Stock market activity and hormonal cycles

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It is shown that the 8 weeks cycle and self-organized criticality at stock markets may have a biological origin related to a 4 weeks hormonal cycle. Threshold triggering mechanism of decision making is responsible for the period doubling (8 weeks instead of 4 weeks) and for the self-organized criticality. The hormonal cycle and the self-organized criticality can serve as stabilizing factors for the stock market fluctuations dynamic.

INTRODUCTION

At least four features of stock market make it an unique laboratory for studying human behaviour and its biological foundations (both individual and collective): 1) huge amount of very different participants (tendency to randomization), 2) strong tendency to self-organization (the dealers most popular saying is "trend is your friend"), 3) long-term digitalization of its activity, 4) very simple bivalued (buy or sell) action after a complex and tantalizing decision making process under high level of uncertainty. Consequently, the collective (market) state is also bivalued: 'bull' - in which prices are rising and/or are expected to rise, and 'bear' - as an opposite to the 'bull'.

It is widely recognized that psychology takes crucial part in the stock market activity and there is a huge amount of literature in this area of studies. On the other hand, understanding of the underlying biology processes is very undeveloped (see, for instance, recent Refs. [1], [2] and references therein). Meanwhile it is obvious that the stock market dealers are first of all biological creatures and the above mentioned decision taking process have to be under strong influence of their biological nature, in particular, their biological cycles.

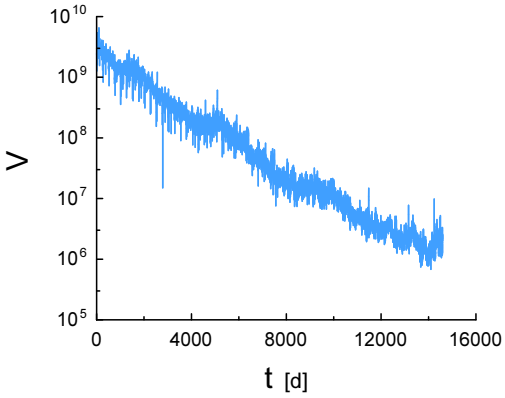

FIG. 1: Daily (business days) S&P 500 trading volume for 1950-2007yy in the semi-log scales.

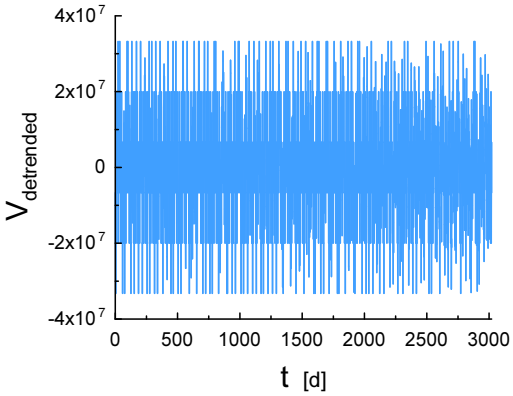

FIG. 2: Wavelet regression detrended daily trading volume for the sub-period 1996-2007yy.

Therefore these biological cycles should have a reflection in the stock market statistical cycles.

WAVELET REGRESSION DETRENDING

The most effective way to observe market cycles is to compute power spectrum of trading volume fluctuations. Trading volume is the total number of a given set of securities that was traded during a given period of time. The volume dynamics gives a dealer an idea about momentum in a stock and can confirm a trend. Since the volume dynamics is rather statistically non-stationary (see, for instance, Fig. 1) it is impossible to apply the spectral analysis to the volume dynamics directly. Even detrending does not allow to do that, because it also produces a statistically non-stationary time series. In order to obtain (approximately) statistically stationary data set one can produce a wavelet detrending of the original time series and then consider only a part of it which is approximately statistically stationary. This part of the time series will necessarily be short and one can use the maximum entropy method which provides optimal spectral resolution for the spectra computed for

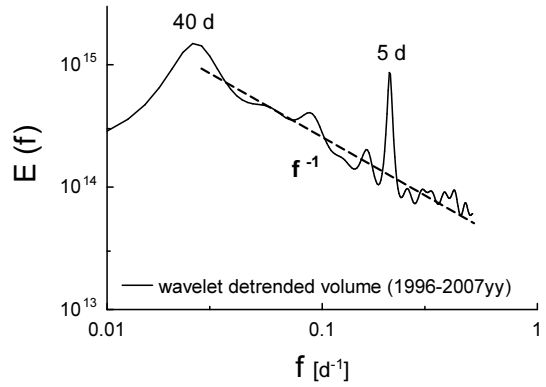

FIG. 3: Power spectrum (in the log-log scales) of the time series shown in the Fig. 2

the short time series [3].

Figure 2 shows such part of the time series representing daily trading volume of the E&P 500 index of the New York stock market for 1996-2007yy period. The wavelet regression detrending was produced using the simplest possible Haar wavelet regression of the E&P 500 trading volume for 1950-2007yy period (see Fig. 1 for the original time series plotted in the semi-logarithmical scales). The S&P 500 (Standard & Poor's 500) is a stock market index corresponding to the market capitalizations of 500 large companies listed on the NYSE or NASDAQ. It is one of the most followed indices, and it is considered as one of the best representations of the US stock market. The only busyness days time (excluding weekends and public holidays) was used in the figures 1 and 2.

Figure 3 shows power spectrum corresponding to the time series shown in the Fig. 2 (in the log-log scales). One can see two prominent peaks at frequencies corresponding to 5 and 40 busyness days time periods. In the common time terms these periods correspond to 1 and 8 weeks.

The appearance of the 1 week period seems to be about obvious. Indeed, it is well known that the same pattern of trading from Monday to Friday statistically repeats itself week after week. It is presumably based on psychology of the dealers and many investigations (both psychological and/or economical) are devoted to this phenomenon. Of course, there is a neuro-hormonal basis for this pattern (much less studied), but this (one week) cycle is not the main subject of present investigation. What will be significant for us here is the existence of the statistical *synchronization* of the individual dealers activity which makes the appearance of this peak possible.

THRESHOLD TRIGGERING AND PERIOD DOUBLING

The prominent peak corresponding to the 8 weeks cycle demands a more non-trivial explanation. It should be noted that a pure empirical '8-Week Hold Rule' exists among the dealers and has been attributed to the IBD founder W.J. O'Neil (in short: one should hold a stock for at least 8 weeks if this stock gains over 20% within 3 weeks). Perhaps the underlying reason for this empirical rule is related to the same mechanism that produces the 8 weeks cycle (see below). But first of all we should ask ourselves whether the periods of the observed cycles have to coincide with periods of the underlying mechanism's cycles? To show that it is not always the case let us consider a threshold triggering mechanism. Let us consider a periodic function $x(t)$ with a period T and let a spike (a threshold triggering decision) be produced when $x(t)$ crosses certain threshold from below. Then the time series of the so produced spikes will have the same period T. Let us define binary function $B(t)$ which takes two values +1 or -1 and changes its sign passing each spike along the time axis. In the market terms value +1 can correspond to the 'bull' and value -1 to the 'bear' market states (see above). Obviously the $B(t)$ function has period equals to $2T$. In reality of stock market any uderlying periodic mechanism works in a chaotic (or random) environment. Let us consider a simple example of the period doubling in a chaotic case (for a completely random - additive white noise environment, the period doubling can be rigorously proved). The x-component fluctuations of a chaotic solution of the so-called Rössler system [4]

$$\frac{dx}{dt} = -y - z; \quad \frac{dy}{dt} = x + ay; \quad \frac{dz}{dt} = b + xz - cz \qquad (1)$$

is shown in figure 4. This system was used in a recent Ref. [5] for simulation of the fundamental cycles of the neurons spontaneous activity. Power spectrum of the $x(t)$ chaotic function is shown in figure 5 (in the semi-log scales). The low frequency peak corresponds to the fundamental period (cycle) T, while the broadband part of the spectrum has exponential decay typical for chaotic systems.

Let to the output spike signal, resulting from overcoming of the threshold value $x = 7$ from below (see Fig. 4), generate corresponding bivalued function $B(t)$. Power spectrum of the $B(t)$ function is shown in figure 6. One can see the period doubling effect and the original exponential broadband decay (Fig. 5) has been transformed into a power law decay $E(f) \propto f^{-1.7}$ (the dashed straight line in the Fig. 6 indicates this power law spectrum in the log-log scales).

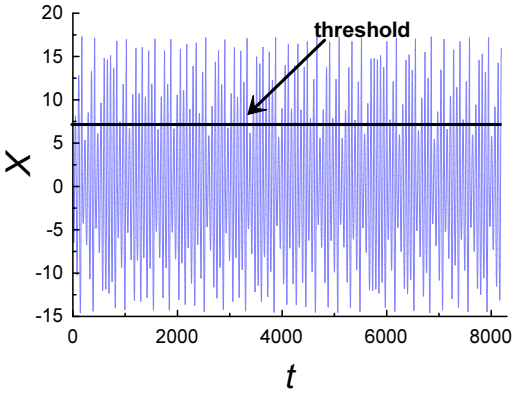

FIG. 4: X(t) component of a chaotic solution of the Rössler system Eq. (1).

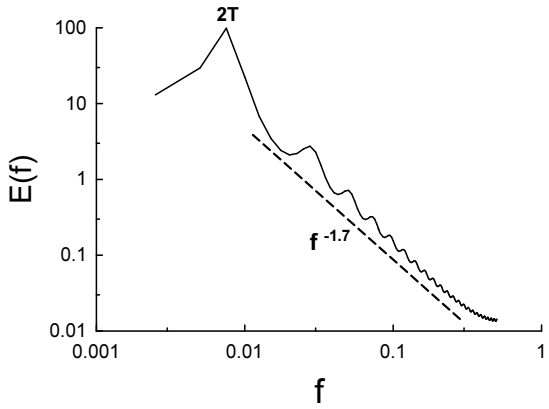

FIG. 6: Power spectrum of the bivalued $B(t)$ function corresponding to the threshold triggering of the $x(t)$ component shown in the Fig. 4.

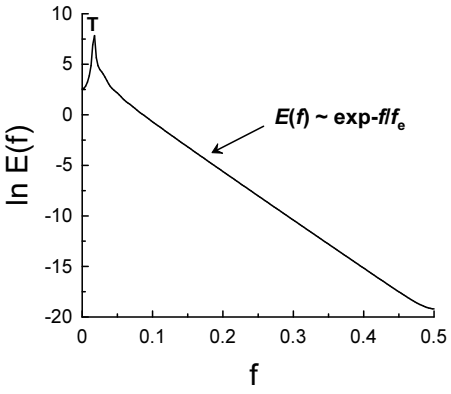

FIG. 5: Power spectrum (in the semi-log scales) of the time series shown in the Fig. 4

One can see that in presence of the threshold triggering mechanism the 8 weeks cycle, observed in the Fig. 3, can correspond to a 4 weeks underlying cycle.

HORMONAL CYCLE

If one could assume that the stock market at the considered period of time was dominated by women dealers the 4 weeks underlying cycle would be readily understood, but in reality it is not the case. Have the man dealers the 4 weeks biological cycle like women (at least some of its psychological consequences)? The question turns out to be rather non-trivial.

Let us start from a survey that was undertaken by the team of vouchercloud.com (see site https://www.vouchercloud.com/resources/men-suffer-from-man-periods). All 1206 Briton respondents were aged 18 and over and have been in a relationship with a woman partner for a minimum of 12 months (cf. more scientific studies below). 26% of respondents stated that they had well known psychological side effects corresponding to the women cycle with the 4 week periodicity.

There were also systematic testosterone measurements in order to find a biological answer to this question (see, for instance Refs. [6],[7] and references therein). In particular it was reported in the Ref. [6] that in some individual cases a peak of the salivary testosterone was not only observed for some men under investigation but this peak was *synchronized* with the woman partner's ovulation. However, on a group level no significant effect was found. In the experiment reported in Ref. [7] such individual cases were identified with the paired men with a current wish for children (that is rather understandable from an evolutionary point of view).

Moreover, the default sleep mode of the 4 weeks cycle in men can be readily understood from the evolutionary point of view. Why would the evolution 'distract' human males without a clear reproductive purpose when they could be used meanwhile for other useful purposes? However, modern men may have other (than reproductive) stimuli to transfer the sleep mode into an active one (cf. above mentioned Britons' survey and Ref. [8], for instance). It is known that competitive games (even chess) decrease the testosterone levels of losers and increase the testosterone levels of the winners [9],[10]. What game can be more competitive (and deadly serious) than stock market trading? On the other hand, it is known (see the Refs. [2],[11] and references therein) that profits of the financial markets' dealers

were larger when their morning's testosterone level was higher than average. This positive feedback alone can provide a wake-up of the 4 week cycle mechanism to an active mode in a sufficiently large number of the stock market male dealers (or in the most aggressive and/or influential ones [12],[13]) to provide to it a statistical importance. In its turn, after activation, the hormonal cycle can serve as a stabilizing factor for the stock market fluctuations dynamic (cf. the Ref. [2]).

The threshold triggering mechanism, revealed by the above consideration, together with the self-organized nature of the stock markets can result into self-organized criticality with a characteristic power law spectrum (see the seminal Ref. [14] and recent Ref. [15])

$$E(f) \propto f^{-1} \tag{2}$$

The dashed straight line is drawn in the Fig. 3 in order to indicate this type of spectrum (in the log-log scales used in the Fig. 3). The scale-free cascade of avalanches, characteristic to the self-organized criticality, can provide a mechanism for the stock market volume fluctuations dissipation (like the Kolmogorov scale-free dissipation mechanism in fluid turbulence, see for instance, Ref. [16]).

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