun. If such a superflare occurs in the present sun, its consequence will be catastrophic.

In this paper, we review the recent advancements of the studies of extremely intense flares and space weather events in the sun and the sun-like stars. Then we make order-of-magnitude estimates of the possible impacts of solar superflares on the Earht’s environments and the human activities. They include significant depletion of the ozone layer for years, almost complete destruction of the space assets, and hazardous radiation dose to astronauts and even to the aircraft passengers.

We also present our ongoing project on the survey of the records of law latitude auroras in the historical documents, mainly from the East Asia but also from the West. It is an interdisciplinary collaboration between the solar and aurora scientists and the humanities scholars who can not only read the documents but also evaluate the nature and reliability of them. The historical records of aurora observation in law latitude regions such as Japan provide an independent proxy for the occurrence of extreme space weather events. It was found that at least those as strong as the Carrington event occurs regularly, about once in 100 years. Moreover, by examining the change of people’s responses to natural disasters as well as to the anomalous events such as auroras throughout the history, we may infer how the scientific thinking and preparedness to natural disasters have been fostered among the people. Their implication to the present society will be discussed.

Keywords: solar activity, space weather, space utilization, historical documents, disasters

The 2011 Tohoku Earthquake and Tsunami: An Unexpected Disaster

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The 11 March 2011 Tohoku-oki earthquake (Mw9.0) was largely unanticipated by many seismologists in Japan. Although this region has frequent M7 and M8 events, there were no historical records of an M9 earthquake during the last 500 years, so the huge earthquake and extensive damage caused by the tsunami was a sobering occurrence. An important lesson is that even in an area of high seismic activity, 500 years history is not long enough to understand the potential earthquakes hazards. Over 18,000 lives were lost in the earthquake, mostly from the tsunami. Although there was very severe shaking for a long duration over a wide area of northern Honshu, there were relatively few lives lost to the collapse of buildings, which is a result of the advanced seismic building standards in Japan.

One of the outstanding features of the 2011 earthquake was the very large amount of slip (30 to 50 meters) on the shallow portion of the megathrust fault. It is the largest fault movement that has ever been observed for an earthquake. Since the fault displacement on the shallow portion of the subduction zone is directly related to the size of the tsunami, this very large slip is the main source for the large tsunami that devastated many areas along the coast of northeast Honshu. For most of the coastlines of Iwate, Miyagi and Fukushima prefectures, tsunami heights reached at least 10 meters, with maximum heights of over 30 meters at some locations. The tsunami was much larger than expected and overtopped protective walls in many places.

The Earthquake Early Warning and Tsunami Warning systems operated by the Japan Meteorological Agency generally performed well. Warning information was broadcast to many areas before the strong shaking and before the tsunami arrived. For almost all areas there was ample warning time before the arrival of the large tsunami. If people had quickly responded to the warning, there would have been many fewer lives lost. This is rather ironic, since the Tohoku area is probably one of the best prepared and educated regions of the world for tsunami hazards.

It is important for scientists to understand the process of large slip during earthquakes, so that the tsunami and ground shaking hazards from future great earthquakes can be properly evaluated. It is equally important to improve the public education and response efforts, so that the scientific information can be appropriately used to reduce the disaster effects.

The title of Prof. Koyama's presentation at the PAST session on 22 Nov. is "How did people observe and describe extraordinary natural phenomena in the period of the Global Crisis? Some cases from the documents of seventeenth century Poland."

His abstract will be uploaded to this web site soon.

Lessons from the global outbreaks of infectious diseases in the past

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Among the various issues we are confronting, infectious diseases, especially pandemic type of them, does not appear to be well recognized as compared to the issues on climate change, natural disasters, energy availability, poverty and so on. However, infectious diseases caused by pathogenic microorganisms have been one of the serious threat to human beings as well as to the animals particularly livestock. According to the available literature, we mankind have experienced a n umber of life-threatening infectious diseases for long. Taking this opportunity, I would like to review some representative outbreaks/pandemics of certain infectious diseases in the modern era and discuss on the socio-economical and medical background.

One of the major pandemics recorded in the literature is plague or black death caused by a bacterium *Yersinia pestis*. In 14th century, this flea-mediated infection killed almost one third of the population in Europe. The continental spread of this pandemic was likely due initially to Mongolian invasion followed by the development of maritime transport and accumulation of population at trading port. Pandemic of plague is the representative example of a large-scale transmission based on the rapid migration of people by means of shipping. It was due to this pandemic that the basic idea of quarantine was established for the prevention and lazarettos were constructed in the major port of trading cities.

Classical type of cholera is a rapidly progressive diarrheal disease caused by a bacterium *Vibrio cholerae*. This infection seems to have been just an endemic disease localized in Bengal area for a long time, but in 1817, this life-threatening enteric disease began to invade the continent coinciding with the commencement of British colonial administration of India. One of

the major reasons of pandemic was the absence of the idea of sanitation including boiling of drinking water. During the cholera outbreak in London, John Snow identified that the spread was due to the contamination of water system by which epidemiology and public health developed even before the bacteriological identification of the causative agent.

Smallpox is believed to have existed with mankind since the pre-era as typical scar can be observed in some mummified body in Egypt. This viral disease is estimated to have killed some 400,000 Europeans every year during 18^{th} century, and was responsible for millions of death until recently. The highly effective vaccine was developed by Edward Jenner as early as in 1796, but it took quite long before smallpox vaccination was introduced and accepted widely. By using highly attenuated and safe vaccine, WHO succeeded in the eradication of this disease completely from the globe as concluded in December 1979. However, we must be aware that there is a special reason why smallpox could have been eradicated by a single vaccine and other viral diseases are difficult to eradicate by extensive vaccination.

One more infectious disease that causes pandemic is influenza (flu). Before the discovery of influenza virus by virologist, Spanish flu (1918 flu pandemic) infected 500 million people across the world and resulted in the death of over 50 million. We know that in every winter season, we are facing the possible risk of flu pandemic caused by different antigenic type (serotype). Influenza virus is a typical virus species that undergoes a significant antigenic change enabling the virus to infect individuals who have gained the immunity to previous serotype. We should be aware of the genetic characteristics of influenza virus evading human protective immunity.

It should be emphasized that different socio-economical factors, human factors and each microbial property underlie the outbreaks or pandemics of certain infectious diseases, and we should take more effective means to prevent further pandemics. In addition, emergence and spread of antibiotic resistant microorganisms means that we are almost back in the old era when no drug was available at all.

The timing of investments for adaptation to climate impacted hazards

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Abstract

Public investment into risk reduction infrastructure plays an important role in facilitating adaptation to climate impacted hazards and natural disasters. We provide an economic framework to in-corporate investment timing and risk preferences when evaluating projects related to reducing extreme climate impacted risks. In a first step, we estimate appropriate probability distributions for the frequency and severity of extreme events using the so-called loss distribution approach. We also show how to combine historical data with expert opinions from e.g. climate scientists or local experts from emergency management. In a second step we illustrate how a real options framework can be used to analyze the optimal timing and scheduling of climate adaptation investments. In a case study we apply the model to bushfire risk management in a region in Northern Sydney. We find that optimal timing of the investment may increase the net present value (NPV) of an adaptation project for various levels of risk aversion. Assuming risk neutrality, while the market is risk averse, is found to result in an unnecessary delay of the investment into risk reduction projects. The optimal waiting time is also shorter when the insurance market is more risk averse or when a more serious scenario for climatic change is assumed. Further, a higher investment cost or a higher discount rate will increase the optimal waiting time. Our approach allows to derive important insights on optimal decision-making for climate adaptation. In particular we show that immediate investment into a risk reduction project might not always be beneficial from an economic perspective, while maximizing flexibility regardless of the opportunity cost, will possibly forego the benefit of durable investment and long lasting policies.

When should a CAT index futures be created?
--- Limits of insurance-risk securitization due to basis risk and adverse selection ---

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Keywords: insurance-linked securities (ILS), reinsurance, CAT (catastrophe) futures and options, basis risk, adverse selection

Abstract

Insurance risks are traditionally borne in reinsurance markets. That is, after originating insurance contracts and bearing risks of customers, the insurers spread and reallocate such insurance risks among themselves and reinsurers.

In 1990's, however, the capability of the reinsurance markets to bear risks was at stake. A sequence of huge natural disasters, including Hurricane Andrew (1992) and Northridge Earthquake (1994), produced huge amount of industry-wide insured losses, more than $ 30 billion just for Hurricane Andrew and Northridge Earthquake. There was the need for additional reinsurance capacity. Capital markets, or the non-insurance investors in them, became the natural target. (Ganapati et. al. (1997))

Then, innovation occurred. Insurance-linked securities (ILS's) were created, which enabled the investors outside the insurance and reinsurance industry to trade the catastrophe insurance risks, so that the capital markets could provide additional capacity for bearing the insurance risks. CAT (catastrophe) bonds traded in over the counter (OTC) markets and/or CAT index futures and options traded in organized exchanges are among those ILS's.

Since the mid 1990's, CAT bond markets have grown steadily. The amount of issuance achieved almost $7.2 billion in 2007 and, though it reduced to $3 billion in 2008 due to the financial crisis, exceeded $7.9 billion in 2014. (Guy Carpenter (2015)) However, despite the success of CAT bonds, interests in CAT index futures and options

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have been quite limited. The CAT futures and options introduced by the Chicago Board of Trade (CBOT) and the Bermuda Commodity Exchange (BCOE) in 1990's failed soon after their launch. Among those introduced by the Insurance Futures Exchange (IFEX), the New York Mercantile Exchange (NYMEX), and the Chicago Mercantile Exchange (CME) in 2000's, only some are traded in the CME group in 2016.

What is wrong? What prevents CAT futures and options from taking off? Under what conditions, can index derivatives, such as a CAT index futures, of insurance-risks be traded and preferred to reinsurance contracts? The purpose of this paper is to investigate these questions theoretically.

In this paper, we focus on the situation where each insurance risk of each insurer cannot be traded separately with the non-insurance outside investors by market breakdown due to severe adverse selection between them. (The insurers know too precisely about the risks than the outside investors.) As a practical way to mitigate such adverse selection problem, we consider an index futures where the index is defined to be the average of the payoffs of the insurance risks that the individual insurers bear.

We formulate a model that describes this situation and first investigate the condition under which bundling these insurance risks into an index futures mitigates the adverse selection problem enough so that the index futures can be traded between the insurers and the outside investors.

We then compare the attractiveness of the index futures with the reinsurance markets from the insurers' viewpoints. Participants in the reinsurance markets are presumably professionals in insurance. They know equally well about the insurance risks that they trade. Adverse selection problem about the insurance risks is small in the reinsurance markets. Thus, we model the reinsurance markets as one representative reinsurer who has the same information as the insurers, but is less risk tolerant than the representative non-insurance outside investor. (This reflects the fact that the reinsurers' capital is more limited than the outside investors'.) We consider the idealized reinsurance markets where the insurers and the reinsurer have the symmetric information, trade their risks competitively, and attain the optimal risk allocation. We then investigate the condition under which each insurer *ex-ante* wish to create and trade the index futures rather than the reinsurance contracts.

Finally, we investigate the attractiveness of creating the index futures from the exchange's viewpoint to see whether the exchange is willing to create the CAT index futures that is desirable to the insurers.