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Author: Raluca Vernic

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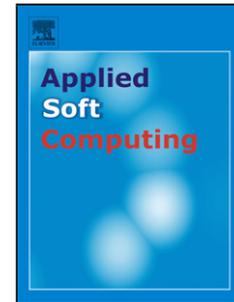
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# On risk measures and capital allocation for distributions depending on parameters with interval or fuzzy uncertainty

Raluca Vernic

Faculty of Mathematics and Computer Science, Ovidius University of Constanta,  
124 Mamaia Blvd., 900527 Constanta, e-mail: rvernic@univ-ovidius.ro, Romania,  
and Institute for Mathematical Statistics and Applied Mathematics,  
Calea 13 Septembrie 13, 050711 Bucharest, Romania

## Abstract

Since risks are regarded as emerging from uncertainty, they can be modeled using probabilistic, interval or fuzzy methods. The probabilistic literature on risk measures, though well developed, quantifies the risks by single values, which could seem restrictive for risk managers who would like to have more insight into the phenomena, like, e.g., an interval covering the single value. Therefore, in this paper, we study the VaR and TVaR risk measures for distributions with parameters of interval type, further extended to fuzzy numbers. In particular, we concentrate on the class of location and/or scale parameters, showing that in this case, the resulting risk measures are also in the form of intervals or, respectively, fuzzy numbers. Moreover, we apply the results to the capital allocation problem and detail the procedure for the normal, Pareto and Farlie-Gumbel-Morgenstern particular distributions. The formulas are numerically illustrated on interval and fuzzy parameters for some classical distributions; in this sense, some applications on real data sets are discussed.

Keywords: risk measures, Value-at-Risk, Tail-Value-at-Risk, parameter of interval type, fuzzy number, location/scale parameter, capital allocation.

## 1 Introduction

Traditionally, a risk measure is a quantitative tool developed to assess stochastic risks (in this paper, mainly financial risks) and it is defined as a mapping from a set of random variables into  $\mathbb{R}$ ; throughout this paper, these random variables are assumed to be losses. The utility of risk measures encompasses insurance problems (such as the evaluation of premiums, reserves, deductibles etc.) as well as pricing assets and managing the wealth of economic agents (for details, see, e.g., [25]). For example, to ensure solvency in view of the regulation requirements, the enterprise risk management requires the determination of an adequate amount of risk capital that must be held by the institution for the entire

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