SEEKING STATISTICAL SIGNATURES OF MARKET EVOLUTION: ANALYSING TRADING DATA OF EMERGING FINANCIAL MARKETS

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Financial markets exemplify adaptive complex systems comprising of large number of interacting components, self-organizing into non-equilibrium steady states [1]. In physics, such states are often characterized by universal properties (e.g., distributions exhibiting power-law tails). The question of whether markets also show similar invariant features is one of great scientific interest. The most promising candidate is the cumulative distribution of stock price (or market index) fluctuations as measured by the corresponding return, whose tails have been reported to follow a power-law with exponent -3. This "inverse cubic law" had been reported initially for a small number of stocks from the S&P 100 list, and was later established for the German and London stock exchanges as well as three major US markets including the New York Stock Exchange (NYSE). The apparent universality implies that different markets self-organize into similar non-equilibrium steady states. However, the above observations are almost exclusively from developed economies, and there is a lack of consensus about the nature of the distribution in *emerging* markets. The question of whether such markets also show this property is of particular relevance towards understanding how developing markets evolve to a mature state. If the "inverse cubic law" is indeed a true indicator of market self-organization, then analyzing the price fluctuation distribution in emerging markets as they develop into maturity, will inform us about the process through which such complex systems evolve to the non-equilibrium steady state characterizing developed markets.

With this aim in view, we have performed a large-scale analysis of the transaction data in the two principal Indian financial markets, the National Stock Exchange (NSE) and Bombay Stock Exchange (BSE), which between them, accounts for almost the entire financial market activity in India. As most preceding studies on price (or index) fluctuations in emerging markets have been performed on low-frequency daily data, we have concentrated on high-frequency tick-by-tick data from NSE, which is backed up by analysis of daily data from both BSE and NSE over much longer periods. The data-set from NSE is of particular importance as we have access to daily data right from the time the market commenced operations in Nov 1994, up to the present, when it has become the largest in India, handling over 85% of the total value of transactions for securities in all market segments. Over this period, the market has grown rapidly, the number of transactions having increased by three orders of magnitude. Therefore, this data is best suited for identifying any discernible transition in the statistical behavior of the market during its evolution, not least because of the rapid transformation of the Indian economy during the liberalization of the 1990s. We focus on two important questions regarding the return distribution: (1) Does an emerging market exhibit a different distribution compared to developed markets, and (2) If the market indeed exhibits the "inverse-cubic law" characteristic of developed economies, whether this has been converged at starting from a different initial distribution. Our analysis answers both of these questions in the negative (Fig.1, left) [2].Our results are further backed up by a detailed investigation of several market indices (e.g., the NSE Nifty and the BSE Sensex) [3]. This is all the more intriguing, as other candidates for universality, viz., the distributions of trading volume and number of trades, have very different natures as compared to those in developed markets [4].

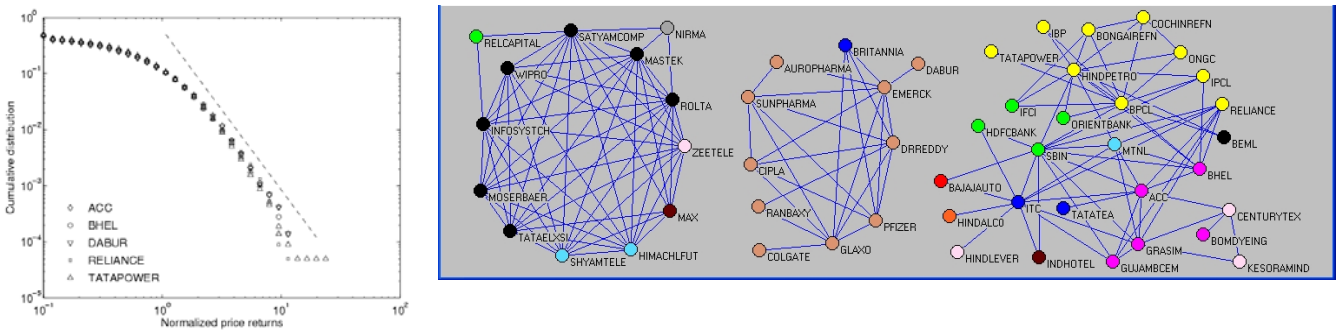

Fig. 1: (Left) Cumulative distribution of the normalized 5-min return distribution of 5 stocks from NSE during the period Jan 2003-March 2004. The broken line indicates a power law fit with exponent -3. (Right) The interaction network in the NSE (comprising only a fourth of the 201 stocks investigated when using a threshold = 0.09), with node colors indicating the business sector a stock belongs to. While one cluster is dominated by information technology, and another by health & pharmaceutical, the largest cluster is not dominated by any particular sector.

The quantitative agreement between the individual stock return and index return distributions brings us to the issue of the degree of correlation between stock price movements in an emerging market. Indeed, it has been pointed out in earlier studies that the latter tend to be more correlated than a developed one. As the return distribution does not show any distinction between these two, we therefore turn to a detailed investigation of the stock correlation properties for identifying tell-tale patterns of a developing market [5]. Using daily returns of 201 frequently traded stocks in the NSE over a period of more than a decade, we analyze the eigenvalue distribution of their cross-correlation matrix. We find the relatively high degree of correlations in the stock price movements (e.g., when compared to NYSE) is due to the dominant influence of a common market mode. By comparison, interactions between related stocks, such as those belonging to the same sector, are seen to be weaker. This lack of distinct sector identity has been explicitly demonstrated by us through a reconstruction of the network of significantly interacting stocks (Fig. 1, right). By modeling stock price dynamics with a 2-factor model, we explain the observed spectral distribution to be a result of the weakness of intra-sector interactions relative to the global (market) mode that corresponds to external information. Thus, our results suggest that a signature of market development is the gradual appearance of a complex interaction structure consisting of multiple groups of strongly coupled stocks (e.g., as seen in NYSE).

Keywords
Statistical properties of financial distributions, emerging markets, return distribution, stock return correlations

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