Econophysics

Two-phase behaviour of financial markets

Buying and selling in financial markets is driven by demand, which can be quantified by the imbalance in the number of shares transacted by buyers and sellers over a given time interval. Here we analyse the probability distribution of demand, conditioned on its local noise intensity $\Sigma$, and discover the surprising existence of a critical threshold, $\Sigma_c$. For $\Sigma < \Sigma_c$, the most probable value of demand is roughly zero; we interpret this as an equilibrium phase in which neither buying nor selling predominate. For $\Sigma > \Sigma_c$, two most probable values emerge that are symmetrical around zero demand, corresponding to excess demand and excess supply; we interpret this as an out-of-equilibrium phase in which the market behaviour is mainly buying for half of the time, and mainly selling for the other half.

We use the Trade and Quote database to analyse each and every transaction of the 116 most actively traded stocks in the two-year period 1994–95. We quantify demand by computing the volume imbalance, $\Omega(t)$, defined as the difference between the number of shares, $Q_b$, traded in buyer-initiated transactions and the number, $Q_s$, traded in seller-initiated transactions in a short time interval, $\Delta t$ (refs 2, 3).

$$\Omega(t) = Q_b - Q_s = \sum_{i=1}^{N} q_i a_i,$$

where $i = 1, \ldots, N$ labels each of the $N$ transactions in the time interval $\Delta t$, $q_i$ denotes the number of shares traded in transaction $i$, and $a_i = \pm 1$ denotes buyer-initiated and seller-initiated trades, respectively.

We also calculate, for the same sequence of intervals, the local noise intensity, $\Sigma(t) = \langle (q_i - \langle q_i \rangle)^2 \rangle$, where $\langle \ldots \rangle$ denotes the local expectation value, computed from all transactions of that stock during the time interval $\Delta t$.

We find (Fig. 1a) that for small $\Sigma$, the conditional distribution, $P(Q|\Sigma)$, is single-peaked, displaying a maximum at zero demand, $\Sigma = 0$. For $\Sigma$ larger than a critical threshold, $\Sigma_c$, the behaviour of $P(Q|\Sigma)$ undergoes a qualitative change, becoming double-peaked with a pair of new maxima appearing at non-zero values of demand, $\Sigma = \Omega_c$, and $\Sigma = \Omega_c^{*}$, which are symmetrical around $\Omega = 0$.

Our findings suggest that there is a link between the dynamics of a human system and physical systems with many interacting units. Physical observables associated with phase transitions undergo large fluctuations that display power-law behaviour, so our results raise the possibility that volatile market movements and their empirically identified power-law behaviour are related to general aspects of phase transitions.

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