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Modeling Multivariate Extreme Events Using Self-Exciting Point Processes

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Abstract

We propose a model that can capture the typical features of multivariate extreme events observed in financial time series, namely, clustering behaviors in magnitudes and arrival times of multivariate extreme events, and time-varying dependence. The model is developed within the framework of the peaks-over-threshold approach in extreme value theory and relies on a Poisson process with self-exciting intensity. We discuss the properties of the model, treat its estimation, and address testing its goodness-of-fit. The model is applied to the return data of two stock markets.

Keywords: Time Series, Peaks-over-threshold, Hawkes Processes, Extreme Value Theory.
JEL classification: C32, C51, C58, G15.

1. Introduction

A characteristic feature of financial time series is their disposition towards sudden extreme jumps. As an empirical illustration consider Figure 1, which shows the exceedances of negated returns of the Morgan Stanley Capital International indices for the US (MSCI-USA) and Europe (MSCI-EU) over high quantiles of their distributions. It is apparent from the figure that both the occurrence times and magnitudes of the exceedances evince a certain clustering behavior. This clustering behavior exists across the markets. Furthermore, at times, the markets tend to synchronize, which manifests itself through the occurrence of joint clusters of exceedances. The synchronization may be attributed to information transmissions across financial markets as widely studied in the finance and economics literature; see, e.g., Wongswan (2006), and Bekaert, Ehrmann, Fratzscher, and Mehl (2014), and references therein. The coaction of extreme asset returns also presents an important topic for risk management research, as was seriously demonstrated during the latest financial crisis. In this paper, we do not attempt to explain the extremes in financial markets, but provide a multivariate modeling framework for analyzing them.

The econometric problem of analyzing and modeling jumps or exceedances above high thresholds in asset returns has been considered in many papers. For example, Bollerslev, Todorov, and Li (2013) analyze the extremal dependencies of idiosyncratic and systemic components of jumps. They apply a continuous-time jump-diffusion model to separate jumps from price increments due to continuous price movements. Aït-Sahalia, Cacho-Diaz, and Laeven (2013) propose a Hawkes jump-diffusion model in which self-exciting processes (with mutual excitement) are used for the explicit modeling of extreme events and their clustering in time and across assets. They develop a feasible estimation approach based on the generalized method of moments and provide strong evidence of self-excitation and asymmetric cross-excitation in the markets. Further studies that are related to modeling clusters in financial data include that of Bowsher (2007), who introduces a new class of generalized Hawkes process (including non-linear models) and studies the transaction times and mid-quote changes of high-frequency data for an NYSE stock, as well as Errais, Giesecke, and Goldberg (2010), who employ self-exciting processes for modeling portfolio credit risk and for the valuation of credit derivatives. Modeling multivariate exceedances above high thresholds is also a topic of intensive theoretical research in extreme value theory (EVT). For example, the multivariate generalized Pareto distribution is the natural distribution for multivariate extreme exceedances, as

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