

## Set - 11 :Modelling stock price variations as a Bachelier-Wiener process

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### I. MODEL

The forward relative change of a stock price,  $S$ , in a finite time interval,  $\Delta t$ , is given by

$$\frac{\Delta S}{S} = a\Delta t + b\Delta W \quad (1)$$

Under an idealized volatility-free condition, we set  $b = 0$ , and then integrate it in continuous time to get a steady compounded growth of  $S$ . The integral solution of  $S$  is exponential in time,

$$S = S_0 \exp(at) \quad (2)$$

$$\Delta(\ln S) = a\Delta t \quad (3)$$

The Gaussian function, with unity added to it, as

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

### II. RESULTS

#### A.

Fig. 1 shows stock price vs time.

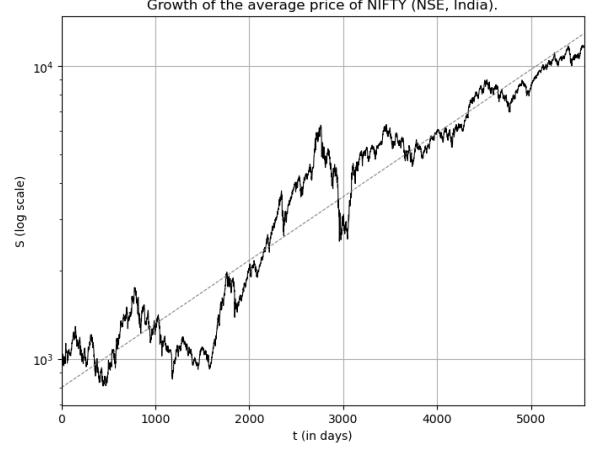


FIG. 1: The daily mean growth of the average price of the stock index, NIFTY (NSE, India). The straight line in this linear-log plot is fitted by the least-squares method, and indicates that the mean growth of  $S$  is exponential. With  $b = 0$ , the mean relative growth rate of stock values is  $a$ . For this plot  $a = 0.05\%$  per day.

#### B.

Fig. 2 shows daily percentage fluctuation of stock values vs time.

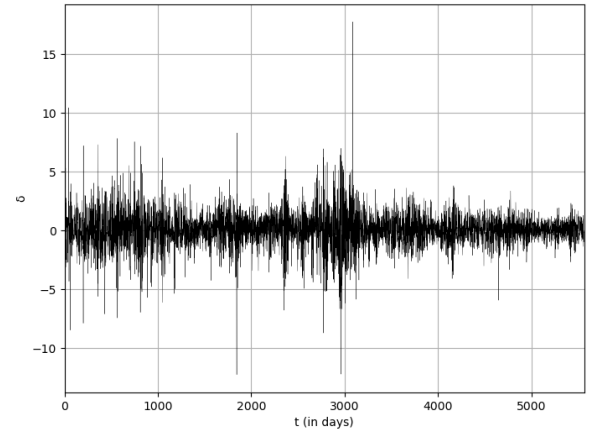


FIG. 2: The time series of the daily percentage fluctuation of prices in the stock index, NIFTY (NSE, India). The daily percentage fluctuation of prices is quantified by  $\delta$ , which, over two decades, has an equal distribution of positive and negative values about  $\delta = 0$ .

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C.

Fig. 3 shows The unnormalized frequency distribution of the daily percentage fluctuation of prices in the stock.

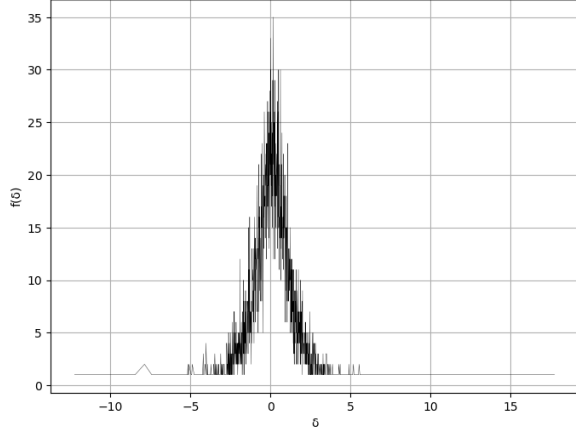


FIG. 3: The unnormalized frequency distribution of the daily percentage fluctuation of prices in the stock index, NIFTY (NSE, India). The distribution appears Gaussian, and is centred around a mean value,  $\mu = 0.057$ , with a standard deviation,  $\sigma = 1.495$ .

D.

Fig. 4 shows The growth of the monthly average of  $\ln S$  vs time.

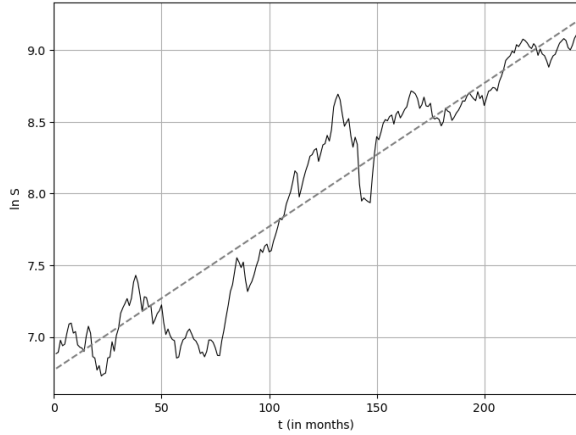


FIG. 4: The growth of the monthly average of  $\ln S$  for NIFTY (NSE, India), as opposed to its daily growth in Fig(1). The straight line, showing the mean growth, is fitted by the least-squares method, and its slope is  $m = 0.01$  per month.

E.

Fig. 5 shows the variance of the monthly prices, vs time.

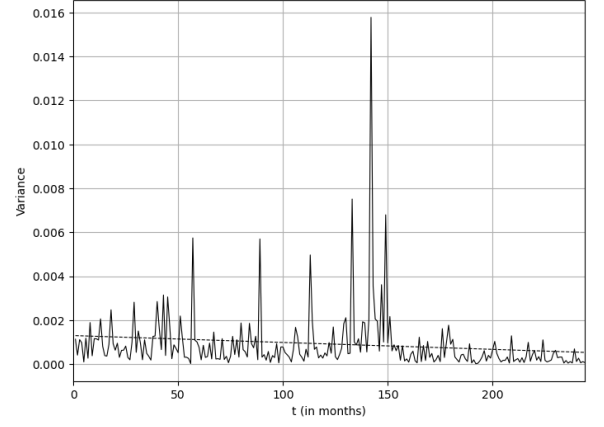


FIG. 5: The Wiener variance about the monthly average of  $\ln S$  for NIFTY (NSE, India) decreases with time, (in months). The straight line, fitted by the least-squares method, traces the mean decline, with a slope of  $w = 3.41 \times 10^{-6}$  per month. With  $w < 0$ , volatility also reduces with time.

F.

Fig. 6 shows the growth of the daily trade volume vs time.

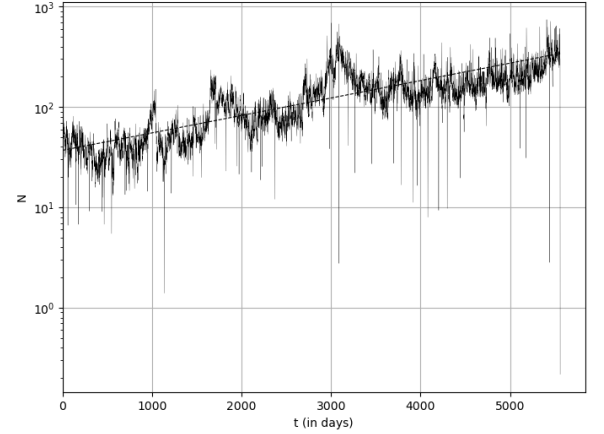


FIG. 6: The growth of the daily trade volume of the NIFTY (NSE, India) index. The straight line in this linear-log plot, fitted by the least-squares method, implies an exponential mean growth of  $N$ . The slope of the straight line,  $v = 0.04\%$  per day, gives the mean relative growth rate of the daily volume of trade.

### III. CONCLUSIONS

⇒Global Regularities: The study reveals consistent patterns across six major stock markets, including the USA, China, Japan, Germany, Britain, and India. These regularities encompass the daily mean growth of stock values, Gaussian fluctuations around this mean, self-similarity in monthly fluctuations, and the exponential growth of daily trade volume. Such global regularities provide insights into the fundamental behaviors of stock markets irrespective of geographic location.

⇒ Exponential Growth and Volatility: Stock values demonstrate exponential growth on a daily basis, with narrow ranges of relative growth rates observed

across different markets. Despite this growth trend, stock prices exhibit Gaussian fluctuations around the mean, with a notable decline in volatility over time. This suggests a stabilizing effect within mature stock markets, where volatility diminishes as markets evolve.

⇒Market Health Indicators: The study underscores the significance of daily trade volume as a key indicator of market health. The exponential growth in trade volume reflects the increasing activity within stock markets, while the observed fluctuations in volume further highlight the interplay between speculation and market dynamics. Understanding these regularities can inform investment strategies and risk management practices in global financial markets.

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[1] Abhin Kakkad, Harsh Vasoya and Arnab K. Ray, '*Regularities in stock markets*'.