Post-Doc Proposal

Title: Modeling and quantifying cyber risks for cyber insurance

Duration of the Post-Doc : 18 months, beginning between January and September 2025.

Research area : Probability and Statistics.

Laboratory: CREST, Finance and Insurance group.
https://crest.science/research/research-fields/finance/

Contacts: olivier.lopez@ensae.fr ; caroline.hillairet@ensae.fr

Job description

This PostDoc proposal is part of the project CyFi «Cyber Financialization », in cooperation with the cyber risk quantification tech startup Citalid (https://citalid.com/) and with the financial support of Bpifrance. The postdoctoral researcher will be part of the CREST finance and insurance research team, and will work in close interaction with the company Citalid.

Cyber risk is often mentioned as one of the most concerning threats to modern societies, who heavily depend on digitalization[1]. The aim of this PostDoc is to investigate innovative models towards a better assessment and management of cyber risks, in order to help to build an efficient insurance ecosystem that contributes to the resilience of society.

Cyber risks, in the broadest sense of the term, are heterogeneous and complex, since the patterns of attacks are numerous, and the consequences on the victims considerably vary depending on their sector of activity and their dependence to digital solutions. Moreover, the ability of insurance or even of the whole society to absorb so-called « systemic cyber-events » is in jeopardy[2]. However, cyber risks are still hard to anticipate, and their economic costs are difficult to assess as these risks are rapidly evolving and the data available is of poor quality (low granularity, bias…). This limited knowledge of cyber risks is also a major obstacle for the design of cyber insurance contracts fully in tune with the market needs.

The research program aims to provide contributions in the following directions:

Risk assessment:
One will propose and study mathematical models and tools that will allow a better prediction and anticipation of the consequences of future attacks. These models will combine statistical experience (claims history) with expert advice as well as Citalid's expertise and technology. Special attention will be paid to systemic events and extreme events, that is catastrophic situations that can weaken a portfolio's equilibrium.

[1] See for example Axa Future Risks Report 2024, https://www.axa.com/fr/actualites/2024-future-risks-report, or the Threat Landscape Report from ENISA https://www.enisa.europa.eu/publications/enisa-threat-landscape-2023

[2] See the Cyber Risk Accumulation Report from Geneva Association https://www.genevaassociation.org/sites/default/files/2023-11/cyber_accumulation_report_91123.pdf

One objective is to better quantify risk accumulation. The aim is to extend previous works on contagion counting processes (as Hawkes processes, see [BBH21]) and stochastic scenarios inspired by epidemiological models (see [HL21], [HLOS22]), by investigating new risk scenarios, generic or dedicated to certain sectors (healthcare, defense…), in order to assess a portfolio's exposure to these systemic scenarios. In particular the impact of such systemic events on the cumulative loss of an insurance portfolio (see [HRR22]), as well as of portfolio diversification measures will be investigated.

A second objective of the PostDoc is to extend previous works on the analysis and extrapolation of tail distributions, and on the classification of extreme cyber risks (see [FLT21]), by introducing techniques for stabilizing classifications such as random forest techniques applied to extreme risks (see [VCJ22]), while maintaining interpretable models (see [M21]).

Risk mitigation and insurability of the risk.
A third objective is to investigate different measures for risk mitigation.
Using statistical data, one would like to quantify the effectiveness of prevention and to model the potential financial impact of protection measures. The aim is to help in determining which technical measures should be deployed in priority, and to provide inputs to make the company's risk insurable.
Finally, for a better insurability of cyber risk, one also would like to focus on optimizing the characteristics of an insurance policy, with the aim to better fit the insured needs in term of protection, and also to be more robust in case of a systemic event (diversification of the risks).

Profile:

- PhD in applied mathematics, actuarial science, finance, econometrics.
- You are familiar with statistics extreme value theory and/or stochastic processes and/or graph theory.
- Computer skills: R or Python.

Bibliographie:

[BBH21] Y. Bessy-Roland, A. Boumezoued et C. Hillairet, «Multivariate Hawkes process for cyber insurance,» Annals of Actuarial Science, vol. 15, p. 14–39, 2021
[FLT21] S. Farkas, O. Lopez et M. Thomas, «Cyber claim analysis using Generalized Pareto regression trees with applications to insurance,» Insurance: Mathematics and Economics, vol. 98, p. 92–105, 1 May 2021.
[FHLT21] S. Farkas, A. Heranval, O. Lopez et M. Thomas, «Generalized Pareto Regression Trees for extreme events analysis,» Extremes, Vol7- 437-477, 2024.
[HL21] C. Hillairet et O. Lopez, «Propagation of cyber incidents in an insurance portfolio: counting processes combined with compartmental epidemiological models,» 2021, Scandinavian Actuarial Journal 2021(6):1-24
[HLOS22] C. Hillairet, O. Lopez, L. d'Oultremont et B. Spoorenberg, «Cyber contagion: impact of the network structure on the losses of an insurance portfolio,» Insurance: Mathematics and Economics, 2022..
[HRR22] C. Hillairet, A. Réveillac et M. Rosenbaum, «An expansion formula for Hawkes processes and application to cyber-insurance derivatives,» Stochastic Processes and their Applications, vol. 160, p. 89–119, 1 June 2023.
[M21] Maillart, Arthur. Some explainability methods for statistical learning models in actuarial science. Diss. Université de Lyon, 2021.
[VCJ22] Velthoen, J., Cai, J. J., & Jongbloed, G. (2022). Forward variable selection for random forest models. *Journal of Applied Statistics*, *50*(13), 2836–2856.