Characteristics of fluctuations for the stock and currency markets

R. Rak[1], S. Drożdż[1,2], J. Kwapień[2], P. Oświęcimka[2]

[1] *University of Rzeszów, Faculty of Mathematics and Natural Sciences, PL–35-310 Rzeszów, Poland*

[2] *Polish Academy of Science, Institute of Nuclear Physics, PL–31-342 Kraków, Poland*

e-mail: Stanislaw.Drozdz@ifj.edu.pl, rafalrak@univ.rzeszow.pl

Making the quantification and interpretation of financial fluctuations constitutes one of the central issues of econophysics. Besides its obvious practical implications studying the nature of financial fluctuations proves extremely inspiring and productive for fundamental reasons. The related by now well identified stylized fact is the so-called inverse cubic power law which applies to developed stock markets, to the commodity market, as well as to the most traded currency exchange rates.

In this contribution we present a systematic study of the stock market return distributions - both for the market index as well as for the individual companies - and identify consistency of those distributions with the inverse cubic power law for the shortest time scales available. In order to verify the degree of convergence towards a Gaussian distribution [1] we extend this study to the time lags of increasing length and, as a result, we report a fast departure from the inverse cubic power-law. For several stocks we in parallel study the distribution of fluctuations of the volume traded and find that it also develops the power-law tails whose scaling indices are consistently about a factor of 2 smaller (tails thicker) than the ones describing the corresponding distributions of returns. Such a correspondence was originally postulated in the context of the inverse cubic power-law [2]. A particularly vital result of the present contribution is that this relation remains preserved even for the larger time lags when the departure from the inverse cubic power-law in the direction of thinner tails is sizeable. This observation opens room for giving a firmer ground to the model introduced in [2] and for extending its range of significance.

The above analysis has been systematically performed using the formalism of the q-Gaussians as it follows from the concept of the nonextensive entropy [3]. This functional form allows to consistently describe the whole range of fluctuations, its asymptotics is power-law type and the corresponding scaling index is uniquely determined by the nonextensivity parameter q. The departures from the inverse cubic power-law towards a Gaussian are then traced by the decreasing value of q. The limiting value $q = 1$ corresponds to the Gaussian.

These investigations have also been extended to the currency exchange rates and, especially, to those triples of pairs whose dynamics of fluctuations remains constrained by the triangle rule. For the individual pairs the distribution of fluctuations turns out to develop similar quantitative characteristics as those observed for the stock market. The fluctuations of residuals calculated as the instantaneous deviations from the triangle rule develop however much heavier tails and appear not describable by one consistent q-Gaussian form.

References

[1] S. Drożdż, M. Forczek, J. Kwapień, P. Oświęcimka, R. Rak, *Stock market return distributions: from past to present*, Physica A 383 (2007) 59

[2] X. Gabaix, P. Gopikrishnan, V. Plerou, H.E. Stanley, *A theory of power-law distributions in financial market fluctuations*, Nature 423 (2003) 267

[3] R. Rak, S. Drożdż, J. Kwapień, *Nonextensive features of the Polish stock market fluctuations*, Physica A 374 (2007) 315