Set 12:Modelling stock price variations as a Bachelier-Wiener process

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CS302, Modelling and Simulation

This report presents a modelling exercise on the price variations of stocks listed in the NIFTY using a Bachelier-Wiener process. The analysis covers the period from January 1997 to April 2019, utilizing data provided by NIFTY. The paper *IJMPC stocks* serves as a reference for the modelling work, with specific attention to six figures and associated data files. The report reproduces these figures, states relevant equations, parameter values, and draws conclusions from the modelling exercise.

I. MODEL

The forward relative change of a stock price, S, in a finite time interval, Δt, is given by

$$\frac{\Delta S}{S} = a\Delta t + b\Delta w \tag{1}$$

in which Δw is Wiener process about the background growth of S. Integral solution of S is given by

$$S = S_0 \exp(at) \tag{2}$$

which, on taking log, can be expressed as,

$$\Delta(\ln S) = a\Delta t \tag{3}$$

The Gaussian function can be modeled using,

$$f(\delta) = 1 + f_0 \exp\left[-\frac{(\delta-\mu)^2}{2\sigma^2}\right] \tag{4}$$

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II. RESULTS

A. Figure 1: Daily Average Price of Stock Index

FIG. 1: The daily mean growth of the average price of the stock index, NIFTY (NSE, India). The linear-log plot is modelled by (1). Here time, t, is measured in days, over more than two decades. The straight line in this linear-log plot is plotted by the least-squares method, and indicates that the mean growth of S is exponential. In (1), with b = 0, the mean relative growth rate of stock values is a. For this plot, a = 0.05 % per day.

B. Figure 2: Daily Percentage Fluctuation of Stock Values

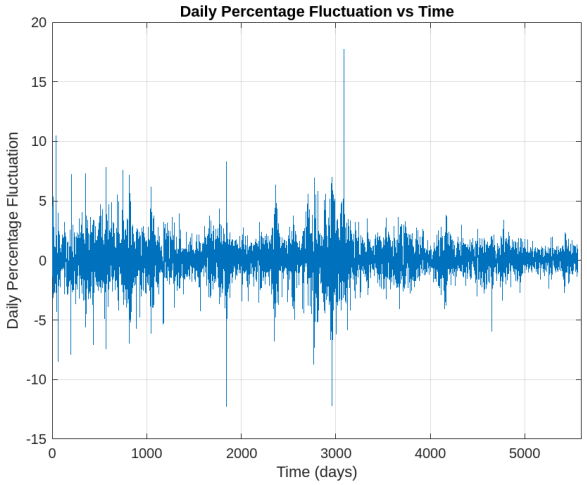

FIG. 2: The time series of the daily percentage fluctuation of prices in the stock index, NIFTY (NSE, India).The daily percentage fluctuation of prices is quantified by , which, over two decades, has an equal distribution of positive and negative values about = 0.

C. Figure 3: Frequency of Daily Percentage Fluctuations

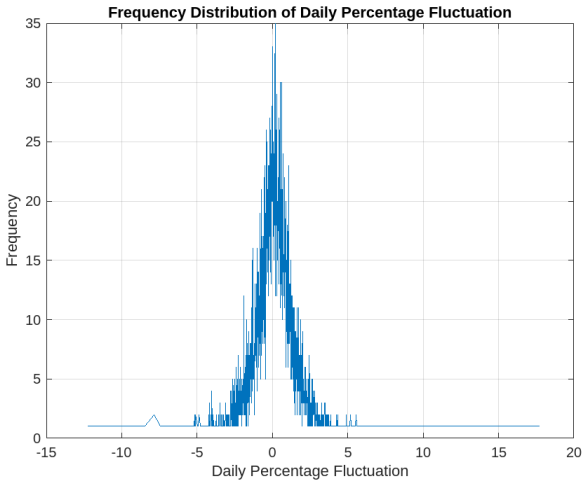

FIG. 3: The unnormalized frequency distribution of the daily percentage fluctuation of prices in the stock index, NIFTY (NSE, India). The distribution appears Gaussian, and is centred around a mean value, $\mu = 0.057$, with a standard deviation, $\sigma = 1.495$.

D. Figure 4: Monthly Average of Logarithm of Stock Values

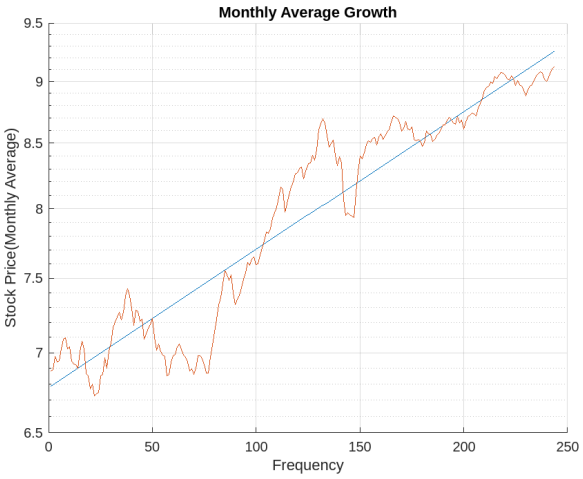

FIG. 4: The growth of the monthly average of ln S for NIFTY (NSE, India), as opposed to its daily growth in Fig. 1. The time, τ, is scaled in months, and spans more than two decades. The straight line, showing the mean growth, is plotted by the least-squares method, and its slope is m = 0.01 per month.

E. Figure 5: Wiener Variance of Monthly Average of Logarithm of Stock Values

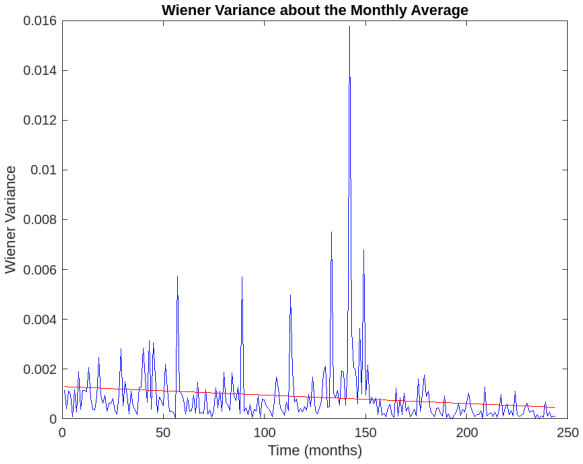

FIG. 5: The Wiener variance about the monthly average of ln S for NIFTY (NSE, India) decreases with time, τ (in months). The straight line, plotted by the least-squares method, traces the mean decline, with a slope of $w = 3.41 * 10^{-6}$ per month.

F. Figure 6: Daily Trade Volume of Stock Index

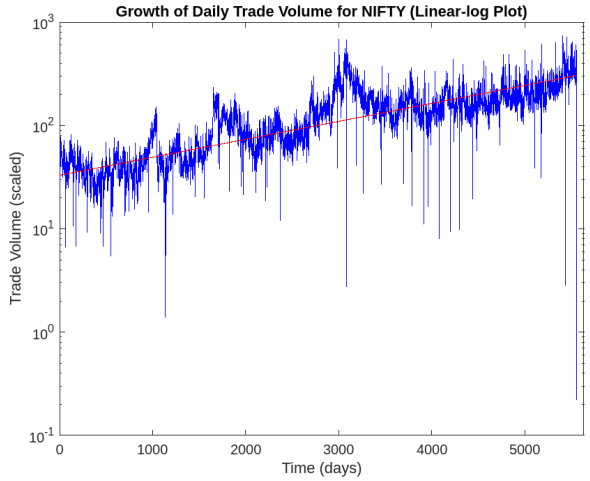

FIG. 6: The growth of the daily trade volume of the NIFTY (NSE, India) index. The number of daily transactions, N, is scaled by 10^6, and the time, t, is scaled in days. The straight line in this linear-log plot,plotted by the least-squares method, implies an exponential mean growth of N. The slope of the straight line,$\nu = 0.04$ % per day, gives the mean relative growth rate of the daily volume of trade.

III. CONCLUSIONS

The modelling exercise yields several salient conclusions:

1. Using historical data to calibrate the process, the Bachelier-Wiener method offers insights into the risk and volatility of NIFTY stocks.

2. Mature markets, like the NSE, typically exhibit stability in the face of turbulence.

3. The NSE index's price variance demonstrates that the market is expanding over the long run despite significant short-term fluctuations.

[1] Kakkad, A., Vasoya, H., & Ray, A. K. (2020). Regularities in Stock Markets. *International Journal of Modern Physics C*, *31*(10), 2050145 (9 pages). World Scientific Publishing Company. Dhirubhai Ambani Institute of Information and Communication Technology, Gandhinagar 382007, Gujarat, India.