Chapter 18
A Review of Standard Spectral Risk Measures

Mohammed Berkhouch
https://orcid.org/0000-0001-7207-4517
LISAD Laboratory, ENSA, Ibn Zohr University, Agadir, Morocco

Ghizlane Lakhnati
LISAD Laboratory, ENSA, Ibn Zohr University, Agadir, Morocco

ABSTRACT

Spectral risk measures are defined as the most attractive subclass of coherent quantile-based risk measures, with a remarkable aptitude for concretizing the decision-maker's subjective attitude toward risk. This chapter raises the problem of underrepresentation of the subclass of spectral risk measures by reviewing the standard spectral risk measures proposed in the literature. In parallel, a discussion about the approaches behind the conception of these risk measures is held. Through this discussion, the authors spot a number of problems with each of these proposals that stand against the reliable applicability of these risk measures in practice.

INTRODUCTION

In quantitative risk management, measuring risk is of crucial importance. For such purpose, a variety of *risk measures* have been proposed in the financial literature. Risk measures are quantitative tools that map financial positions, modelled by random variables, to capital amounts which serve as a hedging against the underlying potential risks. The authors refer the reader to (Pflug & Römisch, 2007; Delbaen, 2012; McNeil et al., 2005; Föllmer & Schied, 2016) for a comprehensive review of the use of risk measures in modern risk management. In this sense, the development of risk measurement theory has been sustained with the proposition of axiomatic approaches for risk measures. Especially, after the pioneering work of (Artzner et al., 1999), who defined the class of coherent risk measures as risk measures that satisfy desirable properties that have been conceded by the modern risk theory, namely: Monotonicity, Translation Invariance, Sub-additivity and Positive Homogeneity.

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Among coherent risk measures an attractive subclass, called *spectral risk measures*, has emerged. Spectral risk measures were primarily introduced, by (Acerbi, 2002), as an extension for *Expected Shortfall* (Acerbi & Tasche, 2002). Beside coherence, spectral risk measures are law-invariant and co-monotonically additive (Kusuoka, 2001). Yet, the substantial contribution brought by this subclass consists in considering the psychological behavior of the decision-maker in the risk measurement process. In fact, a spectral risk measure is characterized with a *weighting function* that attributes subjective weights to the potential outcomes of a financial position, according to the decision-maker's attitude toward risk.

Due to its distinctive features, the subclass of spectral risk measures has been the subject of a wide scope of surveys and works, since its introduction. For instance, spectral risk measures have been studied in the framework of modern portfolio theory (e.g., (Acerbi & Tasche, 2002; Adam et al., 2008; Brandtner, 2013)), for futures cleaning house margin requirements (e.g., (Cotter & Dowd, 2006)), in the framework of Extreme Value Theory (e.g., (Fałdziński et al., 2012)) and on the problem of comparative risk-aversion (e.g., (Brandtner & Kürsten, 2015)), to name a few.

By virtue of the theoretical attractiveness of spectral risk measures, various representative spectral measures have been proposed in the literature, despite the lack of sufficient guidance on how to construct a weighting function that reflects the subjective risk-aversion of decision-makers in a decent way. Mainly, the attempts that have been suggested, in this sense, are from (Acerbi, 2002; Wang, 1995; Wang, 2000; Cherny & Madan, 2008; Dowd et al., 2008; Furman et al., 2017; Berkhouch et al., 2018). In this paper, the authors review, examine and discuss these different proposed approaches. Throughout this discussion, the researchers identify a number of problems within each of these proposals. In other words, through this study the authors spot the problem of underrepresentation of the class of spectral risk measures and conclude that the set of spectral risk measures (or weighting functions) that have been proposed in the financial literature to date does not incorporate the comprehensive theoretical properties of an actual spectral risk measure. Therefrom, the authors argue that more researches shall be conducted in this direction, with the aim of proposing consistent approaches for constructing representative risk measures that appropriately reflect the theoretical appeal of the concept of spectral risk measures.

The rest of the present paper is structured as follows: In the second section, the researchers provide a theoretical background about risk measures, in general, and spectral risk measures, in particular. In the third section, the authors examine different spectral risk measures introduced in the literature and discuss different approaches behind the emergence of these measures. Through this section, a number of issues are spotted for each approach. The last section concludes.

BACKGROUND

Let $(\Omega,\mathrm{F},\mathrm{P})$ be an atomless probability space. Consistently with the literature on risk measures, the authors consider the space $L^{\infty}:=L^{\infty}(\Omega,\mathrm{F},P)$ of equivalent classes of essentially bounded random variables on (Ω,F,P). Throughout this paper, $X\in L^{\infty}$ is a random variable modelling the random future outcomes of a financial position. The authors identify constant random variables with real numbers. The authors denote $E[X]=\int_{\Omega}X d\mathrm{P}$, $F_X(x)=\mathrm{P}(X\leq x)$ and $F_X^{-1}(\alpha)=\inf\{x\colon F_X(x)\geq\alpha\}$ the expected value, the probability function (c.d.f.) and its generalized inverse for X, respectively. The authors say that a pair of random variables $X,\ Y\in L^{\infty}$ is co-monotone when $(X(\omega)-X(\omega'))(Y(\omega)-Y(\omega'))\geq 0$ for all $(\omega,\omega')\in\Omega\times\Omega$.

A risk measure is understood as a tool providing assessment of a capital amount that serves as a buffer against potential future losses. The researchers state the following definition of a risk measure:

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