STOCK MARKETS INDICES IN ARTIFICIAL INSYMMETRIZATION PATTERNS*

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The daily data of indices of Warsaw Stock Exchange — WIG, and New York Stock Exchange — NASDAQ, NYSE and S&P 500 for the last two years are being studied. Properties of fluctuations of daily returns found from scaling analysis of tails are confronted with patterns obtained by the artificial insymmetrization method to specify difference between the world-wide American market and local and rather marginal Polish market.

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1. Introduction

The economists believe that main efforts of investors which actively take part in a stock market game are aimed on outwitting the other investors and gaining risk-free, *i.e.* arbitrage, money [1]. Since Bachelier time [2] it has been believed that this activity is reflected in a stock price in such a way that changes of a price, *i.e.* returns, are independent and identically distributed Gaussian random variables. However, in time series of empirical data, discrepancies are noticed [3–5, 7]. The list of statistical properties of time evolution of the price can be started by well known facts:

- clustering property: while there are only weak correlations between the price changes on successive trading day, nevertheless, there are strong correlations between the absolute values of the returns, which means that periods of high volatility are separated by quiet periods,

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- heavy tails in the probability distribution for the returns: the decay of wings of the distribution is with a power law with exponent near 3 what disagrees with a Gaussian distribution decay,

and closed by the conclusion that the fundamental assumption of the Fama market theory, the, so-called, efficient market hypothesis [8] must be revised.

In the following paper our interest concentrates on different markets to observe if age and localization of a market lead to distinct properties of the distribution of returns. Our empirical study begins with NYSE and S&P 500 data in order to get a view of well developed mature markets. We include NASDAQ Composite because NASDAQ represents stocks related to the so-called "New Economy", *i.e.*, the Internet, computer hardware and software, *etc.* Investors from this market are expecting enormous future earnings due to the increase of sales of Internet technology and computer related products [9]. Polish stock market — Warsaw Stock Exchange, is a young market, it celebrates its tenth anniversary this year. WIG is its main index. Given the transformation to the new economic system in Poland, it is also expected that the Polish stock market may provide an opportunity for extraordinary profits. In particular it was seen at the infancy days of the Warsaw stock market. From the beginning of 1993 the prices of all 22 stocks that were traded, systematically increased. WIG changed its value from about 1400 in March of 1993 to 20 760.3 on the 8th March of 1994 when the market breakdown started. It passed 6 years till 14th of January 2000 when WIG again crossed the 20 000 value. The next top, and up till now the highest value, was achieved on 27th March 2000. WIG was equal to 22 868.40 and on that day the rapid fall dawn started. One can notice that at the same time the crush happened to NASDAQ [9]. However, in contradiction to the NASDAQ crush, the WIG crush cannot be estimated by the periodic power-low development. The log-periodic signatures have been identified for the major financial markets of the world, like the stock markets of Wall Street, Tokyo and Hong Kong [10], as well as on emerging markets like Latin American markets or Asian tiger markets [11], but not for the East European stock markets. It is said that these markets do not resemble the logic of other stock markets [11].

The aim of the following investigation is to determine whether the Polish stock market — one of the youngest markets that is located at the margin of the world economic system, exhibits properties similar to the markets that are known as well developed and mature. To take into account the enormous increase in information flow, exchange as well as globalization process that captures local markets, we concentrate on data of the last two years.

Some empirical study of WIG time series is presented in [12]. Following [6], we estimate the features of WIG such as persistency, the index of the Lévy distribution and its breakdown in the occurrence of rare events.

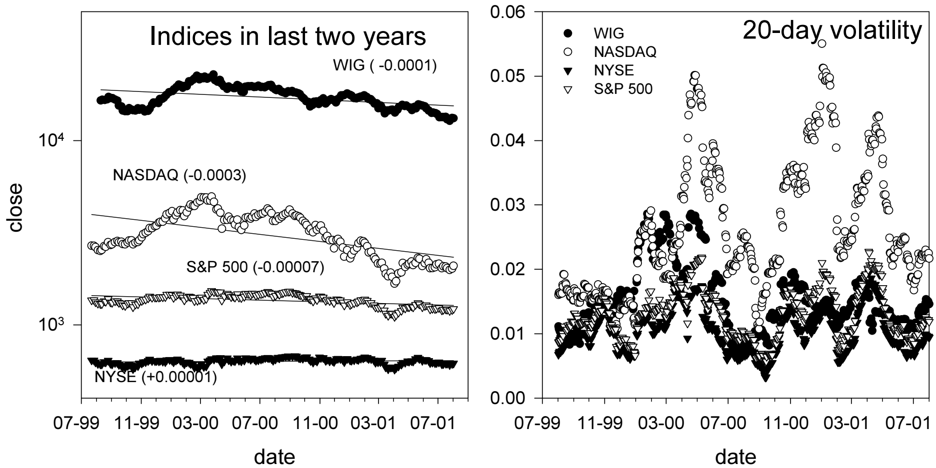

Fig. 1. Time series of indices studied: WIG, NYSE, NASDAQ and S&P500, since 1st August 1999 till 1st August 2001 on the log scale — left picture. Standard deviation error for 20 days in time is plotted on the right picture to present volatility of the markets considered.

All is done for the five-year time series of 1995–1999. However, the last two years are different from the previous years since during 1995–1999 time the stock markets exhibited some noticeable positive trends which now are not present. Therefore, to find the latest features of the Polish system we concentrate on time sequences run for the last two years only, namely, we analyze data that start on August 1st 1999 and end on July 31st 2001. In this time period each of the four sequences: WIG, NASDAQ, NYSE and S&P 500 provides about 500 points, see Fig. 1 for the time series. In the next section we confront the standard methods of getting characterization of fluctuations of returns to the Artificial Insymmetrization Pattern method [13]. This method provides some new insight on autocorrelation of a time series that allows to qualitatively identify the basic differences between markets, namely, the speculativity which drives WIG and NASDAQ indices, and the features that seem to be specific for the WIG time series only.

2. Results

The basic quantities studied are values of the indices WIG, NASDAQ, NYSE and S&P 500 at the closing. The time runs over working days of stock exchanges — weekends and holidays are excluded. For each time evolution of the market index $S(t)$ we calculate a series of returns, *i.e.*, the time series of the changes of the logarithms of the index values:

$$R_{\Delta}(t) = \ln S(t+\Delta) - \ln S(t)\,. \tag{1}$$

The results of our analysis are collected in a series of figures and summarized in the following:

— Fig. 2 shows estimates of the exponent α that describes the power-law decay of the positive and negative tails of cumulative distributions of returns. For markets studies we observe $\alpha > 3$ what is in agreement with earlier studies [6, 14]. In particular, the tail decay exponents found by us are (in brackets — the r^2 coefficient of a linear curve fit on log–log plots):

index	negative returns	positive returns
WIG	3.09(0.97)	3.68(0.92)
NASDAQ	4.64(0.98)	3.21(0.97)
NYSE	3.06(0.96)	3.64(0.98)
S&P500	3.38(0.96)	3.83(0.96)

(2)

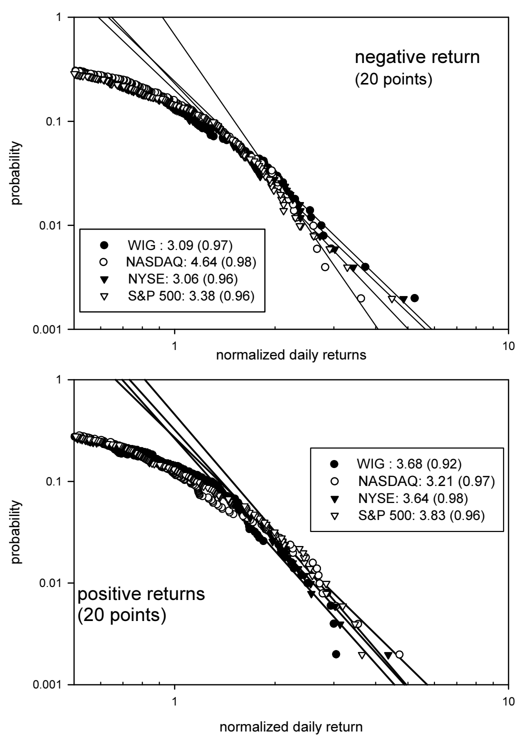

Fig. 2. The estimates of decay of tails of cumulative distribution of returns to observe distinction from Gaussian ($\alpha = 2$) and Lévy decay ($\alpha < 2$). The 20 most rare events are taken into account.

Found values of α correspond to the heavy tails *i.e.* the decay of the wings of distribution is slower than for a Gaussian distribution though the decay is beyond the Lévy distribution regime what was supposed earlier [3].

— Fig. 3 estimates of the long-range correlation exponent obtained by detrended fluctuation analysis [15] of the absolute values of returns.

index	few days scale	few months scale
WIG	0.51(0.99)	0.92(0.98)
NASDAQ	0.53(0.99)	1.03(0.99)
NYSE	0.54(0.99)	0.90(0.99)
S&P500	0.52(0.99)	0.90(0.99)

(3)

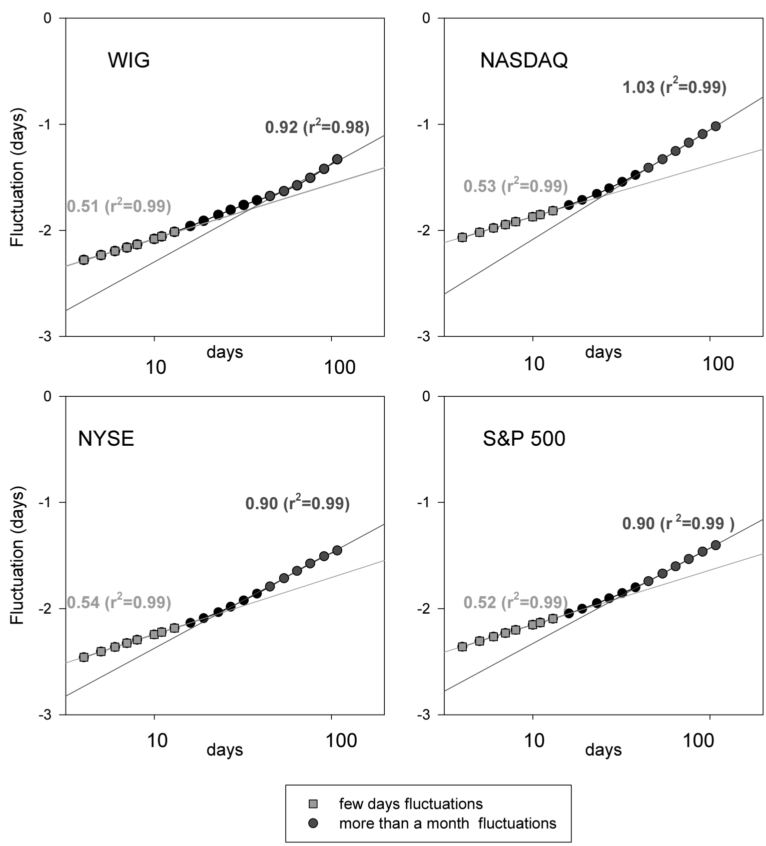

Fig. 3. The estimates of long-range correlations of absolute values of returns obtained due to the DFA-detrended fluctuation analysis method.

— The Artificial Insymmetrization Pattern (AIP) method [13] transforms a time series $f(t)$ to the complex plane according to the formula:

$$\Phi_{\pm}(t;\tau,\phi) = \hat{f}(t)\, \mathrm{e}^{\pm i\left(\hat{f}(t+\tau)+\phi\right)} \,, \tag{4}$$

where

$$\hat{f}(t) = \frac{f(t) - \min_t\{f(t)\}}{\max_t\{f(t)\} - \min_t\{f(t)\}} \,.$$

τ means shift in time with which a dependence in a series is investigated, and ϕ is a phase that is added to mark symmetries of a plot. Thus, the AIP is a point plot where for a given normalized return the next return separated by τ distance in a sequence determines an angle of a plotted point in polar coordinates. Therefore, the AIP plot can be seen as a return map but in polar coordinates. See [16] for test plots and AIP study of six-year time series of WIG, NYSE and NASDAQ. In all figures which are presented below, we use $\phi = 4$, what means that each time series is plotted four times. By this way the symmetry features of a single plot are more visible.

(a) Rare events, which lead to the heavy tails in the distribution of returns, are represented on AIP plots as separated points located near zero — negative tails, and near the unit circle — positive tails. Presence of these events squeezes the "body" of AIPs making the area of the AIP plot much smaller than when the AIP plot is of a Gaussian noise, see Fig. 4.

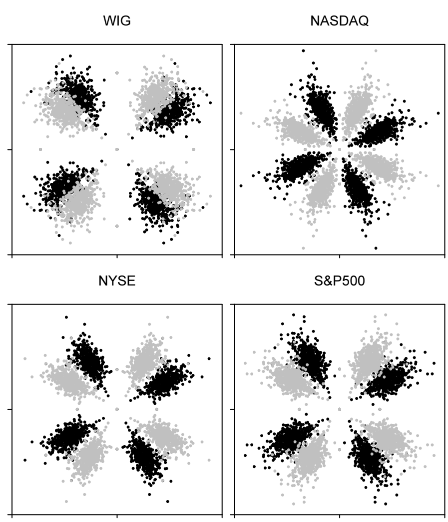

Fig. 4. AIP plot for 1-day returns. Notice the empty center of plots of WIG, NYSE and S&P500 and almost empty ring around the plot of NASDAQ.

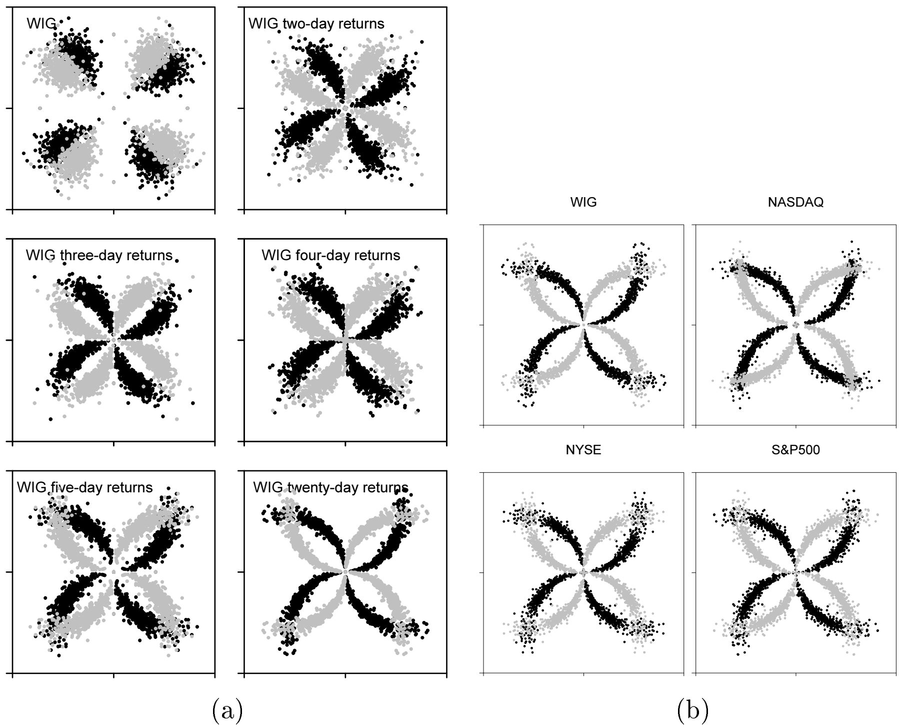

Fig. 5. (a) If n-day returns are considered, then with growing n, returns assemble to the random walk. On the subsequent figures the process of assembling is shown in case of WIG. (b) The 20-day returns for all indices are presented.

(b) Since n-day returns $G_{n \text{ days}}(t)$ are equal to $\sum_{i=0}^{n-1} G_{1 \text{ day}}(t+i)$ and the subsequent returns in 1-day series are weakly correlated, then one should expect the diffusion type dependence in the distribution of n-day returns. This dependence can be read from AIP plots of one-day to two-days, three-days, ..., twenty-days returns, see Fig. 5(a). In the twenty-days time-scale the AIP plots resemble a random walk, see Fig. 5(b).

(c) When time series of indices (not returns) are compared then one notices that the maximal values of WIG and NASDAQ are plotted as isolated points while in case of NYSE and S&P 500 the minimal values are isolated events, see Fig. 6(a), 6(b). This feature manifests in series of the last two years only and it is not such obvious in plots when six years time series are studied, compare [16]. Moreover, it is surprising that the AIP plot of NYSE walk in case when points separated by 20 days are taken into account, becomes very close to a plot of white noise.

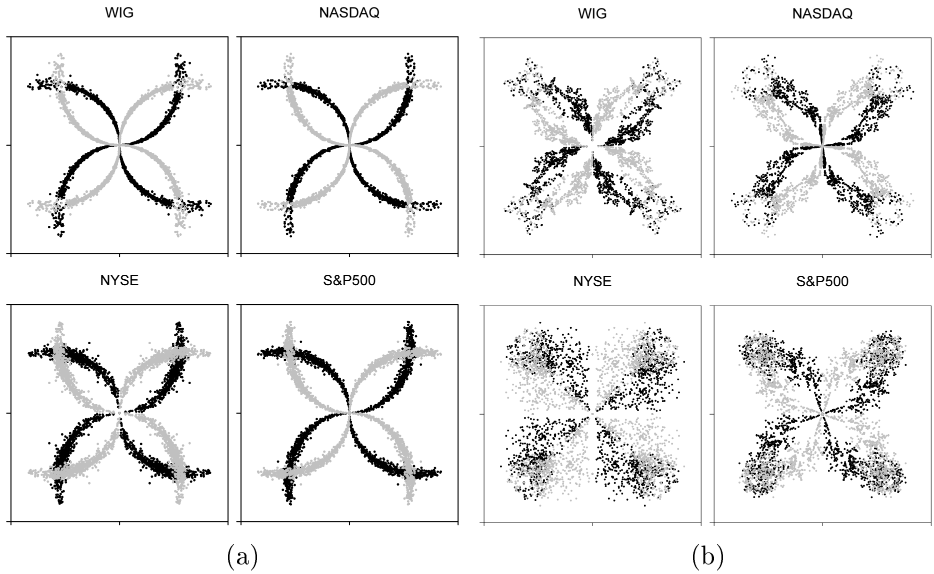

Fig. 6. AIP plots for the time evolution of indices. (a) $\tau = 1$, (b) $\tau = 20$; notice the white noise like picture of NYSE.

(d) One should notice the difference in localization of the center of body of each time series, see Fig. 4. This difference comes from the asymmetry of the distributions of returns. The conditional expectation of the subsequent return in case of the Warsaw stock index is noticeable greater than in case of NYSE and S&P 500. On the other hand this conditional expectation in case of NASDAQ is noticeably smaller than the other three indices studied.

3. Summary

Basing on features of time series that represent evolution of large and stable indices of world-wide stock markets such as NYSE and S&P500, together with NASDAQ — the index that represents the new trends market, we qualify properties of WIG — the index of the local stock market of Eastern Europe. We found that the AIP visualization of the data is particularly useful in getting into relations between markets. We are able to observe such properties of fluctuations like stability of the distribution of returns in general and the heavy tails caused by the rare events. Since procedure of plotting the AIP involves normalization of the data, we can estimate the general prosperity of markets. In the cases considered here it denotes stability for NYSE and S&P500 and large negative trend for NASDAQ.

It is noticeable that prices of NYSE that are separated by a month resemble a white noise. This feature would rather be expected for returns. Finally, we found that Warsaw stock market is distinguishable from other markets by the greatest conditional expectation value for the next day returns.

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