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Granger causality in tail

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Granger causality plays a pivotal role in uncovering directional relationships among time-varying variables and enhancing decision-making in complex systems. While this notion gains heightened importance during extreme events in highly volatile periods,
state-of-the-art methods primarily focus on causality within the body of the distribution. We introduce a new rigorous mathematical framework for “Granger causality in tail,” designed to evaluate whether an extreme event in one time series causes a corresponding extreme event in another. Moreover, we describe how we can quantify the magnitude of the causal impact of an extreme event on other variables.

We establish equivalences between our Granger causality in tail and other causal concepts, including “classical Granger causality,” “Sims causality,” and “structural causality.” By proving the key properties of Granger causality in tail, we assert its usefulness in high-dimensional complex systems with potential hidden confounders. Here, to model the tails of the variables, we utilize the “extreme value theory” framework. We also propose an inference method for detecting the presence of Granger causality in tail and provide insights into the asymptotic properties of our estimator within the framework of a stochastic recurrence equation (SRE) model.