An econophysics approach to analyse uncertainty in financial markets: an application to the Portuguese stock market

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Abstract. In recent years there has been a closer interrelationship between several scientific areas trying to obtain a more realistic and rich explanation of the natural and social phenomena. Among these it should be emphasized the increasing interrelationship between physics and financial theory. In this field the analysis of uncertainty, which is crucial in financial analysis, can be made using measures of physics statistics and information theory, namely the Shannon entropy. One advantage of this approach is that the entropy is a more general measure than the variance, since it accounts for higher order moments of a probability distribution function. An empirical application was made using data collected from the Portuguese Stock Market.

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1 Introduction

The application of mathematical and physics models to finance goes back to Bachelier in 1900, where it tests the hypothesis that stock prices follow a random walk. However this simple version of the model did not account for important characteristics of price variations, such as the occurrence of crashes, nonlinear serial dependence, etc. Bachelier assumed that the price variations follow a normal distribution, constant over time, and do not pay attention to extreme events. However, the empirical evidence has shown that stock prices seldomly behave in such a way as described by Bachelier.

The stock markets are usually complex systems, because they are open systems where innumerous subsystems act and interact in a nonlinear and dynamic way, constituting an attraction for the physicists that studied the working of financial markets using different methods than those used by traditional economists.

Bonanno et al. [1] consider that the financial markets show several levels of complexity that may occurred for being systems composed by agents that interact nonlinearly between them. These authors, among others, consider that the traditional models of asset pricing (CAPM

and APT) failed because the basic assumptions of these models are not verified empirically.

The entropy is a measure of dispersion, uncertainty, disorder and diversification used in dynamic processes, in statistics and information theory, and has been increasingly adopted in financial theory [2–8].

In addition to the studies mentioned above, Bouchaud et al. [9] have used entropy as an integrating measure in the process of portfolio selection based on the mean-variance model of Markowitz. This is because information is imperfect and the theoretical assumptions of portfolio selection models do not apply in the reality. The authors suggest the use of entropy with the purpose of obtaining a minimum diversification and, at the same time, an acceptable risk level to the investor. In a slightly different context, Fernholz [10] and Samperi [11] analysed the entropy as a measure of diversification in financial markets. Gulko [12] analyses market equilibrium by building a model where entropy is maximized subject to certain restrictions. He defends the "entropy pricing theory" as the main characteristic of market efficiency.

The use of entropy as a measure of uncertainty in finance appears to have many potentialities and a vast field of development, both in theoretical and empirical work. In line with the above arguments, this paper examines the ability of entropy as a measure of uncertainty in portfolio management applied to the Portuguese stock market,

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