North American Journal of Economics and Finance 26 (2013) 487–496

Contents lists available at ScienceDirect

North American Journal of Economics and Finance

High quantiles estimation with Quasi-PORT and DPOT: An application to value-at-risk for financial variables

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ARTICLE INFO

JEL classification:
G1
G13
G14

Keywords:
High quantiles
Quantitative risk management
Statistics of extremes
Financial time series

ABSTRACT

Recurrent "black swans" financial events are a major concern for both investors and regulators because of the extreme price changes they cause, despite their very low probability of occurrence. In this paper, we use unconditional and conditional methods, such as the recently proposed high quantile (HQ) extreme value theory (EVT) models of DPOT (Duration-based Peak Over Threshold) and quasi-PORT (peaks over random threshold), to estimate the Value-at-Risk with very small probability values for an adequately long and major financial time series to obtain a reasonable number of violations for backtesting. We also compare these models and other alternative strategies through an out-of-sample accuracy investigation to determine their relative performance within the HQ context. Policy implications relevant to estimation of risk for extreme events are also provided.

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1062-9408/$ – see front matter
http://dx.doi.org/10.1016/j.najef.2013.02.017

1. Introduction

Extreme events, better known as Black Swan events, have the worrying property that when they occur they have great or extreme impacts despite their rarity. These events exist in economics, ecology, earth sciences and biometry, among others. In economics and finance, the "worst-case" events have become more frequent than before, while they have kept their devastating impacts. Examples of recent financial extreme events include the Black Monday of the stock market crash that occurred on October 19, 1987, the turmoil in the bond market in February 1994, the 1997 Asian financial crisis, and the 2007/2009 global financial crisis. These crises are a major concern for regulators and owners of financial institutions because of their heavy consequences. Many economists and financial analysts have shown increasing interest in examining the behavior of financial markets, testing financial stress and managing risks during those events.

This paper examines the extraordinary behavior of certain random variables such as equity returns during extreme events like global financial crises using recently developed, pertinent models known as high quantile (HQ) estimators. This odd behavior is characterized by extreme value changes and very small probabilities of occurrence that are much smaller than the standard $p = 0.01$. The HQ models under consideration are based on the extreme value theory (EVT) models of DPOT and quasi-PORT which quantify risk in tail distributions. They will also be applied to estimate the Value-at-Risk (VaR) for a long major financial time series, which is selected to be the Down Jones Industrial Average index. Thus, the main objective of the paper is to evaluate the performance of the recently proposed DPOT and quasi-PORT models, within the context of high quantiles, apply them to a major financial time series, and compare them with other models having values of p not very small. In our view, financial institutions can and should apply high quantiles estimators to better understand the extreme market risks and be better prepared for extreme adverse price changes in financial markets. Conventional comparison studies for the standard $p = 0.01$ can be found in the existing research such as Chen and Tu (2013) and Hammoudeh, Araújo Santos & Al-Hassan (2013) and the references therein.

A quantile p for a random variable (r.v.) X, denoted by χ_p, is a value exceeded with probability p. A high quantile is a quantile p with a very small probability p. In the context of financial variables, the VaR(p) is a quantile p for the returns. VaR emerged as the primary tool for the assessment of financial risks. As indicated, we are here dealing with rare events and thus with much lower probabilities than the usual $p = 0.01$ used for the calculation of the daily capital requirements under the Basel II Accord. In this work, the very small probability p will be considered as the probability of an adverse extreme price movement that is expected to occur approximately once every four years ($p = 0.001$) or once every eight years ($p = 0.0005$). Therefore, the analysis falls into the context of high quantiles. This context may be related to the development of the stress tests (e.g., Longin, 2001; Tsay, 2010), which are directly related to the occurrence of extremes in financial markets. Some authors (e.g., Danielsson and De Vries, 2000) argued that when small probabilities come into play, an unconditional approach is better suited for VaR estimation than a conditional approach, because extreme price changes do not appear to be related to a particular level of volatility nor exhibit time dependence. In fact, it is demonstrated by de Haan, Resnick, Rootzn, and de Vries (1989) that for certain dependence processes such as ARCH the volatility clustering vanishes at the level of extremes. Moreover, Resnick and Starica (1996) have demonstrated the consistency of the Hill estimator[3], (Hill, 1975) under certain types of dependence, such as GARCH. In this study, both unconditional and conditional VaR models that can be applied to VaR under the context of high quantiles are compared.

The novelty of this paper is that it evaluates the performance of recently proposed EVT models appropriate for high quantiles estimation with a comparative out of sample investigation and an application to a long major financial time series. We use recent EVT methodologies that to our knowledge no other studies have used in the context of the HQ and financial time series. The results highlight that in this context these recent EVT methodologies can perform very well and much better than the other popular econometric models such as the well-known RiskMetrics model.

[3] The Hill estimator is defined in Eq. (4).